NUTRI 335: PRINCIPLES OF FOOD SCIENCE



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Food Science

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Detailed Licensing

Licensing

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1.1: What is Food Science?



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So... What is Food Science?!?!

The definition I like best is that Food Science is everything that happens to the food before the mouth and Nutrition is everything that happens to the food after the mouth! In other words, Food Science involves how the food is grown, harvested, manufactured, packaged, distributed, advertised, sold and more! Nutrition is how the food influences digestion, absorption and overall health!

Food Science is a convenient name used to describe the application of scientific principles to create and maintain a wholesome food supply.

“Just as society has evolved over time, our food system as also evolved over centuries into a global system of immense size and complexity. The commitment of food science and technology professionals to advancing the science of food, ensuring a safe and abundant food supply, and contributing to healthier people everywhere is integral to that evolution. Food scientists and technologists are versatile, interdisciplinary, and collaborative practitioners in a profession at the crossroads of scientific and technological developments. As the food system has drastically changed, from one centered around family food production on individual farms and food preservation to the modern system of today, most people are not connected to their food nor are they familiar with agricultural production and food manufacturing designed for better food safety and quality.”

> *Quote taken from: “Feeding the World Today and Tomorrow: The Importance of Food Science and Technology”; John D. Foloros, Rosetta Newsome, William Fisher; from Comprehensive Reviews in Food Science and Food Safety; 2010*



Food Science has given us things like:

- frozen foods
- canned foods
- microwave meals
- milk which keeps

- packaged snacks
- foods with added nutrients
- more easily prepared foods

The Food Scientist helps supply this bounty by learning to apply a wide range of scientific knowledge to maintain a high quality, abundant food supply. Food Science allows us to make the best use of our food resources and minimize waste.

Most food materials are of biological origin. How they behave in harvesting, processing, distribution, storage and preparation is a complex problem. Full awareness of all important aspects of the problem requires broad-based training.

Example of a local food science laboratory (Mattson of San Francisco)

Mattson WebsiteLinks to an external site.

To be a Food Scientist and help handle the world's food supply to maximum advantage, you need some familiarity with

- Chemistry
- Microbiology
- Biochemistry
- Engineering
- Some specialized Statistics.

Careers in Food Science:

- Product Development Specialist
- Sensory Scientist
- Quality Control Specialist
- Technical Sales Representative

For More Information:

- UC Davis Food Science Program Home Page
- Cal Poly Food Science ProgramLinks to an external site.
- Wikipedia page about Food ScienceLinks to an external site.

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1.2: Why is Food Science Important?

Food Science is Essential

Did you ever imagine what our food and food supply would be like without food science? Please click on this linkLinks to an external site. which will provide insightful information about the different and essential ways food science contributes to ensuring our food supply is:

- Safe
- Nutritious
- Tastes good
- Economical
- Abundant
- Easy to prepare
- Sustainable

What Careers are there in Food Science???

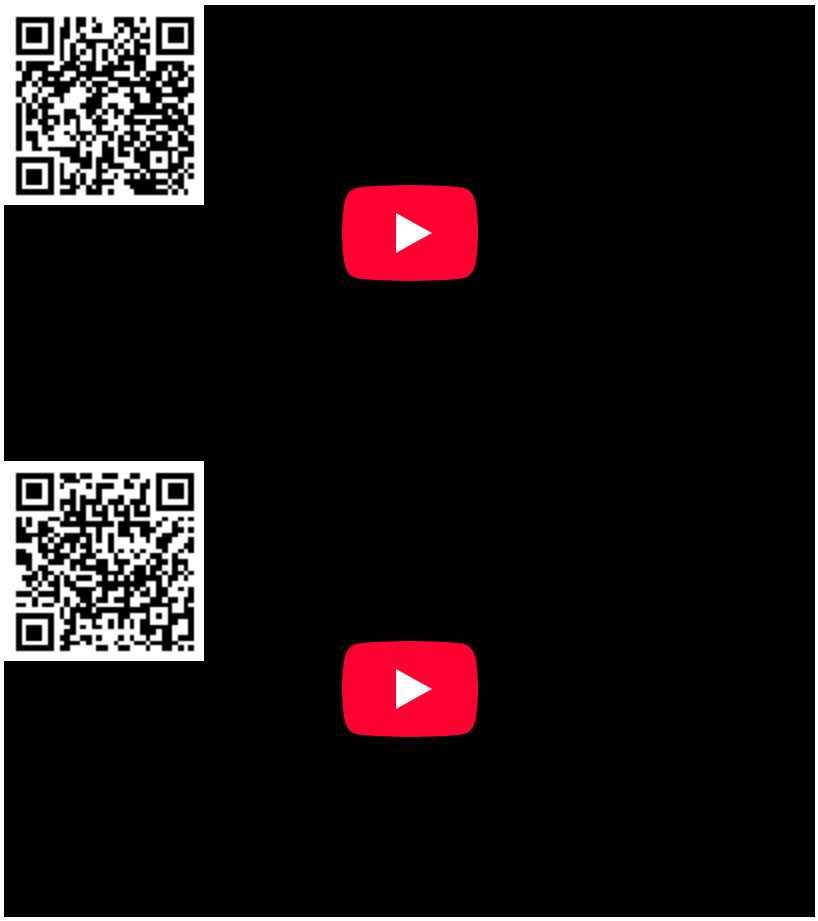
A degree in food science equips you with the knowledge and skills to work in one of the largest industries in the world—the food industry.

While this isn't an exhaustive list, in the video below you will hear about 6 different entry-level positions a food scientist might pursue:

1. Product Development
2. Quality Assurance
3. Food Safety
4. Sensory Science
5. Food Process Engineering
6. Food Research



Do you want to learn more about food science careers? Here's some additional videos:



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1.3: What is the Food System?

The food system is a network of farmers and related operations, including food processing, wholesale and distribution, retail, industry technology, and marketing. The milk industry, for example, includes everything from the farm that raises livestock, to the milking facility that extracts the product, to the processing company that pasteurizes milk and packages it into cartons, to the shipping company that delivers the product to stores, to the markets and groceries that stock and sell the product, to the advertising agency that touts the product to consumers. All of these components play a part in a very large system.



Figure **1.3.1**: Image by Morten Just / CC BY-NC 3.0

Two important aspects of a food system are preservation and processing. Each provides for or protects consumers in different ways. Food preservation includes the handling or treating of food to prevent or slow down spoilage. Food processing involves transforming raw ingredients into packaged food, from fresh-baked goods to frozen dinners. Although there are numerous benefits to both, preservation and processing also pose some concerns, in terms of both nutrition and sustainability.

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1.4: Parts of the Food Industry

Major Segments of the Food industry

Four major segments of the food industry are as follows:

- Production: producing the food
- Manufacturing and processing: treating the food and/or turning fresh food into food products (like corn into corn chips)
- Distribution: getting the food to the consumer
- Marketing: advertising the food

Some Major “Product Lines”



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- Cereals and bakery products
- Dairy products
- Sugars and other sweets
- Fats and oils
- Alcoholic beverages

Consumer consumption is measured and reported.

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1.5: Food Systems and Allied Industries

Definition: Allied Industry

An “allied industry” is a company that does not sell food directly but is still deeply involved in the food industry. Examples include the packaging industry, chemical manufacturers, and food regulators.

Allied Industry Examples:

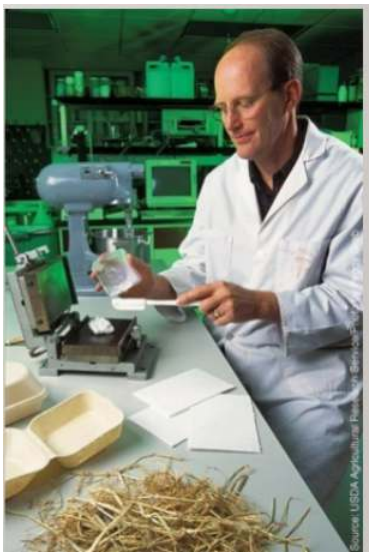


Figure 1.5.1: Copy and Paste Caption here. (Copyright; author via source)

- Packaging industry
- Chemical manufacturers
- Machinery and equipment manufacturers
- Monitoring and regulatory agencies

Vertical Coordination

- Three basic types of vertical coordination:
  - Open production: Example- you produce nuts and then companies reach out to buy them
  - Contract production: Example- you are under contract to produce this crop
  - Vertical integration: Example- you produce the nuts, you process the nuts, package the nuts and sell the nuts (Blue Diamond)
- Traditionally an open production system
- Tailoring raw commodities

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1.6: International Activities

- Food is an international commodity
- Subsidiaries in other countries
  - A company that belongs to another company (parent company)
- World trade imports
  - Worldwide demand for cereal grains and soybeans
    - United States is the largest exporter

Recent trends

- Decreasing trade tariffs world-wide
- Improved transportation and communication
  - Air freight
  - Instant communications
- A nation’s infrastructure policies
  - Communications and transportation sectors
  - Government policies

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1.7: Links to External Websites

Food Science and Technology (USDA website) https://www.nal.usda.gov/fnic/food-science-and-technology-0

Food Systems (USDA) https://www.usda.gov/oce/sustainability/foodsystems

Categories of food and food products https://www.fda.gov/product-categories-and-products

Great video about graduate students in Food Science and peek inside food science laboratories https://www.ift.org/career-development/learn-about-food-science/careers-in-food-science

UCD food science careers https://foodscience.ucdavis.edu/about/careers-food-science

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1.8: Food Supply Chain

https://www.usda.gov/coronavirus/food-supply-chain

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1.9: The Globalization of Food

Learning Objectives

By the end of this section, you will be able to:

- Describe the impacts of globalization on food and food diversity.
- Define food deserts and food oases.

Globalization of Food

Most people, when they think about food, consider it a local, individual choice based on personal preferences and economic possibilities. But food is a global commodity marketed by transnational corporations, health institutes, advertising campaigns, and subtle and not-so-subtle cultural messaging through global media such as movies, television, and online video. Most often, what people choose to eat is based on underlying structures that determine availability and cost. While there are now hothouse businesses growing year-round fruits and vegetables, affordability often prohibits everyone from having access to fresh, ripe foods. Instead, mainstream grocery stores most often stock foods imported across long distances. Most fruits and vegetables sold in the grocery store were harvested unripe (and often tasteless) so that they would last the days and weeks between harvesting and purchase.



Figure **14.13** Pallets of fruit being loaded on deck for shipment overseas. Most commercial fruits are harvested before they are ripe so that they will not spoil before arriving at a supermarket, often far from where they were picked. (credit: Dr. Karl-Heinz Hochhaus/Wikimedia Commons, CC BY 3.0)

In her work on food and globalization, anthropologist and food studies specialist Lynne Phillips points out the “crooked pathways” (2006, 38) that food takes to become a global commodity. Increasingly affected by transnational corporations, food today is marketed for endlessly higher profits. Food no longer goes simply from producer to consumer. There are many turns along the way.

Food globalization has numerous effects on our daily lives:

- The food chains from producers to consumers are increasingly fragile as a small number of transnational corporations provide the basic foods that we eat daily. Failures in this food chain might come from contamination during production or breaks in the supply chain due to climate crises, tariffs, or trade negotiations between countries. Our dependence on global food chains makes the food supply to our communities more vulnerable to disruption and scarcity.
- Our food cultures are less diverse and tend to revolve around a limited number of mass-produced meats or grains. With the loss of diversity, there is an accompanying loss not only of food knowledge but also of nutrition.
- As foods become more globalized, we are increasingly dependent on food additives to enhance the appearance and taste of foods and to ensure their preservation during the long journey from factory farm to table. We are also increasingly exposed to

steroids, antibiotics, and other medicines in the meat we eat. This exposure poses health risks to large numbers of people.

- As plants and animals are subjected to ever more sophisticated forms of genetic engineering, there is an increasing monopoly on basic food items, allowing transnational companies to affect regulatory controls on food safety. As corporate laboratories develop patented seeds (such as the Monsanto Corporation's genetically engineered corn) that are super-producers and able to withstand challenges such as harsh climate conditions and disease, growers become dependent on the seed sold by these corporations. No longer able to save seed from year to year, growers have little choice but to pay whatever price these corporations choose to charge for their genetic material.
- Factory farming of all types, but especially large-scale animal farms, are major contributors to global warming. Not only do they produce large amounts of water and air pollution and contribute to worldwide deforestation, but as more and more forest is turned into pasture, the sheer number of livestock contributes significant levels of greenhouse gases that lead to global warming. Worldwide, livestock account for around 14.5 percent of global greenhouse gas emissions (Quinton 2019).

Food has long been an international commodity, even during the 17th and 18th centuries, when traders sought spice and trade routes connecting Europe and Asia. Today, however, food has become transnational, with production sometimes spanning many different countries and fresh and processed foods moving long distances from their original harvest or production. Because these migrating foods must be harvested early or packaged with preservatives that we may not know or even be able to pronounce, there has been a parallel development in local food movements, organic food movements, and farm-to-table establishments as people see the dangers of food globalization. In the very popular *The Omnivore's Dilemma: A Natural History of Four Meals* (2006), American author and food journalist Michael Pollan advocates that people should know the identity of the foods they eat and should make every effort to eat locally sourced products. Shortly after the book's publication, chef and author Jessica Prentice coined the term **locavore** to refer to those who eat locally and know the origins of their foods. In 2007, *locavore* was chosen as the New Oxford American Dictionary word of the year.

Food Deserts and Oases

Worldwide, access to nutritious and affordable foods is growing increasingly unequal. Areas with inadequate or unreliable access to nutritious foods are sometimes called **food deserts**. Food deserts present serious challenges to health and wellness in multiple ways and have been linked to eating disorders, obesity, and malnutrition. In Western nations, food deserts frequently correspond to other areas of social inequality, such as low-income and minority communities. Reduced availability of healthy and economical food often exacerbates many of the challenges these communities face.

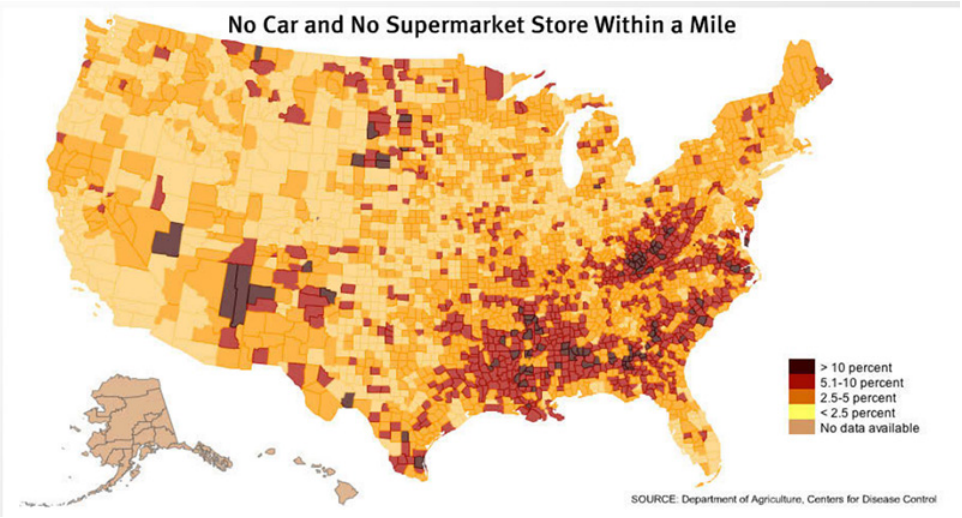


Figure **14.14** Food deserts are common in Western countries, especially in and around urban areas. This chart shows areas in the United States where significant percentages of people both have no car and no grocery store within a mile of their home, which is about a twenty minute walk for a healthy adult. (credit: United States Department of Agriculture and Centers for Disease Control/Wikimedia Commons, Public Domain)

As the world population continues to grow (currently at around 7.9 billion people), climate change accelerates, and food production becomes more and more concentrated in the hands of a few corporations, access to food will become increasingly critical to our survival. The story of progress embraced by Western society tells us that globalization and agricultural developments have

stabilized and secured our food chains, but anthropological studies of foragers suggest otherwise. Agricultural production is tied to access to arable land, clean water, stable climate, and a reliable workforce. Periodically, crops (and animals) fail due to disease, drought, and even disruption from warfare and extreme weather, leading to scarcity and famine in many parts of the world. In addition, as families and communities produce less and less of their own food and become more and more dependent on intermediaries to gain access to food, their vulnerabilities increase. While there are many differences between state societies and foragers, there are valuable lessons we can learn from them. Foragers, facing the same unstable conditions that we all face worldwide, have a more varied and flexible diet and are able to adjust their needs seasonally based on local availability. They eat locally, and they adjust their needs to what is available.

There are also **food oases**, areas that have high access to supermarkets and fresh foods, and these are growing in number. Some are in urban or suburban areas, and some are in rural areas where sustainable farming supports a local community or restaurant. In Harrodsburg, Kentucky, the Trustees' Table serves food from the nearby Pleasant Hill Shaker gardens. Visitors to the Shaker site, a historic cloistered religious community, learn about the Shaker seed industry, plant varieties, and sustainable gardening techniques at Shaker Farm, then walk down to the Trustees' Table to have a farm-to-table meal. The seasonal menu features local Kentucky dishes that would have been common fare during the period of Shaker occupation (1805–1910), such as garlic potatoes, warm or cold salads, vegetable pot pies, and apple pie. By utilizing the foods raised in the nearby gardens, the Trustees' Table serves as a legacy restaurant that helps preserve and sustain Shaker research and farming on-site.

In Richmond, Virginia, an organization called Real Local RVA was founded in 2014 as a grassroots local food movement to support businesses and residential areas in the downtown area of the city. It expresses its core value as "collaboration over competition." The group sponsors monthly meetings, local farm tours, and community events highlighting businesses and prominent figures in the local food movement. The participants are all farmers, independent grocers, or local restaurants that source local ingredients and products as part of their mission. Besides advocating for small farms and independent businesses, Real Local RVA also sponsors workshops and education on sustainable farming, does joint marketing and "storytelling" about its partnership and the values of local food networks, and provide a recognizable brand to identify participating members for the wider urban community.

Although local food movements are increasingly popular, most still primarily operate in more affluent areas. As we develop more of these healthy initiatives, we also must expand the zones in which they operate, especially in cities, to include all of our neighbors and neighborhoods. Food and sociality go hand in hand. As Michael Pollan writes, "The shared meal elevates eating from a mechanical process of fueling the body to a ritual of family and community, from mere animal biology to an act of culture" (2008, 192).

The study of food in anthropology is important for many reasons. Food reveals cultural identities and physical vulnerabilities, and it helps build social networks and mark important life events. How often eating is prescribed, what foods are considered appropriate, who cooks, who serves whom, and what foods are most and least valued all vary across cultures. As anthropologists seek to understand human cultures, food is often a centerpiece ingredient in knowing who we are.

Mini-Fieldwork Activity

Food Memories

Food plays an important role in long-term memory, as it is linked to smell, taste, and texture and often is a central feature of social functions, whether they be family dinners or holiday feasts. In this project, you will interview two individuals who are likely to have different food memories than you; they may be older, they may be living in a different part of the country (or world), or they may have lived part of their lives in a specific environment (rural or urban) that is different from yours. Ask each person to share with you stories about special holiday meals prepared and served as part of their family life, whether as a child or an adult. What foods do they most identify with specific holidays? How did they prepare and consume those foods? Were there specific gender roles during the preparation and holiday meals? After collecting and writing up what you have learned, what conclusions can you make about the role of food in human social and cultural life?

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1.10: UCD food science careers

https://foodscience.ucdavis.edu/about/careers-food-science

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CHAPTER OVERVIEW

Chapter 2: World Food Challenges

2.1: The Globalization of Food

2.2: Food Security

2.3: The Issue of Food Security

Thumbnail: Free variety of beans, lentils, bags. (Public Domain; Rawpixel via Rawpixel)

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2.1: The Globalization of Food

Learning Objectives

By the end of this section, you will be able to:

- Describe the impacts of globalization on food and food diversity.
- Define food deserts and food oases.

Globalization of Food

Most people, when they think about food, consider it a local, individual choice based on personal preferences and economic possibilities. But food is a global commodity marketed by transnational corporations, health institutes, advertising campaigns, and subtle and not-so-subtle cultural messaging through global media such as movies, television, and online video. Most often, what people choose to eat is based on underlying structures that determine availability and cost. While there are now hothouse businesses growing year-round fruits and vegetables, affordability often prohibits everyone from having access to fresh, ripe foods. Instead, mainstream grocery stores most often stock foods imported across long distances. Most fruits and vegetables sold in the grocery store were harvested unripe (and often tasteless) so that they would last the days and weeks between harvesting and purchase.



Figure **14.13** Pallets of fruit being loaded on deck for shipment overseas. Most commercial fruits are harvested before they are ripe so that they will not spoil before arriving at a supermarket, often far from where they were picked. (credit: Dr. Karl-Heinz Hochhaus/Wikimedia Commons, CC BY 3.0)

In her work on food and globalization, anthropologist and food studies specialist Lynne Phillips points out the “crooked pathways” (2006, 38) that food takes to become a global commodity. Increasingly affected by transnational corporations, food today is marketed for endlessly higher profits. Food no longer goes simply from producer to consumer. There are many turns along the way.

Food globalization has numerous effects on our daily lives:

- The food chains from producers to consumers are increasingly fragile as a small number of transnational corporations provide the basic foods that we eat daily. Failures in this food chain might come from contamination during production or breaks in the supply chain due to climate crises, tariffs, or trade negotiations between countries. Our dependence on global food chains makes the food supply to our communities more vulnerable to disruption and scarcity.
- Our food cultures are less diverse and tend to revolve around a limited number of mass-produced meats or grains. With the loss of diversity, there is an accompanying loss not only of food knowledge but also of nutrition.
- As foods become more globalized, we are increasingly dependent on food additives to enhance the appearance and taste of foods and to ensure their preservation during the long journey from factory farm to table. We are also increasingly exposed to

steroids, antibiotics, and other medicines in the meat we eat. This exposure poses health risks to large numbers of people.

- As plants and animals are subjected to ever more sophisticated forms of genetic engineering, there is an increasing monopoly on basic food items, allowing transnational companies to affect regulatory controls on food safety. As corporate laboratories develop patented seeds (such as the Monsanto Corporation's genetically engineered corn) that are super-producers and able to withstand challenges such as harsh climate conditions and disease, growers become dependent on the seed sold by these corporations. No longer able to save seed from year to year, growers have little choice but to pay whatever price these corporations choose to charge for their genetic material.
- Factory farming of all types, but especially large-scale animal farms, are major contributors to global warming. Not only do they produce large amounts of water and air pollution and contribute to worldwide deforestation, but as more and more forest is turned into pasture, the sheer number of livestock contributes significant levels of greenhouse gases that lead to global warming. Worldwide, livestock account for around 14.5 percent of global greenhouse gas emissions (Quinton 2019).

Food has long been an international commodity, even during the 17th and 18th centuries, when traders sought spice and trade routes connecting Europe and Asia. Today, however, food has become transnational, with production sometimes spanning many different countries and fresh and processed foods moving long distances from their original harvest or production. Because these migrating foods must be harvested early or packaged with preservatives that we may not know or even be able to pronounce, there has been a parallel development in local food movements, organic food movements, and farm-to-table establishments as people see the dangers of food globalization. In the very popular *The Omnivore's Dilemma: A Natural History of Four Meals* (2006), American author and food journalist Michael Pollan advocates that people should know the identity of the foods they eat and should make every effort to eat locally sourced products. Shortly after the book's publication, chef and author Jessica Prentice coined the term **locavore** to refer to those who eat locally and know the origins of their foods. In 2007, *locavore* was chosen as the New Oxford American Dictionary word of the year.

Food Deserts and Oases

Worldwide, access to nutritious and affordable foods is growing increasingly unequal. Areas with inadequate or unreliable access to nutritious foods are sometimes called **food deserts**. Food deserts present serious challenges to health and wellness in multiple ways and have been linked to eating disorders, obesity, and malnutrition. In Western nations, food deserts frequently correspond to other areas of social inequality, such as low-income and minority communities. Reduced availability of healthy and economical food often exacerbates many of the challenges these communities face.

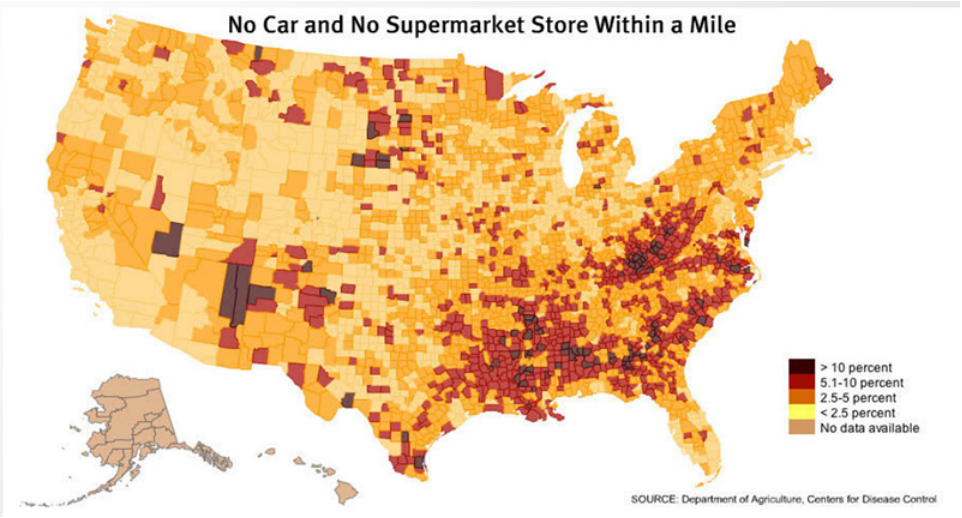


Figure **14.14** Food deserts are common in Western countries, especially in and around urban areas. This chart shows areas in the United States where significant percentages of people both have no car and no grocery store within a mile of their home, which is about a twenty minute walk for a healthy adult. (credit: United States Department of Agriculture and Centers for Disease Control/Wikimedia Commons, Public Domain)

As the world population continues to grow (currently at around 7.9 billion people), climate change accelerates, and food production becomes more and more concentrated in the hands of a few corporations, access to food will become increasingly critical to our survival. The story of progress embraced by Western society tells us that globalization and agricultural developments have

stabilized and secured our food chains, but anthropological studies of foragers suggest otherwise. Agricultural production is tied to access to arable land, clean water, stable climate, and a reliable workforce. Periodically, crops (and animals) fail due to disease, drought, and even disruption from warfare and extreme weather, leading to scarcity and famine in many parts of the world. In addition, as families and communities produce less and less of their own food and become more and more dependent on intermediaries to gain access to food, their vulnerabilities increase. While there are many differences between state societies and foragers, there are valuable lessons we can learn from them. Foragers, facing the same unstable conditions that we all face worldwide, have a more varied and flexible diet and are able to adjust their needs seasonally based on local availability. They eat locally, and they adjust their needs to what is available.

There are also **food oases**, areas that have high access to supermarkets and fresh foods, and these are growing in number. Some are in urban or suburban areas, and some are in rural areas where sustainable farming supports a local community or restaurant. In Harrodsburg, Kentucky, the Trustees' Table serves food from the nearby Pleasant Hill Shaker gardens. Visitors to the Shaker site, a historic cloistered religious community, learn about the Shaker seed industry, plant varieties, and sustainable gardening techniques at Shaker Farm, then walk down to the Trustees' Table to have a farm-to-table meal. The seasonal menu features local Kentucky dishes that would have been common fare during the period of Shaker occupation (1805–1910), such as garlic potatoes, warm or cold salads, vegetable pot pies, and apple pie. By utilizing the foods raised in the nearby gardens, the Trustees' Table serves as a legacy restaurant that helps preserve and sustain Shaker research and farming on-site.

In Richmond, Virginia, an organization called Real Local RVA was founded in 2014 as a grassroots local food movement to support businesses and residential areas in the downtown area of the city. It expresses its core value as "collaboration over competition." The group sponsors monthly meetings, local farm tours, and community events highlighting businesses and prominent figures in the local food movement. The participants are all farmers, independent grocers, or local restaurants that source local ingredients and products as part of their mission. Besides advocating for small farms and independent businesses, Real Local RVA also sponsors workshops and education on sustainable farming, does joint marketing and "storytelling" about its partnership and the values of local food networks, and provide a recognizable brand to identify participating members for the wider urban community.

Although local food movements are increasingly popular, most still primarily operate in more affluent areas. As we develop more of these healthy initiatives, we also must expand the zones in which they operate, especially in cities, to include all of our neighbors and neighborhoods. Food and sociality go hand in hand. As Michael Pollan writes, "The shared meal elevates eating from a mechanical process of fueling the body to a ritual of family and community, from mere animal biology to an act of culture" (2008, 192).

The study of food in anthropology is important for many reasons. Food reveals cultural identities and physical vulnerabilities, and it helps build social networks and mark important life events. How often eating is prescribed, what foods are considered appropriate, who cooks, who serves whom, and what foods are most and least valued all vary across cultures. As anthropologists seek to understand human cultures, food is often a centerpiece ingredient in knowing who we are.

Mini-Fieldwork Activity

Food Memories

Food plays an important role in long-term memory, as it is linked to smell, taste, and texture and often is a central feature of social functions, whether they be family dinners or holiday feasts. In this project, you will interview two individuals who are likely to have different food memories than you; they may be older, they may be living in a different part of the country (or world), or they may have lived part of their lives in a specific environment (rural or urban) that is different from yours. Ask each person to share with you stories about special holiday meals prepared and served as part of their family life, whether as a child or an adult. What foods do they most identify with specific holidays? How did they prepare and consume those foods? Were there specific gender roles during the preparation and holiday meals? After collecting and writing up what you have learned, what conclusions can you make about the role of food in human social and cultural life?

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2.2: Food Security

Progress continues in the fight against hunger, yet an unacceptably large number of people lack the food they need for an active and healthy life. The latest available estimates indicate that about 795 million people in the world – just over one in nine –still go to bed hungry every night, and an even greater number live in poverty (defined as living on less than $1.25 per day). Poverty—not food availability—is the major driver of food insecurity. Improvements in agricultural productivity are necessary to increase rural household incomes and access to available food but are insufficient to ensure food security. Evidence indicates that poverty reduction and food security do not necessarily move in tandem. The main problem is lack of economic (social and physical) access to food at national and household levels and inadequate nutrition (or hidden hunger). Food security not only requires an adequate supply of food but also entails availability, access, and utilization by all—people of all ages, gender, ethnicity, religion, and socioeconomic levels.

From Agriculture to Food Security

Agriculture and food security are inextricably linked. The agricultural sector in each country is dependent on the available natural resources, as well as the politics that govern those resources. **Staple food crops** are the main source of dietary energy in the human diet and include things such as rice, wheat, sweet potatoes, maize, and cassava.

Food security

Food security is essentially built on four pillars: **availability**, **access**, **utilization** and **stability**. An individual must have access to sufficient food of the right dietary mix (quality) at all times to be food secure. Those who never have sufficient quality food are **chronically food insecure**.

When food security is analyzed at the national level, an understanding not only of national production is important, but also of the country's **access** to food from the global market, its foreign exchange earnings, and its citizens' consumer choices. Food security analyzed at the household level is conditioned by a household's own food production and household members' ability to purchase food of the right quality and diversity in the market place. However, it is only at the individual level that the analysis can be truly accurate because only through understanding who consumes what can we appreciate the impact of sociocultural and gender inequalities on people's ability to meet their nutritional needs.The definition of food security is often applied at varying levels of aggregation, despite its articulation at the individual level. The importance of a pillar depends on the level of aggregation being addressed. At a global level, the important pillar is food**availability**. Does global agricultural activity produce sufficient food to feed all the world's inhabitants? The answer today is yes, but it may not be true in the future given the impact of a growing world population, emerging plant and animal pests and diseases, declining soil productivity and environmental quality, increasing use of land for fuel rather than food, and lack of attention to agricultural research and development, among other factors.

The third pillar, food **utilization**, essentially translates the food available to a household into nutritional security for its members. One aspect of utilization is analyzed in terms of distribution according to need. Nutritional standards exist for the actual nutritional needs of men, women, boys, and girls of different ages and life phases (that is, pregnant women), but these "needs" are often socially constructed based on culture. For example, in South Asia evidence shows that women eat after everyone else has eaten and are less likely than men in the same household to consume preferred foods such as meats and fish. **Hidden hunger** commonly results from poor food utilization: that is, a person's diet lacks the appropriate balance of macro- (calories) and micronutrients (vitamins and minerals). Individuals may look well nourished and consume sufficient calories but be deficient in key micronutrients such as vitamin A, iron, and iodine.

When food security is analyzed at the national level, an understanding not only of national production is important, but also of the country's access to food from the global market, its foreign exchange earnings, and its citizens' consumer choices. Food security analyzed at the household level is conditioned by a household's own food production and household members' ability to purchase food of the right quality and diversity in the market place. However, it is only at the individual level that the analysis can be truly accurate because only through understanding who consumes what can we appreciate the impact of sociocultural and gender inequalities on people's ability to meet their nutritional needs.

Food **stability** is when a population, household, or individual has access to food at all times and does not risk losing access as a consequence of cyclical events, such as the dry season**.** When some lacks food stability, they have **malnutrition,** a lack of essential

nutrients. This is economically costly because it can cost individuals 10 percent of their lifetime earnings and nations 2 to 3 percent of gross domestic product (GDP) in the worst-affected countries (Alderman 2005). Achieving food security is even more challenging in the context of HIV and AIDS. HIV affects people's physical ability to produce and use food, reallocating household labor, increasing the work burden on women, and preventing widows and children from inheriting land and productive resources.

Obesity

Obesity means having too much body fat. It is not the same as overweight, which means weighing too much. Obesity has become a significant global health challenge, yet is preventable and reversible. Over the past 20 years, a global overweight/obesity epidemic has emerged, initially in industrial countries and now increasingly in low- and middle-income countries, particularly in urban settings, resulting in a triple burden of undernutrition, micronutrient deficiency, and overweight/obesity. There is significant variation by region; some have very high rates of undernourishment and low rates of obesity, while in other regions the opposite is true (Figure **2.2.1**).

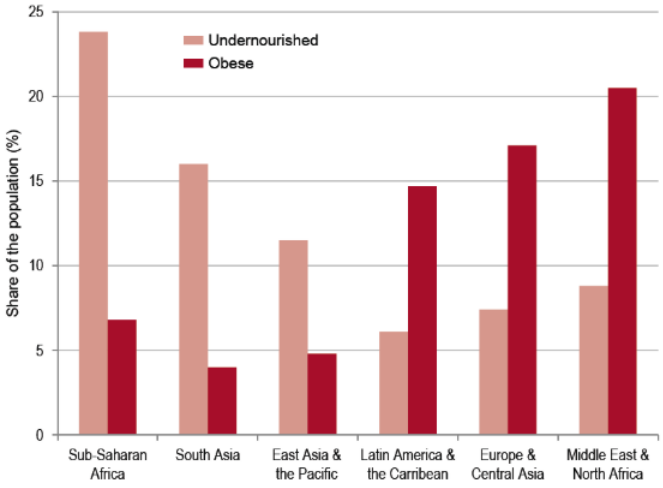


Figure **2.2.1**. Obesity and undernourishment by region.

However, obesity has increased to the extent that the number of overweight people now exceeds the number of underweight people worldwide. The economic cost of obesity has been estimated at $2 trillion, accounting for about 5% of deaths worldwide. Almost 30% of the world's population, or 2.1 billion people, are overweight or obese, 62% of whom live in developing countries.

Obesity accounts for a growing level and share of worldwide noncommunicable diseases, including diabetes, heart disease, and certain cancers that can reduce quality of life and increase public health costs of already under-resourced developing countries. The number of overweight children is projected to double by 2030. Driven primarily by increasing availability of processed, affordable, and effectively marketed food, the global food system is falling short with rising obesity and related poor health outcomes. Due to established health implications and rapid increase in prevalence, obesity is now a recognized major global health challenge.

Suggested Supplementary Reading:

McMillan, T. 2018. How China Plans to Feed 1.4 Billion Growing Appetites. *National Geographic*. February.

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2.3: The Issue of Food Security

Learning Objectives

- Share an example of a food and nutrition program that seeks to mitigate hunger in the United States and/or Canada.

Physiologically, hunger relates to appetite and is the body's response to a need for nourishment. Through stomach discomfort or intestinal rumbling, the body alerts the brain that it requires food. This uneasy sensation is easily addressed with a snack or a full meal. However, the term "hunger" also relates to a weakened condition that is a consequence of a prolonged lack of food. People who suffer from this form of hunger typically experience malnourishment, along with poor growth and development.

Hunger

Adequate food intake that meets nutritional requirements is essential to achieve a healthy, productive lifestyle. However, millions of people in North America, not to mention globally, go hungry and are malnourished each year due to a recurring and involuntary lack of food. The economic crisis of 2008 caused a dramatic increase in hunger across the United States.World Hunger.org. "Hunger in America: 2011 United States Hunger and Poverty Facts." Accessed October 10, 2011. www.worldhunger.org/articles/...nger_facts.htm.

Key Hunger Statistics

In 2010, 925 million people around the world were classified as hungry. Although this was a decrease from a historic high of more than one billion people from the previous year, it is still an unbearable number. Every night, millions and millions of people go to sleep hungry due to a lack of the money or resources needed to acquire an adequate amount of food. This graph shows the division of hungry people around the globe.

Key Hunger Terms

A number of terms are used to categorize and classify hunger. Two key terms, food security and food insecurity, focus on status and affect hunger statistics. Another term, malnutrition, refers to the deficiencies that a hungry person experiences.

Food Security

Most American households are considered to be food secure, which means they have adequate access to food and consume enough nutrients to achieve a healthy lifestyle. However, a minority of US households experiences food insecurity at certain points during the year, which means their access to food is limited due to a lack of money or other resources. This graphic shows the percentage of food-secure and food-insecure households in the United States during the year 2010.

Food Insecurity

Food insecurity is defined as not having adequate access to food that meets nutritional needs. According to the USDA, about 48.8 million people live in food-insecure households and have reported multiple indications of food access problems. About sixteen million of those have "very low food security," which means one or more people in the household were hungry at some point over the course of a year due to the inability to afford enough food. The difference between low and very low food security is that members of low insecurity households have reported problems of food access, but have reported only a few instances of reduced food intake, if any.Coleman-Jensen, A. et al. "Household Food Security in the United States in 2010." US Department of Agriculture, *Economic Research Report*, no. ERR-125 (September 2011). African American and Hispanic households experience food insecurity at much higher rates than the national average.Coleman-Jensen, A. et al. "Household Food Security in the United States in 2010." US Department of Agriculture, *Economic Research Report*, no. ERR-125 (September 2011).

Households with limited resources employ a variety of methods to increase their access to adequate food. Some families purchase junk food and fast food—cheaper options that are also very unhealthy. Other families who struggle with food security supplement the groceries they purchase by participating in government assistance programs. They may also obtain food from emergency providers, such as food banks and soup kitchens in their communities.

Malnutrition

A person living in a food-insecure household may suffer from malnutrition, which results from a failure to meet nutrient requirements. This can occur as a result of consuming too little food or not enough key nutrients. There are two basic types of malnutrition. The first is macronutrient deficiency and relates to the lack of adequate protein, which is required for cell growth, maintenance, and repair. The second type of malnutrition is micronutrient deficiency and relates to inadequate vitamin and mineral intake.World Hunger. “2011 World Hunger and Poverty Facts and Statistics.” Accessed October 10, 2011. http://www.worldhunger.org/articles/...cts%202002.htm. Even people who are overweight or obese can suffer from this kind of malnutrition if they eat foods that do not meet all of their nutritional needs.

At-Risk Groups

Worldwide, three main groups are most at risk of hunger: the rural poor in developing nations who also lack access to electricity and safe drinking water, the urban poor who live in expanding cities and lack the means to buy food, and victims of earthquakes, hurricanes, and other natural and man-made catastrophes.Food and Agriculture Organization of the United Nations. “Hunger: Frequently Asked Questions.” Accessed October 10, 2011. www.fao.org/hunger/en/ In the United States, there are additional subgroups that are at risk and are more likely than others to face hunger and malnutrition. They include low-income families and the working poor, who are employed but have incomes below the federal poverty level.

Senior citizens are also a major at-risk group. Many elderly people are frail and isolated, which affects their ability to meet their dietary requirements. In addition, many also have low incomes, limited resources, and difficulty purchasing or preparing food due to health issues or poor mobility. As a result, more than six million senior citizens in the United States face the threat of hunger. Meals on Wheels. “Our Vision and Mission.” Accessed October 10, 2011. www.mowaa.org/page.aspx?pid=299

The Homeless

One of the groups that struggles with hunger are the millions of homeless people across North America. According to a recent study by the US Conference of Mayors, the majority of reporting cities saw an increase in the number of homeless families.The United States Conference of Mayors. “Hunger and Homelessness Survey: A Status Report on Hunger and Homelessness in America’s Cities, a 27-City Survey.” December 2009. usmayors.org/pressreleases/up...eteWEB2009.pdf. Hunger and homelessness often go hand-in-hand as homeless families and adults turn to soup kitchens or food pantries or resort to begging for food.

Children

Rising hunger rates in the United States particularly affect children. Nearly one out of four children, or 21.6 percent of all American children, lives in a food-insecure household and spends at least part of the year hungry.Coleman-Jensen, A. et al. “Household Food Security in the United States in 2010.” US Department of Agriculture, *Economic Research Report*, no. ERR-125 (September 2011). Hunger delays their growth and development and affects their educational progress because it is more difficult for hungry or malnourished students to concentrate in school. In addition, children who are undernourished are more susceptible to contracting diseases, such as measles and pneumonia.World Hunger. “2011 World Hunger and Poverty Facts and Statistics.” Accessed October 10, 2011.



Video 2.3.1: Going Hungry in America. This video examines the effect of hunger on many American children.

Government Programs

The federal government has established a number of programs that work to alleviate hunger and ensure that many low-income families receive the nutrition they require to live a healthy life. A number of programs were strengthened by the passage of the Healthy, Hunger-Free Kids Act of 2010. This legislation authorized funding and set the policy for several key core programs that provide a safety net for food-insecure children across the United States.

The Federal Poverty Level

The federal poverty level (FPL) is used to determine eligibility for food-assistance programs. This monetary figure is the minimum amount that a family would need to acquire shelter, food, clothing, and other necessities. It is calculated based on family size and is adjusted for annual inflation. Although many people who fall below the FPL are unemployed, the working poor can qualify for food programs and other forms of public assistance if their income is less than a certain percentage of the federal poverty level, along with other qualifications.

USDA Food Assistance Programs

Government food and nutrition assistance programs that are organized and operated by the USDA work to increase food security. They provide low-income households with access to food, the tools for consuming a healthy diet, and education about nutrition. The USDA monitors the extent and severity of food insecurity via an annual survey. This contributes to the efficiency of food assistance programs as well as the effectiveness of private charities and other initiatives aimed at reducing food insecurity.Coleman-Jensen, A. et al. “Household Food Security in the United States in 2010.” US Department of Agriculture, *Economic Research Report*, no. ERR-125 (September 2011).

The Supplemental Nutrition Assistance Program

Formerly known as the Food Stamp Program, the Supplemental Nutrition Assistance Program (SNAP) provides monthly benefits for low-income households to purchase approved food items at authorized stores. Clients qualify for the program based on available household income, assets, and certain basic expenses. In an average month, SNAP provides benefits to more than forty million people in the United States.Coleman-Jensen, A. et al. “Household Food Security in the United States in 2010.” US Department of Agriculture, *Economic Research Report*, no. ERR-125 (September 2011).

The program provides Electronic Benefit Transfers (EBT) which work similarly to a debit card. Clients receive a card with a certain allocation of money for each month that can be used only for food. In 2010, the average benefit was about $134 per person, per month and total federal expenditures for the program were $68.2 billion.Coleman-Jensen, A. et al. “Household Food Security in the United States in 2010.” US Department of Agriculture, *Economic Research Report*, no. ERR-125 (September 2011).

The Special, Supplemental Program for Women, Infants, and Children

The Special, Supplemental Program for Women, Infants and Children (WIC) provides food packages to pregnant and breastfeeding women, as well as to infants and children up to age five, to promote adequate intake for healthy growth and development. Most state WIC programs provide vouchers that participants use to acquire supplemental packages at authorized stores. In 2010, WIC served approximately 9.2 million participants per month at an average monthly cost of about forty-two dollars per person.Coleman-Jensen, A. et al. “Household Food Security in the United States in 2010.” US Department of Agriculture, *Economic Research Report*, no. ERR-125 (September 2011).

The National School Lunch Program

The National School Lunch Program (NSLP) and School Breakfast Program (SBP) ensure that children in elementary and middle schools receive at least one healthy meal each school day, or two if both the NSLP and SBP are provided. According to the USDA, these programs operate in over 101,000 public and nonprofit private schools and residential child-care institutions.US Department of Agriculture. “National School Lunch Program.” October 2011. www.fns.usda.gov/cnd/Lunch/Ab...PFactSheet.pdf. In 2010, the programs provided meals to an average of 31.6 million children each school day. Fifty-six percent of the lunches served were free, and an additional 10 percent were provided at reduced prices.

Other Food-Assistance Programs for Children

Other government programs provide meals for children after school hours and during summer breaks. The Child and Adult Care Food Program (CACFP) offers meals and snacks at child-care centers, daycare homes, and after-school programs. Through CACFP, more than 3.2 million children and 112,000 adults receive nutritious meals and snacks each day.US Department of Agriculture. “Child & Adult Care Food Program.” Last modified June 10, 2011. www.fns.usda.gov/cnd/care/. The Summer Food Service Program provides meals to children during summer break. Sponsors include day camps and other recreation programs where at least half of the attendees live in households with incomes below the federal poverty level.US Department of Agriculture. “Summer Food Service Program.” st.TER 14 2011r Congressbrary. Last modified July 20, 2011. http://www.summerfood.usda.gov/default.htm. These and other programs help to fill in the gaps during the typical day of a food-insecure child.

The Head Start Program

Head Start is a health and development program for children ages three to five, from low-income families. The philosophy behind the organization is that early intervention can help address the educational, social, and nutritional deficiencies that children from lower-income families often experience. Launched in 1965, it is one of the longest-running, poverty-related programs in the United States. Today, Head Start programs include education, meals, snacks, and access to other social services and health guidance.US Department of Health and Human Services. “About the Office of Head Start.” Last reviewed February 23, 2011. www.acf.hhs.gov/programs/ohs/about/index.html.

Other Forms of Assistance

Other forms of assistance include locally-operated charitable organizations, such as food banks and food pantries, which acquire food from local manufacturers, retailers, farmers, and community members to give to low-income families. Neighborhood soup kitchens provide meals to the homeless and other people in need. These and other organizations are run by nonprofit groups, as well as religious institutions, to provide an additional safety net for those in need of food.

Meals on Wheels

An organization known as Meals on Wheels delivers meals to elderly people who have difficulty buying or making their own food because of poor health or limited mobility. It is the oldest and largest program dedicated to addressing the nutritional needs of senior citizens. Each day, Meals on Wheels volunteers deliver more than one million meals across the United States. The first Meals on Wheels program began in Philadelphia in the 1950s. In the decades since, the organization has expanded into a vast network that serves the elderly in all fifty states and several US territories. Today, Meals on Wheels remains committed to ending hunger among the senior citizen community.Meals on Wheels. “The Meals on Wheels Association of America.” Accessed October 10, 2011. www.mowaa.org/page.aspx?pid=212.



Figure 2.3.1: Delivery of Thanksgiving dinner to a Meals on Wheels recipient. Clara Donney, (right), a Meals on Wheels recipient of a Thanksgiving dinner sponsored by the Great Falls Community Food Bank, is all smiles as Airman 1st Class Courtney Taylor, customer service technician with the 341st Comptroller Squadron, delivers her meal. (Public Domain; US Air Force).

Key Takeaways

Around the world, nearly one billion people suffer the effects of constant hunger. Key terms related to hunger include food security, which means having continual access to safe, sufficient, nutritious food, and food insecurity, which means not having continual access to safe, sufficient, nutritious food. There are two types of malnutrition. The first is macronutrient deficiency and relates to the lack of adequate protein, which is required for cell growth, maintenance, and repair. The second type of malnutrition is micronutrient deficiency and relates to inadequate vitamin and mineral intake. There are a number of groups at risk for hunger, including the unemployed and underemployed, poor families, the elderly, and the homeless. The United States has a number of federal and state programs, as well as local charities, which provide assistance and education for people who fall into the category of food insecurity.

Discussion Starter

1. Do you believe there are enough government programs currently in place to address the problem of hunger? Why or why not? If not, what additional solutions would you recommend?

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CHAPTER OVERVIEW

Chapter 3: Food Composition

3.1: What Are Nutrients?

3.1.1: Videos

3.2: Caloric Value of Food

Thumbnail: Burning marshmellow. (Unsplash License; Leon Contreras via Unsplash)

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3.1: What Are Nutrients?

Learning Objective

- Define the word “nutrient” and identify the six classes of nutrients essential for health.
- List the three main energy (Calorie) yielding nutrients and how many Calories each of these nutrients provide.

What is in Food?

Your "diet" is defined as the foods you choose to eat. The diet of most people contains a variety of foods: nuts, seeds, leafy green vegetables and more! The foods we eat contain nutrients. Nutrients are substances required by the body to perform its basic functions. Nutrients must be obtained from diet, since the human body does not synthesize them, or does not synthesize them in large enough amounts for human health. Nutrients are used for many body functions such as: growing, moving your muscles, repairing tissues and much more! There are six classes of essential nutrients required for the body to function and maintain overall health. These six classes of essential nutrients are: carbohydrates, lipids (fats), proteins, water, vitamins, and minerals. Foods also contain non-nutrients. Some non-nutrients appear to be very important for human health, like fiber and antioxidants, some non-nutrients may be harmful to human health such as: preservatives, colorings, flavorings and pesticide residues.

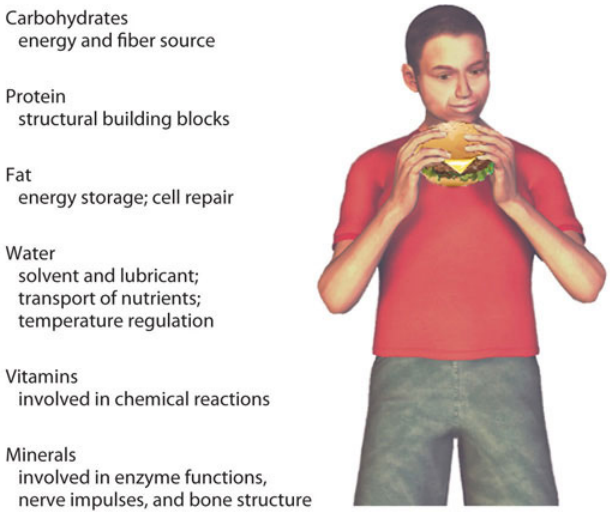


Figure **3.1.1**: The Six Classes of Nutrients. Source: http://www.chemistry.wustl.edu/~edud.../vitamins.html.

Macronutrients

Nutrients that are needed in large amounts are called macronutrients. There are three major classes of macronutrients: carbohydrates, lipids, and proteins. All three of these nutrients are needed in relatively large amounts AND they contain Calories (note the capital C which indicates kilocalories) which can be "burned" in your body to create energy for your body cells. The energy from these macronutrients comes from their chemical bonds. This chemical energy is converted into cellular energy that is then utilized to perform work, allowing our bodies to conduct their basic functions. A unit of measurement of food energy is the Calorie. The next time you are eating a packaged food, look on the "Nutrition Facts" panel to find out how many Calories you getting when you eat one serving of that food. Water is also a macronutrient in the sense that you require a large amount of it, but unlike the other macronutrients it does not yield calories. One other possible component of the diet that can provide Calories is alcohol though it is generally NOT considered to be a nutrient. Alcohol (in the form of ethanol) provides about 7 Calories per gram.

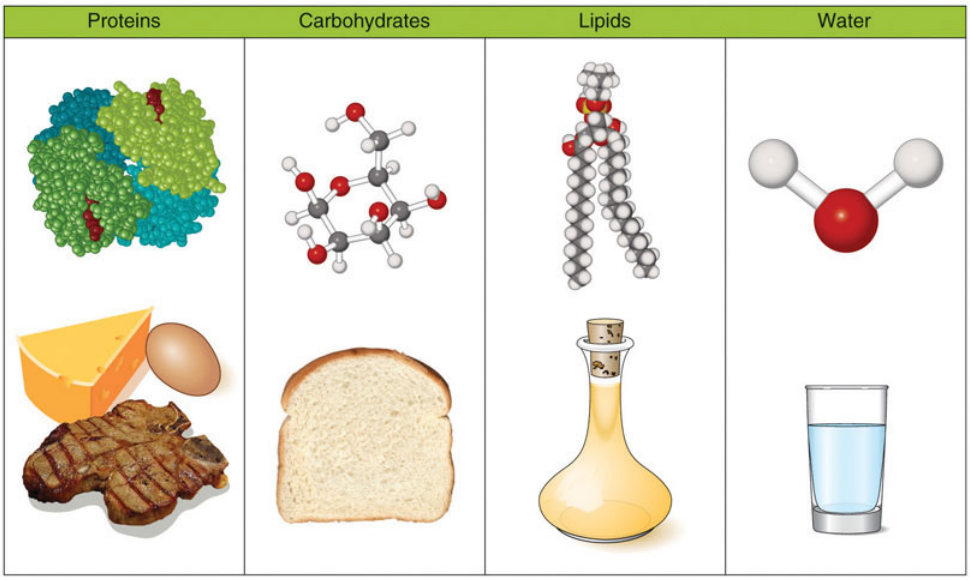


Figure **3.1.2**: The Macronutrients: Carbohydrates, Lipids, Protein, and Water

Carbohydrates

When you eat a food that contains carbohydrate, like bread for example, you will be receiving approximately 4 Calories for every gram of carbohydrate you eat. Carbohydrates are molecules composed of carbon, hydrogen, and oxygen. The major food sources of carbohydrates are grains, milk, fruits, and starchy vegetables like potatoes. Non-starchy vegetables also contain carbohydrates, but in lesser quantities. Carbohydrates are broadly classified into two forms based on their chemical structure: fast-releasing carbohydrates, often called "simple sugars", and slow-releasing carbohydrates, often called "complex carbohydrates".

Fast-releasing carbohydrates consist of one or two basic sugar units. They are sometimes called "simple sugars" because their chemical structure is fairly simple with only one or two sugar units. If the carbohydrate has one sugar unit we call it a "monosaccharide". Mono means one and saccharide means sugar. Examples of monosaccharides you have heard of are: Glucose (the sugar that is in your blood); Fructose (a sugar commonly found in fruit); and Galactose (a sugar that is found as part of milk sugar). If the carbohydrate has two sugar units we call it a "disaccharide". Di means two and saccharide means sugar. Examples of disaccharides you may be familiar with are: sucrose (table sugar); lactose (milk sugar) and maltose (malt sugar). Sucrose is made of a Glucose linked together with a Fructose. Lactose is made of Glucose linked together with Galactose. Maltose is made of two Glucose molecules bonded together. In order to digest a disaccharide, your body has to break the two sugars apart. We will talk more about this when we discuss lactose intolerance!

Slow-releasing carbohydrates are long chains of simple sugars (polysaccharides) that can be branched or unbranched. Some polysaccharides that you have probably heard of are starch and fiber. During digestion, the body does its best to break down all slow-releasing carbohydrates like starch to simple sugars, mostly glucose. Glucose is then transported to all our cells where it is stored, used to make energy, or used to build macromolecules. Fiber is also a slow-releasing carbohydrate, but it cannot be broken down in the human body and passes through the digestive tract undigested unless the bacteria that live in the large intestine break it down for us.

One gram of carbohydrates yields four Calories of energy for the cells in the body to perform work. In addition to providing energy and serving as building blocks for bigger macromolecules, carbohydrates are essential for proper functioning of the nervous system, heart, and kidneys. As mentioned, glucose can be stored in the body for future use. In humans, the storage molecule of carbohydrates is called glycogen and in plants it is known as starches. Glycogen and starches are slow-releasing carbohydrates.

Lipids

Lipids are also a family of molecules composed of carbon, hydrogen, and oxygen, but unlike carbohydrates, they are insoluble in water. Lipids are found predominately in butter, oils, meats, dairy products, nuts, and seeds, and in many processed foods. The three main types of lipids are triglycerides (triacylglycerols), phospholipids, and sterols. The main job of lipids is to store energy.

Lipids provide more energy per gram than carbohydrates (nine Calories per gram of lipids versus four Calories per gram of carbohydrates). In addition to energy storage, lipids serve as cell membranes, surround and protect organs, aid in temperature regulation, and regulate many other functions in the body.

Proteins

Proteins are macromolecules composed of chains of subunits called amino acids. Amino acids are simple subunits composed of carbon, oxygen, hydrogen, and nitrogen. The food sources of proteins are meats, dairy products, seafood, and a variety of different plant-based foods, most notably soy. The word protein comes from a Greek word meaning “of primary importance,” which is an apt description of these macronutrients; they are also known colloquially as the “workhorses” of life. Proteins provide four Calories of energy per gram; however providing energy is not protein’s most important function. Proteins provide structure to bones, muscles and skin, and play a role in conducting most of the chemical reactions that take place in the body. Scientists estimate that greater than one-hundred thousand different proteins exist within the human body.

Water

There is one other nutrient that we must have in large quantities: water. Water does not contain carbon, but is composed of two hydrogens and one oxygen per molecule of water. Water does not provide any Calories. More than 60 percent of your total body weight is water. Without it, nothing could be transported in or out of the body, chemical reactions would not occur, organs would not be cushioned, and body temperature would fluctuate widely. On average, an adult consumes just over two liters of water per day from food and drink. According to the “rule of threes,” a generalization supported by survival experts, a person can survive three minutes without oxygen, three days without water, and three weeks without food. Since water is so critical for life’s basic processes, the amount of water input and output is supremely important, a topic we will explore in detail in Chapter 7.

Alcohol (not a nutrient)

Alcoholic drinks are a source of Calories even though they are generally not considered nutrients. Alcohol itself provides approximately 7 Calories for every gram consumed. In addition to alcohol, many alcoholic drinks contain carbohydrate as well.

Micronutrients

Micronutrients are nutrients required by the body in lesser amounts, but are still essential for carrying out bodily functions. Micronutrients include all the essential minerals and vitamins. There are sixteen essential minerals and thirteen vitamins (Tables **3.1.1** and **3.1.2** for a complete list and their major functions). In contrast to carbohydrates, lipids, and proteins, micronutrients do not contain Calories. This is often confusing because most people have heard how tired a person will feel if they are low in a micronutrient such as Iron. The tiredness can be explained by the fact that, micronutrients assist in the process of making energy by being part of enzymes (i.e., coenzymes). Enzymes catalyze chemical reactions in the body and are involved in many aspects of body functions from producing energy, to digesting nutrients, to building macromolecules. Micronutrients play many roles in the body.

Minerals

Minerals are solid inorganic substances that form crystals and are classified depending on how much of them we need. Trace minerals, such as molybdenum, selenium, zinc, iron, and iodine, are only required in a few milligrams or less and macrominerals, such as calcium, magnesium, potassium, sodium, and phosphorus, are required in hundreds of milligrams. Many minerals are critical for enzyme function, others are used to maintain fluid balance, build bone tissue, synthesize hormones, transmit nerve impulses, contract and relax muscles, and protect against harmful free radicals.

Table **3.1.1**: : Minerals and Their Major Functions

Minerals	Major Functions
Macro	
Sodium	Fluid balance, nerve transmission, muscle contraction
Chloride	Fluid balance, stomach acid production
Potassium	Fluid balance, nerve transmission, muscle contraction
Calcium	Bone and teeth health maintenance, nerve transmission, muscle contraction, blood clotting
Phosphorus	Bone and teeth health maintenance, acid-base balance
Magnesium	Protein production, nerve transmission, muscle contraction
Sulfur	Protein production
Trace	
Iron	Carries oxygen, assists in energy production
Zinc	Protein and DNA production, wound healing, growth, immune system function
Iodine	Thyroid hormone production, growth, metabolism
Selenium	Antioxidant
Copper	Coenzyme, iron metabolism
Manganese	Coenzyme
Fluoride	Bone and teeth health maintenance, tooth decay prevention
Chromium	Assists insulin in glucose metabolism
Molybdenum	Coenzyme

Vitamins

The thirteen vitamins are categorized as either water-soluble or fat-soluble. The water-soluble vitamins are vitamin C and all the B vitamins, which include thiamine, riboflavin, niacin, pantothenic acid, pyroxidine, biotin, folate and cobalamin. The fat-soluble vitamins are A, D, E, and K. Vitamins are required to perform many functions in the body such as making red blood cells, synthesizing bone tissue, and playing a role in normal vision, nervous system function, and immune system function.

Table **3.1.1**: Vitamins and Their Major Functions

Vitamins	Major Functions
Water-soluble	
B_1 (thiamine)	Coenzyme, energy metabolism assistance
B_2 (riboflavin)	Coenzyme, energy metabolism assistance
B_3 (niacin)	Coenzyme, energy metabolism assistance
B_5 (pantothenic acid)	Coenzyme, energy metabolism assistance
B_6 (pyroxidine)	Coenzyme, amino acid synthesis assistance
Biotin	Coenzyme
Folate	Coenzyme, essential for growth
B_{12} (cobalamin)	Coenzyme, red blood cell synthesis
C	Collagen synthesis, antioxidant
Fat-soluble	
A	Vision, reproduction, immune system function
D	Bone and teeth health maintenance, immune system function
E	Antioxidant, cell membrane protection
K	Bone and teeth health maintenance, blood clotting

Vitamin deficiencies can cause severe health problems. For example, a deficiency in niacin causes a disease called pellagra, which was common in the early twentieth century in some parts of America. The common signs and symptoms of pellagra are known as the “4D’s—diarrhea, dermatitis, dementia, and death.” Until scientists found out that better diets relieved the signs and symptoms of pellagra, many people with the disease ended up in insane asylums awaiting death (Video **3.1.1**). Other vitamins were also found to prevent certain disorders and diseases such as scurvy (vitamin C), night blindness (vitamin A), and rickets (vitamin D).



Video **3.1.1**: This video provides a brief history of Dr. Joseph Goldberger’s discovery that pellagra was a diet-related disease.

Food Energy

Though this is only Chapter 1, you have already seen the words "Calories" and "Energy" used several times. In everyday life you have probably heard people talk about how many Calories they burned on the treadmill or how many Calories are listed on a bag of chips. Calories, are a measure of energy. It takes quite a lot of Calories (energy) to keep us alive. Even if a person is in a coma, they still burn approximately 1000 Calories of energy in order for: their heart to beat, their blood to circulate, their lungs to breathe,

etc... We burn even more calories when we exercise. The carbohydrates, fats and proteins we eat and drink provide calories for us (and alcohol as well if we choose to consume it). Sometimes people refer to these nutrients as "energy yielding". As you read above, carbohydrates provide 4 Calories for every gram we consume; proteins provide 4 Calories for every gram we consume; fats provide 9 Calories for every gram we consume and alcohol provides 7 Calories of energy for every gram we consume. Vitamins, minerals and water do not provide any calories, even though they are still essential nutrients.

Food Quality: Nutrient Density compared to Calorie Density

One way to think about the quality of your food is to consider how many nutrients you receive from a serving of that food compared to the number of Calories you receive from one serving of the food. For example, a candy bar gives you quite a few Calories but not very many of the essential nutrients. We would say that the candy bar has Calorie density but low Nutrient density. An apple on the other hand, has quite a few essential nutrients but not very many Calories. We would say that the apple has high Nutrient density but low Calorie density.

Please watch the following Ted Ed video called "What is a Calorie" which will describe in more detail what a Calorie is and why you may want to know how many Calories you are consuming compared to how many you are burning each day.



Video: What is a calorie? - Emma Bryce

One measurement of food quality is the amount of nutrients it contains relative to the amount of energy (Calories) it provides. High-quality foods are nutrient dense, meaning they contain lots of the nutrients relative to the amount of Calories they provide. Nutrient-dense foods are the opposite of “empty-calorie” foods such as carbonated sugary soft drinks, which provide many calories and very little, if any, other nutrients. Food quality is additionally associated with its taste, texture, appearance, microbial content, and how much consumers like it.

Food: A Better Source of Nutrients

It is better to get all your micronutrients from the foods you eat as opposed to from supplements. Supplements contain only what is listed on the label, but foods contain many more macronutrients, micronutrients, and other chemicals, like antioxidants that benefit health. While vitamins, multivitamins, and supplements are a $20 billion industry in this country and more than 50 percent of Americans purchase and use them daily, there is no consistent evidence that they are better than food in promoting health and preventing disease. Dr. Marian Neuhouser, associate of the Fred Hutchinson Cancer Research Center in Seattle, says that “…scientific data are lacking on the long-term health benefits of supplements. To our surprise, we found that multivitamins did not lower the risk of the most common cancers and also had no impact on heart disease. ”Woodward, K. “Multivitamins Each Day Will Not Keep Common Cancers Away; Largest Study of Its Kind Provides Definitive Evidence that Multivitamins Will Not Reduce Risk of Cancer or Heart Disease in Postmenopausal Women.” Fred Hutchinson Cancer Research Center. *Center News* 16 (February 2009). http://www.fhcrc.org/about/pubs/center_news/online/2009/02/multivitamin_study.html

Key Takeaways

- Foods contain nutrients that are essential for our bodies to function.
- Four of the classes of nutrients required for bodily function are needed in large amounts. They are carbohydrates, lipids, proteins, and water, and are referred to as macronutrients.
- Two of the classes of nutrients are needed in lesser amounts, but are still essential for bodily function. They are vitamins and minerals.
- One measurement of food quality is the amount of essential nutrients a food contains relative to the amount of energy it has (nutrient density).

Discussion Starters

1. Make a list of some of your favorite foods and visit the “What’s In the Foods You Eat?” search tool provided by the USDA. What are some of the nutrients found in your favorite foods?

   http://www.ars.usda.gov/Services/docs.htm?docid=17032

2. Have a discussion in class on the “progression of science” and its significance to human health as depicted in the video on pellagra (Video **3.1.1**.

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3.1.1: Videos

-
- Micronutrients overview video: https://youtu.be/gwGr4N1BcLI
- Water overview: https://youtu.be/9iMGFqMmUFs

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3.2: Caloric Value of Food

When it's said that an apple has 80 calories, this isn't exactly correct. It's more accurate to say that an apple provides the body with about 80 calories. As measured in a bomb calorimeter, an apple has more calories than the 80 that the body can use. All of a food's calories can't be used if the body can't digest it or break it down to carbon dioxide and water.

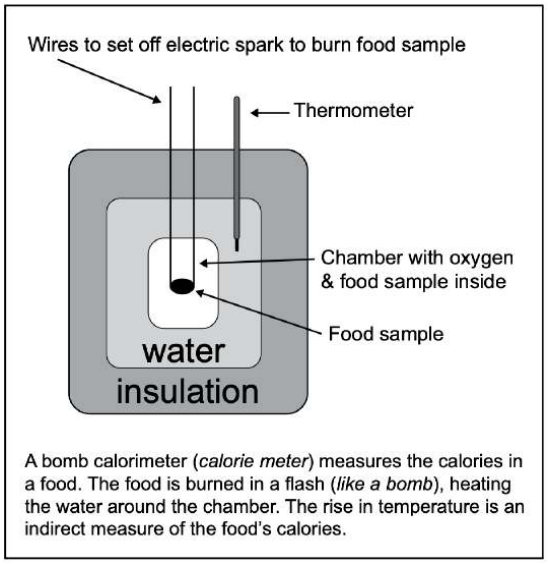


Figure 3.4: Bomb Calorimeter

Fiber in apples has calories as measured in a bomb calorimeter, but we don't have the enzymes to digest it. Thus, fiber doesn't provide the body with energy. Similarly, wood burns and gives off heat, but we don't get any calories from eating it.

Another example is saccharin, the non-caloric sweetener. It has calories as measured in a bomb calorimeter and is absorbed by the body, but we don't have the necessary enzymes to break it down (i.e., our body can't release any of its energy). We don't get any calories from it, and it's excreted unchanged in the urine. When it's said that fiber and saccharin don't have calories, what's meant is that we can't use those calories. The caloric values we're familiar with are actually *physiological calories* (calories that the body can use).

Carbohydrate, protein, and fat are called energy-providing nutrients because the body gets energy from them. Conversely, vitamins, minerals, and substances like saccharin don't have calories because the body doesn't get energy from them. The [physiological] caloric values of the energy-providing nutrients are:

Carbohydrate* = 4 calories per gram

Protein = 4 calories per gram

Fat = 9 calories per gram

Alcohol = 7 calories per gram

Calculating Food Calories

Knowing the amounts of carbohydrate, protein, fat, and alcohol in a food, we can calculate its calories. For example, a cup of whole milk that has 11 grams (g) carbohydrate, 8 g protein, and 8 g fat has 148 calories (usually rounded to 150):

11 g carbohydrate X 4 calories/g	= 44 calories
8 g protein X 4 calories/g	= 32 calories
8 g fat X 9 calories/g	= 72 calories
	Total = 148 calories

It's also useful to calculate how calories are distributed in a food, e.g., what percent of calories comes from fat. It's easier to compare foods when fat content is given as a percent of total calories, rather than as a percent of total weight. When given as a percent of total weight, comparisons are distorted by the amount of water in the food.

For example, whole milk has, by weight, about 3.5% fat, lower-fat milk 1-2% fat, and fat-free milk almost none. It isn't obvious that switching from whole milk to lower-fat milk would make much difference in % calories from fat. But milk is mostly water, so its fat content, by weight, is low and misleading.

Calculating % calories from fat, we see that about 50% of the calories comes from fat in whole milk, whereas it's 35% for reduced-fat (2% fat) milk, 15% for low-fat (1% fat) milk, and 5% for fat-free milk. Looking at milk's fat content this way, the advice to switch to a lower-fat milk is obviously a good way to lower fat intake.

For this calculation, you only need to know the grams of fat and the total calories in the food, numbers which are on food labels and in food composition tables:

1 cup **whole milk** (3.5% fat by weight): 8 g fat, 150 calories: 8 g fat X 9 cal/g X 100 = **48%** of total calories from fat 150 total calories

1 cup **reduced-fat milk** (2% fat by weight): 5 g fat, 125 cal 5 g fat X 9 cal/g X 100 = **36%** of total calories from fat 125 total calories

1 cup **low-fat milk** (1% fat by weight): 2 g fat, 120 calories: 2 g fat X 9 cal/g X 100 = **15%** of total calories from fat 120 total calories

1 cup of **fat-free milk** (0% fat by weight): 0.5 g fat, 90 cal 0.5 g fat X 9 cal/g X 100 = **5%** of total calories from fat 90 total calories

On a package of frankfurters, does 80% fat-free mean that 80% of the fat was taken out, making them low in fat? Looking more carefully at the label, we find that one of these frankfurter has 100 calories and 8 grams of fat. This means that 72% of the calories comes from fat!

8 g fat X 9 cal/g X 100 = **72%** of total cal from fat 100 total calories

The label is misleading but technically correct because fat is given as a percent of total weight, and over half of the frankfurter is water. The label says that each frankfurter weighs 45 g and has 8 g of fat. This means that, by weight, the frankfurter is 18% fat [(8 g fat/45 g total weight) X 100 = 18% fat by weight]. The other 82% is fat-free! It would be more to the point to say, *more than 70% of the calories come from fat*. This, of course, would be bad for sales.

U.S. government standards allow a maximum of 30% fat (by weight) in frankfurters. If it's less than 30%, we'd expect this to be emphasized on the label. A label stating 33% less fat means that the frankfurters are 20% fat by weight (80% fat-free!) instead of the usual 30% (70% fat-free!). Fortunately, food labels are required to give nutrition information, and claims are more tightly regulated. Unfortunately, the percent of calories from fat isn't given on the label (it can be calculated). Guess which food companies object to listing fat this way!

*When talking about carbohydrate's calories or the carbohydrate content of foods, only digestible carbohydrates are considered. Indigestible carbohydrates—dietary fiber—are simply called fiber.

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CHAPTER OVERVIEW

Chapter 4: Digestion and Nutrition

4.1: Digestion and Absorption in the Gastrointestinal Tract (GI tract)

4.2: Video on Digestion

4.3: Nutrients Are Essential for Organ Function

Thumbnail: Woman eating fries. (Unslash License; Karsten Winegeart via Unsplash)

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4.1: Digestion and Absorption in the Gastrointestinal Tract (GI tract)

Learning Objectives

- Sketch and label the major organs of the digestive system and state their functions.

Digestion begins even before you put food into your mouth. When you feel hungry, your body sends a message to your brain that it is time to eat. Sights and smells influence your body's preparedness for food. Smelling food sends a message to your brain. Your brain then tells the mouth to get ready, and you start to salivate in preparation for a delicious meal.

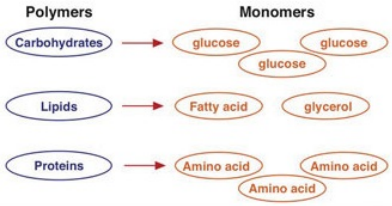


Figure **4.1.1**: The Digestion Process. Digestion converts the food we eat into smaller particles, which will be processed into energy or used as building blocks

Once you have eaten, your digestive system (Figure **4.1.1**) breaks down the food into smaller components. Another word for the breakdown of complex molecules into smaller, simpler molecules is "catabolism" or a "catabolic reaction". To do this, catabolism functions on two levels, mechanical and chemical. Once the smaller particles have been broken down, they will be absorbed into the blood and delivered to cells throughout the body for energy or for building blocks needed for cells to function. The digestive system is one of the eleven organ systems of the human body and it is composed of several hollow tube-shaped organs including the mouth, pharynx, esophagus, stomach, small intestine, large intestine (or colon), rectum, and anus. It is lined with mucosal tissue that secretes digestive juices (which aid in the breakdown of food) and mucus (which facilitates the propulsion of food through the tract). Smooth muscle tissue surrounds the digestive tract and its contraction produces waves, known as peristalsis, that propel food down the tract. Nutrients as well as some non-nutrients are absorbed. Substances such as fiber get left behind and are appropriately excreted.

From the Mouth to the Stomach

There are four steps in the digestion process (Figure **4.1.2**). The first step is ingestion, which is the collection of food into the digestive tract. It may seem a simple process, but ingestion involves smelling food, thinking about food, and the involuntary release of saliva in the mouth to prepare for food entry. In the mouth, where the second step of digestion occurs, the mechanical and chemical breakdown of food begins. The chemical breakdown of food involves enzymes, which break apart the components in food. Theses enzymes are secreted by the salivary glands, stomach, pancreas, and small intestine. Mechanical breakdown starts with mastication (chewing) in the mouth. Teeth crush and grind large food particles, while saliva initiates the chemical breakdown of food and enables its movement downward. The slippery mass of partially broken-down food is called bolus, which moves down the digestive tract as you swallow. Swallowing may seem voluntary at first because it requires conscious effort to push the food with the tongue back toward the throat, but after this, swallowing proceeds involuntarily, meaning it cannot be stopped once it begins.

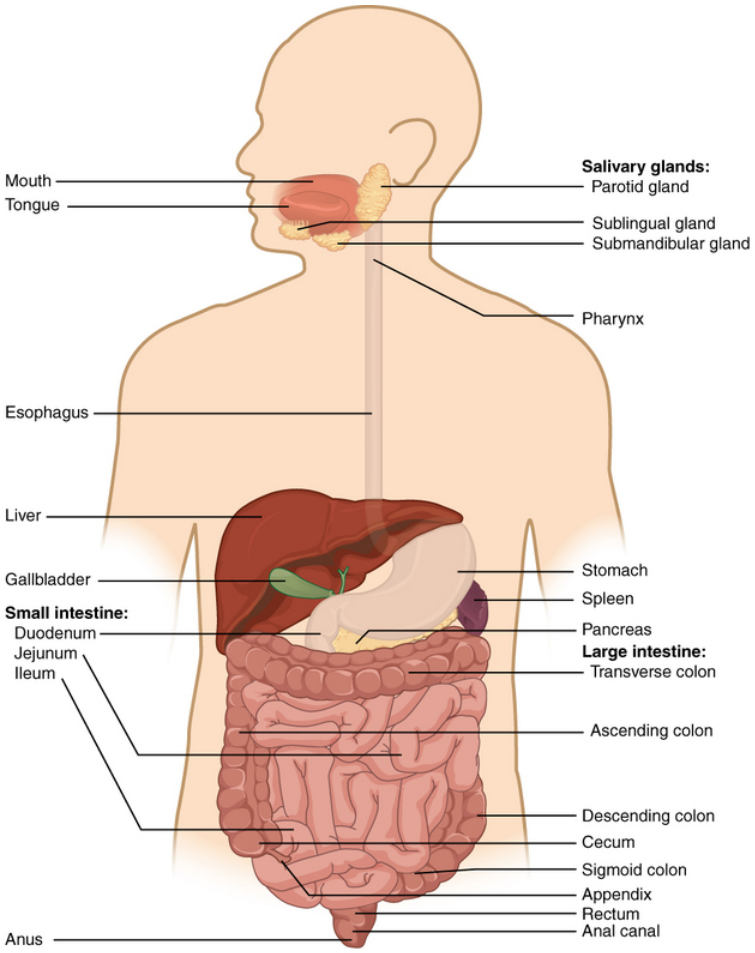


Figure **4.1.2**: Components of the Human Digestive System. All digestive organs play integral roles in the life-sustaining process of digestion. (CC BY 3.0; OpenStax).

As you swallow, the bolus is pushed from the mouth through the pharynx and into a muscular tube called the esophagus. As it travels through the pharynx, a small flap called the epiglottis closes, to prevent choking by keeping food from going into the trachea. Peristaltic contractions in the esophagus propel the food down to the stomach. At the junction between the esophagus and stomach there is a sphincter muscle that remains closed until the food bolus approaches. The pressure of the food bolus stimulates the lower esophageal sphincter to relax and open and food then moves from the esophagus into the stomach. The mechanical breakdown of food is accentuated by the muscular contractions of the stomach and small intestine that mash, mix, slosh, and propel food down the alimentary canal. Solid food takes between four and eight seconds to travel down the esophagus, and liquids take about one second.

From the Stomach to the Small Intestine

When food enters the stomach, a highly muscular organ, powerful peristaltic contractions help mash, pulverize, and churn food into chyme. Chyme is a semiliquid mass of partially digested food that also contains gastric juices secreted by cells in the stomach. Cells in the stomach also secrete hydrochloric acid and the enzyme pepsin, that chemically breaks down food into smaller molecules. The stomach has three basic tasks:

1. To store food
2. To mechanically and chemically break down food
3. To empty partially broken-down food into the small intestine

The length of time food spends in the stomach varies by the macronutrient composition of the meal. A high-fat or high-protein meal takes longer to break down than one rich in carbohydrates. It usually takes a few hours after a meal to empty the stomach contents completely.

Video 4.1.1: Digestion Video

This video shows the mechanical and chemical breakdown of food into chyme.



Video **4.1.2**: the food machine - great endoscopic images, xray and ultrasound images of food being digested (pretty graphic). Great visuals! Also talks about energy from food

The small intestine is divided into three structural parts: the duodenum (the top), the jejunum (the middle), and the ileum (the last part). Once the chyme enters the duodenum (the first segment of the small intestine), three accessory (or helper) organs: liver, pancreas and gallbladder are stimulated to release juices that aid in digestion. The pancreas secretes up to 1.5 liters of pancreatic juice through a duct into the duodenum per day. This fluid consists mostly of water, but it also contains bicarbonate ions that neutralize the acidity of the stomach-derived chyme and enzymes that further breakdown proteins, carbohydrates, and lipids. The gallbladder secretes a much smaller amount of bile to help digest fats, also through a duct that leads to the duodenum. Bile is made in the liver and stored in the gall bladder. Bile's components act like detergents by surrounding fats similar to the way dish soap removes grease from a frying pan. This allows for the movement of fats in the watery environment of the small intestine. Two different types of muscular contractions, called peristalsis and segmentation, move and mix the food in various stages of digestion through the small intestine. Similar to what occurs in the esophagus and stomach, peristalsis is circular waves of smooth muscle contraction that propel food forward. Segmentation sloshes food back and forth in both directions promoting further mixing of the chyme. Almost all the components of food are completely broken down to their simplest unit within the first 25 centimeters of the small intestine. Instead of proteins, carbohydrates, and lipids, the chyme now consists of amino acids, monosaccharides, and emulsified fatty acids.

The next step of digestion (nutrient absorption) takes place in the remaining length of the small intestine, or ileum (> 5 meters).

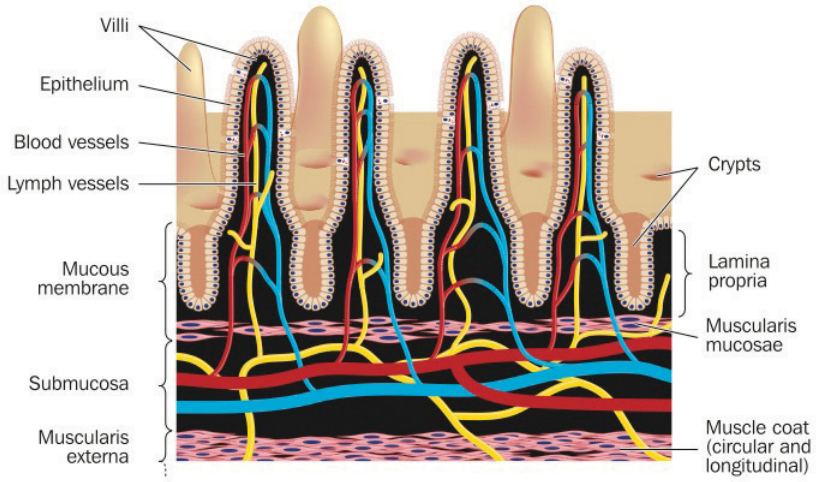


Figure **4.1.3**: The way the small intestine is structured gives it a huge surface area to maximize nutrient absorption. The surface area is increased by folds, villi, and microvilli. Digested nutrients are absorbed into either capillaries or lymphatic vessels contained within each microvilli. © Shutterstock

The small intestine is perfectly structured for maximizing nutrient absorption. Its surface area is greater than 200 square meters, which is about the size of a tennis court. The surface area of the small intestine increases by multiple levels of folding. The internal tissue of the small intestine is covered in villi, which are tiny finger-like projections that are covered with even smaller projections, called microvilli (Figure **4.1.1**). The digested nutrients pass through the absorptive cells of the intestine via diffusion or special transport proteins. Nutrients that are water soluble (dissolve in water) like amino acids and monosaccharides (sugars) are transported from the intestinal cells into capillaries (blood), but the fat soluble nutrients like fatty acids, fat-soluble vitamins, and other lipids are transported first through lymphatic vessels (lymph), which soon meet up with blood vessels.

From the Small Intestine to the Large Intestine

The process of digestion is fairly efficient. Any food that is still incompletely broken down (usually less than ten percent of food consumed) and the food's indigestible fiber content moves from the small intestine to the large intestine (colon) through a connecting valve. The main task of the large intestine is to reabsorb water. Remember, water is present not only in solid foods, but also the stomach releases a few hundred millilters of gastric juice and the pancreas adds approximately another 500 milliliters during the digestion of the meal. For the body to conserve water, it is important that the water be reabsorbed. In the large intestine, no further chemical or mechanical breakdown of food takes place, unless it is accomplished by the bacteria that inhabit this portion of the digestive tract. The number of bacteria residing in the large intestine is estimated to be greater than $10^{(14)}$, which is more than the total number of cells in the human body ($10^{(13)}$). This may seem rather unpleasant, but the great majority of bacteria in the large intestine are harmless and some are even beneficial.

Kefir

There has been significant talk about pre- and probiotic foods in the mainstream media. The World Health Organization defines probiotics as live bacteria that confer beneficial health effects on their host. They are sometimes called "friendly bacteria." The most common bacteria labeled as probiotic is lactic acid bacteria (lactobacilli). They are added as live cultures to certain fermented foods such as yogurt. Prebiotics are indigestible foods, primarily soluble fibers, that stimulate the growth of certain strains of bacteria in the large intestine and provide health benefits to the host. A review article in the June 2008 issue of the *Journal of Nutrition* concludes that there is scientific consensus that probiotics ward off viral-induced diarrhea and reduce the symptoms of lactose intolerance.Farnworth, E. R. "The Evidence to Support Health Claims for Probiotics." *J Nutr* 138, no. 6 (2008): 1250S–4S. http://jn.nutrition.org/content/138/6/1250S.long. Expert nutritionists agree that more health benefits of pre- and probiotics will likely reach scientific consensus. As the fields of pre- and probiotic manufacturing and their clinical study progress, more information on proper dosing and what exact strains of bacteria are potentially "friendly" will become available.



Kefir, a dairy product fermented with probiotic bacteria, can make a pleasant tasting milkshake. (CC BY-SA 3.0; Quijote)

You may be interested in trying some of these foods in your diet. A simple food to try is kefir. Several websites provide good recipes, including www.kefir.net/recipes.htm.

From the Large Intestine to the Anus

After a few hours in the stomach, plus three to six hours in the small intestine, and about sixteen hours in the large intestine, the digestion process enters step four, which is the elimination of indigestible food as feces. Feces contain indigestible food and gut bacteria (almost 50 percent of content). It is stored in the rectum until it is expelled through the anus via defecation.

Video 4.1.3: The Stages of Digestion

This video reviews the sequence of events during food digestion.



Key Takeaways

- The breakdown of complex macromolecules in foods to simple absorbable components is accomplished by the digestive system. These components are processed by cells throughout the body into energy or are used as building blocks.
- The digestive system is composed of the mouth, pharynx, esophagus, stomach, small intestine, large intestine (or colon), rectum, and anus. There are four steps in the digestion process: ingestion, the mechanical and chemical breakdown of food, nutrient absorption, and elimination of indigestible food.
- The mechanical breakdown of food occurs via muscular contractions called peristalsis and segmentation. Enzymes secreted by the salivary glands, stomach, pancreas, and small intestine accomplish the chemical breakdown of food. Additionally, bile emulsifies fats.

Discussion Starter

1. Decide whether you want to consume pre- and probiotic foods to benefit your health. Visit the websites below to help in your decision-making process. Defend your decision scientifically.

   http://www.health.harvard.edu/fhg/up...ate0905c.shtml

   https://ods.od.nih.gov/factsheets/Probiotics-HealthProfessional/

4.1: Digestion and Absorption in the Gastrointestinal Tract (GI tract) is shared under a CC BY-NC-SA license and was authored, remixed, and/or curated by LibreTexts.

4.2: Video on Digestion

https://youtu.be/Og5xAdC8EUI

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4.3: Nutrients Are Essential for Organ Function

Learning Objectives

- Generalize how the body distributes nutrients to the rest of the body.
- Summarize the importance of adequate nutrition on other organ systems.

When the digestive system has broken down food to its nutrient components they are ready to get absorbed. Absorption is the movement of the nutrient molecules from the digestive tract into the blood or lymph. If the absorbed nutrient is water soluble it will be absorbed into the blood and if the nutrient is fat soluble it will be packaged into a special transport package, called a chylomicron, and absorbed into the lymph. For water soluble nutrients, the first stop is the liver. The liver has the ability to store some nutrients, send some nutrients on to other parts of the body and/or change some nutrients into other molecules the body needs! Fat soluble nutrients, because they are absorbed into the lymph and only later spill into the blood, travel first to the heart but eventually they too will end up at the liver.



The liver is the checkpoint for metabolic activity. © Shutterstock

The liver is the only organ in the human body that is capable of exporting nutrients for energy production to other tissues. Therefore, when a person is in between meals (fasted state) the liver exports nutrients and when a person has just eaten (fed state) the liver stores nutrients within itself. Nutrient levels and the hormones that respond to their levels in the blood provide the input so that the liver can distinguish between the fasted and fed states and distribute nutrients appropriately.

All eleven organ systems in the human body require nutrient input to perform their specific biological functions. No energy in means no work output. Overall health and the ability to carry out all of life's basic processes is fueled by nutrients. Without them organ systems would fail, humans would not reproduce, and the race would disappear. In this section, we will discuss some of the critical nutrients that support specific organ system functions.

The Circulatory System (Cardiovascular System)

The circulatory system, which is part of the "cardiovascular" system, is one of the eleven organ systems of the human body. Its main function is to transport nutrients to cells and wastes from cells (Figure 4.3.1). This system consists of the heart, blood, and blood vessels. The heart pumps the blood, and the blood is the transportation fluid. The transportation route to all tissues is a highly intricate blood-vessel network, comprised of arteries, veins, and capillaries. Nutrients absorbed in the small intestine travel mainly to the liver through the hepatic portal vein. From the liver, nutrients travel upward through the inferior vena cava blood vessel to the heart. The heart forcefully pumps the nutrient-rich blood first to the lungs to pick up some oxygen and then to all other cells in the body. Arteries become smaller and smaller on their way to cells, so that by the time blood reaches a cell, the artery's diameter is

extremely small and the vessel is now called a capillary. The reduced diameter of the blood vessel substantially slows the speed of blood flow. This dramatic reduction in blood flow gives cells time to harvest the nutrients in blood and exchange metabolic wastes.

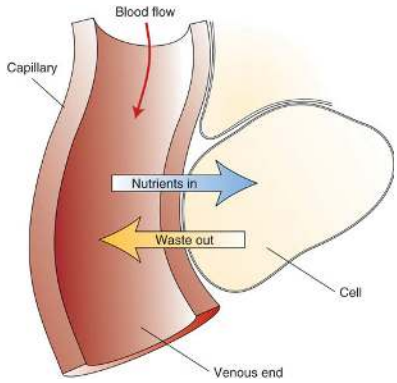
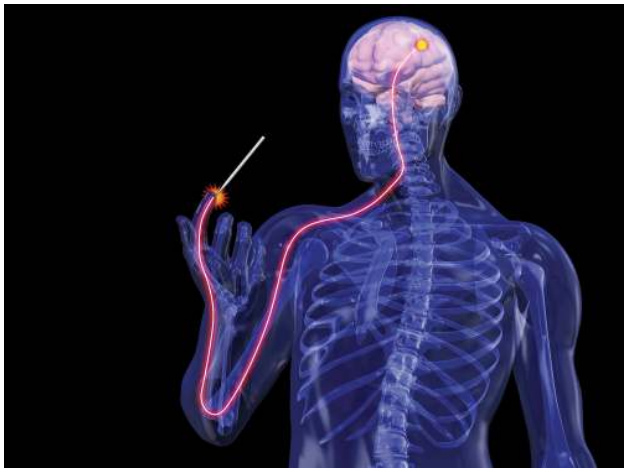


Figure **4.3.1**: The Circulatory System: The circulatory system transports nutrients to all cells and carries wastes out.

The Central Nervous System

The human brain (which weighs only about 3 pounds, or 1,300 kilograms) is estimated to contain over one hundred billion neurons. Neurons form the core of the central nervous system, which consists of the brain, spinal cord, and other nerve bundles in the body. The main function of the central nervous system is to sense changes in the external environment and create a reaction to them. For instance, if your finger comes into contact with a thorn on a rose bush, a sensory neuron transmits a signal from your finger up through the spinal cord and into the brain. Another neuron in the brain sends a signal that travels back to the muscles in your hand and stimulates muscles to contract and you jerk your finger away. All of this happens within a tenth of a second. All nerve impulses travel by the movement of charged sodium, potassium, calcium, and chloride atoms. These are some of the essential minerals in our diets—essential because they are absolutely required for central nervous system function. Nerves communicate with each other via chemicals built from amino acids called neurotransmitters. Eating adequate protein from a variety of sources will ensure the body gets all of the different amino acids that are so important for central nervous system function.



The brain has been compared to a central computer that controls all body functions. It relays messages to and from various body parts at lightning speed within a vast communication network of cells. © Shutterstock

Every day the brain uses over 20 percent of the energy obtained from nutrients. Its main fuel is glucose and only in extreme starvation will it use anything else. For acute mental alertness and clear thinking, glucose must be systematically delivered to your brain. This does not mean that sucking down a can of sugary soda before your next exam is a good thing. Just as too much glucose is bad for other organs, such as the kidneys and pancreas, it also produces negative effects upon the brain. Excessive glucose levels in the blood can cause a loss of cognitive function and chronically high blood-glucose levels can damage brain cells. The brain's cognitive functions include language processing, learning, perceiving, and thinking. Recent scientific studies demonstrate that

having continuously high blood-glucose levels substantially elevates the risk for developing Alzheimer's disease, which is the greatest cause of age-related cognitive decline.

The good news is that much research is directed toward determining the best diets and foods that slow cognitive decline and maximize brain health. A study in the June 2010 issue of the *Archives of Neurology* reports that people over age sixty-five who adhered to diets that consisted of higher intakes of nuts, fish, poultry, tomatoes, cruciferous vegetables, fruits, salad dressing, and dark green, and leafy vegetables, as well as a lower intake of high-fat dairy products, red meat, organ meat, and butter, had a much reduced risk for Alzheimer's disease.Gu, Y., PhD et al. "Food Combination and Alzheimer Disease Risk: A Protective Diet." *Arch Neurol* 67, no. 6 (2010): 699–706. doi: 10./1001/archneurol.2010.84. Other scientific studies provide supporting evidence that foods rich in omega-3 fatty acids and/or antioxidants provide the brain with protection against Alzheimer's disease. One potential "brain food" is the blueberry. The protective effects of blueberries upon the brain are linked to their high content of anthocyanins, which are potent antioxidants and reduce inflammation. A small study published in the April 2010 issue of the *Journal of Agricultural and Food Chemistry* found that elderly people who consumed blueberry juice every day for twelve weeks had improved learning and memorization skills in comparison to other subjects given a placebo drink.Krikorian, R. et al. "Blueberry Supplementation Improves Memory in Older Adults." *J Agric Food Chem* 58, no. 7 (2010): 3996–4000. doi: 10.1021/jf9029332. More clinical trials are evaluating the effects of blueberries and other foods that benefit the brain and preserve its function as we age.

The Muscular System

The muscular system allows the body to move voluntarily, but it also controls involuntary movements of other organ systems such as heartbeat in the circulatory system and peristaltic waves in the digestive system. It consists of over six hundred skeletal muscles, as well as the heart muscle, the smooth muscles that surround your entire alimentary canal, and all your arterial blood vessels. Muscle contraction relies on energy delivery to the muscle. Each movement uses up cellular energy and without an adequate energy supply muscle function suffers. Muscle, like the liver, can store the energy from glucose in the large polymeric molecule glycogen. But unlike the liver, muscles use up all of their own stored energy and do not export it to other organs in the body. When muscle energy stores are diminished, muscle contraction weakens. However, muscle is not as susceptible to low levels of blood glucose as the brain because it will readily use alternate fuels, such as fatty acids and protein to produce cellular energy.

"Hitting the Wall" or "Bonking"

If you are familiar with endurance sports, you may have heard of "hitting the wall" or "bonking." These colloquial terms refer to the extreme fatigue that sets in after about 120 minutes of performing an endurance sport, such as marathon running or long-distance cycling. The physiology underlying "hitting the wall" means that muscles have used up all their stored glycogen and are therefore dependent on other nutrients to support their energy needs. Fatty acids are transported from fat-storing cells to the muscle to rectify the nutrient deficit. However, fatty acids take more time to convert to energy than glucose, thus decreasing performance levels. To avoid "hitting the wall" or "bonking," endurance athletes load up on carbohydrates a few days before the event. This will maximize an athlete's amount of glycogen stored in their liver and muscle tissues. It is important not to assume that carbohydrate loading works for everyone. Without accompanied endurance training you will not increase the amount of stored glucose. If you plan on running a five-mile race for fun with your friend and decide to eat a large amount of carbohydrates in the form of a big spaghetti dinner the night before, the excess carbohydrates will be stored fat. Another way for athletes to avoid "hitting the wall" is to consume carbohydrate-containing drinks and foods during an endurance event. In fact, throughout the Tour de France—a twenty-two-day, twenty-four-hundred-mile race—the average cyclist consumes greater than 60 grams of carbohydrates per hour.



In order to avoid "hitting the wall," athletes consume large amounts of carbohydrates before and during events to ensure enough glucose is available for optimal performance, especially during endurance activities such as cycling. (Public Domain; Vzach).

The Endocrine System

The functions of the endocrine system are intricately connected to the body's nutrition. This organ system is responsible for regulating appetite, nutrient absorption, nutrient storage, and nutrient usage, in addition to other functions, such as reproduction. The glands in the endocrine system are the pituitary, thyroid, parathyroid, adrenals, thymus, pineal, pancreas, ovaries, and testes. The glands secrete hormones, which are biological molecules that regulate cellular processes in other target tissues, so they require transportation by the circulatory system. Adequate nutrition is critical for the functioning of all the glands in the endocrine system. A protein deficiency impairs gonadal-hormone release, preventing reproduction. Athletic teenage girls with very little body fat often do not menstruate. Children who are malnourished usually do not produce enough growth hormone and fail to reach normal height for their age group. Probably the most popularized connection between nutrition and the functions of the endocrine system is that unhealthy dietary patterns are linked to obesity and the development of Type 2 diabetes. The Centers for Disease Control and Prevention (CDC) estimates that twenty-six million Americans have Type 2 diabetes as of 2011. This is 8.3 percent of the US population. The maps in Note 3.35 show the percentage of adults who are obese, and those with diagnosed Type 2 diabetes within all American counties. You can see that those counties with the highest incidence of obesity also have the highest incidence of Type 2 diabetes.

Video 4.3.1: Obesity and Type 2 Diabetes

Watch the National Health video to see the relationship between the rise in obesity and the rise in Type 2 diabetes.



What is the causal relationship between overnutrition and Type 2 diabetes? The prevailing theory is that the overconsumption of high-fat and high-sugar foods causes changes in muscle, fat, and liver cells that leads to a diminished response from the pancreatic hormone insulin. These cells are called “insulin-resistant.” Insulin is released after a meal and instructs the liver and other tissues to take up glucose and fatty acids that are circulating in the blood. When cells are resistant to insulin they do not take up enough glucose and fatty acids and so glucose and fatty acids remain at high concentrations in the blood. The continuously high amounts of glucose and fatty acids in the blood impair the release of insulin from the pancreas, further exacerbating the situation. The chronic elevation of glucose and fatty acids in the blood also causes damage to other tissues over time, so that people who have Type 2 diabetes are at increased risk for cardiovascular disease, kidney disease, nerve damage, and eye disease.

Tools for Change

Do your part to slow the rising tide of obesity and Type 2 diabetes in this country. On the individual level, improve your own family’s diet; at the local community level, support the development of more nutritious school lunch programs; and at the national level, support your nation’s nutrition goals. Visit the CDC Diabetes Public Health Resource website at http://www.cdc.gov/diabetes/. It provides information on education resources, projects, and programs, and spotlights news on diabetes and obesity. The CDC also has a new workplace program called CDC’s LEAN *Works!* (LEAN: Leading Employees to Activity and Nutrition). The program provides free web-based resources with the mission of designing worksites that prevent obesity. See http://www.cdc.gov/leanworks/ for more details.

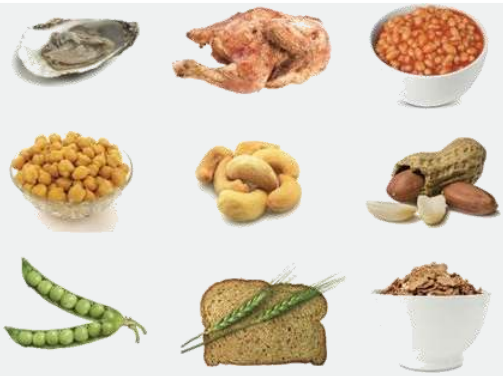
The Immune System

The immune system is comprised of several types of white blood cells that circulate in the blood and lymph. Their jobs are to seek, recruit, attack, and destroy foreign invaders, such as bacteria and viruses. Other less realized components of the immune system are the skin (which acts as a barricade), mucus (which traps and entangles microorganisms), and even the bacteria in the large intestine (which prevent the colonization of bad bacteria in the gut). Immune system functions are completely dependent on dietary nutrients. In fact, malnutrition is the leading cause of immune-system deficiency worldwide. When immune system functions are inadequate there is a marked increase in the chance of getting an infection. Children in many poor, developing countries have protein- and/or energy-deficient diets that are causative of two different syndromes, kwashiokors and marasmus. These children often die from infections that their bodies could normally have fought off, but because their protein and/or energy intake is so low, the immune system cannot perform its functions.

Other nutrients, such as zinc, selenium, copper, folate, and vitamins A, B_6, C, D, and E, all provide benefits to immune system function. Deficiencies in these nutrients can cause an increased risk for infection and death. Zinc deficiency results in suppression of the immune system’s barrier functions by damaging skin cells; it is also associated with a decrease in the number of circulating white blood cells. A review of several studies in the journal *Pediatrics* concluded that zinc supplements administered to children under age five for longer than three months significantly reduces the incidence and severity of diarrhea and respiratory illnesses.Aggarwal R., MD, DM, J. Sentz, MPH and M. A. Miller, MD. “Role of Zinc Administration in Prevention of Childhood Diarrhea and Respiratory Illnesses: A Meta-Analysis.” *Pediatrics* 119, no. 6 (2007): 1120–30. doi: 10.1542/peds.2006–3481. Zinc supplementation has also been found to be therapeutically beneficial for the treatment of leprosy, tuberculosis, pneumonia, and the common cold. Equally important to remember is that multiple studies show that it is best to obtain your minerals and vitamins from eating a variety of healthy foods.

Tools for Change

To ensure that your diet includes zinc-friendly foods, try these foods high in zinc and other immune-system friendly nutrients: oysters, poultry, baked beans, chick peas, cashews, sesame seeds, peanuts, whole grains, and zinc-fortified cereals.



These are just some of the foods that are high in zinc.

Just as undernutrition compromises immune system health, so does overnutrition. People who are obese are at increased risk for developing immune system disorders such as asthma, rheumatoid arthritis, and some cancers. Both the quality and quantity of fat affect immune system function. High intakes of saturated and trans fats negatively affect the immune system, whereas increasing your intake of omega-3 fatty acids, found in salmon and other oily fish, decreases inflammatory responses. High intakes of omega-3 fatty acids are linked to a reduction in the risk of developing certain autoimmune disorders, such as rheumatoid arthritis, and are used as part of a comprehensive treatment for rheumatoid arthritis.

Key Takeaways

- Metabolic homeostasis occurs when the amount of nutrients consumed matches the energy required to carry out life's biological processes.
- The circulatory system transports nutrients to cells and transports wastes from them.
- The essential minerals sodium, potassium, calcium, and chloride, and the macronutrients protein and carbohydrates, are required for central nervous system function. Fat is also critical for central nervous system function (see the Discussion Starter below).
- Without energy from nutrients, muscles cannot contract.
- Undernutrition and overnutrition compromise endocrine and immune system functions. Type 2 diabetes, increased rates of infection, and inflammatory disorders are symptoms of an imbalance in the diet.

Interactive 3.1

Take a look at the PowerPoint presentation prepared by the CDC that captures the concurrent rises of obesity and Type 2 diabetes in this country. Click on "Maps of Trends in Diabetes and Obesity." www.cdc.gov/diabetes/statisti...tes_slides.htm

Discussion Starter

1. Find out how fat supports brain function and protects nerves by visiting the Franklin Institute Resources for Science Learning website.

   www.fi.edu/learn/brain/fats.html

   Now look at the websites below to see how too much of the wrong kind of fats may be bad for the brain, while other types of fat are good for the brain.

   archneur.ama-assn.org/cgi/content/full/60/2/194

   http://www.sciencedaily.com/releases/2007/12/071210163251.htm

   http://www.webmd.com/alzheimers/news/20070418/omeg-3-fatty-acid-slows-alzheimers

   After viewing all of the videos, discuss the importance of "good fats" in the diet for optimizing brain function and preventing diseases such as Alzheimer's.

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CHAPTER OVERVIEW

Chapter 5: Review of Chapters 1-4

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CHAPTER OVERVIEW

Chapter 6: Food and our Senses

6.1: Food Selection
6.2: Taste and Smell

Thumbnail: Man tasting red wine with friends. (Public Domain; **Jira** via RawPixel)

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6.1: Food Selection

A lot goes into the how and why for why we choose the foods that we choose. Whether done consciously or unconsciously food selection criteria may be thought of as falling into 5 categories:

Sensory: choosing foods based on our sense of taste, smell, sight, sound, and touch.

Nutritional: choosing foods based on whether or not they meet our current nutritional needs. Do they work for a particular dietary pattern? Do they trigger food allergies or sensitives?

Cultural/Religious: Are there practices and rules that are governed by religious practice? Are there traditional foods that are consumed or avoided to honor ancestors or in observation of a holiday?

Sociological/Psychological: choosing foods for more than just nourishment. There may be an influence or endorsement from a well known celebrity or influencer. Perhaps we are peer pressured to try a food we otherwise wouldn't. This category also describes the feeling of choosing foods based on environmental impact and how these foods make us feel.

Budget/cost: How much does food costs and how much we have to spend on food is a major driver of food selection.

Sensory

Choosing foods based on how they look, feel, sound, taste, and smell are all ways in which we may be influenced. Again, these may be done cosciously or unconsciously. Have you ever been walking down the street and started to smell the distinguishable scent of freshly baked bread in the air? Did you then go and buy the bread? Or maybe you just thought about it as you walked down the street. This example would demonstrate the sensory aspect of foods.

Children are particularly in tune with their senses when choosing foods. Think about it, how often have you heard a child say, "that looks gross, I'm not eating that!," or, "this food smells funny!". We can develop likes and dislikes from a young age basing them soley on our sensory food selection criteria.

Smell: How a food smells. Is this good? Bad? Does the smell drive you a way or pull you in?

Taste: Do you have a memory of how the food tastes or perhaps based on prior experiences and the smell the food has you can guess that it will taste good. Enjoying the taste of a food is a major driver for choosing that food again. Meanwhile, disliking the way a food tastes is another major driver for not choosing that food again if it is offered.

Texture: Have you ever craved something crunchy? If you have, you may have picked up a bag of chips, crackers, or pretzels to satisfy that craving. In this example you were driven to choose a food based on texture criteria. Mouthfeel of a food would also fit into this category. For example, diet colas would taste flat if bulking agents were not added in to simulate the effect sugar has on mouthfeel. No one would want to drink it if those were omitted.

Sight: We use our eye sight to help and aid us in making lots of every day decisions such as which direction to take, what to wear, and given our current discussion what to eat. We can use our sense of sight to see if food has spoiled or gone bad or looks good to eat. Sometimes all it takes is a picture which is why advertisers spend lots of money making their food look the best in their ads using specialized techniques. It is also why chef's will use garnishes on plates or strategic plating methods to make the food look as visually appealing as possible.

Sound: Sounds that food makes is a lesser thought of sensory aspect to food choice but is a driver in the reasons behind making some food choices. The sound a bag of chips makes is an example of a sound that may make you want to then snack on a crunchy snack. We can also tell if soda is flat if there is an absent of noise.

Nutritional:

Nutrition, both perceived or verified, is the second greatest motivator in food preference and selection. Perhaps someone has made weight loss goals or is on a specialized diet due to allergies these individuals are going to choose foods that fit into their lifestyle and dietary needs.

Cultural/Religious:

There are greater than 4,000 recognized religions worldwide so it would be impossible to cover them here. How does or would religion alter food choice? Religions may have different "rules" to follow in either what is acceptable to eat (or not) and how the food is prepared. In some instances there are even rules about where the food is prepared and by whom. It is important to recognize that not everyone who follows or observed a certain religion follows all of the (or any) of the dietary recommendations. There are some individuals who are considered devout who follow the written or estabilished doctrine closely and then others who choose not to follow any. As opposed to listing any specific religions here and outlining dietary practices I encourage you to read about cultural aspects in food choices here.

Cultural aspects to food selection go beyond religion as well with cultural "norms" and traditions. Getting an alcoholic drink on one's 21st birthday (legal drinking age in the U.S.) would be an example of this or serving cake at a birthday party.

Sociological and Psychological:

Peer pressure falls into this category as well as hospitality norms and choices. These two are listed together instead of separately because there is often overlap in the two categories. These are often intertwined with cultural normals as well.

Budget and Costs:

Food costs have skyrocketed over the past couple of years with increased inflation in the United States. At home food costs, meaning food bought at the grocery store to prepare at home, increased 12.4% from October 2021 to October 2022. In comparison food inflation cost from 2019-2020 was around 3.4% and prior to the COVID-19 pandemic the average food-cost increase was around 1.2% per year. With increasing costs, many individuals are now dealing with choosing their foods based on cost alone or higher towards the top of the list. Food insecurity is also a major issue in the U.S. with sides arguing whether or not access to food is a human right or on the individual. As such, there are many grass-roots efforts to bridge the gap for many Americans to provide them with foods in order to provide nutritious foods.

Ways to over-come costs of food many people turn to store discount cards and coupons. Another way to cut costs at the grocery store is to choose store brand or generic brand over name-brand labels.

Souces: U.S. Labor and Statistics

Nuance and Food Selection:

While at first glance it may seem very simple as to why people choose the foods that they do there is a larger system at play that many are not aware of. The social determinants of health play a major role in how access, costs, beliefs all work together to either improve health or reduce ones health outcomes.

To learn more on this topic of food selection please visit this website The Determinants of Food Choice. It has a lot of information that explains the nuance behind food choices.

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6.2: Taste and Smell

Skills to Develop

- Explain in what way smell and taste stimuli differ from other sensory stimuli
- Identify the five primary tastes that can be distinguished by humans
- Explain in anatomical terms why a dog's sense of smell is more acute than a human's

Taste, also called gustation, and smell, also called olfaction, are the most interconnected senses in that both involve molecules of the stimulus entering the body and bonding to receptors. Smell lets an animal sense the presence of food or other animals—whether potential mates, predators, or prey—or other chemicals in the environment that can impact their survival. Similarly, the sense of taste allows animals to discriminate between types of foods. While the value of a sense of smell is obvious, what is the value of a sense of taste? Different tasting foods have different attributes, both helpful and harmful. For example, sweet-tasting substances tend to be highly caloric, which could be necessary for survival in lean times. Bitterness is associated with toxicity, and sourness is associated with spoiled food. Salty foods are valuable in maintaining homeostasis by helping the body retain water and by providing ions necessary for cells to function.

Tastes and Odors

Both taste and odor stimuli are molecules taken in from the environment. The primary tastes detected by humans are sweet, sour, bitter, salty and umami. The first four tastes need little explanation. The identification of umami as a fundamental taste occurred fairly recently—it was identified in 1908 by Japanese scientist Kikunae Ikeda while he worked with seaweed broth, but it was not widely accepted as a taste that could be physiologically distinguished until many years later. The taste of umami, also known as savoriness, is attributable to the taste of the amino acid L-glutamate. In fact, monosodium glutamate, or MSG, is often used in cooking to enhance the savory taste of certain foods. What is the adaptive value of being able to distinguish umami? Savory substances tend to be high in protein.

All odors that we perceive are molecules in the air we breathe. If a substance does not release molecules into the air from its surface, it has no smell. And if a human or other animal does not have a receptor that recognizes a specific molecule, then that molecule has no smell. Humans have about 350 olfactory receptor subtypes that work in various combinations to allow us to sense about 10,000 different odors. Compare that to mice, for example, which have about 1,300 olfactory receptor types, and therefore probably sense more odors. Both odors and tastes involve molecules that stimulate specific chemoreceptors. Although humans commonly distinguish taste as one sense and smell as another, they work together to create the perception of flavor. A person's perception of flavor is reduced if he or she has congested nasal passages.

Reception and Transduction

Odorants (odor molecules) enter the nose and dissolve in the olfactory epithelium, the mucosa at the back of the nasal cavity (as illustrated in Figure **6.2.1**). The olfactory epithelium is a collection of specialized olfactory receptors in the back of the nasal cavity that spans an area about 5 cm^2 in humans. Recall that sensory cells are neurons. An olfactory receptor, which is a dendrite of a specialized neuron, responds when it binds certain molecules inhaled from the environment by sending impulses directly to the olfactory bulb of the brain. Humans have about 12 million olfactory receptors, distributed among hundreds of different receptor types that respond to different odors. Twelve million seems like a large number of receptors, but compare that to other animals: rabbits have about 100 million, most dogs have about 1 billion, and bloodhounds—dogs selectively bred for their sense of smell—have about 4 billion. The overall size of the olfactory epithelium also differs between species, with that of bloodhounds, for example, being many times larger than that of humans.

Olfactory neurons are bipolar neurons (neurons with two processes from the cell body). Each neuron has a single dendrite buried in the olfactory epithelium, and extending from this dendrite are 5 to 20 receptor-laden, hair-like cilia that trap odorant molecules. The sensory receptors on the cilia are proteins, and it is the variations in their amino acid chains that make the receptors sensitive to different odorants. Each olfactory sensory neuron has only one type of receptor on its cilia, and the receptors are specialized to detect specific odorants, so the bipolar neurons themselves are specialized. When an odorant binds with a receptor that recognizes

it, the sensory neuron associated with the receptor is stimulated. Olfactory stimulation is the only sensory information that directly reaches the cerebral cortex, whereas other sensations are relayed through the thalamus.

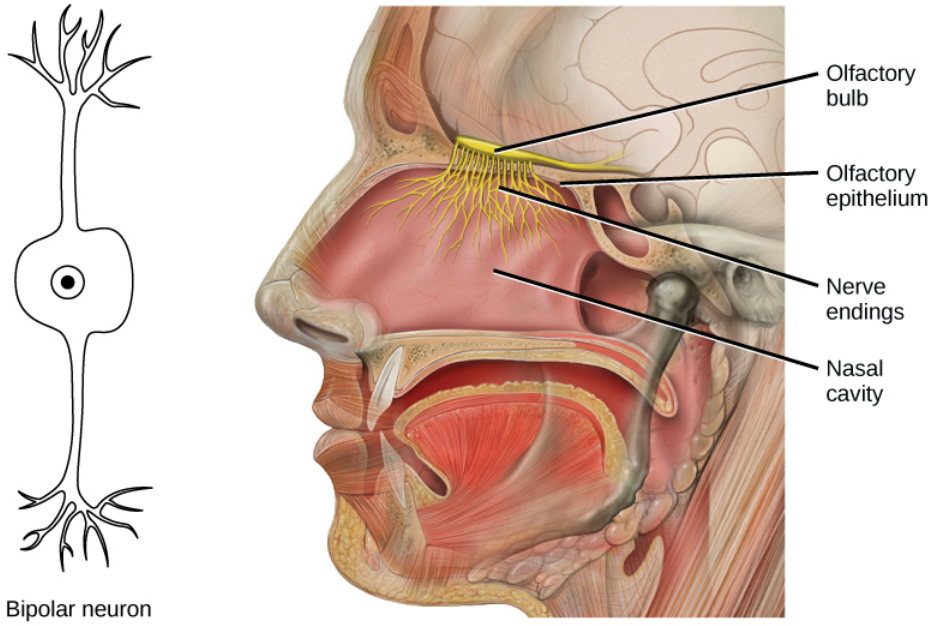


Figure **6.2.1**: In the human olfactory system, (a) bipolar olfactory neurons extend from (b) the olfactory epithelium, where olfactory receptors are located, to the olfactory bulb. (credit: modification of work by Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist)

Evolution Connection: Pheromones

A pheromone is a chemical released by an animal that affects the behavior or physiology of animals of the same species. Pheromonal signals can have profound effects on animals that inhale them, but pheromones apparently are not consciously perceived in the same way as other odors. There are several different types of pheromones, which are released in urine or as glandular secretions. Certain pheromones are attractants to potential mates, others are repellants to potential competitors of the same sex, and still others play roles in mother-infant attachment. Some pheromones can also influence the timing of puberty, modify reproductive cycles, and even prevent embryonic implantation. While the roles of pheromones in many nonhuman species are important, pheromones have become less important in human behavior over evolutionary time compared to their importance to organisms with more limited behavioral repertoires.

The vomeronasal organ (VNO, or Jacobson's organ) is a tubular, fluid-filled, olfactory organ present in many vertebrate animals that sits adjacent to the nasal cavity. It is very sensitive to pheromones and is connected to the nasal cavity by a duct. When molecules dissolve in the mucosa of the nasal cavity, they then enter the VNO where the pheromone molecules among them bind with specialized pheromone receptors. Upon exposure to pheromones from their own species or others, many animals, including cats, may display the flehmen response (Figure **6.2.2**), a curling of the upper lip that helps pheromone molecules enter the VNO.

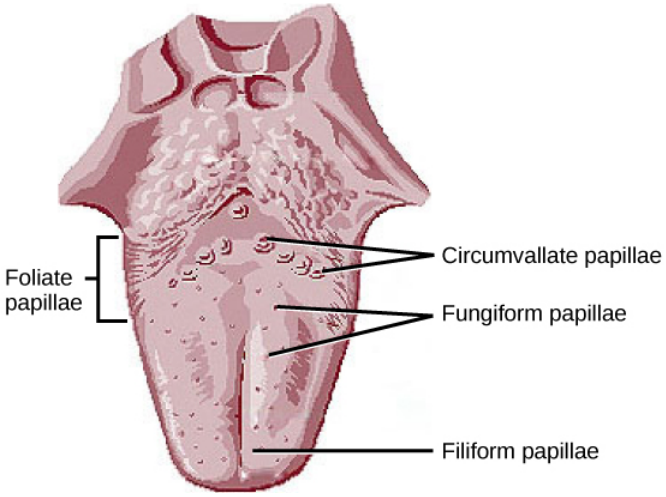


Figure 6.2.2: The flehmen response in this tiger results in the curling of the upper lip and helps airborne pheromone molecules enter the vomeronasal organ. (credit: modification of work by "chadh"/Flickr)

Pheromonal signals are sent, not to the main olfactory bulb, but to a different neural structure that projects directly to the amygdala (recall that the amygdala is a brain center important in emotional reactions, such as fear). The pheromonal signal then continues to areas of the hypothalamus that are key to reproductive physiology and behavior. While some scientists assert that the VNO is apparently functionally vestigial in humans, even though there is a similar structure located near human nasal cavities, others are researching it as a possible functional system that may, for example, contribute to synchronization of menstrual cycles in women living in close proximity.

Taste

Detecting a taste (gustation) is fairly similar to detecting an odor (olfaction), given that both taste and smell rely on chemical receptors being stimulated by certain molecules. The primary organ of taste is the taste bud. A taste bud is a cluster of gustatory receptors (taste cells) that are located within the bumps on the tongue called papillae (singular: papilla) (illustrated in Figure 6.2.3). There are several structurally distinct papillae. Filiform papillae, which are located across the tongue, are tactile, providing friction that helps the tongue move substances, and contain no taste cells. In contrast, fungiform papillae, which are located mainly on the anterior two-thirds of the tongue, each contain one to eight taste buds and also have receptors for pressure and temperature. The large circumvallate papillae contain up to 100 taste buds and form a V near the posterior margin of the tongue.



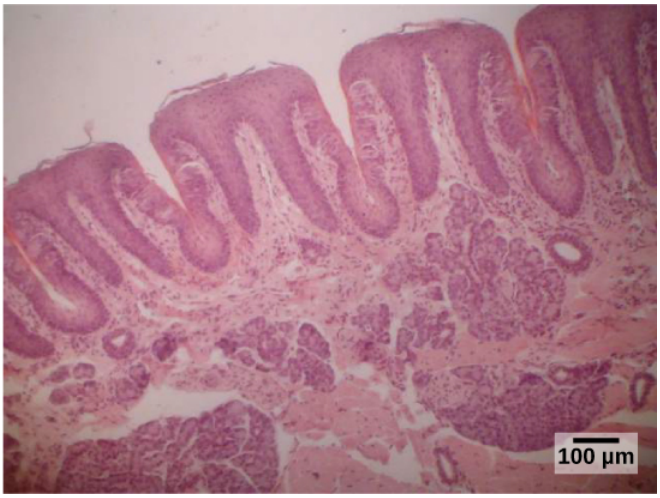


Figure 6.2.3: (a) Foliate, circumvallate, and fungiform papillae are located on different regions of the tongue. (b) Foliate papillae are prominent protrusions on this light micrograph. (credit a: modification of work by NCI; scale-bar data from Matt Russell)

In addition to those two types of chemically and mechanically sensitive papillae are foliate papillae—leaf-like papillae located in parallel folds along the edges and toward the back of the tongue, as seen in the micrograph. Foliate papillae contain about 1,300 taste buds within their folds. Finally, there are circumvallate papillae, which are wall-like papillae in the shape of an inverted "V" at the back of the tongue. Each of these papillae is surrounded by a groove and contains about 250 taste buds.

Each taste bud's taste cells are replaced every 10 to 14 days. These are elongated cells with hair-like processes called microvilli at the tips that extend into the taste bud pore (illustrated in Figure **6.2.4**). Food molecules (tastants) are dissolved in saliva, and they bind with and stimulate the receptors on the microvilli. The receptors for tastants are located across the outer portion and front of the tongue, outside of the middle area where the filiform papillae are most prominent.

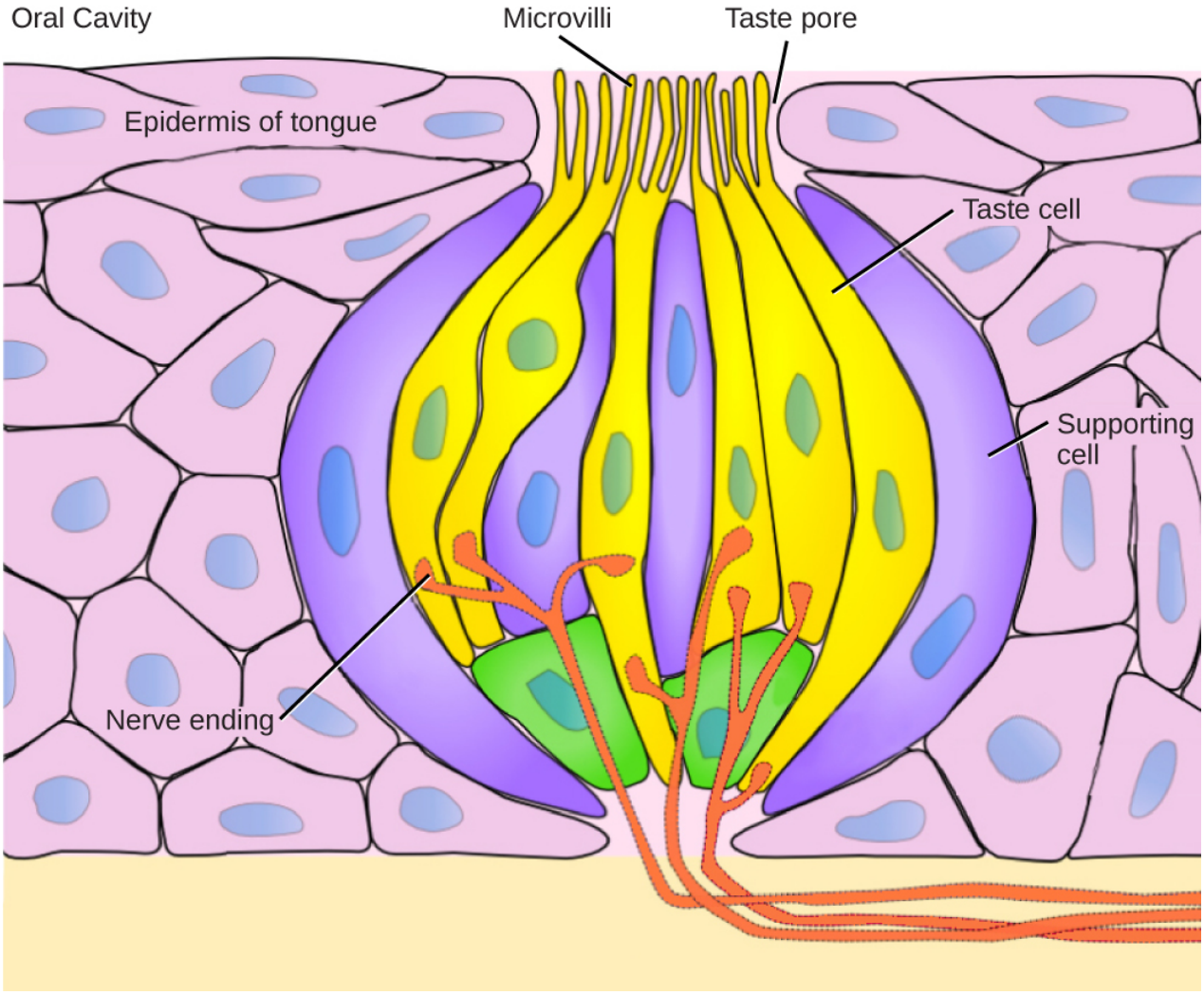


Figure **6.2.4**: Pores in the tongue allow tastants to enter taste pores in the tongue. (credit: modification of work by Vincenzo Rizzo)

In humans, there are five primary tastes, and each taste has only one corresponding type of receptor. Thus, like olfaction, each receptor is specific to its stimulus (tastant). Transduction of the five tastes happens through different mechanisms that reflect the molecular composition of the tastant. A salty tastant (containing NaCl) provides the sodium ions (Na^+) that enter the taste neurons and excite them directly. Sour tastants are acids and belong to the thermoreceptor protein family. Binding of an acid or other sour-tasting molecule triggers a change in the ion channel and these increase hydrogen ion (H^+) concentrations in the taste neurons, thus depolarizing them. Sweet, bitter, and umami tastants require a G-protein coupled receptor. These tastants bind to their respective receptors, thereby exciting the specialized neurons associated with them.

Both tasting abilities and sense of smell change with age. In humans, the senses decline dramatically by age 50 and continue to decline. A child may find a food to be too spicy, whereas an elderly person may find the same food to be bland and unappetizing.

Link to Learning



View this animation that shows how the sense of taste works.

Smell and Taste in the Brain

Olfactory neurons project from the olfactory epithelium to the olfactory bulb as thin, unmyelinated axons. The olfactory bulb is composed of neural clusters called glomeruli, and each glomerulus receives signals from one type of olfactory receptor, so each glomerulus is specific to one odorant. From glomeruli, olfactory signals travel directly to the olfactory cortex and then to the frontal cortex and the thalamus. Recall that this is a different path from most other sensory information, which is sent directly to the thalamus before ending up in the cortex. Olfactory signals also travel directly to the amygdala, thereafter reaching the hypothalamus, thalamus, and frontal cortex. The last structure that olfactory signals directly travel to is a cortical center in the temporal lobe structure important in spatial, autobiographical, declarative, and episodic memories. Olfaction is finally processed by areas of the brain that deal with memory, emotions, reproduction, and thought.

Taste neurons project from taste cells in the tongue, esophagus, and palate to the medulla, in the brainstem. From the medulla, taste signals travel to the thalamus and then to the primary gustatory cortex. Information from different regions of the tongue is segregated in the medulla, thalamus, and cortex.

Summary

There are five primary tastes in humans: sweet, sour, bitter, salty, and umami. Each taste has its own receptor type that responds only to that taste. Tastants enter the body and are dissolved in saliva. Taste cells are located within taste buds, which are found on three of the four types of papillae in the mouth.

Regarding olfaction, there are many thousands of odorants, but humans detect only about 10,000. Like taste receptors, olfactory receptors are each responsive to only one odorant. Odorants dissolve in nasal mucosa, where they excite their corresponding olfactory sensory cells. When these cells detect an odorant, they send their signals to the main olfactory bulb and then to other locations in the brain, including the olfactory cortex.

Glossary

bipolar neuron

neuron with two processes from the cell body, typically in opposite directions

glomerulus

in the olfactory bulb, one of the two neural clusters that receives signals from one type of olfactory receptor

gustation

sense of taste

odorant
airborne molecule that stimulates an olfactory receptor

olfaction
sense of smell

olfactory bulb
neural structure in the vertebrate brain that receives signals from olfactory receptors

olfactory epithelium
specialized tissue in the nasal cavity where olfactory receptors are located

olfactory receptor
dendrite of a specialized neuron

papilla
one of the small bump-like projections from the tongue

pheromone
substance released by an animal that can affect the physiology or behavior of other animals

tastant
food molecule that stimulates gustatory receptors

taste bud
clusters of taste cells

umami
one of the five basic tastes, which is described as “savory” and which may be largely the taste of L-glutamate

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CHAPTER OVERVIEW

Chapter 7: Food Spoilage and Food Preservation

7.1: Food Spoilage

7.2: Food Preservation

7.3: Waste Reduction

Thumbnail: Rotting apples. (Unsplash License; Joshua Hoehne via Unsplash)

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7.1: Food Spoilage

As discussed previously in the food safety and Foodborne illness sections food can go bad and when food goes bad- people can get sick. Aside from potential illness that can be the result of food spoilage another issue is food waste. Food waste is estimated to be the largest portion of the items found in U.S. landfills and also estimated to somewhere around 40% of all food purchased by U.S. households ends up in the trash.

Since the beginning of time, humans have tried to extend the life of their food. Ancient Egyptians fermented grains and dried fish, meat has been salted (cured) and stored for long hunting trips, canning made its way into the forefront to help feed troops which eventually gave way to the modern day "meal ready to eat" (MRE) used by modern day troops and even freeze drying foods for NASA astronauts.

While we may not be NASA astronauts or needing food to fuel us on the battlefield reducing food waste at home is an important idea in ending wastes. For that reason, we will focus more on the food preservation methods that may be taken by everyday people rather than commercialized processes.

When discussing food spoilage there are three categories of foods based on their perishability. There are foods that will spoil quicker than others.

Perishable: Will keep for hours or days (e.g. flesh meats, eggs, milk) think about foods that need refrigeration.

Semi-perishable: will keep for a couple of weeks or months (e.g. processed grains, root vegetables and some fruits) Think items that can be kept out of the freezer or refrigerator and are shelf-stable for a short while.

Nonperishable: These foods will keep for awhile. Some of which have undergone methods of preservation that will be discussed later. Foods in this category include canned fruits and vegetables, dried fruits, beans, honey, salt and spices, and whole grains.

Food spoilage can occur in three main ways. There may be biological changes, chemical changes, or due to physical changes with the food. Foods may also be damaged due to pests, bugs, and animals. Some sources cite animal/pest damage in the physical category while others acknowledge it as a category all of its own. For the purposes of this class we will discuss this separately but not a primary cause of food spoilage.

Physical: Physical changes can occur when food is subjected to varying and sometimes big swings in temperature changes. Think back to when we discussed what happens with ice cream and freezer burn. Ice cream may melt (or become soft) and refrozen but this occurs at a cost. The ice crystals may from on the ice cream which destroys some of the texture and flavor of the product. Other types of physical damage include light exposure (e.g. potatoes or onions allowed to sprout in sunshine) and mechanical damage.

Chemical: Both enzymatic and non-enzymatic reactions are in this category. Chemical reactions may be caused by proteolytic enzymes. Recall that proteolytic enzymes otherwise known as proteases break down proteins found in foods. Other ways this can occur is through lipases (breaking down of fats) and Oxidizing compounds.

Biological: Biological food spoilage include many of the things that we spoke about in Foodborne illness section. Microorganisms, yeast, molds, and bacteria. Now keep in mind that some of these things such as yeasts and bacteria may be used strategically in food preservation methods (fermentation!) however, as we have discussed previously- there are good and bad bacteria and some yeast growth will make us sick if not done properly. Other: In this "other" category food may be spoiled if affected by animals, pests, or bugs. Weevils in flour would be an example of this or a wormy apple.

More information on this topic may be found at the following page: Food Spoilage Resource Citation: https://www.rts.com/resources/guides...waste-america/ https://nchfp.uga.edu/publications/n...pres_hist.html https://stealtharmour.wordpress.com/...fermented%20to %20create%20beer.

Tags recommended by the template: article:topic

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7.2: Food Preservation

Refrigeration

Keeping foods at or below a certain temperature can help maintain foods freshness and prevent spoilage from occurring. A more apt way to look at it would actually be that we are slowing down the process of spoilage. However, not all food should be stored within the refrigerator. For example some fresh produce actually keeps better outside of the refrigerator such as potatoes, onions, and oranges. Other produce items do well in the crisper while others do not. Produce high in water such as celery can even be stored in glass containers filled with water to prolong their life.

Please visit this informational site from the Academy of Nutrition and Dietetics on all things refrigeration: How To Guide for Refrigeration.

And this handy guide for which produce to store in the refrigerator and how: Produce storage guide.

Freezing

Freezing is a highly effective method for preserving most foods but temperature fluctuations or improper storage containers can lead to freezer burn and food spoilage.

For more information about how freezing works and also foods to freeze visit this site: here.

Canning

Canning is a process of food preservation that can extend a foods shelf life from less than one week to over 5 years. Home canning can lead to outbreaks of foodborne illness if not done properly but there is less risk if buying canned goods from the grocery store. It is however important to learn how to identify cans of suspicious safety and you can keep everyone safe by discarding cans that are buliding, dented on the seal, or are covered in rust.

To learn more about home canning please visit: Home Canning Basics.

Drying

Drying as a food preservation method works by removing most of the moisture that exists naturally in foods which bacteria need to survive. By removing most of the water we are drastically cutting down biological changes that can occur in the food.

For information about drying foods at home please visit: UMN Extension: Guide to Home Drying.

Fermentation

Fermentation can help prevent spoilage by preserving food through reduction of its water activity. The shared link below is jam packed with information about fermentation that you may find helpful in general but the section on food preservation close to the end is what this section is all about.

Link to "How Fermentation Makes Food Taste Good"

Curing

By now you may be sensing a trend. If you want to preserve food you must decrease the amount of water activity. The process of curing does this through the power of salt! To learn more about this process visit this science of cooking article.

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- **9.6: Selecting, Purchasing and Storing Fruits** by William R. Thibodeaux is licensed CC BY-NC-SA 4.0. Original source: https://louis.oercommons.org/authoring/87-fruits-vegetables-farinaceous-products/view.

7.3: Waste Reduction

The **waste management hierarchy** lists processes to address waste in order of preference with the goals of limiting waste, minimizing environmental impact, and maximizing additional benefits (such as electricity generation or production of recycled goods). It is symbolized as an upside triangle, meaning that the largest volume of waste should be handled using the first process (most preferred), and the smallest volume should be handled using the last process (least preferred). These processes in order of preference are reduction, recycling, energy recovery (such as incineration), treatment, and disposal (figure **7.3.*a***). Individuals can exercise the first two processes by applying the four R's (see below). Unfortunately, the U.S. and the world overall, handles a large volume of waste using the least preferred method (disposal). As previously mentioned, about half of municipal solid waste (MSW) goes to a sanitary landfill for disposal. In contrast, only 23.5% of municipal solid waste (MSW) was recovered and recycled and another 8.5% was composted in 2018. Waste stream percentages also vary widely by region. As an example, San Francisco, California recycles or composts 80% of its waste material, whereas Houston, Texas recycles or composts only 19%.

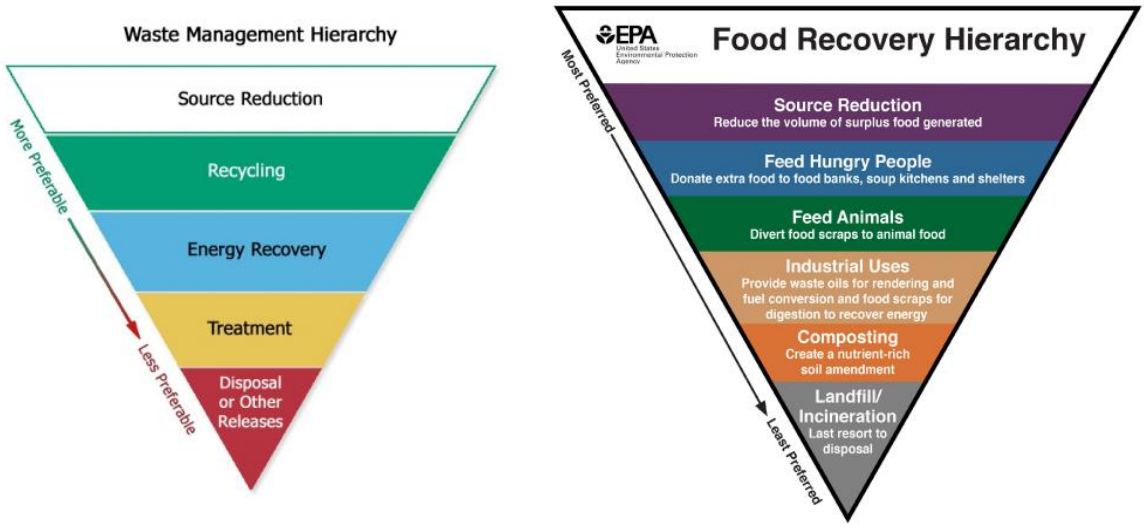


Figure 7.3.*a*: Left: The waste management hierarchy lists processes for handling waste from most to least preferable. They are source reduction, recycling, energy recovery, treatment, and disposal or other releases. Right: The food recovery hierarchy is a waste management hierarchy specific to food waste. It begins with source reduction (reduce the volume of surplus food generated). Next is feed hungry people (donate extra food to food banks, soup kitchens, and shelters. Third is feed animals (divert food scraps to animal food. Fourth is industrial uses (provide waste oils for rendering and fuel conversion and food scraps for digestion to recover energy. Fifth is composting (create a nutrient-rich soil amendment). The remaining waste goes to landfill or incineration as a last resort to disposal. Images by EPA (public domain).

Source reduction (waste minimization) refers to the strategies that minimize the amount of generated waste and/or reduce the toxicity of the resultant waste when designing or manufacturing products or services. Waste can be reduced by reusing materials, using less hazardous substitute materials, or by modifying components of design and processing. Source reduction in manufacturing not only saves resources, but it also reduces costs for the manufacturer and indirectly for the consumer. For example, minimal packaging reduces material use, increases distribution efficiency, and reduces fuel consumption and resulting air emissions. Similarly, building materials can be designed to reduce the overall mass of material needed for a given structure.

Recycling refers to recovery and reprocessing of useful materials. Numerous examples of successful recycling and reuse efforts are encountered every day. Many construction materials can be reused, including concrete, asphalt materials, masonry, and reinforcing steel. "Green" plant-based wastes are often recovered and immediately reused for mulch or fertilizer applications. Many industries also recover various byproducts for reuse. In some cases, the recycled materials are used as input materials and are heavily processed into end products. Common examples include the use of scrap paper for new paper manufacturing, or the processing of old aluminum cans into new aluminum products. In other cases, reclaimed materials undergo little or no processing prior to their

reuse. Some common examples include the use of tree waste as wood chips, or the use of brick and other fixtures into new structural construction. In any case, the success of recycling depends on effective collection and processing of recyclables, markets for reuse, and public acceptance and promotion of recycled products and applications utilizing recycled materials.

The Four R's

The **four R's** (refuse, reduce, reuse, and recycle) are strategies that allow individuals to limit the volume and negative impacts of the waste they generate. They resemble the waste management hierarchy, but focus at the individual scale rather than the scale of a company or waste management system. They are listed in order of most to least environmentally beneficial, and they are all better alternatives than discarding trash into the landfill. Recycling is last because it requires energy to reprocess waste.

To **refuse** is to decline products or processes that harm the environment if you do not need them. Choosing products without packaging is an example of refusing. To **reduce** is to choose products or processes with lower **ecological footprint** (the area of land required to produce them). Examples include products with limited packaging or durable items rather than flimsy or disposable ones. **Reuse** refers to using a product multiple times or finding an alternative use for it. For example, one could share, borrow, or rent items. A plastic yogurt or pudding container could be repurposed for storage or gardening. As noted above, **recycling** means to return used items to be reprocessed (figure **7.3.*b***). Commonly recycled materials include cardboard, glass, cans, and certain plastics.



Figure 7.3.*b*: Recycling, or returning materials to be reprocessed,is the last of the four R's. If items cannot be refused, reduced, or reused, recycling is a better alternative than discarding into the landfill. Image by Intel Free Press (CC-BY).

Resin identification codes are the triangular symbols on recyclable plastics that indicate their composition (figure **7.3.*c***). A variety of materials make up plastics, and they are not all recycled the same way. Furthermore, your local recycling service may recycle some types of plastics but not others. Plastics with codes 1 and 2 are commonly recycled. For the codes, check with your local recycling service. Local businesses may house collection bins for plastics that are not commonly recycled. For example, grocery stores commonly have receptacles for recycling plastic bags, which fall under code 4.

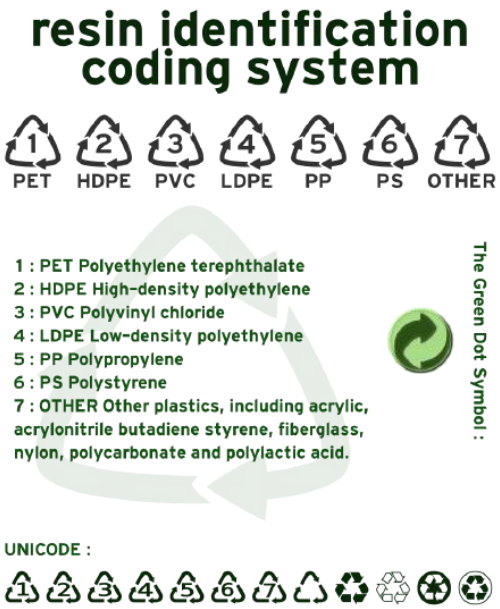


Figure **7.3.*c***): The resin identification coding system explains the chemical composition of various plastics. Some are commonly recycled, and others are not. The text in the image is, "1: PET Polyethylene terephthalate, 2: HDPE High-density polyethylene, 3: PVC Polyvinyl chloride, 4: LDPE Low-density polyethylene, 5: PP Polypropylene, 6: PS Polystyrene, 7: OTHER Other plastics, including acrylic, acrylonitrille butadiene styrene, fiberglass, nylon, polycarbonate and polylactic acid. Image by Filtre/OpenClipart Library (public domain).

Composting

Compost is organic material that can be added to soil to help plants grow (figure **7.3.*d***). Food scraps and yard waste together currently make up more than 30% of what we throw away and could be composted instead. Making compost keeps these materials out of landfills where they take up space and release methane, a potent greenhouse gas that contributes to climate change. Furthermore, compost enriches soil, helping retain moisture and suppress plant diseases and pests. It reduces the need for chemical fertilizers and encourages the production of beneficial bacteria and fungi. Composting can be done at an industrial scale, such as with yard waste collected from homes in a city. It can also be done at home.



Figure **7.3.*d***): Compost is a nutrient-rich substance formed from decomposition of yard and food waste that enriches garden soil. Image by EPA (public domain).

All composting requires three basic ingredients: browns, greens, and water. "Browns" are materials such as dead leaves, branches, and twigs. "Greens" are materials such as grass clippings, vegetable waste, fruit scraps, and coffee grounds. The brown materials provide carbon for your compost, the green materials provide nitrogen, and the water provides moisture to help break down the organic matter. A compost pile should have an equal amount of browns to greens. Layers of these organic materials with different particle sizes should be alternated.

Backyard Composting

Backyard composting requires a compost bin or pile to be placed in dry, shady spot near a water source (figure **7.3.*e***). Brown and green materials are added as they are collected, and larger pieces are chopped or shredded before they are added to the pile. Dry materials are moistened as they are added. Once the compost pile is established, grass clippings and green waste are mixed into the pile when added. When fruit and vegetable wastes are added, they are buried under 10 inches of compost material. Some homeowners cover the top of the compost with a tarp to keep it moist. When the material at the bottom is dark and rich in color, the compost is ready to use. This usually takes anywhere between two months to two years.

 Figure **7.3.*e***): This compost bin contains food scraps and yard waste. Image by Ben_Kerckx/Pixabay (Pixabay license)

Indoor Composting

For those who do not have the space for an outdoor compost pile, materials can be composted indoors using a special type of bin, which can be purchased at a local hardware store, gardening supplies store, or made at home. Care must be taken to properly manage the compost pile and keep track of what is added such that it does not attract pests or rodents or smell bad. The compost should be ready in two to five weeks.

Attribution

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- Systems of Waste Management from *Sustainability: A Comprehensive Foundation* by Tom Theis and Jonathan Tomkin, Editors (CC-BY). Download for free at CNX.
- Composting at Home. Environmental Protection Agency. Accessed 01-18-2021 (public domain).

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CHAPTER OVERVIEW

Chapter 8: Food Safety

8.1: Food Safety
8.2: Causes of Foodborne Illnesses
8.3: Preventing Foodborne Illness
8.4: Storage Temperatures and Procedures
8.5: Sanitation and Personal Hygiene

Thumbnail: Food thermometer in pork. (Public Domain; United States Department of Agriculture via Wikipedia)

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SECTION OVERVIEW

8.1: Food Safety

An Approach to Food Safety

Food safety does not happen by accident. To prepare safe food, you must follow certain steps and procedures throughout the entire food preparation process. An approach to food safety is to divide the process into four simple steps: clean, separate, cook, and chill. These four steps will be explored later on in the chapter.



Image Source: https://www.fda.gov/food/buy-store-s...-food-handling

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8.2: Causes of Foodborne Illnesses

Causes of Foodborne Illnesses

Foodborne illnesses can be caused by:

- Contaminants
- Improper food handling practices
- Food allergies

Understanding each of these is critical in ensuring that food safety is maintained.[1]

Food **contaminants** can be:

- Chemical, such as cleaning agents or pesticides
- Physical, such as hair, bandages, or glass
- Biological, such as pathogens and microbes introduced from infected workers, unsanitary work surfaces, or contaminated water

Biological causes of foodborne illness

Biological contaminants are by far the greatest cause of illness. Many of the risks associated with biological contaminants can be controlled or removed by effective food handling practices, so it is critical that the safe food handling and prevention procedures outline in the rest of the book be followed.

Microbes are all around us. They are living things, often too small to be seen without a microscope. Many microbes are beneficial, but some can cause illness or even death. These harmful microbes are called **pathogens.** Five types of microbes include bacteria, viruses, parasites, protozoa, and fungi (mold).

- Bacteria are present in many of the foods we eat and the body itself. Most bacteria are not harmful, some are even very beneficial to people, but some types of bacteria are pathogenic and can cause illness. Campylobacter, E.coli, Listeria, and Salmonella are examples of pathogenic bacteria. Foods that contain these bacteria must be handled correctly and cooked appropriately.
- Viruses frequently cause illness, and are found in food, but do not grow or multiply in food. Most foodborne illness caused by viruses happens because the person handling the food has transmitted to the virus to the food through improper food handling or poor sanitation. Hepatitis A and Norovirus are examples of viruses that are responsible for foodborne illness.
- Parasites live in or on animals and people cause illness when the food infected with the parasite is not cooked to a temperature high enough or frozen to a temperature cold enough to kill the parasite. Roundworms (found in raw fish) are examples of parasites found in food.
- Protozoa are single-celled animals that may be found in water. Use of water from unsafe sources can lead to illness. Giardia lamblia is an example of protozoa that may be found in water from rivers, lakes, streams and shallow wells. Food washed in water containing Giardia lamblia that is served without any further cooking (such as salad greens) can cause illness.
- Fungi grow on decaying organic matter. Many fungi are harmless or beneficial, but some, such as mold that grows on spoiled food, can be harmful and remain even after cutting or scraping the visible mold off the food.

Food Intoxication and Food Infection

Have you ever had the “24-hour flu”? Many people who think they have the 24-hour flu have had a foodborne illness caused by some type of pathogen. A rapid reaction is normally caused by a food intoxication. A slower reaction is normally caused by a food infection. Here’s how to tell the difference between the two:

- Food **intoxication** occurs when bacteria grow in food and produce a waste product called a toxin. When the food is eaten, the toxins are immediately introduced into the body, causing a rapid reaction. Example: Staphylococcus
- Food **infection** occurs when food contains living pathogens that grow in the human intestinal tract after the food is eaten. Because the bacteria continue to multiply in the body and cause infection, the reaction will be slower. Example: Salmonella

There is also **toxin-mediated infection** which occurs when a biological pathogens are introduced to the body and after entering the digestive tract begin to produce a toxin. The toxin is what is responsible for the many symptoms associated with foodborne illness. Example: E.coli

Common Causes of Foodborne Illness

Bacteria:

While there are hundreds of different strains of bacteria that can cause illness in humans the Centers for Disease Control and Prevention (CDC) recognizes the top 5 types bacteria to cause illness in the United States as:

Table 1. Foodborne Illnesses

	Hepatitis A	Campylobacter Jejuni	Clostridium perfringens	E.coli	Listeria
Source	• Raw/undercooked shellfish from contaminated waters • Raw produce • Contaminated drinking water • Uncooked foods • Cooked foods that are not reheated after contact with an infected food handler.	• Unpasteurized (raw) milk • Chicken • Shellfish • Turkey • Contaminated water	• Beef • Poultry • Gravies • Food left for long periods in steam tables or at room temperature • Time and/or temperature abused foods.	• Contaminated food such as: ◦ Undercooked ground beef ◦ Unpasteurized (raw) milk and juice ◦ Soft cheeses made from raw milk ◦ Raw fruits/vegetables • Contaminated water, including drinking untreated water and swimming in contaminated water. • Animals and their environment, particularly cows, sheep, and goats. • Feces of infected people.	• Unpasteurized (raw) milk ar dairy products. • Soft cheese made with unpasteurized milk, such as fresco, feta, Brie, Camembe • Raw fruits and vegetables (s as sprouts). • Ready-to-eat deli meats and dogs. • Refrigerated pâtés or meat spreads. • Refrigerated smoked seafoo
Incubation Period	28 days average (ranges from 15 to 50 days)	2 to 5 days	6 to 24 hours	3 to 4 days for most people, can be 1 to 10 days	• Usually 1 to 4 weeks • Can be as long as 70 days
Symptoms	• Diarrhea • Dark urine or Light-colored stools • Jaundice • Fever • Fatigue • Nausea • Joint pain • Stomach pain • Upset stomach • Loss of appetite.	• Diarrhea, cramps • Fever • Vomiting • Diarrhea may be bloody.	• Diarrhea • Stomach cramps (no fever or vomiting)	• Severe diarrhea that is often bloody • Severe stomach pain and vomiting. • Usually little or no fever is present. • Symptoms of hemolytic uremic syndrome (HUS) : ◦ decreased urine production ◦ Dark or tea-colored urine, ◦ Losing pink color in cheeks and inside the lower eyelids.	• Fever and diarrhea similar t other foodborne germ Symptoms in people with invas listeriosis, meaning the bacteria spread beyond the gut, include: • For pregnant women: ◦ Fever ◦ Fatigue ◦ Muscle aches. ◦ Pregnant women may al have no symptoms but experience fetal death, p term labor, or infection newborn. • For all others: ◦ Stiff neck ◦ Confusion ◦ Loss of balance ◦ Convulsions in addition fever and muscle aches.
Duration	Less than 2 months. Some people can be ill for as long as 6 months.	~1 week	• <24 hours • In severe cases: 1-2 weeks.	• 5 to 10 days • Most people will be better in 5 to 7 days. If HUS develops, it usually occurs after about 1 week.	Days to weeks
Prevention	• Avoid eating raw oysters or other raw/undercooked shellfish. • Wash hands frequently with soap and running water for at least 20 seconds after using the bathroom, after changing diapers, and before, during, and after preparing food. • Vaccination	• Drink pasteurized milk. • Avoid raw milk/dairy. • Do not drink untreated water.	• Thoroughly cook foods, particularly meat, poultry, and gravies, to a safe internal temperature. • Use a food thermometer • Keep food hot after cooking (at 140˚ F or above) • Serve meat dishes hot, within 2 hours after cooking. • Microwave leftovers thoroughly (to 165˚F or above). • Refrigerate leftovers within two hours of preparation (at 40˚F or below). • Divide large amounts of food, such as roasts or big pots of stew into shallow containers and refrigerate immediately. • It is OK to put hot foods directly in the refrigerator.	• Avoid high-risk foods such as: ◦ Unpasteurized milk or juice ◦ Undercooked ground beef ◦ Soft cheeses made from unpasteurized milk ◦ Sprouts • Use a food thermometer • Wash hands before, during, and after preparing food, after diapering infants, and after contact with cows, sheep, or goats, their food or treats, or their living environment.	• Avoid raw (unpasteurized) r soft cheeses made with it, su queso fresco. • Eat cut melon right away or refrigerate it. • People at higher risk **should eat** the following foods: ◦ Refrigerated pâtés or me spreads from a deli or m counter or from the refrigerated section of a ◦ Hot dogs, cold cuts, and meats, unless heated to a internal temperature of 1 ◦ Refrigerated smoked sea unless canned or shelf-st or cooked dish, such as a casserole ◦ Raw or lightly cooked sp of any kind

"Adapted from: https://www.fda.gov/food/consumers/w...orne-illnesses"

For more information on the above bacteria please visit the CDC website: here.

Viruses:

The majority of foodborne illnesses are caused by bacteria, however, there are several viruses that are common within the United States that can also cause illness. Examples of viruses are:

1. Norovirus

2. Hepatitis A

Please visit the link above to learn more about Norovirus.

For more information on Norovirus please watch the following video from the CDC: CDC Norovirus Prevention Video.

Improper Food Handling Practices

The top 10 causes of foodborne illness are the following:

1. Improper cooling
2. Advance preparation
3. Infected person
4. Inadequate reheating for hot holding
5. Improper hot holding
6. Contaminated raw food or ingredient
7. Unsafe source
8. Use of leftovers
9. Cross-contamination
10. Inadequate cooking

Food Allergies

Food allergies are specific to individuals, but can be life threatening, and can be prevented by a thorough understanding of the allergy issue, knowledge of ingredients used in the preparation of foods, including pre-prepared foods, and care in ensuring separate cooking utensils, cookware, and food preparation surfaces. Oftentimes, the smallest oversights can have serious consequences, as indicated in the example below:

A customer has indicated they have an allergy to shellfish and ordered chicken strips with a house dipping sauce. The server assures the customer that there will be no shellfish used in the preparation of what they ordered. After eating the meal, the customer experiences tingling lips and hives. In follow up, the manager discovers that the oil used to fry the chicken strips had also been used to fry shrimp.

This incident could have been prevented if cross contact was eliminated and different fryers were used to prepare menu items.

Allergic reactions occur when the body mistakenly reacts to a food that has been eaten as an intruder to the body. Allergens trigger the immune system whose job it is to eliminate harmful foreign bodies from circulation. This reaction results in an increase in white blood cells and the production of antibodies (Immunoglobulin E IgE). Allergic reactions can be experienced as mild symptoms such as a runny nose or itching, to more severe reactions such as anaphylaxis.

Anaphylaxis involves multiple organ system and can decrease an individuals blood pressure and affect their ability to breathe making this a life-threatening reaction.

Top Food Allergies:

There are currently 8 food allergens recognized in the United States that are responsible for 90% of all allergic reactions. In April of 2021, the Food Allergy Safety, Treatment, Education, and Research (FASTER) Act was signed into law by President Joe Biden making sesame the 9th major food allergen. Starting January 1, 2023 foods produced for sale in the United States will be required to identify food sources of sesame on the labels.

Major Food Allergens

Top allergens:

1. Peanuts
2. Tree nuts
3. Milk
4. Soy
5. Wheat
6. Eggs
7. Fish
8. Shellfish
9. Sesame

Source: https://www.fda.gov/food/food-labeli...nited%20States.

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8.3: Preventing Foodborne Illness

Food-handling and Storage Procedures

Proper food handling and storage can prevent most foodborne illnesses. In order for pathogens to grow in food, certain conditions must be present. By controlling the environment and conditions, even if potentially harmful bacteria are present in the unprepared or raw food, they will not be able to survive, grow, and multiply, causing illness.

There are six factors that affect bacterial growth, which can be referred to by the mnemonic **FATTOM**:

1. **F**ood
2. **A**cid
3. **T**emperature
4. **T**ime
5. **O**xygen
6. **M**oisture

Each of these factors contributes to bacterial growth in the following ways:

- Food: Bacteria require food to survive. For this reason, moist, protein-rich foods are good potential sources of bacterial growth.
- Acid: Bacteria do not grow in acidic environments. This is why acidic foods like lemon juice and vinegar do not support the growth of bacteria and can be used as preservatives
- Temperature: Most bacteria will grow rapidly between 40°F and 140°F. This is referred to as the **danger zone** (see the section below for more information on the danger zone).
- Time: Bacteria require time to multiply. When small numbers of bacteria are present, the risk is usually low, but extended time with the right conditions will allow the bacteria to multiply and increase the risk of contamination
- Oxygen: There are two types of bacteria. **Aerobic bacteria** require oxygen to grow, so will not multiply in an oxygen-free environment such as a vacuum-packaged container. **Anaerobic bacteria** will only grow in oxygen-free environments. Food that has been improperly processed and then stored at room temperature can be at risk from anaerobic bacteria. A common example is a product containing harmful *Clostridium botulinum* (botulism-causing) bacteria that has been improperly processed during canning, and then is consumed without any further cooking or reheating.
- Moisture: Bacteria need moisture to survive and will grow rapidly in moist foods. This is why dry and salted foods are at lower risk of being hazardous.

Identifying Time/Temperature Control for Safety Foods (TCS Foods)

Foods that have the FATTOM conditions are considered **Time/Temperature Control for Safety Foods (TCS Foods).** TCS foods are those foods that are considered perishable. That is, they will spoil or “go bad” if left at room temperature. TCS foods support the growth or survival of disease-causing bacteria (pathogens) or may be contaminated by pathogens.

Generally, a food is a TCS if it is:

- Of animal origin such as meat, milk, eggs, fish, shellfish, poultry (or if it contains any of these products)
- Of plant origin (vegetables, beans, fruit, etc.) that has been heat-treated or cooked
- Any of the raw sprouts (bean, alfalfa, radish, etc.)
- Any cooked starch (rice, pasta, etc.)
- Any type of soya protein (soya milk, tofu, etc.)

Table 2 identifies common foods as either TCS or non-TCS:

Table 2. Common TCS and non-TCS

TCS	**Non-TCS**
Chicken, beef, pork, and other meats	Beef jerky
Pastries filled with meat, cheese, or cream	Bread
Cooked rice	Uncooked rice
Tofu	Uncooked beans
Fresh garlic in oil	Fresh garlic
Fresh or cooked eggs	Powdered eggs
Gravy	Flour
Dry soup mix with water added	Dry soup mix

The Danger Zone

One of the most important factors to consider when handling food properly is temperature. Table 3 lists the most temperatures to be aware of when handling food.

Table 3. Important temperatures to remember

Fahrenheit	What happens?
212°	Water boils
140°	Most pathogenic bacteria are destroyed. Keep hot foods above this temperature.
68°	Food must be cooled from 140°F to 70°F(60°C to 20°C) within two hours or less
40°	Food must be cooled from 70°F to 40°F (20°C to 4°C) within four hours or less
32°	Water freezes
0°	Frozen food must be stored at 0°F (−18°C) or below



Figure 1. Danger Zone Chart, Used with permission from BC Centre for Disease Control (BCCDC). [Image description]

The range of temperature from 40°F and 140°F (4°C and 60°C)is known as the **danger zone**, or the range at which most pathogenic bacteria will grow and multiply.

Time-temperature Control

Pathogen growth is controlled by a time-temperature relationship. To kill micro-organisms, food must be held at a sufficient temperature for a sufficient time. Cooking is a scheduled process in which each of a series of continuous temperature combinations can be equally effective.

Table 4 show the minimum time-temperature requirements to keep food safe.

Table 4. Temerature control for TCS

Critical control point	Type of food	Temperature
Refrigeration	Cold food storage, all foods.	40°F (4°C) or less
Freezing	Frozen food storage, all foods.	0°F (−18°C) or less
Cooking	Food mixtures containing poultry, eggs, meat, fish, or other potentially hazardous foods	Internal temperature of 165°F (74°C)for at least 15 seconds
Cooking	Pork, lamb, veal, beef	Internal temperature of 145°F (63°C)
Cooking	Poultry	Internal temperature of 74°C (165°F) for 15 seconds
Cooking	Ground meat (Includes chopped, ground, flaked, or minced beef, pork, or fish)	160°F (71°C)
Cooking	Eggs[1]	160°F (71°C)
Cooking	Fish[2]	Internal temperature of 145°F (63°C)
Holding	Hot foods	140°F (60°C)
Reheating	All foods	165°F (74°C) for at least 15 seconds

The Top 10 List: Do's and Don'ts

Figure 1 illustrates the top 10 improper food-handling methods and the percentage of foodborne illnesses they cause.

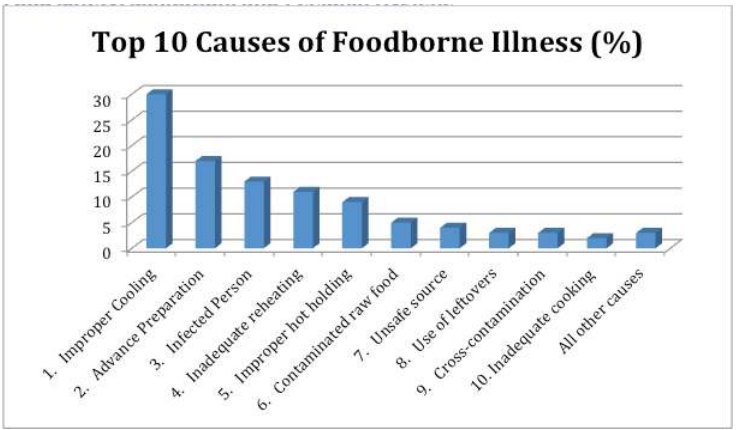


Figure 2. Top 10 causes of foodborne illness. Chart created by go2HR under CC BY. [Image description]

This section describes each food-handling practice outlined in the top 10 list and the ways to prevent each problem.

1. Improper cooling

Many people think that once a food has been properly cooked, all disease-causing organisms (pathogens) have been killed. This is not true. Some pathogens can form heat-resistant spores, which can survive cooking temperatures. When the food begins cooling down and enters the danger zone, these spores begin to grow and multiply. If the food spends too much time in the danger zone, the pathogens will increase in number to a point where the food will make people sick. That is why the **cooling** process is crucial. Cooked food must be cooled from 140°F to 70°F (60°C to 20°C) in two hours or less, AND then from 70°F to 40°F (60°C to 20°C) in four hours or less.

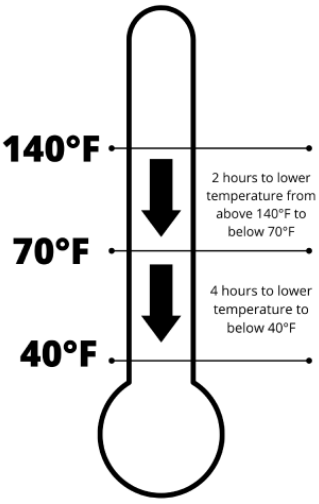


Image by: Lizz Daniels, RDN

Even in modern walk-in coolers, large cuts of meat will not cool down properly. Neither will whole poultry. Even large pots (4 L/1 gal. or more) of soup, stews, gravy, etc., can take a day or more to cool to 40°F . However, you can cool these foods down quickly by using one or more of the following methods depending on the type of food being cooled:

- Place the food in **shallow pans** (with the food no deeper than 5 cm/2 in.) and put the pans in the cooler.
- When the food is cooling, do not tightly cover. Doing so only seals in the heat.

- Do not stack the shallow cooling pans during the cooling step. This will defeat the purpose of shallow panning by preventing cold air from reaching the food. You may need to add more shelves to your cooler.
- Cut large cuts of meat or whole poultry into smaller or thinner portions. Then place these portions into shallow pans for cooling.
- Use **cooling wands** or cooling sticks to cool foods quickly.
- Use rapid cooling equipment such as walk-in coolers with wire shelving and good air flow. Home-style refrigerators or reach-ins do not cool food well.
- Stir the food in a container placed in an ice-water bath.
- Use containers that help heat transfer, such as stainless steel or aluminum. Plastic does not transfer heat well.
- Use ice as an ingredient (e.g., in stews or soups).
- For large pots of cooked desserts (e.g., custard), divide it into serving sizes and then cool.

2. Advance preparation

Advance preparation is the cause of many food-poisoning outbreaks, usually because food has been improperly cooled. Often, foods that are prepared well before serving spend too much time in the danger zone. This may happen for one or more of the following reasons:

- The food is left out at room temperature too long.
- The food is not heated or reheated properly (to a high enough temperature), or not cooled properly.
- The food is brought in and out of the danger zone too many times (e.g., cooked, hot held, cooled, reheated, hot held, cooled, reheated again).

To prevent problems of advance preparation:

- Try to prepare all foods for same-day use and as close to serving time as possible.
- To prevent outside contamination of foods prepared in advance, cover them tightly after they have been properly cooled.
- Reheat leftovers only once. If leftovers are not consumed after being reheated, throw them out.
- For foods prepared and held refrigerated in the cooler for more than 24 hours, mark the date of preparation and a “serve by” date. Generally, TCS foods should be thrown out if not used within three days from date they were made.
- If you must prepare foods in advance, be sure you properly cool and refrigerate them.

3. Infected person

Many people carry pathogens somewhere on or in their bodies without knowing it—in their gut, in their nose, on their hands, in their mouth, and in other warm, moist places. People who are carrying pathogens often have no outward signs of illness. However, people with symptoms of illness (diarrhea, fever, vomiting, jaundice, sore throat with a fever, hand infections, etc.) are much more likely to spread pathogens to food.

Another problem is that pathogens can be present in the cooked and cooled food that, if given enough time, can still grow. These pathogens multiply slowly but they can eventually reach numbers where they can make people sick. This means that foods that are prepared improperly, many days before serving, yet stored properly the entire time can make people sick.

Some pathogens are more dangerous than others (e.g., salmonella, E. coli, campylobacter). Even if they are only present in low numbers, they can make people very sick. A food handler who is carrying these kinds of pathogens can easily spread them to foods – usually from their hands. **Ready-to-eat food** is extra dangerous. Ready-to-eat food gets no further cooking after being prepared, so any pathogens will not be killed or controlled by cooking.

To prevent problems:

- Make sure all food handlers wash their hands properly after any job that could dirty their hands (e.g., using the toilet, eating, handling raw meats, blowing their nose, smoking).
- Food handlers with infected cuts on their hands or arms (including sores, burns, lesions, etc.) must not handle food or utensils unless the cuts are properly covered (e.g., waterproof bandage covered with a latex glove or finger cot).
- When using **gloves** or **finger cots**, food handlers must still wash their hands. As well, gloves or cots must be replaced if they are soiled, have a hole, and at the end of each day.
- Food handlers with infection symptoms must not handle utensils or food and should be sent home.

- Where possible, avoid direct hand contact with food – especially ready-to-eat foods (e.g., use plastic utensils plastic or latex gloves).

4. Inadequate reheating for hot holding

Many restaurants prepare some of menu items in advance or use leftovers in their **hot hold** units the next day. In both cases, the foods travel through the danger zone when they are cooled for storage and again when they are reheated.

Foods that are hot held before serving are particularly vulnerable to pathogens. In addition to traveling through the danger zone twice, even in properly operating hot hold units, the food is close to the temperature that will allow pathogens to grow.

To prevent problems:

- Do not use hot hold units to reheat food. They are not designed for this purpose. Instead, rapidly reheat to 165° (and hold the food at that temperature for at least 15 seconds before putting it in the hot hold unit. This will kill any pathogens that may have grown during the cool-down step and the reheat step.
- If using direct heat (stove top, oven, etc.), the temperature of the reheated food must reach at least 165°F for at least 15 seconds within two hours. Keep a thermometer handy to check the temperature of the food.
- If using a microwave, rotate or stir the food at least once during the reheat step, as microwaves heat unevenly. As well, the food must be heated to at least 165°F and then stand covered for two minutes after reheating before adding to the hot hold unit. The snapping and crackling sounds coming from food being reheated in a microwave do not mean the food is hot.

5. Improper hot holding

Hot hold units are meant to keep hot foods at 140°F or hotter. At or above this temperature, pathogens will not grow.

6. Contaminated raw food or ingredient

We know that many raw foods often contain pathogens, yet certain foods are often served raw.

- Raw oysters served in the shell
- Raw eggs in certain recipes (e.g., Caesar salad, eggnog made from raw eggs)
- Rare hamburger
- Sushi/sashimi
- Steak tartare

These foods have caused many food-poisoning outbreaks. Always remember: you cannot tell if a food contains pathogens just by look, taste, or smell.

To prevent problems:

- Buy all your foods or ingredients from approved suppliers.
- If available, buy foods or ingredients from suppliers who also have food safety plans for their operations.
- Where possible, use processed or pasteurized alternatives (e.g., pasteurized liquid eggs).
- Never serve these types of foods to high-risk customers (e.g., seniors, young children, people in poor health, people in hospitals or nursing homes).

7. Unsafe source

Foods from approved sources are less likely to contain high levels of pathogens or other forms of contamination. Approved sources are those suppliers that are inspected for cleanliness and safety by a government food inspector. Foods supplied from unreliable or disreputable sources, while being cheaper, may contain high levels of pathogens that can cause many food-poisoning outbreaks.

Fly-by-night suppliers (trunk sales) often do not care if the product is safe to sell to you, but approved suppliers do! As well, many fly-by-night suppliers have obtained their product illegally (e.g., closed shellfish fisheries, rustled cattle, poached game and fish) and often do not have the equipment to properly process, handle, store, and transport the food safely.

Of particular concern is seafood from unapproved sources. Seafood, especially shellfish, from unapproved sources can be heavily contaminated with pathogens or poisons if they have been harvested from closed areas.

8. Use of leftovers

Using leftovers has been the cause of many outbreaks of food poisoning because of improper cooling and reheating (of “hot” leftovers). Leftovers that are intended to be served hot pass through the danger zone twice (during the initial cooling of the hot food and when reheating). Those leftovers intended to be served without reheating, or as an ingredient in other foods (e.g., sandwich filler), go through the danger zone during cooling and then, when being prepared and portioned, often stay in the danger zone for another long period. The time in the danger zone adds up unless the food is quickly cooled and then quickly reheated (if being served hot), or kept cold until serving (if not being served hot).

Contamination can also occur with leftover foods when they are stored in the cooler. Improperly stored leftovers can accidentally be contaminated by raw foods (e.g., blood dripping from a higher shelf).

To prevent problems:

- Reheat leftovers only once. Throw out any leftovers that have already been reheated once.
- Do not mix leftover foods with fresh foods.
- Be sure to follow the proper cooling and reheating procedures when handling leftovers. These are critical control points.
- Cool leftovers in uncovered containers separate from any raw foods. After they are cooled, cover them tightly.

9. Cross-contamination

You can expect certain foods to contain pathogens, especially raw meat, raw poultry, and raw seafood. Use extreme caution when you bring these foods into your kitchen. Cross-contamination happens when something that can cause illness (pathogens or chemicals) is accidentally put into a food where not previously found. This can include, for example, pathogens from raw meats getting into ready-to-eat foods like deli meats.

A term used to describe when this occurs with an allergen, such as nuts or dairy, is **cross contact**. Cross contact can be avoided using the same prevention steps as cross contamination..

To prevent problems:

- Use separate cutting boards, separate cleaning cloths, knives/utensils, sinks, preparation areas, etc., for raw and for ready-to-eat foods. Otherwise, wash all of these items with detergent and **sanitize** them with bleach between use.
- Use separate storage areas for raw and ready-to-eat foods. Always store ready-to-eat foods on separate shelves and above raw foods. Store dry foods above wet foods.
- After handling raw foods, always wash your hands properly before doing anything else.
- Use clean utensils, not your hands, to handle cooked or ready-to-eat foods.
- If a customer indicates a food allergy, follow all the same steps to avoid cross contact and use separate or freshly sanitized tools and utensils to prepare food for the individual with the allergy.

10. Inadequate cooking

Proper cooking is one of the best means of making sure your operation does not cause a food-poisoning outbreak. Proper cooking kills all pathogens (except spores) or at least reduces their numbers to a point where they cannot make people sick. Inadequate cooking is often done by accident: for example, cooking a hamburger until the meat is no longer pink instead of checking the internal temperature to ensure it has reached the proper endpoint cooking temperature.

To prevent problems:

- Don’t rely on cooking times alone. Check the **internal temperature** of the food being cooked.
- For large cuts of meat or large batches of food, check the temperature in several spots.
- Be extra careful when cooking partially frozen foods. There can be cold spots in the food that are not properly cooked. The normal cooking time will have to be increased.
- When grilling or frying meat, cook until the juices run clear. Cooked fish until it flakes easily. Make thin, not thick, hamburgers.

Figure 2 image description:

1. Improper cooling, 30%.
2. Advance preparation, 15%.
3. Infected person, 12%.
4. Inadequate reheating, 10%.

5. Improper hot holding, 8%.
6. Contaminated raw food, 4%.
7. Unsafe source, 3%.
8. Use of leftovers, 2%.
9. Cross-contamination, 2%.
10. Inadequate cooking, 1%.
11. All other causes, 3%.

[Return to Figure 2]

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8.4: Storage Temperatures and Procedures

A food service operation needs to have clearly defined storage areas and procedures for several reasons. First, by providing storage facilities it is possible to purchase supplies in quantities large enough quantities to get price breaks. Second, the ability to store supplies on the premises reduces the cost and time needed to order supplies and handle them upon delivery. Third, menu planning is easier when you are aware of the quality, quantity, and types of supplies that are on hand. If there is a run on a particular menu item, it is nice to know there are enough materials on hand to ensure that everyone who orders the item can be served.

In today's market, many food service operations are reducing the amount of stock they keep on hand because storage is expensive. Not only does space need to be found but security needs to be tight. Many operators are willing to pay a bit extra to suppliers in order to avoid the headaches of keeping track of expensive items such as large quantities of high-quality meat, wines, and spirits.

Regardless, there still is a need for storing many types of supplies including dry foods, dairy products, frozen foods, produce, and fresh meats. Storage areas for such items often have design requirements that must be built into the space in order to efficiently handle the specific types of supplies.

Dry Foods

The storeroom for dry foods should be located near the receiving area and close to the main kitchen. Unfortunately, the storeroom for dry foods is often an afterthought in food service facility designs, and the area designated for storage is sometimes in an inconvenient location.

No matter where the location, there are several essential points to be observed in the care and control of the dry storeroom.

- The area should be dry and cool to prevent spoilage and the swelling of canned goods. The ideal temperature range is 50°F to 59°F (10°C to 15°C).
- The storeroom should be easy to keep clean and free from rodents and vermin. This means all wall, ceiling, and floor openings should be sealed and protected to prevent access.
- It should be designed so it is easy to arrange and rearrange supplies to facilitate stock rotation. The best arrangement is to have shelves situated in the middle of the room so they can be stocked from both sides. This allows you to rotate stock by simply pushing out old stock by sliding new stock in from the other side of the shelf. This guarantees that first items received will be the first items used, or the "first in, first out" (**FIFO**) concept in stock rotation.
- The area should be well lit.
- Shelving must be at least 15 cm (6 in.) above the floor. Do not store items right on the floor.
- Aisles should be wide enough to allow room for carts or dollies, which should be used to prevent possible injuries from lifting.
- Food and supply storage areas should be kept under lock and key to prevent pilferage. Food storage control is an important step in the overall control of food costs. All storerooms should be considered to be like bank safes where the assets of the operation are being stored. This may mean that more valuable commodities such as liquor and wine should be stored and locked inside a larger storage area, such as the dry food storage area.

Refrigerated Products

The refrigerator, whether a walk-in or a standard upright, is an important component in planning the storage of food items. Most fresh foods must be stored in the refrigerator to delay their deterioration and decomposition. The most basic rule must be always followed: store raw products below, *never* above, your cooked or ready-to-eat products.

Critical Control Point

Keep foods 39°F (4°C) or colder, the safe temperature for refrigerated storage.

Here are some considerations to ensure that the refrigerator does not break down and risk spoiling food:

- Monitor the temperature of the refrigerator daily. All refrigerators should be provided with a thermometer so that daily readings can be taken.
- Keep refrigerators in good working order. Maintain a regular servicing contract with a local refrigerator repair company.
- Most breakdowns are beyond the ability of kitchen staff to repair, but if the refrigerator does stop running, first check that the power supply cord hasn't simply been pulled out or the breaker has flipped off.

- Clean refrigerators regularly. Shelves should be shallow and well vented to make such cleaning quick and easy. Develop and follow a schedule to ensure that refrigerators are cleaned on a consistent basis.

There are also several general rules that all personnel using the refrigerator should follow:

- Store raw products below cooked or ready-to-eat products.
- Develop and follow a FIFO system for refrigerated food.
- Designate areas in the refrigerator for certain items, and keep only those items in their designated place.
- Never put hot foods in the refrigerator unless absolutely necessary. (Unfortunately, one person's understanding of "necessary" may not be the same as another person's, so consider developing guidelines.)
- Never leave the refrigerator door open longer than needed.

Although lack of time and personnel shortages often make it difficult to observe these rules, it is imperative that they be followed.

Dairy Products

Dairy products must be stored in the refrigerator at temperatures of 36° to 39°F (2°C to 4°C). Follow these guidelines:

- The fat in dairy products has a tendency to absorb strong odors from the storage surroundings. To reduce the likelihood of this happening, store dairy products in their own area in protective coverings.
- Do not store dairy products in a vegetable cooler; a separate refrigerator is much more acceptable.
- Keep the refrigerator clean at all times.
- Rotate dairy products when fresh product arrives. Dairy products should not be ordered too far in advance of when they will be used. Ideally, such products should be delivered on a daily basis.

Produce

Most produce is stored in the refrigerator at 36° to 39°F (2° to 4°C) to ensure freshness and to prevent rapid deterioration. There are, however, a number of exceptions, including potatoes and bananas, which should be stored at higher temperatures.

Keep these factors in mind when storing produce:

- Soft fruits should not be stored too long. It is often best to buy soft fruit as you need it, keeping very little on hand.
- Unripe fruit can be ripened at storeroom temperatures of 50°F to 59°F (10°C to 15°C). It will ripen much more slowly under refrigerator conditions.
- Before storing and when rotating stock, it is important to remove rotting fruit from cases as one piece can affect others. The chain reaction can quickly destroy the quality of a whole case of fruit.
- Be aware of special storage problems. For example, bananas stored in the refrigerator turn black quickly. Bananas should be stored under conditions where the temperature range is 50°F to 59°F (10°C to 15°C).
- The length of time produce can be stored varies widely. For example, hardy vegetables such as carrots and cabbage will last for weeks, while delicate vegetables such as lettuce should be bought as fresh as possible as they do not keep for long.
- Moisture on vegetables tends to soften them, causing rot. Even though in the early stages of rot there is nothing basically wrong with such vegetables, they can be unattractive to the eye.

Fresh Meats, Poultry, and Seafood

These items are the most difficult to store and the most expensive food items sold by the restaurant. When storing meats, poultry, and seafood items, remember the critical control point.

Critical Control Point

Keep foods 39°F (4°C) or colder, the safe temperature for refrigerated storage.

Keep these factors in mind when storing fresh meats, poultry, and produce:

- All carcass meats should be unwrapped and hung so that air can circulate around them. They should be stored at 34°F to 37°F (1°C to 3°C) in a walk-in refrigerator. Place absorbent paper under the meats for quick cleanup of any unwanted drips.
- Fresh meat must not be kept too long. Boned meat should be kept no longer than three days. Individual cuts should be used within two days, preferably on the day they are cut.

- Individual meat cuts such as steaks, chops, stewing meat, and ground meat should be kept covered on plastic or stainless steel trays at 36°F to 39°F (2°C to 4°C).
- Fresh poultry should be packed in ice and stored in the refrigerator.
- Fresh seafood should be packed in ice, stored at 30°C to 34°F (−1°C to 2°C) and used as soon as possible.
- Store raw products on the lower shelves of the refrigerator, below cooked products.

Frozen Foods

Frozen foods should be stored at 0°F (–18°C) or lower. If the temperature rises above 0°F, food can become discolored and lose vitamin content. Lowering the temperature after it has risen does not correct the damage.

Critical Control Point

Frozen food must be kept at 0°F or lower to maintain its quality.

Keep these factors in mind when storing frozen foods:

- Fruit and vegetables that are received frozen will keep for months if they are properly wrapped. Fish and meat properly wrapped also have a relatively long freezer shelf life.
- Freezing fresh fruits and vegetables on the premises is time consuming and may be too expensive to consider. Fresh fruit must be properly prepared for freezing or it will not store well.
- All freezer products not properly wrapped will develop freezer burn, which is a loss of moisture that affects both the texture and the flavor of the food. A common sign of freezer burn is a white or grey dry spot developing on the surface of the frozen product. Meat is particularly susceptible to freezer burn.
- Rotating stock is extremely important with frozen foods. Such rotation is difficult in standard chest freezers as it often means that old stock must be removed before new stock is added. The temptation with frozen foods is to develop the unacceptable habit of using the last item bought first, instead of FIFO (first in, first out).

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8.5: Sanitation and Personal Hygiene

Maintaining a clean work environment is critical in preventing foodborne illness. Bacteria can grow on unsanitary surfaces and then contaminate food. Just because a work surface looks clean does not mean that it is sanitary. Always ensure that you clean and sanitize a work area before starting to prepare food.

Cleaning Procedures and Schedules

Cleaning with soap and other detergents is just one step of the cleaning procedure. It is also necessary to sanitize. Cleaning will remove any dirt or grease, but will not necessarily kill any bacteria or other pathogens. Only a sanitizer will kill bacteria and ensure the area is safe for food preparation.

Developing a cleaning plan can help prevent the spread of foodborne pathogens and prevent an outbeak. Cleaning surfaces regulary will ensure a safe cooking environment. It is important to remember that just because it looks clean does not mean that it is free of harmful bacteria that could cause illness. Sanitizing of counter tops and cooking utensils is an important step in the cleaning process.

Routine Equipment Maintenance

All equipment must be routinely cleaned and inspected. Older equipment may have nooks and crannies where dirt and bacteria can hide, which can be difficult to clean effectively. Proper cleaning procedures must be established and followed at all times with regular review to ensure that procedures are working. If equipment is replaced or cleaning materials change, the process may have to be adjusted. Regular cleaning of equipment is also a good time to assess the equipment for any damage or wear and tear such as frayed cords, missing pieces, or broken parts. Keeping equipment clean and safe to use will prevent both illness and injury.

Importance of Personal Hygiene

It is imperative for safe food-handling outcomes for all workers to be familiar with standard sanitation and hygiene practices. Figure 6 shows the cycles of transmission of micro-organisms. One of the basic principles is to break the cycle by avoiding cross-contamination, which can be achieved by ensuring personal hygiene practices are followed.

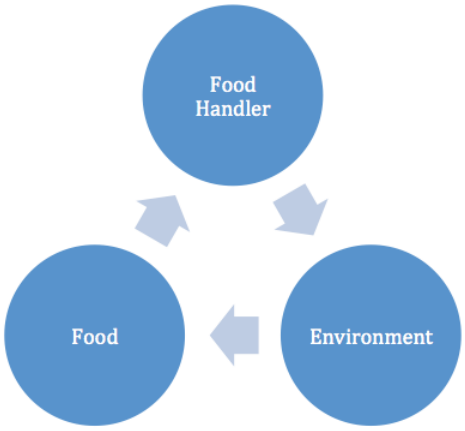


Figure 6. The cycle of bacterial transmission. Image created by go2hr and used under a CC BY 4.0 Licence.

Proper personal hygiene is critical in any food service premise. Personal hygiene includes:

- Showering and bathing regularly
- Keeping hair clean and covered or tied back
- Keeping clean clothing and footwear that is used only at work
- Handwashing regularly
- Using clean utensils for tasting food
- Using separate cloths for cleaning and wiping plates

Handwashing

Proper and regular handwashing is a critical part of any food safety system. You must always wash your hands after:

- Sneezing, coughing, or touching your mouth or nose
- Using the bathroom
- Smoking or using toothpicks
- Handling raw foods
- Cleaning and wiping tables, food preparation surfaces, or equipment
- Handling soiled objects, garbage, or money

The steps for proper handwashing are as follows:

1. **Wet** hands with clean, running water and apply soap.
2. **Lather** your hands by rubbing them together with soap.
3. **Scrub** your hands for at least 20 seconds.
4. **Rinse** hands under running water.
5. **Dry** hands using clean towel or air drying them.



Use of Hand Sanitizers

Alcohol based hand sanitizers may be used in certain circumstances and can play a role in proper hand hygiene and reduce the spread of disease. Please view the following CDC link for more information:

https://www.cdc.gov/clean-hands/about/hand-sanitizer.html

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CHAPTER OVERVIEW

Chapter 9: Review of Chapter 6-8

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CHAPTER OVERVIEW

Chapter 10: Food Processing

10.1: Food Processing
10.2: Evolution of Food Processing

Thumbnail: Ordinary sausage making in Hungary. (Public Domain; László Szalai via Wikipedia)

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10.1: Food Processing

Learning Objectives

- Learn about the pros and cons of food processing

Food processing includes the methods and techniques used to transform raw ingredients into packaged food. Workers in this industry use harvested crops or slaughtered and butchered livestock to create products that are marketed to the public. There are different ways in which food can be processed, from a one-off product, such as a wedding cake, to a mass-produced product, such as a line of cupcakes packaged and sold in stores.

The Pros and Cons of Food Processing

Food processing has a number of important benefits, such as creating products that have a much longer shelf life than raw foods. Also, food processing protects the health of the consumer and allows for easier shipment and the marketing of foods by corporations. However, there are certain drawbacks. Food processing can reduce the nutritional content of raw ingredients. For example, canning involves the use of heat, which destroys the vitamin C in canned fruit. Also, certain food additives that are included during processing, such as high fructose corn syrup, can affect the health of a consumer. However, the level of added sugar can make a major difference. Small amounts of added sugar and other sweeteners, about 6 to 9 teaspoons a day or less, are not considered harmful.[1]



Figure **10.1.1**: Processed food. Image by Dean Hochman / CC BY 2.0.

Food Additives

If you examine the label for a processed food product, it is not unusual to see a long list of added materials. These natural or synthetic substances are food additives and there are more than three hundred used during food processing today. The most popular additives are benzoates, nitrites, sulfites, and sorbates, which prevent molds and yeast from growing on food.[2] Food additives are introduced in the processing stage for a variety of reasons. Some control acidity and alkalinity, while others enhance the color or flavor of food. Some additives stabilize food and keep it from breaking down, while others add body or texture. Table **10.1.1** lists some common food additives and their uses:

Table **10.1.1**: Food Additives.

Additive	Reason for Adding
Beta-carotene	Adds artificial coloring to food
Caffeine	Acts as a stimulant
Citric acid	Increases tartness to prevent food from becoming rancid
Dextrin	Thickens gravies, sauces, and baking mixes
Gelatin	Stabilizes, thickens, or texturizes food
Modified food starch	Keeps ingredients from separating and prevents lumps
MSG	Enhances flavor in a variety of foods
Pectin	Gives candies and jams a gel-like texture
Polysorbates	Blends oil and water and keep them from separating
Soy lecithin	Emulsifies and stabilizes chocolate, margarine, and other items
Sulfites	Prevent discoloration in dried fruits
Xanthan gum	Thickens, emulsifies, and stabilizes dairy products and dressings

Source: Chemical Cuisine: Learn about Food Additives. Center for Science in the Public Interest.http://www.cspinet.org/reports/chemcuisine.htm. Published 2012. Accessed January 20, 2018.

The Pros and Cons of Food Additives

The FDA works to protect the public from potentially dangerous additives. Passed in 1958, the Food Additives Amendment states that a manufacturer is responsible for demonstrating the safety of an additive before it can be approved. The Delaney Clause that was added to this legislation prohibits the approval of any additive found to cause cancer in animals or humans. However, most additives are considered to be “generally recognized as safe,” a status that is determined by the FDA and referred to as GRAS.

Food additives are typically included in the processing stage to improve the quality and consistency of a product. Many additives also make items more “shelf stable,” meaning they will last a lot longer on store shelves and can generate more profit for store owners. Additives can also help to prevent spoilage that results from changes in temperature, damage during distribution, and other adverse conditions. In addition, food additives can protect consumers from exposure to rancid products and foodborne illnesses.

Food additives aren’t always beneficial, however. Some substances have been associated with certain diseases if consumed in large amounts. For example, the FDA estimates that sulfites can cause allergic reactions in 1 percent of the general population and in 5 percent of asthmatics. Similarly, the additive monosodium glutamate, which is commonly known as MSG, may cause headaches, nausea, weakness, difficulty breathing, rapid heartbeat, and chest pain in some individuals.[3]

Footnotes

1. Sugar and Carbohydrates. American Heart Association. www.heart.org/HEARTORG/Gettin...6_Article.jsp#. Updated April 20, 2017. Accessed January 4, 2018.
2. The Dangers of Food Additives. How Stuff Works. health.howstuffworks.com/well...angers-of-food -additives.htm. Accessed October 5, 2011.
3. The Issues: Additives. Sustainable Table. www.sustainabletable.org/issu...dditives/#fn14. Accessed October 10, 2011.

Contributors and Attributions

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10.2: Evolution of Food Processing

Imagine what eating must have been like in the days of the caveman. You would feast on meat when an animal hunt was successful. Between times, you'd eat what edible plants could be found. Worrying about your next meal was a constant thing. Too often, it was a cycle of feast and famine. What, you might ask, could you do to save some of the feast to avoid the famine?

We might imagine that the first food preservation discoveries were accidental. Perhaps a scrap of meat or a piece of fruit, leftover from the feasting, may have been overlooked. You find it days later, on a boulder in the sun, all dried out. Hungry, you tear off a piece with your teeth, and find it quite edible. Ways to preserve food were among our first discoveries.

The Egyptians of the First Dynasty, about 3000 B.C., not only knew much about drying and salting and cooking, but had learned to preserve milk by making cheese. By 2000 B.C. they were baking bread and brewing beer. In the ancient world, alcoholic beverages were as important for food preservation as for revelry. (But keep in mind that beer then was a thick, nutritious brew.) And indeed almost every primitive culture seems to have developed a preservative use for fermentation.

Whole grains of salt were known as "corn" in England, and were used make "corned beef."

The relatively recent American pioneers extended this use for fermentation. In Kentucky and thereabouts, the land along the Ohio River was fine for growing corn. But it grew more than they could use. How could they utilize the leftover corn so it could be transported to a buyer elsewhere? The answer was to make it into corn whisky, which was shipped on rafts down the Ohio and Mississippi Rivers to New Orleans, and thence around the world. Kentucky still produces fine bourbon.

Warfare and empire-building have been important factors in the evolution of food preservation and processing—creating the need to supply armies on the march. Modern food preserving is often said to have begun with Napoleon's forays. In 1810, the French brewer, Nicholas Appert, was awarded a grand prize for developing canning. He had sealed food in jars and then heated them in boiling water, a process which was believed to work because the food was shut away from air. It wasn't until later that science understood that the process actually worked because the heat destroyed microbes present in the food, and the sealing prevented new infections.

During World War II, demand went beyond merely edible food for the troops, to nutritionally adequate food—an impetus for the first set of Recommended Dietary Allowances (RDAs). Then, military demand went beyond nutritionally adequate food, to pleasurable food. In the 1991 Gulf War, the U.S. troops were even provided with chocolate bars specially made for desert eating.

Food processing as we know it today, goes far beyond mere preservation. We have a vast array of such things as *convenience foods* (e.g., frozen dinners), *health foods* (e.g., bran-fortified breakfast cereals), and *fabricated foods* (e.g., meatless "hamburger meat" made from soybeans).

Perhaps the ultimate in fabricated food is the diet soft drink. This drink raises the ultimate question asked of some processed foods: Is it *really* food? After all, any nutrient in a diet soft drink is unintentional. We might say that food processing has also given us "fun foods," foods eaten mainly to please our senses.

So we ask a lot of food processing, and sometimes the result is nutrition confusion.

Industry's Desire to Please

Much of our nutrition confusion is blamed on the food industry. The food industry is in many ways a passive force—amoral but not really immoral—trying simply to turn out a decent product and make a profit. Basically, industry responds to what we think our needs are. It's very expensive to try and create public demands. It's much cheaper simply to find out what people want to buy and give it to them.

For example, the broad food-industry use of added vitamin C is a recognition of the public's distorted idea of the need for this vitamin. *Tang* (an orange-flavored sugar mixture) is touted as having "twice as much vitamin C as orange juice." It does so because the public believes that vitamin C is badly needed, and the more the better.

Meanwhile, the Florida citrus industry markets its oranges as having "natural vitamin C from the Florida sunshine tree." It does this because so many people mistakenly believe that there is a health difference between "natural" and synthetic vitamin C. Both are identical molecules.

Taking this consumer confusion a bit further, Sunkist sells tablets of synthetic vitamin C in a colorful bottle adorned with juicy oranges and emblazoned with *Sunkist Vitamin C*. The implication, of course, is that this synthetic vitamin C is more "natural"—and thus more healthful and desirable—than other synthetic C tablets on the vitamin shelf.

While these sales efforts may be somewhat misleading, they are realistic to the extent that they give the public what the public thinks it needs. The industrial reality is that, while production methods are controlled by technologists of great sophistication, the businesses are guided by marketers. Their training is in the economics of producing and selling. Their information about nutrition may be minimal. Their primary interest lies in what will sell, and this is determined by what the public wants. Their foremost research effort is to determine public wishes and to meet them.

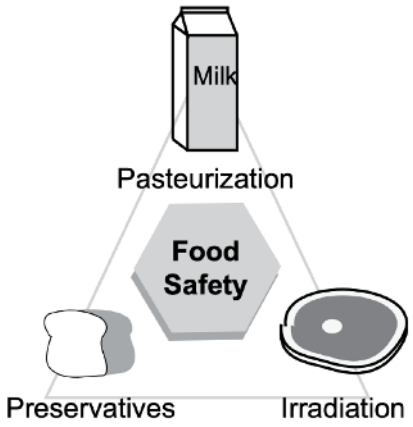


Figure 21-1: Methods of preparing food for safe consumption.

The industry's marketing people often know even less about nutrition. Their aim is to express as dramatically as possible the idea that the product furnishes what the buyer thinks is important. Essentially their sales message is that "What you want is what we have to sell."

To see how ironically this system works, look down the aisle of breakfast cereals. Most of the "natural" cereals are made by the same companies that sell the regular ones with the usual additives. One part of the company heralds its "natural" cereals by implying that additives and such are unhealthful, and "natural" products are superior. Another part of the same company spends millions to sell us its other cereals with the added colors, vitamins, preservatives, flavors, etc.

In an individual, such behavior might be described as "schizophrenic." In food companies, it's simply a matter of *market identification* and *market penetration*—in two markets.

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CHAPTER OVERVIEW

Chapter 11: Food Additives

11.1: Food Additives (FDA)

11.2: Food Additives

11.3: Generally Recognized As Safe Additives

Thumbnail: Food coloring in a glass of water. (Unsplash License; Luke Schobert via Unsplash)

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11.1: Food Additives (FDA)

https://www.fda.gov/food/food-ingred...ives-petitions

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11.2: Food Additives

Food additives are substances added to food to preserve flavor or enhance its taste and/or appearance. Some additives have been used for centuries; for example, preserving food by pickling (with vinegar), salting, as with bacon, preserving sweets or using sulfur dioxide as with wines. With the advent of processed foods in the second half of the twentieth century, many more additives have been introduced, of both natural and artificial origin. Please take a look at two of the most common additives, coloring agents and preservatives using the Wikipedia links below. When you see these items listed in the "ingredients" section of a food label, will you be able to recognize them? What are they made from? Are they safe to eat in small amounts? Are they safe to eat in large amounts?

Food Colorings

Food coloring, or color additive, is any dye, pigment or substance that imparts color when it is added to food or drink. They come in many forms consisting of liquids, powders, gels, and pastes. Food coloring is used both in commercial food production and in domestic cooking. Food colorants are also used in a variety of non-food applications including cosmetics, pharmaceuticals, home craft projects, and medical devices. Color additives are used in foods for many reasons including:

- To make food more attractive, appealing, appetizing, and informative
- Offset color loss due to exposure to light, air, temperature extremes, moisture and storage conditions
- Correct natural variations in color
- Enhance colors that occur naturally
- Provide color to colorless and "fun" foods
- Allow consumers to identify products on sight, like candy flavors or medicine dosages

In the 20th century, the improvement of chemical analysis and the development of trials to identify the toxic features of substances added to foods led to the replacement of the negative lists by lists of substances allowed to be used for the production and the improvement of foods. This principle is called a positive listing, and almost all recent legislations are based on it. Positive listing implies that substances meant for human consumption have been tested for their safety, and that they have to meet specified purity criteria prior to their approval by the corresponding authorities.

Food Preservatives

A preservative is a substance or a chemical that is added to products such as food, beverages, pharmaceutical drugs, paints, biological samples, cosmetics, wood, and many other products to prevent decomposition by microbial growth or by undesirable chemical changes. In general, preservation is implemented in two modes, chemical and physical. Chemical preservation entails adding chemical compounds to the product. Physical preservation entails processes such as refrigeration or drying. Preservative food additives reduce the risk of foodborne infections, decrease microbial spoilage, and preserve fresh attributes and nutritional quality. Some physical techniques for food preservation include dehydration, UV-C radiation, freeze-drying, and refrigeration. Chemical preservation and physical preservation techniques are sometimes combined.

Antimicrobial preservatives prevent degradation by bacteria. This method is the most traditional and ancient type of preserving—ancient methods such as pickling and adding honey prevent microorganism growth by modifying the pH level. The most commonly used antimicrobial preservative is lactic acid. Common antimicrobial preservatives are presented in the table. Nitrates and nitrites are also antimicrobial. The detailed mechanism of these chemical compounds range from inhibiting growth of the bacteria to the inhibition of specific enzymes.

11.2.1: Antimicrobial Preservatives

Compound	Comment
sorbic acid, sodium sorbate and sorbates	common for cheese, wine, baked goods
benzoic acid, sodium benzoate and benzoates	used in acidic foods such as jams, salad dressing, juices, pickles, carbonated drinks, soy sauce
hydroxybenzoate and derivatives	stable at a broad pH range
sulfur dioxide and sulfites	common for fruits
nitrite	used in meats to prevent botulism toxin
nitrate	used in meats
lactic acid	-
propionic acid and sodium propionate	baked goods

The oxidation process spoils most food, especially those with a high fat content. Fats quickly turn rancid when exposed to oxygen. Antioxidants prevent or inhibit the oxidation process. The most common antioxidant additives are ascorbic acid (vitamin C) and ascorbates. Thus, antioxidants are commonly added to oils, cheese, and chips. Other antioxidants include the phenol derivatives. These agents suppress the formation of hydroperoxides. Other preservatives include ethanol and methylchloroisothiazolinone.

11.2.2: Antioxidant Preservatives

Compound	Comment
ascorbic acid, sodium ascorbate	cheese, chips
butylated hydroxytoluene, butylated hydroxyanisole	also used in food packaging
gallic acid and sodium gallate	oxygen scavenger
sulfur dioxide and sulfites	beverages, wine
tocopherols	vitamin E activity

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11.3: Generally Recognized As Safe Additives

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CHAPTER OVERVIEW

Chapter 12: Fruit and Vegetables

12.1: Agriculture—Realities of Leaf and Soil

12.1.1: Agriculture—Realities of Leaf and Soil

12.1.2: The Nutrition of Plants

12.1.3: The Farm in Our Food

12.1.4: Biotechnology in Agriculture

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12.4: Fruits and Vegetables for the Marketplace

12.4.1: Selecting, Purchasing, Storing and Preparing Fruits

12.4.2: Vegetable Nutrition, Storage and Preparation

Thumbnail: Fruits and Vegetables in a market. (Unsplash License; Thomas Le via Unsplash)

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SECTION OVERVIEW

12.1: Agriculture—Realities of Leaf and Soil

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12.1.2: The Nutrition of Plants

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12.1.8: Guest Lecturer

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12.1.1: Agriculture—Realities of Leaf and Soil

The interrelationship of plants and animals (including humans) is fascinating. We often take for granted that plants are just "there," not only filling the yard, shading neighborhood streets, and peeking through cracks in the sidewalk, but providing us with fruit, vegetables, and grain. When we take a closer look, however, we find there's an awesome continuous flow of essential chemical elements between plant and animal worlds, and words like "worldwide ecology" take on a new meaning.

With an increasing respect for our dependence on plant life, it's natural to feel added concern, particularly as science provides us with more and more ways of utilizing biotechnology. There's a perception that we've become too eager to mess with things better left alone in their "natural" state—that economic gain drives the machine in ways that can be shortsighted and ultimately harmful. Thus the understandable attraction of movements supporting "natural" and "organic" methods.

Like so many areas of public concern and advocacy, the facts behind the issues are often poorly understood. A thorough understanding will not of course guarantee universal agreement, but arguments tend to become more specific and logical. Science and technology can be viewed as useful tools for the betterment of our health and environment.

As consumers have become more interested in nutrition, they have also become more suspicious of the quality of the food supply. They are encouraged in their fears by charges that our crops are grown on depleted soil, making them nutritionally inferior, and that we are being poisoned by pesticides and food additives.

Is our food supply adequate and safe? This is a concern of such importance that government agencies such as the U.S. Dept. of Agriculture (USDA), the Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA) devote considerable amounts of time and money to do the best they can to see that our food supply is, in fact, adequate and safe.

But what our government agencies see as the biggest concerns are quite different from the perceptions of the general public. The public perception is that farm pesticides and food additives top the list of food hazards. In contrast, these experts put these concerns at the bottom, with disease-causing microbes at the top, and environmental contaminants and naturally-occurring food toxins in between (see Fig. 20-1).

So let's examine the realities of our food supply—from farm to table—starting with a look at some agricultural concerns: basic plant nutrition; uses of fertilizer, pesticides, and biotechnology; natural toxins in food; and how agriculture today relates to world food production and world health.

The next chapter examines various aspects of food processing, in particular those substances that intentionally or unintentionally get into our food as it is commercially processed, and further processed as we store and prepare the food. These substances include food additives and toxins produced by microorganisms.

The last chapter concerns food labeling, and what the label tells us of the food. We should read these labels in selecting our food. For all our concerns about food adequacy and safety, whether or not our food is healthful depends mostly on what—and how much—we choose to eat.

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12.1.2: The Nutrition of Plants

Much of what we've discussed of human nutrition may also be applied to the nutrient needs of plants. Like us, they are organized groups of cells. Like us, their cells must also be supplied with the raw materials of life, and the materials which they require are determined by the DNA in their cells. Their chemical makeup is, like ours, ordained by heredity.

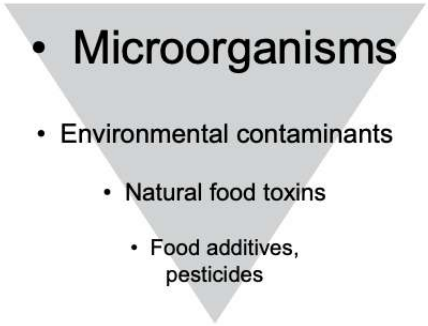


Figure 20-1: Microbes are our greatest food hazard.

If we think about it for a moment, we realize that the life chemistry of plants must be somewhat similar to our own. For we get our fuel (e.g., fat) and building blocks (e.g., amino acids) from plants, either by consuming them directly, or by eating animals which have fed on them.

Of course, there are also striking differences. One is that plants don't consume other life forms as we do to get their nutrients. Instead, they take in nutrients in very simple form, and use chlorophyll to trap solar energy. Another difference is that, unlike us, plants can't move around to seek food. So they depend on natural phenomena—or on us—to bring them food.

From the beginning of our dependence on agriculture, we've tended to provide plants with a kind of room service. This service was unnecessary when we simply gathered plants by foraging over the land, seeking out those which were edible. But once we began, some 9,000 years ago, growing plants in batches for a more dependable and convenient food source, "man-made" growing methods became essential to the survival of the crops and us.

At first glance, it may seem that there's a striking difference between the ways in which we and the plants take in food. But there's a basic similarity. Like us, the plants can absorb and take into their cells only the simpler structural units of their food.

Of course, our food first has to be processed through our digestive tract, so that our digestive enzymes can break it down into forms that we can absorb and use. But even here, there's some similarity. The roots of a plant may be seen as similar to our intestinal walls. If soil nutrients are in too complex forms, the enzymes of soil bacteria do the work of breaking them apart into forms that plants can absorb and use. This is what happens when we make compost. By mixing complex organic matter (gardening and food scraps, manure, etc.) into the soil, the bacteria work to "digest" it into plant food.

The Need for Nitrogen

What sort of nutrients must plants take in? Like us, plants mostly need carbon, hydrogen, oxygen, and nitrogen. Plant cells have no problem getting their carbon, hydrogen, and oxygen from water and the carbon dioxide in the air. But they must get their nitrogen from the soil. (We get ours from the protein we eat.)

The plant can't absorb protein or amino acids. It takes up its nitrogen in a simpler form from the soil, combined with oxygen as a nitrate (NO_3). In nature, the nitrogen comes mainly from the protein in decaying plant materials, such as leaves and stems. But it must wait for the soil bacteria to turn the plants' decaying proteins into nitrates, and for rainwater to carry these chemicals to its roots for absorption (see Fig. 20-2). Then, the plant uses the nitrates to make its own amino acids and proteins.

By trial and error, early farmers found that manure and decomposing life materials would keep soils fertile. These materials provide nitrogen. We learned that we must keep the soil supplied with nitrogen, or plants won't grow—without nitrogen they can't form the proteins for new cells. Once we understood this chemistry, we realized that simpler, more concentrated sources of nitrogen supplied these needs faster and more efficiently— resulting in a larger crop in a shorter time.

Our modern “chemical” fertilizers supply nitrates rapidly in a simple, immediately usable (inorganic) form. “Organic” farming, with its compost piles of decaying manure and plants, doesn’t directly supply the nitrate. Its nitrogen is tied up in elaborate carbon-skeleton (organic) molecules. The ironic reality of organic farming is that plants can’t use nitrogen in organic form.

Industrial production of fertilizer from nitrogen gas uses a lot of energy, whether for the strong electrical currents passed through contained air, or the compression of nitrogen, hydrogen, and oxygen gases at extremely high temperatures. Energy sources for this process (and required technology) are out of reach for many developing countries.

Plants can’t use nitrogen in gaseous form either. Ironically, three-fourths of the air we breathe is the nitrogen that both we and plants need so urgently. But in this gaseous state (N_2), it’s a chemical loner, reluctant to join with any other element and so is useless to us or plants.

But nitrogen gas can be made (“fixed”) into usable form (ammonia, NH_3) by nitrogen-fixing bacteria, which invade the roots of legumes (e.g., soybeans, peas), and provide them with nitrogen usable to make protein. (Recall that legumes are rich plant sources of protein.) The conversion of nitrogen gas to ammonia requires a lot of energy (ATP), made by photosynthesis in the legumes. About one-fifth of the ATP made by photosynthesis in the pea plant, for example, is used by the nitrogen-fixing bacteria residing in its roots.

Legumes and the nitrogen-fixing bacteria have a symbiotic relationship: The bacteria provide the legumes with usable nitrogen; the legumes provide the bacteria with the ATP energy to do so.

How did nitrogen get into the soil in usable form before life began on earth? Scientists believe that continual lightning storms struck through the primeval atmosphere. These storms are thought to have supplied the energy for the nitrogen gas to combine with hydrogen gas (forming ammonia, NH_3) and with oxygen gas (forming nitrates, NO_3).

Today, this is the process used by industry to make our fertilizers. In one method, electrical charges are passed through air in closed containers, trapping the nitrogen gas as ammonia and/or nitrates. These ultimately are added to the soil, often in water, just as primeval rains washed nitrogen compounds out of the atmosphere and into the earth’s crust.

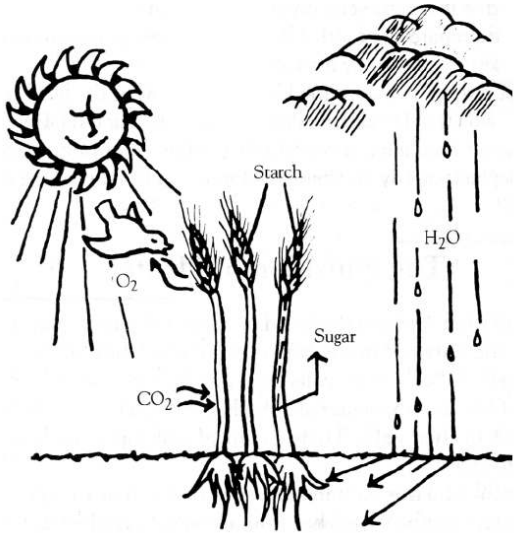


Figure 20-2: Nutritional Sustenance of Plants Plants take in water and carbon dioxide and, using solar energy, combine the two chemicals into sugar and starch, releasing oxygen. Birds use the sugar and starch for energy by using oxygen to oxidize them. The birds’ waste products in this reaction are carbon dioxide and water, which plants use to make sugar and starch, continuing the cycle.

The Need for Minerals

Of course, plants need more than nitrogen to grow. They need minerals. These needs are also somewhat parallel to those of humans. The minerals come from the rock and soil of the earth. The plants need as wide a variety as we do—where else would we get ours? Dominant among their needs are phosphorus, potassium, sulfur, and calcium.

Phosphorus is usually incorporated in ammonium phosphates (ammonium, phosphorus, oxygen) or calcium phosphates. Potassium is acquired almost entirely from mined potassium chloride ores. During the last century we began to seek out phosphorus and potassium deposits, grind and modify them into useful form, and return them to our fields to feed the crops.

Calcium sulfate (calcium, sulfur, oxygen) is another "chemical" fertilizer. And, of course, trace minerals such as iron, which we seek for our own nutrition, are part of the hereditary plant chemistry—how else could we depend on getting iron from eating beans and greens?

Does Agriculture Deplete Soil Minerals?

Certainly. That's why we use fertilizers to supply minerals as well as nitrogen. The plants, responding to their necessities, need minerals just as much as we do. These minerals are called for by the plant's metabolism. If the minerals are missing, the plants can't grow.

What if the minerals aren't entirely missing, but are merely in short supply? Then only as many plants as can be nourished by the available minerals will grow. Or, like undernourished humans, their growth and development will be stunted. As surely as human development is thwarted by inadequate nutrition, so is the development of plants. The farmer who exploits the soil learns the hard way from a crop with very poor yield.

Plants don't need an outside source of vitamins, as we do. Vitamins are used in their metabolism, much as they are used in ours, but plants make their own—and ours too. It's useless to feed plants vitamins.

So plants which exist at all must be complete. They must contain a full complement of substances called for in their genes. Otherwise, they wouldn't exist. All of the elements known to be essential in plant and human nutrition are easily identified in soils by modern analytic methods. Our soils and foods are regularly tested, for good reason.

For one, farmers have an acute economic interest in their soil. It's their most costly and basic asset. A flawed soil, untreated, will produce a poor crop or none at all. The fertilizers which the farmers add are expensive. They can't afford to guess—so they have their soil analyzed.

In addition, the soils are important economic assets to the society, especially in those states that produce most of our food. Governments of agricultural states such as California and Florida have a vested interest in keeping watch over their soils.

No evidence has come to light that our crops are grown on depleted soil, making them nutritionally inferior. Nor has there been any nutritive differences found between plants fertilized "organically" and plants fertilized "chemically."

Are There Unobservable Deficiencies?

A few trace minerals can be low. These are the elements which are essential for animal life, but have little use in plant chemistry. So the plant content of these elements varies, because they are taken up incidentally. These elements are only a few—chiefly iodine, selenium, cobalt, and zinc. Fluoride might be considered another. There are easy safeguards against shortages of iodine and fluoride—iodine through the iodizing of salt, and fluoride through fluoridation of water.

The human needs for some of these trace elements were identified largely through inadequacies in the diets of pasture-raised livestock, mainly sheep and cattle. Nutritionally, our main sources of these elements are animal foods. (Recall, for example, that cobalt is a critical constituent of vitamin B_{12}, a vitamin not found in plant foods. Since cobalt isn't needed by the plant, it's only there incidentally when it's in the soil.) Where these elements are lacking in the soil, the deficiency signs are apparent in the animals that graze off the land, and in general are easily supplemented, by adding them to the soil or to animal feed.

Note that the shortages of such trace minerals aren't due to farming practices, but to regional soil differences. Plants grown in certain areas will, for example, contain little iodine or selenium. If such plants are used for compost, they will obviously not supply any deficiencies of the soil in which they grew.

Many of the world's poor only have locally grown produce available. If their soil happens to be low in selenium, the crops grown in them—and the local animals and people who eat them exclusively—also will be low in selenium.

Note, also, that plants can incidentally take up undesirable elements as well. Plants grown in lead-contaminated soil, for example, can contain lead, a human toxin. Plants grown in soil contaminated by radioactive fallout (e.g., as from the Chernobyl nuclear accident) can contain radioactive iodine, which can damage the thyroid gland. (Iodine—radioactive or not—concentrates in this gland.) Plants can, in fact, be used in this way for environmental clean up, e.g., to remove toxic metals from polluted ground water.[1]

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12.1.3: The Farm in Our Food

One of the more unfortunate terms in the world of food regulation is filth. A sure way to arouse reader alarm is with the news that more filth has been found in a food than the law allows. Invariably, some readers write outraged letters questioning why "*filth*" should be allowed in our food at all.

Filth is really incidental matter which gets into food while it's being grown, harvested, transported, processed, or stored. It's inevitable that there will always be some in the food supply, and it isn't really as awful as it sounds. Consider "insect parts," one kind of filth. Generally these aren't large juicy bug bits, but more often microscopic fractions of tiny aphids, mites, or weevils, members of the insect world which tend to live in and around the soil and food.

Farms are often near woods and uncultivated lands, and city dwellers sometimes forget that there's an unpaved world of dirt and leaves, and that worms and beetles and bugs make their homes in the soils where our food grows. As neat and clean as farmers may be, some vestige of the country almost invariably remains with the food.

Pesticides—Competing for the Crop

Wherever there's a great deal of food, whether harvested or still growing, there is a tempting buffet for various creatures. Indeed, our unbalancing of nature—gathering food plants into concentrated growing grounds for convenience and economy—has led us to turn to pesticides (pest killers). We compete with fungi, insects, and such, for the crop. (To them, of course, we are the pests. But a big dose for them is a small dose for us.)

Pesticides are regulated by Federal law. A special Pesticides Amendment to the Food and Drug Act (passed in 1954) sets forth most of our current policies.

We know a lot about how to identify pesticides in our food, and a lot about how pesticides affect our bodies. So we're able to make some measurements and do a fair job of determining how much we're endangered by them. (Risk assessment will be discussed in the next chapter.)

Traces of pesticides do appear in our food, but it's not all from the hand of the farmer. Pesticides are used for many purposes, from mosquito abatement to highway weed control, from home gardening to forest conservation.

The Pesticides Amendment requires the Food and Drug Administration (FDA) to monitor pesticides in our food by sampling our market supplies. The criteria for judging safe levels of pesticides in food are determined by our own experts and by expert committees of the United Nations.

It isn't possible to prove a negative (i.e., that there's absolutely no danger), but neither government, nutrition science, nor medicine has seen significant evidence that pesticides in food are causing cancer, birth deformities, or genetic problems. Nor has there been any evidence of illness or death in North America from eating pesticide residues in food. (Accidental overdoses of pesticides inhaled or sprayed onto the skin of farm workers are another matter.)

Pesticides sometimes can lessen the natural toxins in food. Plants damaged by insects or fungi often make more toxins, e.g., mold damage to some kinds of celery can cause the celery to make 100-times more of a natural toxin—so much, that this "natural celery toxin" can be an occupational hazard for celery pickers and produce checkers.

According to the FDA, the scant amount of pesticide residues in our food supply is safe. In other words, the fear that we have been and are being poisoned by pesticides in our food isn't based on solid evidence. Moreover, no one at FDA has any intention of letting the fear become a reality. Improved controls and greater restrictions come into being with any threat, and scientists continue to look for alternatives to pesticides, and use them when practical.

One such alternative is using the pests' natural predators. But they can take a long time to arrive (just as it took three years for the seagulls to come to Utah to rescue the crops from the plague of locusts in the 1850s), so we usually have to help the situation along. We have, for example, collected parasitic wasps in Iran and brought them to California to successfully combat the olive scale (a pest of olives, plums, apricots, and many other plants) that was damaging many crops.[2]

Another alternative used extensively in the past and present is the use of crossbreeding to obtain plants resistant to particular diseases. Since the mid-90's, biotechnology, also known as genetic engineering, has been used to make crops more resistant to viruses or insect pests, and tolerant to weed herbicides.

Integrated Pest Management

Integrated Pest Management (IPM) takes an ecological and customized approach to pest management. The aim is to minimize pesticide use, and to use that which is needed in the safest and most effective way possible.

One study (part of a Univ. of Calif. IPM Project) found that releasing certain predator mites on cotton crops in late May and early June was more effective than in late June and early July, and that an efficient and accurate way to release them is to mix them with corn cob grit and use a leaf-blower to dispense the mixture.

IPM integrates various types of controls and strategies, based on the biology of the pests and their predators, the particular crop, local soil and weather conditions, etc. IPM for grapes, for example, might include removal of leaves around developing grape clusters—this has been found to reduce bunch rot and reduce the number of pesticide applications needed to control powdery mildew. IPM for strawberry crops might include:

- Careful monitoring of its pests, to decide if control efforts are needed.
- Using weed control to reduce pest reservoirs.
- Using weather information to predict when the pests will be at the most susceptible stage of their life cycle, so that if pesticides are needed, minimal amounts can be used in a timely way.

When one considers the variety of crops, pests, predators, and local conditions, it's clear that effective IPM relies on an extensive base of knowledge. Even when one knows, for example, that predator mites can be used to control spider mites in cotton crops, one has to decide when and how to release the predator mites.

Also, when an IPM plan is formulated for a crop, it has to be implemented. Implementation efforts include development of software and databases (e.g., *Database of alternatives to targeted pesticides*), publications (e.g., *IPM for apples and pears*), and hands-on workshops (e.g., how to distinguish between spider mites and predatory mites) for growers and farm workers. IPM research and implementation is supported mainly by state and federal funding.

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12.1.4: Biotechnology in Agriculture

Biotechnology is a general term, meaning the use of technology to study or solve problems of living organisms. But the term is commonly used (as it is here) to mean genetic engineering, the altering of an organism's genes (its DNA), resulting in what the popular press terms a genetically modified organism (GMO). The term now includes genome editing, the precise alteration of DNA using tools such as CRISPR-Cas.[10]

"Genetic engineering" or "genetically modified organism" sounds ominous—like something that might concern us.

As applied in agriculture, biotechnology is used to create desired genetic characteristics in plants. Ordinarily, these goals have been (and still are) done by crossbreeding—to get more nutritious vegetables, more drought-resistant plants, apples that don't brown, roses with fewer thorns, etc.

In many cases, biotechnology is simply used as a faster and a more direct and precise method of crossbreeding. (Crossbreeding has sometimes taken decades and thousands of pain-staking crosses to get a desired genetic change in a plant.) A desirable gene can be selectively transferred into a plant, or an undesirable gene can be inactivated.

One scientist tried to use crossbreeding to combine the leaf of a cabbage with the root of a radish to get an entirely edible plant. Alas, what resulted was the leaf of the radish with the root of the cabbage.

Agricultural biotechnology has the potential to make a tremendous impact on the health of many people, especially in countries where food is scarce and the nutritional quality of the staple diet is inadequate. Often, the scarcity isn't due to inadequate food production, but is the result of losses in the food supply system.

Year after year of drought causes extensive crop losses, resulting in economic losses to the farmer, and the consumer who pays higher food prices.

There are tremendous losses—particularly in developing countries—from infestation of crops by pests, harsh weather, and deterioration of the harvest during transport or storage. Biotechnology holds dramatic promise for such problems—to obtain plants that are more nutritious, need less fertilizer, and have increased resistance to viral infection, pests, deterioration, etc.

The achievement of a tastier tomato by genetic alteration pales by comparison. However, in 1989, Calgene, Inc. received a patent for a tomato (dubbed Flavr Savr), in which the enzyme that causes it to deteriorate rapidly was inactivated by genetic engineering (see Fig. 20-3). Without this enzyme, the tomato lasts longer after picking and thus can be picked when ripe and tasty rather than when green with flavor compounds not yet activated. Campbell Soup Company helped finance its development. But in response to public fear of scary-sounding *genetically modified food*, they announced that they wouldn't use it in their products; however it was used for a time in tomato sauce in the U.K.

A tastier vine-ripened tomato can make for a more nutritious diet. Presumably, people eat more tomatoes when they are tastier.

In 2015, the Innate™ potato passed muster as being as safe and nutritious as regular potatoes. It's Innate in that the inserted genes come from other varieties of potatoes. The potato is genetically modified to produce less acrylamide (a carcinogen in rodents and possibly in humans) when deep-fried and to prevent black spots from forming when raw potatoes are bruised (lots of potatoes are discarded because of bruising). A second-generation Innate potato was engineered to be resistant to potato blight, which caused the Irish potato famine. In response to anti-GMO voices, McDonald's announced it will not use these potato varieties.

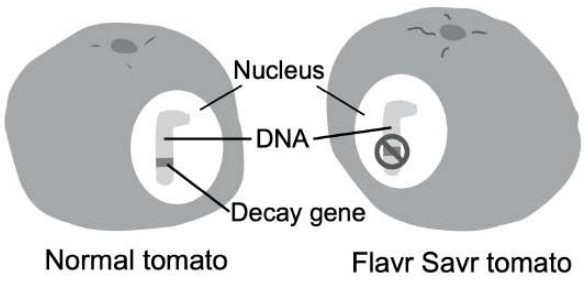


Figure 20-3: The decay gene is inactivated in the Flavr Savr tomato

With biotechnology, genes can be transferred across a wider range of plant species than by crossbreeding. One plant might, for example, make a protein that provides resistance to the formation of damaging ice crystals in freezing weather. The gene for this protein might then be transferred to other plants, making them resistant to frost damage.

One thing that crossbreeding can't do, but biotechnology can, is transfer non-plant genes into a plant. One such gene is for a protein found in the coat of a virus that infects and damages crops. (In nature, some plant viruses transfer their genes into a plant's DNA as part of their normal disease-causing process.)

It's been known for some time that crops infected with a mild strain of some viruses aren't as susceptible to infection by more damaging strains (similar to the way infection with the cowpox virus protected people against smallpox in the days before vaccines). In investigating this phenomenon, scientists found that one of the virus's proteins, alone, could confer the same protection. Plants, in this way, can be "vaccinated" against a viral infection.

Just the protein part of a virus is used in some human vaccines—the protein doesn't cause the disease when injected, nor is it infective. But it causes us to make the antibodies that protect against the virus.

Using biotechnology, the gene that provides the directions to make the desired protein can be removed from the virus and inserted into a plant's DNA. This genetically altered plant then makes this "foreign protein" for its own protection against disease. This method has been used, for example, to create rice varieties that resist infection by a virus that causes the loss of millions of dollars worth of rice crops in countries worldwide.[4]

When we eat the "foreign protein," it is digested quickly into its component amino acids. The digestive tract doesn't see it any differently than other proteins in the plant. After all, a plant's native protein is "foreign" to us as well.

Biotechnology might also be used to transplant a set of genes that, for example, gives an organism the ability to convert nitrogen gas into ammonia. As discussed earlier, the nitrogen-fixing bacteria that reside in the roots of legumes can convert nitrogen gas into ammonia for use by the plant (plants can use ammonia—but not nitrogen gas— to make protein). If these bacterial genes could be transferred into plants that aren't infected by these nitrogen-fixing bacteria, they wouldn't need nitrogen-containing fertilizer—the plants would make their own.

Using abundant natural resources—nitrogen from the air and energy from the sun—to make fertilizer "on site" is an attractive alternative to industrial production which, as said earlier, requires energy and technology, limiting its use in developing countries.

The FDA treats bioengineered food as it does any other food. The Flavr Savr tomato, for example, had its "decay gene" inactivated by biotechnology, whereas the DiVine Ripe tomato had its "decay gene" activity bred out. As another example, a plant can be made to produce its own fungicide by the bioengineered introduction of an antifungal gene. There are many other crop plants that naturally have the genes to produce such agents in even larger amounts (*naturally disease-resistant varieties*).

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12.1.5: The Good and Bad of Natural Plant Substances

One can see that it's hard to separate the "natural" from the "unnatural." It should also be clear by now that, contrary to popular sentiment, "natural" isn't necessarily better than "unnatural."

Plants—like all living organisms—are made up of a huge variety of substances. So many, that it's impossible to test them all. As new varieties of plant life appear, so do new substances. Conversely, as varieties of plant life become extinct, so do some unique substances—including undiscovered medicinal substances.

Plants have long been a source of medicines. Even today, pharmaceutical companies continually search for—and find—novel medications in plants. The bark of the willow tree was known in ancient civilizations as a source of a substance that relieves pain. Based on this substance (salicylic acid), a German chemist synthesized aspirin (acetylsalicylic acid) in 1853. The heart medicine digitalis comes from the leaves of the purple foxglove plant.

Many anticancer drugs also come from plants, such as taxol (for ovarian cancer) from the bark of the Pacific yew tree, and vinblastine (for breast cancer) and vincristine (for leukemia) from the tropical flower rosy periwinkle. As more plants become extinct, particularly those in tropical forests, the worry is that the plants becoming extinct today contain what may have been tomorrow's "miracle drugs."

Many people are severely allergic to peanuts. The peanut proteins responsible for the allergic reaction are being identified, in hope that the genes for these proteins can be eliminated or replaced by genetic modification to create allergen-free peanuts.[5]

Those who like to divide substances into "good" and "bad" would have a hard time with a plant's constituents. The easiest ones to categorize might be vitamins—but then, again, too much of even these can be toxic. Nutmeg, ginger, cloves, and cinnamon contain a bit of safrole—a carcinogen (cancer-causing substance). Sounds bad. Should we leave out these spices in our recipe for pumpkin pie? What about the caffeine in our coffee? Not so good when it makes the hand of a surgeon tremble during a delicate operation. But good when it keeps a tired surgeon awake on the drive home.

Do we include as plant substances those that form when a plant deteriorates or is cooked? Recall from Chapter 15, that animals that eat spoiled sweet clover can die of hemorrhagic disease, yet the same substance that causes their hemorrhage is used in much smaller doses as human medicine to prevent clots that can lead to a fatal heart attack. Almonds and lima beans are among those foods that produce hydrogen cyanide when cooked or digested—the same poison used in the gas chamber for capital punishment.

But some plant substances are outrightly classified as toxins.[6] Plants contain a variety of these, often in very large amounts. This isn't surprising. To survive, plants must have their own defenses against predators—thorns are the closest they come to having claws to defend themselves, and they can't run from their enemies.

Among these toxins are the naturally-occurring pesticides alluded to earlier. In fact, the amount of synthetic pesticide residues in our food pales in comparison to the amount and variety of naturally-occurring pesticides in our food.[7,8]

Some of these naturally-occurring pesticides have chemical actions identical to those of the pesticides farmers apply to their crops. For example, some plants contain substances that play havoc with the transmission of nerve impulses. From the plant perspective, this is an ideal toxin—plants don't have nerves, whereas most of their predators do.

Nerve impulse inhibitors are also used in flea collars—a big dose for fleas, a small dose for cats or dogs. During the 1991 Persian Gulf War, we feared that Iraq would use them in nerve gases—in big enough doses to kill humans. The substances can stop breathing through a spasm of the respiratory muscles.

Since we have nerves, these substances can be toxic to us as well. But a large dose for an insect is a very small dose for us. Again we're reminded that what's toxic or not is in the size of the dose.

What's Good and What's Bad?

There are valid arguments to be made concerning what and how much of various substances should be allowed in our food. But we confuse rather than enlighten if we focus only on those that we add to food. We do better when we compare these objectively to

those that are there “naturally” as part of a native species, or are incorporated by conventional crossbreeding techniques, or are there because of infection by plant microorganisms, the presence of insects, or “natural” deterioration.

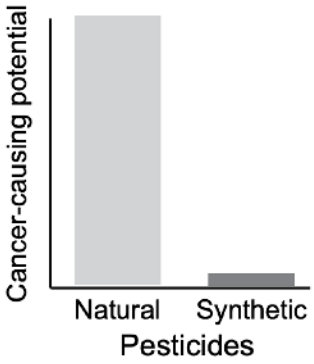


Figure 20-4: Cancer-causing potential of natural vs. residue from synthetic pesticides in our food[5,6]

Especially now, when we have more options than in the past, and we see agriculture in the context of world ecology, there’s a much greater need for more objective public dialogue: Is it reasonable to spend more on “organic” produce because of concern about pesticides? What if the particular organic produce happens to “naturally” contain more pesticides? How much are we as taxpayers willing to support Integrated Pest Management Programs as a way to minimize pesticide use?

There are valid concerns about pesticide sprays. The spray isn’t confined to the pests alone and can upset the natural ecology. There’s the danger of accidental spills, and worry of the hazards to farm workers. Again there’s the potential trade-off with the possible use of biotechnology to make the crop plant more disease resistant so that less or no spraying is needed.

In 1970, about 15% of the U.S. corn crop (over a billion bushels) was lost to corn blight. Most of the corn in the U.S. were the same “super variety” of hybrid corn, developed by crossbreeding.

Some who argue against genetically modified crops correctly state that the development and widespread use of “super varieties” reduces genetic diversity, making much larger portions of crops vulnerable to a single disease, extreme weather condition, etc. Crops with the same genes have the same genetic susceptibilities.

This isn’t a new concern. It has been, and still is a concern in the development of “super varieties” by conventional crossbreeding as well.[9] In large part because of this concern, the National Seed Storage Laboratory in Colorado maintains a stock of wild and “older” varieties of plants.

Non-scientists are understandably uneasy with regard to science and technology. Dramatic changes can seem “unnatural” at first, even those we later take for granted—the Wright brothers flying through the air, inoculation with a vaccine, the splitting of an atom.

The uneasiness is greater today, because of the wide gap between the general public’s scientific literacy. and the increased complexity of scientific achievement. When the Wright brothers took off, this gap was narrow, and everyone could make a reasonable assessment of the bright and dark sides of aircraft. Today the situation is far different, particularly in areas like biotechnology—even though we all still do share a common goal of doing what’s best for our own body, our own community, our own world.

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12.1.6: Of Science and Malnutrition

Worldwide, hundreds of millions of people are malnourished, and millions die each year of malnutrition. Far too many people are sick and dying for lack of good food.

Although there are gifts of food to the world's hungry, the greater gifts come from advances in agriculture and food science. Even in our own not-so-distant past, we've come to know the benefits of these advances.

We may have a sentimental attraction for the days when organic farming on small family farms was the only farming, but the reality is that the advent of "chemical" fertilizers, pesticides, and such, helped make the rapid development of other industries possible.

Increased crop yields became possible with fewer farmers, allowing many to leave the farms for the cities. Even with only a relatively small segment of our population continuing to do our farming, we're able to provide an abundance of food, not only for ourselves, but plenty to export as well.

High-yielding seeds have been developed— seeds which have been said to advance the health of more of the world's people in a shorter time than any other technological advance in history. Plants have been bred which produce less stalk to yield more rice. The development of hybrid corn increased U.S. corn production from 23 bushels per acre in 1936 to 114 bushels in 1982—a 5-fold increase.[10] From all parts of the world came reports of incredible increases in crop yield from the use of such hybrid seeds—and with it the alleviation of much hunger.

In 1964, the opaque-2 gene was discovered, a corn gene that markedly increased the nutrient value of the corn protein. (But the gene was recessive and the crop yield was less, so it was with some difficulty that researchers were finally able, by crossbreeding, to develop it into a commercially useful breed of corn.) This astonishing grain has protein of a quality that approaches that of cow's milk. Even when it's the only protein source in the diet, it meets the hard test of curing kwashiorkor, the tragic protein-deficiency disease which has crippled too many of the world's children.

Many such rabbits have come out of food technology's hat. The new tools of biotechnology have broadly widened the possibilities for agriculture and food technology, promising much faster and more precise contributions. But the goals of agricultural scientists and food technologists remain as before—greater crop yields, the need for less fertilizers and pesticides, more nutritious and tastier plant foods, drought-resistant varieties of staple crops, crops that stay fresh longer from farm to table.

The greatest gains are for the world's hungry. Many can't afford the fertilizers that can result in more food from their plot of land, nor the pesticides that would preserve more of the crop for human consumption. Many live long distances from the farming—with no refrigerated trucks to bring food without spoiling.

A varied diet is a tenet of good nutrition, yet the world's hungry typically have but a few staple plant foods to choose from. For them, new crop varieties can mean the difference between health and disease, between life and death.

Rice, a dietary staple for half the world's population, lacks beta-carotene, which our bodies can convert to vitamin A. Vitamin A deficiency, common in developing countries, impairs immunity, causes blindness, much suffering, and millions of deaths each year. Golden Rice goldenrice.org was created by biotechnology to enable rice to produce beta-carotene, giving it its golden color.

Creating Golden Rice was a huge scientific endeavor. Beta-carotene isn't a protein, so it was not a matter of inserting a single gene. Biosynthesis required several genes for the needed enzymes (proteins) that had to work in sequence —a breakthrough in biotech. It was also a humanitarian endeavor, the seeds to be offered free to poor farmers in developing countries.

The 8-year project was headed by Ingo Potrykus and Peter Beyer and funded by the Rockefeller Foundation, culminating in 2000 by publication in the journal *Science* and a *Time* magazine cover featuring Potrykus.

Much to the distress of the science community, Golden Rice still isn't available commercially (as of 2020) and isn't widely available to people who would benefit the most. Potrykus retired in 1999 at age 65 from his professorship at the Institute of Plant Sciences of the Swiss Federation of Technology, but continues to work to make Golden Rice available. In 2013, he even met with the Pope, who gave Golden Rice his personal blessing.

In 2016, more than 100 Nobel laureates signed a letter asking Greenpeace to end its opposition to Golden Rice and to GMOs (genetically modified organisms) in general. In 2018, the U.S. joined Canada, Australia, and New Zealand in approving Golden

Rice for human consumption.

It’s hard to cross the barriers of old taboos, of unconscious fears and frightening myths, of suspicion of new food forms or tastes. Let’s go on in the next chapter to examine our fears of the food additives that are added in food processing.

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12.1.7: Summary

Plants require nutrients in simple form. They get their carbon, hydrogen, and oxygen from carbon dioxide and water, their nitrogen from nitrates and ammonia, and their minerals from the soil. Plant growth is limited by the availability of the required nutrients—the quantity of plant produced is reduced, not its quality. Fertilizers provide nutrients that increase crop yield.

Some of the minerals we require (e.g., iodine) aren't required by plants. But plants can take these in—and also ones we don't want (e.g., lead)—if they happen to be in the soil. This means the plant content of these "extraneous" minerals vary according to the amount present in the local soil.

Crop yield is also affected by how well we protect our crops from insects and disease. Pesticides are commonly used for this purpose. Alternatively, natural predators of the pests can be used, and plants can be bred to be more pest resistant. Integrated Pest Management customizes pest-control strategies for individual crops and local conditions, using alternatives to pesticides whenever possible—the aim is to minimize the use of pesticides, and to use that which is needed in the safest and most effective way possible.

Plant genes can be altered by biotechnology to create desired characteristics. Biotechnology can be used to transfer desired genes (e.g., ones that provide disease resistance) into a plant or to inactivate undesirable genes (e.g., ones that cause decay) or to edit a plant's gene.

"Natural" plant substances aren't inherently better or worse than "man-made" ones. Both the natural and the man-made are important to consider in assessing the safety and adequacy of our agricultural products.

Advances in agriculture and food science have had—and are expected to continue to have—the greatest benefit for the world's hungry.

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12.1.8: Guest Lecturer

***Guest Lecturer**: Peggy G. Lemaux, PhD*

Do We Need Genetically Modified Foods to Feed the World?

A Scientific Perspective

My focus and my area of expertise is that of a practicing scientist—one involved in the genetic engineering of cereal crops and in trying to improve the nutritional quality of sorghum. So my interests in the application of biotechnology are practical—can the technology be used to improve agriculture, and can it improve the lot of the world's poor?

I'm not a governmental official; I'm not an economist; I'm a scientist. What can I do? Of course, the answer as to whether I can make a contribution to agricultural productivity in the developed and developing world depends only in part on the technology. The answer goes far beyond science.

Many forces limit the application of biotechnology in developed countries. We have invented techniques for inserting genes responsible for valuable traits in most crop plants. Major factors affecting the use of genetically engineered crops in developed countries include intellectual property issues, regulatory costs, economic incentives and, in my opinion, the limited ability of the public sector to directly contribute to the development of engineered crops that can be grown in fields by farmers.

The application of biotechnology in developing countries has some of the same limitations, but includes others, such as inadequate infrastructure, unique political and economic hurdles, and societal issues. And, as I can personally attest, lack of funding for scientists and economists to participate effectively. I don't think it is possible to focus on scientific challenges alone without a consideration of the other issues, particularly in developing countries.

In 2001, the United Nations released a report called, Making New Technologies Work for Human Development. The report provided an analysis of the potential of biotech and information and communications technology for developing countries. Summarizing his thoughts on this topic, Peter Rosset of Food First said, "Complex problems of hunger and agricultural development will not be solved by technological silver bullets." I couldn't agree more!

And even if it could be done, biotechnology would not be that bullet. Our world and its increases in population and food shortages are too complex to be addressed adequately with simple solutions—whether they are the application of biotechnology or the use of organic methods to address agricultural problems. The question for me really is, can biotechnology ease problems of food insufficiency and environmental degradation, due in large part to population expansion?

First, as a practicing scientist in the field of biotechnology and genomics, I remind you that agricultural biotechnology is more than just genetically modified organisms. Based on what we have learned about manipulating plant tissues and DNA, alternative approaches have been developed that don't involve genetic engineering, and some of these are important in developing countries.

A recent example is a new pearl millet hybrid to be released in India that is resistant to downy mildew. In years of severe attack, this organism can cause the loss of up to 30% of the crop.

Another example involves micropropagation methods to rid plants, like banana, potatoes and taro, of viruses and other pests by passing them through tissue culture. This has helped African and Philippino farmers. Although tissue-cultured plants cost more, disease-free plants give higher yields, resulting in more money for farmers.

The last example is Polymerase Chain Reaction (PCR) techniques, which are being used to detect and control pests and viruses in crops like banana and papaya.

But when biotechnology is discussed, most of the focus is on genetic engineering of crop plants —adding new or modified genes. Here I want to focus on the question of whether this technology holds any hope for developing countries.

I would first like to look at the impact of genetically engineered crops available commercially today. An example is transgenic Bt* plants like corn, potatoes, and cotton. The agricultural economist David Zilberman and his colleagues at UC Berkeley concluded that increases in yields of Bt cotton could be be significant in countries where there are a lot of pests, but minimal pesticide use—like some developing countries. They calculated that, although Bt cotton gains in the U.S. and China would range from 0-15%, gains in South Africa could be 20-40%, and in India 60-80%.

But won't intellectual property issues interfere with deployment of such crops in developing countries, since U.S. companies created them? Zilberman and other agricultural economists claim that, since these crops are generated in developed countries, the companies generally do not patent these inventions in developing countries. They worry most about liability and transaction costs.

Use of genetically engineered crops in Africa, for example, has faced controversy. Some claim that the presently available crops, like Bt corn, do not address small farmers' needs in developing countries and that they will be expensive—only agrochemical companies developing them will benefit. Also, these crops will make farmers dependent on the new varieties, and the biodiversity of the old varieties will be lost. In addition, genetically engineered crops might pose environmental risks by leading to insect resistance, gene flow into wild species, and disruption of non-target organisms.

Most farmers in Kenya use local varieties, and they select varieties based on yield, early maturity and tolerance to drought, field pests and storage pests. One approach is to involve these farmers in testing the new varieties of maize. Working within the Kenyan regulatory system, existing Bt technology has been found to be effective in the laboratory on leaf samples against all major stem borer species, except one.

The next step is to test the Bt varieties in biosafety greenhouses and in open quarantine facilities. Finally, local farmers will test these crops in the field.

No patents were filed in Kenya restricting the use of Bt genes in maize. Therefore, Bt maize is likely to be commercialized by local Kenyan companies. Since Bt genes are dominant, farmers don't need to become dependent on the seed industry since they can recycle seed. In addition, farmers are free to incorporate the gene into local varieties, if they view it as a valuable trait.

Is this a "magic bullet" solution? No, it is only one approach. Biotechnology must be pursued as part of a portfolio of technologies used to enhance productivity and environmental sustainability of agriculture. Although agricultural technology, like any other technology, will never be "zero risk." If it is carefully considered and introduced, shouldn't farmers and consumers be able to try these products and help develop varieties suited to their local areas?

Is this the only way to address these problems? Certainly not. In many cases the problem is not as simple as pest resistance in maize. Are the food and agricultural problems of poor countries like those of rich countries? No, for the poor in most developing countries, things are different—they live in different ecological zones, face different health conditions, and must overcome agronomic limitations very different from those of developed countries.

I believe that science, technology, economics and government policy must all be directed toward solving these problems. Technological gains in developed countries will only be minimally applicable to problems in poorer countries. Technologies directed to poorer countries are not likely to reap economic rewards. Therefore, the private sector is not likely to assume a major responsibility in this area.

This brings me to the last point. What about the role of public sector scientists, both in developed countries and in the developing countries? Finally we come to a topic where I have some personal experience. For years, my laboratory has worked on the genetic engineering of cereal crops. One application focused on reducing wheat allergenicity—a problem of little significance in developing countries. But another application of the same technology appears to improve protein and starch digestibility—a recognized problem with sorghum, a staple in parts of Africa.

For this reason colleague Bob Buchanan and I are attempting to improve the nutritional quality of sorghum. We are focusing on improving its digestibility and its amino acid profile, given that cereals are notoriously deficient in lysine.

We found a U.S. company with a modified barley gene that could improve lysine content, and we approached them for the project. We have worked out the intellectual property issues, and are currently introducing this gene into sorghum. Of course, before this is released to African farmers, liability and environmental and food safety issues have to be addressed, The project is moving forward.

There are potential problems in introducing these crops into developing countries, just as there are dangers in introducing other elements of our agricultural system. Care needs to be taken in releasing genetically engineered varieties in areas where there are wild relatives of the commercially grown crop. But this warning is tempered by the fact that you have to look at the actual genes that will be introduced to see if this might cause problems if they were to escape. In our sorghum project, we are working with a sorghum breeder in the Midwest to assess the possible consequences of the movement of our genes into wild species.

Genes have been flowing back and forth between sorghum and their wild relatives for millennia. The issue becomes what effect—negative or positive—might the particular genes we are using have? If our approaches are successful and we can address food and environmental safety issues, African breeders will move these genes into local sorghum varieties.

Why did we become involved in this project? For me personally, I believe it is part of my mandate as a public sector scientist to use the skills I have to make a contribution to improve the lot of farmers and consumers in developing countries. Is this the only answer? Is this the best answer? No, it is only part of an answer, but it is something I want to and can do.

It has been said that one-fifth of the world's population is at the bottom of the economic ladder, and over 95% of their food supply is produced locally. Therefore, improving agricultural productivity in developing countries may more directly benefit "consumers," since in many cases they are also "producers." Increasing local food production will also contribute to lower food costs and food security. I hope that I can use my knowledge of science and cooperative extension to make a difference in the developing world.

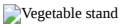
*Bacillus thuringiensis, commonly known as Bt, is a bacterium that occurs naturally in soil. Some strains of Bt produce proteins that kill certain insects, but are not harmful to humans, other mammals, birds, or fish. Certain crop plants have been genetically engineered to produce their own Bt.

Dr. Lemaux is a faculty member and Cooperative Extension Specialist, Dept. of Plant and Microbial Biology at the Univ. of Calif. Berkeley plantandmicrobiology.berkeley.edu Her work on sorghum is funded by the Bill & Melinda Gates Foundation. She's also a popular speaker on agriculture and biotechnology ucbiotech.org This lecture is an excerpt from the Future of Food Symposium: Value vs. Risk in the Biotechnology Debate at Santa Clara University (4/15/05).

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12.2: Vegetables

The debates between what is a fruit and what is a vegetable has been a ongoing one among many. In this chapter we explain that vegetables are defined as "mostly herbaceous annual plants of which some portion is eaten, either cooked or raw, during the principal part of the meal to complement starchy food and other food items", and dive deeper into the different categories of vegetables as well as how to utilize the.



"Vegetable stand" by comprock is licensed under CC BY-SA 2.0.

The term vegetable refers to any herbaceous plant that can be partially or, wholly eaten. An herbaceous plant has little or no woody tissue. The portions we consume include the leaves, stems, roots, tubers, seeds and flowers. Vegetables contain more starch and less sugar than fruits. Therefore, vegetables tend to be savory, not sweet. Also unlike fruits, vegetables are most often eaten cooked, not raw.

Classification:

Click the images bellow to learn more about the categories of vegetables.



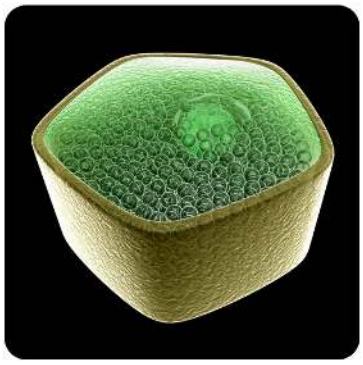


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12.2.1: Plant Cell Structures



What do plants have to do that animals don't?

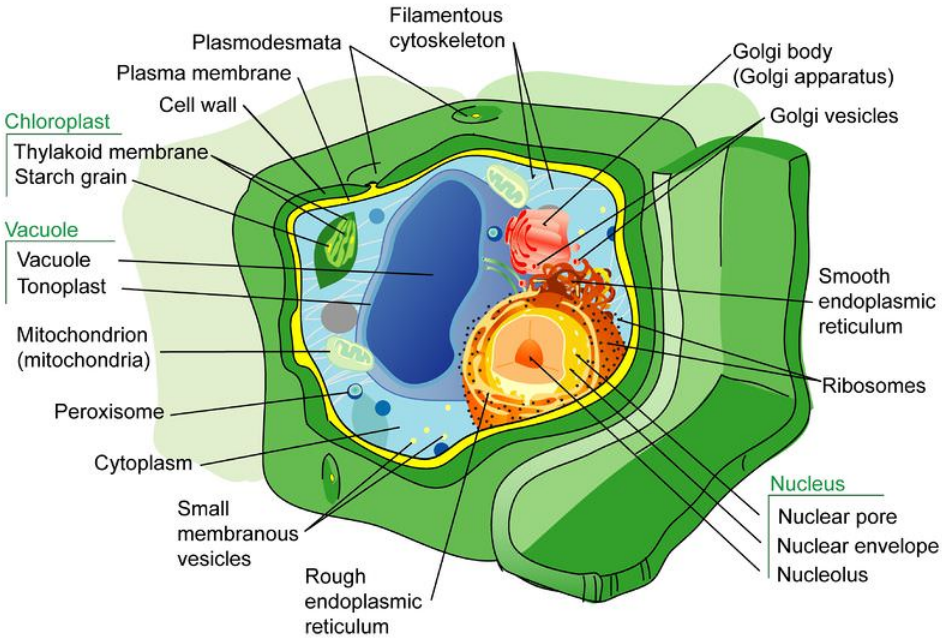
Many plant cells are green. Why? Plant cells also usually have a distinct shape. The rigid exterior around the cells is necessary to allow the plants to grow upright. Animal cells do not have these rigid exteriors. There are other distinct differences between plant and animal cells. These will be the focus of this concept.

Plant Cells

Special Structures in Plant Cells

Most organelles are common to both animal and plant cells. However, plant cells also have features that animal cells do not have: a cell wall, a large central vacuole, and plastids such as chloroplasts.

Plants have very different lifestyles from animals, and these differences are apparent when you examine the structure of the plant cell. Plants make their own food in a process called **photosynthesis**. They take in carbon dioxide (CO_2) and water (H_2O) and convert them into sugars. The features unique to plant cells can be seen in **Figure** below.



In addition to containing most of the organelles found in animal cells, plant cells also have a cell wall, a large central vacuole, and plastids. These three features are not found in animal cells.

The Cell Wall

A **cell wall** is a rigid layer that is found outside the cell membrane and surrounds the cell. The cell wall contains not only cellulose and protein, but other polysaccharides as well. The cell wall provides structural support and protection. Pores in the cell wall allow water and nutrients to move into and out of the cell. The cell wall also prevents the plant cell from bursting when water enters the cell.

Microtubules guide the formation of the plant cell wall. Cellulose is laid down by enzymes to form the primary cell wall. Some plants also have a secondary cell wall. The secondary wall contains a lignin, a secondary cell component in plant cells that have completed cell growth/expansion.

The Central Vacuole

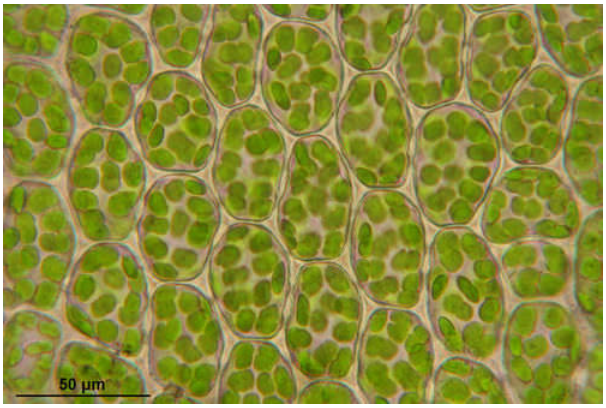
Most mature plant cells have a **central vacuole** that occupies more than 30% of the cell's volume. The central vacuole can occupy as much as 90% of the volume of certain cells. The central vacuole is surrounded by a membrane called the **tonoplast**. The central vacuole has many functions. Aside from storage, the main role of the vacuole is to maintain turgor pressure against the cell wall. Proteins found in the tonoplast control the flow of water into and out of the vacuole. The central vacuole also stores the pigments that color flowers.

The central vacuole contains large amounts of a liquid called cell sap, which differs in composition to the cell cytosol. Cell sap is a mixture of water, enzymes, ions, salts, and othersubstances. Cell sap may also contain toxic byproducts that have been removed from the cytosol. Toxins in the vacuole may help to protect some plants from being eaten.

Plastids

Plant **plastids** are a group of closely related membrane-bound organelles that carry out many functions. They are responsible for photosynthesis, for storage of products such as starch, and for the synthesis of many types of molecules that are needed as cellular building blocks. Plastids have the ability to change their function between these and other forms. Plastids contain their own DNA and some ribosomes, and scientists think that plastids are descended from photosynthetic bacteria that allowed the first eukaryotes to make oxygen. The main types of plastids and their functions are:

- **Chloroplasts** are the organelle of photosynthesis. They capture light energy from the sun and use it with water and carbon dioxide to make food (sugar) for the plant. The arrangement of chloroplasts in a plant's cells can be seen in **Figure** below.
- **Chromoplasts** make and store pigments that give petals and fruit their orange and yellow colors.
- **Leucoplasts** do not contain pigments and are located in roots and non-photosynthetic tissues of plants. They may become specialized for bulk storage of starch, lipid, or protein. However, in many cells, leucoplasts do not have a major storage function. Instead, they make molecules such as fatty acids and many amino acids.



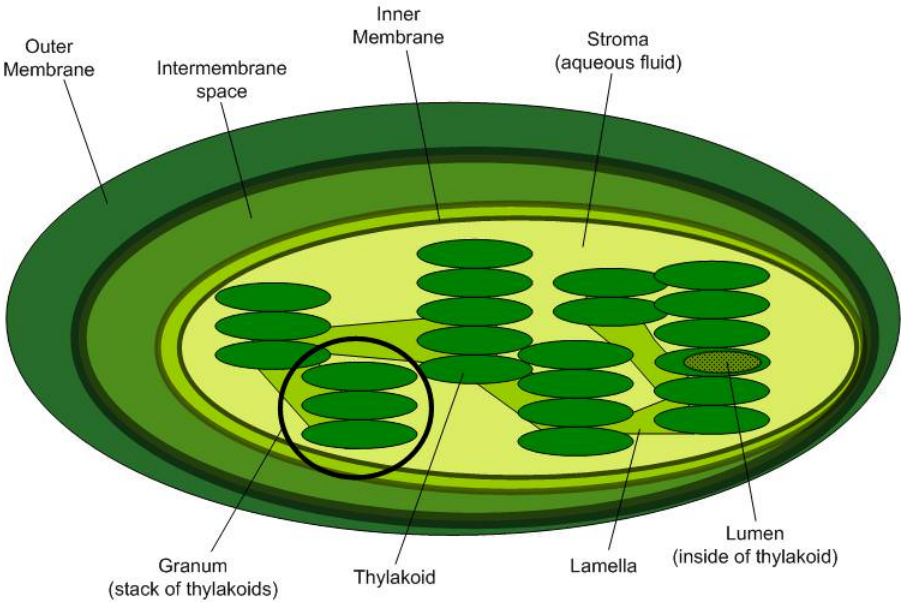
Plant cells with visible chloroplasts.

Chloroplasts

Chloroplasts capture light energy from the sun and use it with water and carbon dioxide to produce sugars for food. Chloroplasts look like flat discs and are usually 2 to 10 micrometers in diameter and 1 micrometer thick. A model of a chloroplast is shown in **Figure** below. The chloroplast is enclosed by an inner and an outer phospholipid membrane. Between these two layers is the

intermembrane space. The fluid within the chloroplast is called the **stroma**, and it contains one or more molecules of small, circular DNA. The stroma also has ribosomes. Within the stroma are stacks of **thylakoids**, sub-organelles that are the site of photosynthesis. The thylakoids are arranged in stacks called **grana** (singular: granum). A thylakoid has a flattened disk shape. Inside it is an empty area called the thylakoid space or lumen. Photosynthesis takes place on the thylakoid membrane.

Within the thylakoid membrane is the complex of proteins and light-absorbing pigments, such as chlorophyll and carotenoids. This complex allows capture of light energy from many wavelengths because chlorophyll and carotenoids both absorb different wavelengths of light. These will be further discussed in the "Photosynthesis" concept.



The internal structure of a chloroplast, with a granal stack of thylakoids circled.

Summary

- Plant cells have a cell wall, a large central vacuole, and plastids such as chloroplasts.
- The cell wall is a rigid layer that is found outside the cell membrane and surrounds the cell, providing structural support and protection.
- The central vacuole maintains turgor pressure against the cell wall.
- Chloroplasts capture light energy from the sun and use it with water and carbon dioxide to produce sugars for food.

Explore More

Explore More I

Use this resource to answer the questions that follow.

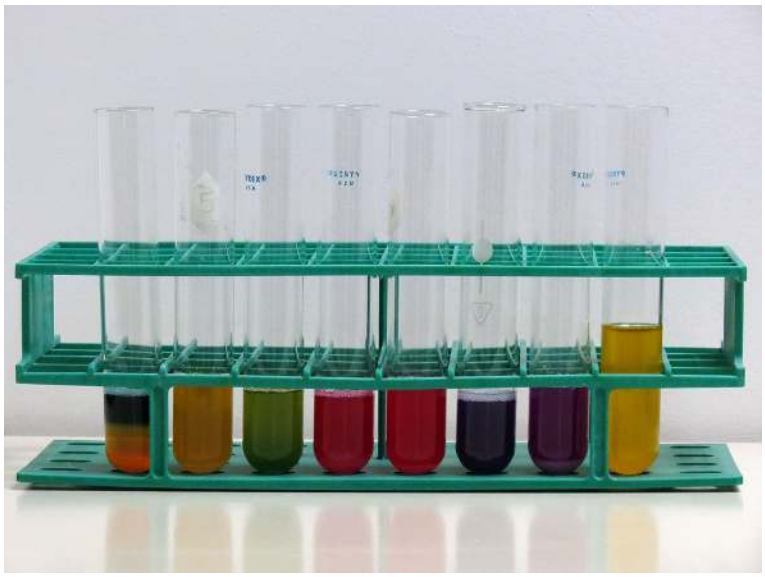
- **Plant Cells, Chloroplasts, and Cell Walls** at http://www.nature.com/scitable/topicpage/plant-cells-chloroplasts-and-cell-walls-14053956.

Explore More II

- **Eukaryotic Cell Interactive Animation: Plant Cell** at http://www.cellsalive.com/cells/cell_model.htm.

Plant Pigments

Click the diagram bellow to learn about chlorophyl, carotenoids and anthocyanins.



https://harvardforest.fas.harvard.edu/leaves/pigment

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12.2.2: Cabbages and Greens

Bok Choy

Bok choy, also known as ‘pok choy’, is a white-stemmed variety of southern Chinese cabbage.



Broccoli

Broccoli, a type of flower, has a thick central stalk with grayish-green leaves topped with one or more heads of green florets.



Brussel Sprouts

Brussels sprouts) were first cultivated around 1700. The plant produces numerous small heads arranged in neat rows along a thick stalk.



Cauliflower

Cauliflower is the king of the cabbage family. Each stalk produces one flower or head surrounded by large green leaves.



Kale

Kale has large ruffled, curly or bumpy leaves. Its rather bitter flavor goes well with rich meats such as game, pork or ham. Kale is typically prepared boiled, stuffed, or used in soups.



Kohlrabi

Although it looks rather like a round root, kohlrabi is actually a bulbous stem vegetable created by crossbreeding cabbages and turnips. Both the leaves (which are attached directly to the bulbous stem) and the roots are generally removed before sale.



Napa Cabbage

Napa cabbage, also known as Chinese cabbage, is widely used in Asian cuisines.



Greens:

The term greens refers to a variety of leafy green vegetables that may be served raw, but are usually cooked. Greens have long been used in the cuisines of India, Asia and the Mediterranean and are an important part of regional cuisine in the southern United States. Most have strong, spicy flavors. The milder varieties of greens that are usually eaten raw include the lettuces.

Greens have an extremely high water content, which means that cooking causes drastic shrinkage. As a rule, allow 8 ounces (250 grams) per portion before cooking.

-Among these include: collards, mustard, sorrel, spinach, Swiss chard and turnip greens. Click the image bellow to learn more about each type of green listed.



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12.2.3: Cucurbitaceae and Fruit-Vegetable Misclassifications

The Cucurbitaceae

or gourd family includes almost 750 species; its members are found in warm regions worldwide. Gourds are characterized by large, complex root systems with quick-growing, trailing vines and large leaves. Their flowers are often attractive and edible. Although some members of the gourd family originated in Africa, chayotes and most squashes are native to the Americas. Among these include chayote, cucumbers, squashes (winter/summer).



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Misclassifications:

Botanists classify avocados, eggplants, peppers and tomatoes as **fruits** because they develop from the **ovary** of flowering plants and contain one or more seeds. Chefs, however, **prepare and serve them like vegetables**; therefore, they are discussed here.

Avocados

Avocados include several varieties of pear-shaped fruits with rich, high-fat flesh. This light golden-green flesh surrounds a large, inedible, oval-shaped seed (pit). Some varieties have smooth, green skin; others have pebbly, almost black skin. Avocados should be used at their peak of ripeness, a condition that lasts only briefly. Firm avocados lack the desired flavor and creamy texture. Ripe avocados should be soft to the touch but not mushy. Ripe Haas avocados have almost black skins; the skins of the other varieties remain green when ripe. Firm avocados can be left at room temperature to ripen and then refrigerated for one or two days. Because avocado flesh turns brown very quickly once cut, dip avocado halves or slices in lemon juice and keep unused portions tightly covered with plastic wrap.



Eggplants

Two types of eggplants (Fr. Aubergine) are commonly available: Asian and western. Asian varieties are either round or long and thin, with skin colors ranging from creamy white to deep purple. Western eggplants, which are more common in the United States, tend to be shaped like a plump pear with a shiny lavender to purple-black skin. Both types have a dense, khaki-colored flesh with a rather bland flavor that absorbs other flavors well during cooking. Eggplants can be grilled, baked, steamed, fried or sautéed. They are commonly used in Mediterranean and Indian cuisines (especially in vegetarian dishes), but also appear in European and North American dishes.

- ***Eggplant - to salt or not salt?***

Eggplants are filled with cells that contain water and are surrounded by tiny air pockets. The presence of heat will squeeze the air out of the pockets. If the eggplant has not been salted, oil is then free to seep into these pockets and the eggplant becomes soggy when fried. But when salt is sprinkled on an eggplant, it draws the water out of the cells. The cells then collapse, which in turn makes the air pockets collapse. As a result, no oil can seep into the tiny pockets during the frying process.



Peppers

Members of the Capsicum family are native to the New World. When "discovered" by Christopher Columbus, he called them "peppers" because of their sometimes-fiery flavor. These peppers, which include sweet peppers and hot peppers (chiles), are unrelated to peppercorns, the Asian spice for which Columbus was actually searching.



Tomatillos

Also known as Mexican or husk tomatoes, grow on small, weedy bushes. They are bright green, about the size of a small tomato, and are covered with a thin, papery husk. They have a tart, lemony flavor and crisp, moist flesh. Although they are an important ingredient in southwestern and northern Mexican cuisines, tomatillos may not be readily available in other areas. Tomatillos can be used raw in salads, pureed for salsa or cooked in soups, stews or vegetable dishes.



Tomatoes

Tomatoes (Fr. Tomate or pomme d'amour; It. pomodoro) are available in a wide variety of colors and shapes. They vary from green (unripe) to golden yellow to ruby red; from tiny spheres (currant tomatoes) to huge, squat ovals (beefsteak). Some, such as the plum tomato, have lots of meaty flesh with only a few seeds; others, such as the slicing tomato, have lots of seeds and juice, but only a few meaty membranes.



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12.2.4: Mushrooms,Truffles, Onions, and Roots

Mushrooms

Mushrooms are members of a broad category of plants known as fungi. (Fungi have no seeds, stems, or flowers; they reproduce through spores.) Mushrooms have a stalk with an umbrella-like top. Although not actually a vegetable, mushrooms are used and served in much the same manner as vegetables.

Several types of cultivated mushroom are available. They include the common (or white), shiitake, crimini (also known as the Italian brown), straw, enokidake (also called enoki) and cloud ear (also known as wood ear or Chinese black). Button mushrooms are the smallest, most immature form of the common mushroom. The largest cultivated mushroom is the portabella, which is actually an overgrown crimini; it can grow up to 6 inches (15 centimeters) in diameter.

Mushroom safety. Some mushrooms are deadly; others can cause severe illness. Picking edible mushrooms in the wild is not simply a process of comparing specimens with photographs or illustrations in a guidebook. So do not gather mushrooms from the wild unless you are accompanied by a well-trained, experienced mycologist or guide. Always purchase wild mushrooms from reputable purveyors.



Truffles

Truffles are actually tubers that grow near the roots of oak or beech trees. They can be cultivated only to the extent that oak groves are planted to encourage truffle growth. The two principal varieties are the Perigord (black) and the Piedmontese (white). Fresh truffles are gathered in the fall and are rarely marketed outside their locale. Truffles, especially white ones, have a strong aroma and flavor, requiring only a small amount to add their special flavor to soups, sauces, pasta and other items.



Onions

Bulb Onions

Common or bulb onions may be white, yellow (Bermuda or Spanish) or red (purple). Medium-sized yellow and white onions are the most strongly flavored. Larger onions tend to be sweeter and milder.



Onion Varietals

Garlic

Garlic is also used in almost all the world's cuisines. A head of garlic is composed of many small cloves. Each clove is wrapped in a thin husk or peel; the entire head is encased in several thin layers of papery husk.



Leeks

Leeks look like large, overgrown scallions with a fat white tip and wide green leaves. Their flavor is sweeter and stronger than scallions, but milder than common bulb onions. Leeks must be carefully washed to remove the sandy soil that gets between the leaves.



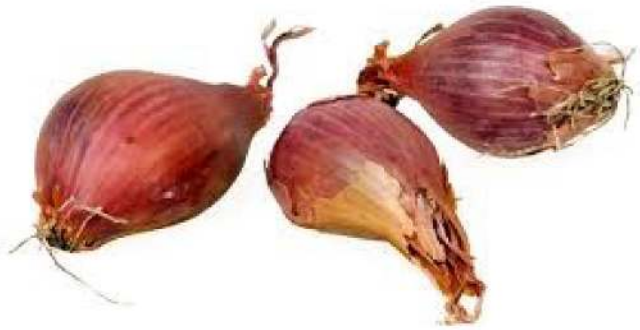
Scallions

Scallions, also known as green onions or bunch onions, are the immature green stalks of bulb onions. The leaves are bright green with either a long and slender or a slightly bulbous white base.



Shallots

Shallots are shaped like small bulb onions with one flat side. When peeled, a shallot separates into multiple cloves, similar to garlic. They have a mild, yet rich and complex flavor.



Roots and Tubers

Taproots (more commonly referred to as roots) are single roots that extend deep into the soil to supply the above -ground plant with nutrients. Tubers are fat underground stems. Most roots and tubers can be used interchangeably. All store well at cool temperatures, without refrigeration. These include, beets, carrots, potatos, celery root, turnips, water chestnuts, parsnips, radishes and rutabagas.

- Click the Graphic bellow to lean more about the uses of root vegetables:



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Stalks

Stalk vegetables are plant stems with a high percentage of cellulose fiber. These vegetables should be picked while still young and tender. Tough fibers should be trimmed before cooking. Stalks include artichokes, asparagus, bamboo shoots, celery, fennel, and hearts of palm.

Baby Vegetables

Many fine restaurants serve baby vegetables: tiny turnips, finger-length squash, miniature carrots and petite heads of cauliflower.

Discussion Questions: Spinach, mushrooms, truffles, pods and seeds

1. When is the best time to pick collard greens?
2. Name two kinds of greens.
3. What type of mushrooms are most commonly used in cooking?
4. Describe shallots and green onions. Which one is commonly used in south Louisiana dishes?
5. Other than its use in gumbo – how else may okra be prepared/cooked?

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12.2.5: Pods and Seeds

Pod and seed vegetables include corn, legumes and okra. They are grouped together here because the parts consumed are all the seeds of their respective plants. In some cases, only the seeds are eaten; in others, the pod containing the seeds are eaten as well. Seeds are generally higher in protein and carbohydrates (starch and fiber) than other vegetables.

Corn

Sweet corn is actually a grain, a type of grass. Corn kernels, like peas, are plant seeds. (Dried corn products are discussed in Chapter 23, Potatoes, Grains and Pasta.) The kernels, which may be white or yellow, are attached to a woody, inedible cob. The cob is encased by strands of hair-like fibers called silks and covered in layers of thin leaves called husks.



Legumes

Beans and peas are members of the legume family, a large group of vegetables with double-seamed pods containing a single row of seeds. Of the hundreds of known varieties of beans, some are used for their edible pods, others for shelling fresh and some only for their dried seeds. Dried beans are actually several varieties of seeds or peas left in the pod until mature, then shelled and dried.

Fresh Beans

Beans used for their edible pods, commonly referred to as green beans, string beans, runner beans or snap beans, are picked when immature. Except for the stem, the entire pod can be eaten. This category includes the American green bean, the yellow wax bean and the French haricot vert, a long, slender pod with an intense flavor and tender texture.



Dried Beans

Anthropologists report that for thousands of years, cultures worldwide have preserved some members of the legume family by drying. Common dried beans include kidney beans, pinto beans, chickpeas, lentils, black beans, black-eyed peas and split green peas. Shape is the clearest distinction among these products: Beans are oval or kidney-shaped; lentils are small, flat disks and peas are round.

Beans and peas destined for drying are left on the vine until they are fully matured and just beginning to dry. They are then harvested, shelled, and quickly dried with warm air currents. Some dried legumes are sold split, which means the skin is removed, causing the seed's two halves to separate. Most dried beans need to be soaked in water before cooking. Soaking softens and rehydrates the beans, thus reducing cooking time.



Shelling Peas

Of the shelling peas that are prepared fresh, the most common are green garden peas (English peas) and the French petit pois. Because they lose flavor rapidly after harvest, most shelling peas are sold frozen or canned.



Edible Pea Pods

Snow peas, also known as Chinese pea pods, are a common variety of edible pea pod. They are flat and have only a few very small green peas. Snow peas have a string along their seams that can be removed by holding the leafy stem and pulling from end to end.



Okra

Okra, a common ingredient in African and Arab cuisines, was brought to the United States by slaves and French settlers . It is now integral to Creole, Cajun, southern and southwestern cuisines. Its mild flavor is similar to that of asparagus.



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12.3: Fruits

We covered some fruits briefly in the vegetable chapter but now we will be delving into this topic in more detail. Click the image bellow to begin learning about what makes a fruit, a fruit.



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A fruit, botanically, is an organ that develops from the ovary of a flowering plant and contains one or more seeds. From a culinary perspective, a fruit is the perfect snack food, the basis of a dessert, colorful sauce or soup or an accompaniment to meat, fish, shellfish or poultry. No food group offers a greater variety of colors, flavors and textures than fruit.

Fruits, whether fresh, frozen, canned or dried, are one of the most versatile and popular of foods. Fruits can be used uncooked or incorporated into a soup, salad, bread, meat dish or dessert. When selecting fresh fruits, it is important to consider seasonal availability, storage conditions and ripeness. When using them, it is important that they be at their peak of ripeness for the best flavor, texture, aroma and appearance.

This fruit presentation is according to the ways most people view them and use them, rather than by rigid botanical classifications. Fruits divide into eight categories:

1. Berries
2. Citrus
3. Exotics
4. Grapes
5. Melons
6. Pomes
7. Stone fruits
8. Tropical varieties

The category separations are according to either their shape, seed structure or natural habitat. Botanically, tomatoes, beans, eggplant, capsicum peppers and other produce are fruits. However, in ordinary thinking, they are not; they are vegetables. A fruit may have several names, varying from region to region or on a purveyor's choice. Botanists are also constantly reclassifying items to fit new findings. The names given here follow generally accepted custom and usage.

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12.3.1: Berries and Citrus

Berries:

Berries are small, juicy fruits that grow on vines and bushes worldwide. Thin skins and many tiny seeds that are often so small they go unnoticed characterize berries. Some of the fruits classified here as berries do not fit the botanical definition (for example, raspberries and strawberries), while fruits that are berries botanically (for example, bananas and grapes) are classified elsewhere. Berries may be eaten plain or used in everything from bread to soup and sorbet. They make especially fine jams and compotes.

Berries must be fully ripened on the vine, as they will not ripen further after harvesting. Select berries that are plump and fully colored. Avoid juice-stained containers and berries with whitish-gray or black spots of mold. All berries should be refrigerated and used promptly. Do not wash berries until just before they are needed, as washing removes some of their aromas and softens them.

Blackberries

Blackberries are similar to raspberries, but are larger and shinier, with a deep purple to black color. Thorny blackberry vines are readily found in the wild; commercial production is limited. Their peak season is mid-June through August. Loganberries, Marionberries, olallie berries and boysenberries are blackberry hybrids.



Blueberries

Blueberries are small and firm, with a true blue to almost black skin and a juicy, light gray-blue interior. Cultivated berries (high-bush varieties) tend to be larger than wild (low-bush) ones. Blueberries are native to North America and are grown commercially from Maine to Oregon and along the Atlantic seaboard. Their peak season is short, from mid-June to mid-August.



Cranberries

Cranberries, another native North American food, are tart, firm fruit with a mottled reel skin. They grow on low vines in cultivated bogs (swamps) throughout Massachusetts, Wisconsin, and New Jersey. Rarely eaten raw, they are made into sauce or relish or are used in breads, pies, or pastries. Cranberries are readily available frozen or made into a jelly-type sauce and canned. Although color does not indicate ripeness, cranberries should be picked over before cooking to remove those that are soft or bruised. Their peak harvesting season is from Labor Day through October, leading to the association of cranberries with Thanksgiving dinner.



Currants

Currants are tiny, tart fruits that grow on shrubs in grapelike clusters. The most common are a beautiful, almost translucent red, but black and golden (or white) varieties also exist. All varieties are used for jams, jellies and sauces, and black currants are made into a liqueur, crème de cassis. Although rarely grown in the United States, currants are very popular and widely available in Europe, with a peak season during the late summer. (The dried fruits called currants are not produced from these berries; they are a special variety of dried grapes.)



Raspberries

Raspberries are perhaps the most delicate of all fruits. They have a tart flavor and velvety texture. Red raspberries are the most common, with black, purple and gold en berries available in some markets. When ripe, the berry pulls away easily from its white core, leaving the characteristic hollow center. Because they can be easily crushed and are susceptible to mold, most of the raspberries grown are marketed frozen. They grow on thorny vines in cool climates from Washington State to western New York and are imported from New Zealand and South America. The peak domestic season is from late May through November.



Strawberries

Strawberries are brilliant red, heart-shaped fruits that grow on vines. The strawberry plant is actually a perennial herb; the berry's flesh is covered by tiny black seeds called achenes, which are the plant's true fruits.

Select berries with a good red color and intact green leafy hull. (The hulls can be easily removed with a paring knife.) Avoid berries with soft or brown spots. Huge berries may be lovely to look at, but they often have hollow centers and little flavor or juice. Although strawberries are available to some extent all year, fresh California strawberries are at their peak from April through June.



Citrus:

Citrus fruits include lemons, limes, grapefruits, tangerines, kumquats, oranges and several hybrids. They are characterized by a thick rind, most of which is a bitter white pith (albedo) with a thin exterior layer of co lore d skin known as the zest. Their flesh is segmented and juicy. Citrus fruits are acidic, with a strong aroma; their flavors vary from bitter to tart to sweet.

Citrus fruits grow on trees and shrubs in tropical and subtropical climates worldwide. All citrus fruits are fully ripened on the tree and will not ripen further after harvesting. They should be refrigerated for longest storage. Select fruits that feel heavy and have thin, smooth skins. Avoid those with large blemishes or moist spots.

Grapefruits

Grapefruits are large and round with yellow skin, thick rind, and tart flesh. They are an 18th-century hybrid of the orange and pummelo (a large, coarse fruit used mostly in Middle and Far Eastern cuisines). Two varieties of grape fruit are widely available all year: white-fleshed and pink- or ruby-fleshed. White grapefruits produce the finest juice, although pink grapefruits are sweeter.



Kumquats

Kumquats are very small, oval-shaped, orange-colored fruits with a soft, sweet skin and slightly bitter flesh. They can be eaten whole, either raw or preserved in syrup, and may be used in jams and preserves.



Lemons

The most commonly used citrus fruits, lemons, are oval-shaped, bright yellow fruits available all year. Their strongly acidic flavor makes them unpleasant to eat raw but perfect for flavoring desserts and confections. Lemon juice is also widely used in sauces, especially for fish, shellfish and poultry. Lemon zest is candied, or used as garnish. Rubbing the skin of a lemon or other citrus fruit with a sugar cube extracts much of the aromatic oil. The cube can then be crushed or dissolved to use in formulas calling for citrus flavor.



Limes

Limes are small fruits with thin skins ranging from yellow-green to dark green. Limes are too tart to eat raw and are often substituted for lemons in prepared dishes. They are also juice d or used in cocktails, curries or desserts. Lime zest can be grated and used to give color and flavor to a variety of dishes. Limes are available all year; their peak season is during the summer. The key lime is a small tart lime variety native to South Florida and used to make key lime pie.



Oranges

Oranges are round fruits with a juicy, orange –colored flesh and a thin, orange skin. They can be either sweet or bitter.

Valencia oranges and navel oranges (a seed less variety) are the most popular sweet oranges. They can be juiced for beverages or sauces, and the flesh may be eaten raw, added to salads, cooked in desserts or use d as a garnish. The zest may be grated or julienned for sauces or garnish. Sweet oranges are available all year; their peak season is from December to April.



Blood Oranges

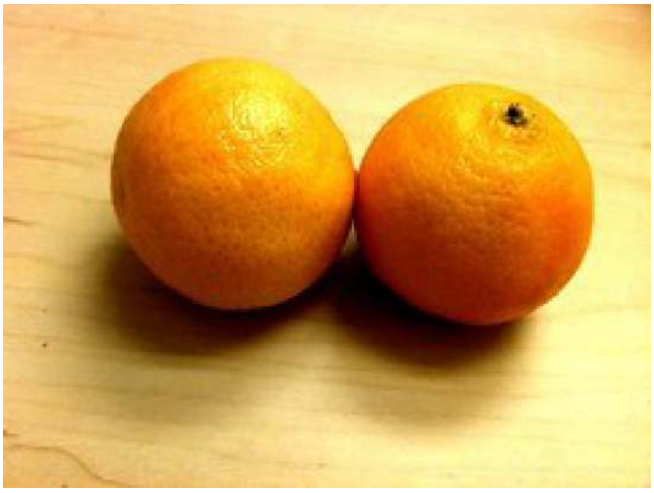
Blood oranges are also sweet but are small, with a rough, reddish skin. Their flesh is streaked with a blood-red color. Blood oranges are available primarily during the winter months and are eaten raw, juiced or used in salads or sauces. When selecting sweet oranges, look for fruits that feel plump and heavy, with unblemished skin. The color of the skin depends on weather conditions; a green rind does not affect the flavor of the flesh.

Bitter oranges include the Seville and bergamot. They are used primarily for the essential oils found in their zest. Oil of bergamot gives Earl Grey tea its distinctive flavor; oil of Seville is essential to curacao, Grand Marnier and orange flower water. Seville oranges are also used in marmalades and sauces for meats and poultry.



Tangerines

Tangerines, sometimes referred to as mandarins, are small and dark orange. Their rind is loose and easily removed to reveal sweet, juicy, aromatic segments. Tangerines are most often eaten fresh and uncooked, but are available canned as mandarin oranges. Tangelos are a hybrid of tangerines and grapefruits. They are the size of a medium orange; they have a bulbous stem end and few to no seeds.



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12.3.2: Exotics and Grapes

Exotics

Improved transportation has led to the increasing availability (although sporadic in some areas) of exotic or unusual fresh fruits such as:

- Figs
- Persimmons
- Pomegranates
- Prickly pears
- Rhubarb
- Star fruits

Other exotic fruits, such as breadfruit, durian, feijoa and loquat, are still available only on a limited basis from specialty purveyors.

Figs

Figs are the fruit of ficus trees. They are small, soft, pear-shaped fruits with an intensely sweet flavor and rich, moist texture made crunchy by a multitude of tiny seeds. Fresh figs can be sliced and served in salads or with cured meats such as prosciutto. They can also be baked, poached, or used in jams, preserves, or compotes.

Dark-skinned figs, known as Mission figs, are a variety planted at Pacific Coast missions during the 18th century. They have a thin skin and small seeds and are available fresh, canned or dried. The white-skinned figs grown commercially include the White Adriatic, used principally for drying and baking, and the all-purpose Kadota. The most important domestic variety, however, is the Calimyrna. These large figs have a rich yellow color and large nutty seeds. Fresh Calimyrna figs are the finest for eating out of hand; they are also available dried.

For the best flavor, figs should be fully ripened on the tree. Unfortunately, fully ripened figs are very delicate and difficult to transport. Most figs are in season from June through October; fresh Calimyrna figs are available only during June.



Gooseberries

Several varieties of gooseberry are cultivated for culinary purposes. One well-known variety is the European gooseberry, a member of the currant family that grows on spiny bushes in cool, moist regions of the Northern Hemisphere. Its berries can be relatively large, like a small plum, but are usually less than 1 inch (2.5 centimeters) in diameter. The skin, which is firm and smooth or only slightly hairy, can be green, white (actually gray-green), yellow or red. The tart berries contain many tiny seeds. They are eaten fresh or used for jellies, preserves, tarts and other desserts or as a traditional accompaniment to rich or fatty dishes, such as goose and mackerel. North American gooseberry varieties are smaller, perfectly round, and pink to deep red at maturity. Although more prolific, these varietals lack flavor and are generally considered inferior to European gooseberries.

Cape gooseberries, also known as ‘physalis’, ground cherries and ‘poha’, are unrelated to European and American gooseberries. Native to Peru, they became popular during the 19th century along the African Cape of Good Hope, for which they are named. Australia and New Zealand are currently the largest producers. Cape gooseberries are covered with a paper-thin husk or calyx. About the size of a cherry, they have a waxy, bright orange skin and many tiny seeds. Their flavor is similar to coconut and oranges, but tarter. Cape gooseberries may be eaten raw, made into jam or used in desserts. Fresh, they make an especially striking garnish.



Guava

Guava are a small, oval or pear-shaped fruit with a strong fragrance and a mild, slightly grainy flesh. They are excellent in jams and preserves, and guava juice is available plain or blended with other tropical fruit juices. Guava paste, a thick, sliceable gel, is a popular treat throughout Central America and the Caribbean. Guava will ripen if stored at room temperature and should be slightly soft and fully ripened for the best flavor.



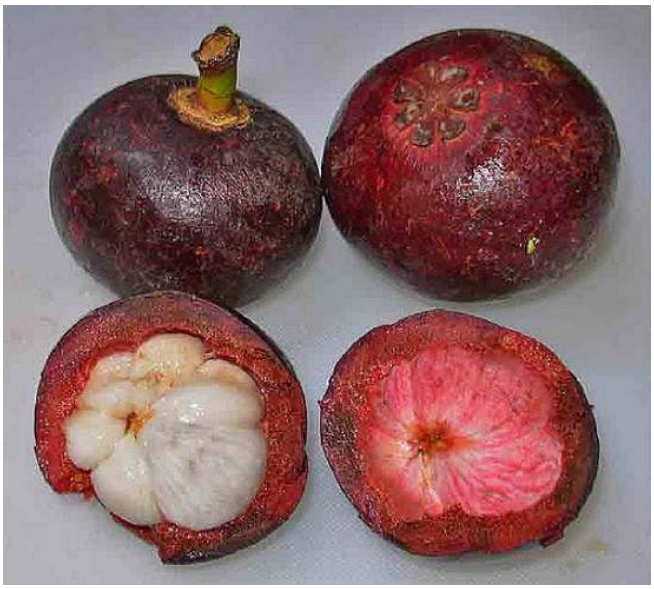
Lychees

The lychee, also spelled litchi or leechee, is the fruit of a large tree native to southern China and Southeast Asia. The fruits, which grow in clusters, are oval to round, red and about 1 inch (2.5 centimeters) in diameter. The tough outer skin encloses juicy, white, almost translucent flesh and one large seed. Neither the skin nor the seed are edible. The fruit travels well and is now cultivated in Florida and Hawaii, so supplies are relatively stable. Lychees are eaten fresh out of hand or juiced, and are widely available canned or dried. Fresh lychees are mild but sweet with a pleasant aroma.



Mangosteens

The mangosteen, another native of Southeast Asia, is cultivated in Java, Sumatra and the Philippines. Mangosteens (no relation to mangos) are the size of a small orange, with flattened ends. They have a thick, hard, deep reddish-purple rind with hard white petal-shaped protrusions at the stem end. The interior flesh is snow-white and segmented, looking something like a mandarin orange. The texture is juicy and delicate with a slightly astringent flavor. Because the fruit must ripen on the tree and keeps only a short time. Mangosteens are usually eaten fresh, although canned fruit and mangosteen juice is available.



Persimmons

Persimmons, sometimes referred to as kaki or Sharon fruits, are a bright orange, acorn-shaped fruit with a glossy skin and a large papery blossom. The flesh is bright orange and jelly-like, with a mild but rich flavor similar to honey and plums. Persimmons should be peeled before use; any seeds should be discarded. Select bright orange fruits and refrigerate only after they are completely ripe. When ripe, persimmons will be very soft and the skin will have an almost translucent appearance.

Ripe persimmons are delicious eaten raw; halved and topped with cream or soft cheese; or peeled, sliced and added to fruit salads. Persimmon bread, muffins, cakes and pies are also popular. Under-ripe persimmons are almost inedible, however. They are strongly tannic with a chalky or cottony texture.

Persimmons are tree fruits grown in subtropical areas worldwide, although the Asian varieties- now grown in California-are the most common. Fresh persimmons are available from October through January.



Pomegranates

An ancient fruit native to Persia (now Iran), pomegranates have long been a subject of poetry and a symbol of fertility. Pomegranates are round, about the size of a large orange, with a pronounced calyx. The skin forms a hard shell with a pinkish-red color. The interior is filled with hundreds of small, red seeds (which are, botanically, the actual fruits) surrounded by juicy reel pulp. An inedible yellow membrane separates the seeds into compartments. Pomegranates are sweet-sour, and the seeds are pleasantly crunchy. The bright red seeds make an attractive garnish. Pomegranate juice is a popular beverage in Mediterranean cuisines, and grenadine syrup is made from concentrated pomegranate juice.

Select heavy fruits that are not rock-hard, cracked, or heavily bruised. Whole pomegranates can be refrigerated for several weeks. Pomegranates are available from September through December; their peak season is in October.



Prickly Pears

Prickly pear fruits, also known as cactus pears and Barbary figs, are actually the berries of several varieties of cactus. They are barrel- or pear-shaped, about the size of a large egg. Their thick, firm skin is green or purple with small sharp pins and nearly invisible stinging fibers. Their flesh is spongy, sweet and a brilliant pink-red, dotted with small black seeds. Prickly pears have the aroma of watermelon and the flavor of sugar water.

Once peeled, prickly pears can be diced and eaten raw, or they can be pureed for making jams, sauces, custards or sorbets, to which they give a vivid pink color. Prickly pears are especially common in Mexican and southwestern cuisines.

Select fruits that are full-colored, heavy and tender, but not too soft. Avoid those with mushy or bruised spots. Ripe prickly pears can be refrigerated for a week or more. Prickly pears are grown in Mexico and several southwestern states and are available from September through December.



Rambutans

Rambutans, the fruit of a tree in the soapberry family, are closely related to lychees. Native to Malaysia, they are now cultivated throughout Southeast Asia. The bright red, oval fruit is about the size of a small hen's egg, and is covered with long, soft spines, hence the name "hairy" lychees. The interior has a white, lightly acidic pulp. Rambutans darken with age, so select brightly colored fruit with soft, fleshy spines. Rambutans are eaten fresh, used in preserves, and ice cream; they are also available canned.



Rhubarb

Although botanically a vegetable, rhubarb is most often prepared as a fruit. A perennial plant, rhubarb grows well in temperate and cold climates. Only the pinkish-red stems are edible; the leaves contain high amounts of oxalic acid, which is toxic.

Rhubarb stems are extremely acidic, requiring large amounts of sugar to create the desired sweet-sour taste. Cinnamon, ginger, orange and strawberry are particularly compatible with rhubarb. It is excellent for pies, cobblers, preserves, or stewing. Young, tender stalks of rhubarb do not need peeling. When cooked, rhubarb becomes very soft and turns a beautiful light pink color.

Fresh rhubarb is sold as whole stalks, with the leaves removed. Select crisp, unblemished stalks. Rhubarb's peak season is during the early spring, from February through May. Frozen rhubarb pieces are readily available and are excellent for pies, tarts or jams.



Star Fruit

Star fruits, also known as carambola, are oval, up to 5 inches (12.5 centimeters) long, with five prominent ribs or wings running their length. A cross-section cut is shaped like a star. The edible skin is a waxy orange-yellow; it covers a dry, paler yellow flesh. Its flavor is similar to that of plums, sweet but bland. Star fruits do not need to be peeled or seeded. They are most often sliced and added to fruit salad or used as a garnish. Unripe fruits can be cooked in stews or chutneys.

Color and aroma are the best indicators of ripeness. The fruits should be a deep golden-yellow and there should be brown along the edge of the ribs. The aroma should be full and floral. Green fruits can be kept at room temperature to ripen, then refrigerated for up to 2 weeks. Star fruits are cultivated in Hawaii, Florida and California, though some are still imported from the Caribbean. Fresh fruits are available from August to February.



Grapes

Grapes are the single largest fruit crop in the world, due, of course, to their use in wine making. This section, however, discusses only table grapes, those grown for eating. Grapes are berries that grow on vines in large clusters. California is the world's largest producer, with more than a dozen varieties grown for table use. Grapes are classified by color as white (which are actually green) or black (which are actually reel). White grapes are generally blander than black ones, with a thinner skin and firmer flesh. The grape's color and most of its flavor are found in the skin. Grapes are usually eaten raw, either alone or in fruit salads. They are also used as a garnish or accompaniment to desserts and cheeses. Dried grapes are known as raisins; usually made from Thompson Seedless or Muscat grapes), currants (made from Black Corinth grapes and labeled Zante currants) or sultana s (made from sultana grapes).

Grapes are available all year because the many varieties have different harvesting schedules. Look for firm, unblemished fruits that are firmly attached to the stem. A surface bloom or dusty appearance is caused by yeasts and indicates recent harvesting. Wrinkled grapes or those with brown spots around the stem are past their prime. All grapes should be rinsed and drained prior to use.

Red Flame Grapes

Red Flame grapes are a seed less California hybrid, second only in importance to the Thompson Seedless. Red Flame grapes are large and round with a slightly tart flavor and variegated red color.

Thompson Seedless Grapes

The most commercially important table grapes are a variety known as Thompson Seedless, which are pale green with a crisp texture and sweet flavor. Their peak season is from June to November. Many are dried in the hot desert sun of California's San Joaquin Valley to produce dark raisins. For golden raisins, Thompson Seedless grapes are treated with sulfur dioxide to prevent browning, and then dried mechanically.

Other Table Grapes

Of the table grapes containing seeds, the most important varieties are the Concord, Ribier and Emperor. They range from light red to deep black, and all three are in season during the autumn. Concord grapes, one of the few grape varieties native to the New World, are especially important for making juices and jellies.

Virtually all the fine wine made in the world comes from varieties of a single grape species, Vitis vinifera. It is grown in the United States, Europe, South Africa, South America, the Middle East, Australia, and wherever fine wine is made.

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12.3.3: Melons and Pomes

Melons

Like pumpkins and cucumbers, melons are members of the gourd family (Cucurbitaceae). The dozens of melon varieties can be divided into two general types: sweet (or dessert) melons and watermelons. Sweet melons have a tan, green or yellow netted or furrowed rind and dense, fragrant flesh. Watermelon has a thick, dark green rind surrounding crisp, watery flesh.



Melons are almost 90 percent water, so cooking destroys their texture, quickly turning the flesh to mush. Most are served simply sliced, perhaps with a bit of lemon or lime juice. Melons also blend well in fruit salads or with rich, cured meats such as prosciutto. Melons may be pureed and made into sorbet or chilled, uncooked soup.

Melons should be vine-ripened. A ripe melon should yield slightly and spring back when pressed at the blossom end (opposite the stem). It should also give off a strong aroma. Avoid melons that are very soft or feel damp at the stem end. Ripe melons may be stored in the refrigerator, although the flavor will be better at room temperature. Slightly under-ripe melons can be stored at room temperature to allow flavor and aroma to develop.

Cantaloupes

American cantaloupes, which are actually muskmelons, are sweet melons with a thick, yellow-green netted rind, a sweet, moist, orange flesh and a strong aroma. (European cantaloupes, which are not generally available in this country, are more craggy and furrowed in appearance.) As with all sweet melons, the many small seeds are found in a central cavity. Cantaloupes are excellent for eating alone and are especially good with ham or rich meats.

Avoid cantaloupes with the pronounced yellow color or moldy aroma that indicates over-ripeness. Mexican imports ensure a year-round supply, although their peak season is summer.



Casaba Melons

The casaba melon is a teardrop-shaped sweet melon. It has a coarse, yellow skin and a thick, ridged rind; its flesh is creamy white to yellow. Casaba melons are used like cantaloupes. Casaba melons do not have an aroma, so selection must be based on a deep skin color and the absence of dark or moist patches. Their peak season is during September and October.

Crenshaw Melons

Crenshaw (or cranshaw) melons have a mottled, green-yellow ridged rind and orange-pink flesh. They are large pear-shaped sweet melons with a strong aroma. The flesh has a rich, spicy flavor and may be used like cantaloupe. Crenshaws are available from July through October; their peak season is during August and September.

Honeydew Melons

Honeydew melons are large oval sweet melons with a smooth rind that ranges from white to pale green. Although the flesh is generally pale green, with a mild, sweet flavor, pink-or gold-fleshed honeydews are also available. Like casaba melons, honeydew melons have little to no aroma. They are available almost all year; their peak season is from June through October.

Santa Claus Melons

Santa Claus or Christmas melons are large, elongated sweet melons with a green-and-yellow-striped, smooth rind. The flesh is creamy white or yellow and tastes like casaba. They are a winter variety, with peak availability during December, which explains the name.

Watermelons

Watermelons are large (up to 30 pounds or 13.5 kilograms) round or oval-shaped melons with a thick rind. The skin may be solid green, green-striped or mottled with white. The flesh is crisp and extremely juicy with small, hard, black seeds throughout. Seedless hybrids are available. Most watermelons have pink to reel flesh, although golden-fleshed varieties are becoming more common. Watermelons are of a different genus from the sweet melons described earlier. They are native to tropical Africa but grow commercially in Texas and several southern states.



Pomes

Pomes are tree fruits with thin skin and firm flesh surrounding a central core containing many small seeds called pips or carpels. Pomes include apples, pears and quince.

Apples

Apples, perhaps the most common and commonly appreciated of all fruits, grow on trees in temperate zones worldwide. They are popular because of their convenience, flavor, variety and availability.

Apples can be eaten raw out of hand, or they can be used in a wide variety of cooked or baked dishes. They are equally useful in breads, desserts or vegetable dishes and go well with game, pork and poultry. Classic dishes prepared with apples are often referred

to as a la Normande. Apple juice (cider) produces alcoholic and nonalcoholic beverages and cider vinegar.

Of the hundreds of known apple varieties, only 20 or so are commercially significant in the United States. Most have a moist, creamy white flesh with a thin skin of yellow, green or red. They range in flavor from very sweet to very tart, with an equally broad range of textures, from firm and crisp to soft and mealy.

In Europe, apples are divided into distinct cooking and eating varieties. Cooking varieties are those that disintegrate to a puree when cooked. American varieties are less rigidly classified. Nevertheless, not all apples are appropriate for all types of cooking. Those that retain their shape better during cooking are the best choices when slices or appearances are important. Varieties with a higher malic acid content break down easily, malting them more appropriate for applesauce or juicing. Either type may be eaten out of hand, depending on personal preference.



Varieties of Apples

Variety	Skin Color	Flavor	Peak Season	Use
Fiji	Yellow-green with red highlights	Sweet-spicy	All year	Eating, in salads
Gala	Yellow-orange with red stripes	Sweet	August - March	Eating, in salads, sauce
Golden Delicious	Glossy, greenish-gold	Sweet	September - October	In tarts, with cheese, in salads
Granny Smith	Bright green	Tart	October - November	Eating, in tarts
Jonathan	Brilliant red	Tart to acidic	September - October	Eating, all-purpose
McIntosh	Red with green background	Tart to acidic	Fall	Applesauce, in closed pies
Pippin (Newton)	Greenish-yellow	Tart	Fall	In pies, eating, baking
Red Delicious	Deep red	Sweet but bland	September - October	Eating
Rome	Red	Sweet-tart	October - November	Baking, pies, sauces
Winesap	Dark red with streaks	Tangy	October - November	Cider, all-purpose

Although not native to North America, apples are now grown commercially in 35 states, with Washington and New York leading in production. Apples are harvested when still slightly under-ripe, then stored in a controlled atmosphere (temperature and oxygen are greatly reduced) for extended periods until ready for sale. Modern storage techniques make fresh apples available all year, although their peak season is during the autumn.

When selecting apples, look for smooth, unbroken skins and firm fruits, without soft spots or bruises. Badly bruised or rotting apples should be discarded immediately. They emit quantities of ethylene gas that speed spoilage of nearby fruits. (Remember the saying that "one bad apple spoils the barrel.") Store apples chilled for up to 6 weeks. Apple peels (the skin) may be eaten or removed as desired, but in either case, apples should be washed just prior to use to remove pesticides and any wax that was applied to improve appearance. Apple slices can be frozen (often with sugar or citric acid added to slow spoilage) or dried.

Pears

Pears are an ancient tree fruit grown in temperate areas throughout the world. Most of the pears marketed in the United States are grown in California, Washington and Oregon.



Pear Varieties

Variety	Appearance	Flavor	Peak Season	Use
Anjou (Beurre d'Anjou)	Greenish-yellow skin; egg- shaped with short neck; red variety also available	Sweet and juicy	October - May	Eating, poaching
Bartlett (Williams)	Thin yellow skin; bell-shaped; red variety also available	Very sweet, buttery, juicy	August - December	Eating, canning, in salads
Bose	Golden-brown skin; long tapered neck	Buttery	September - May	Poaching, baking
Cornice	Yellow-green skin; large and chubby	Sweet, juicy	October - February	Eating
Sekel	Tiny; brown to yellow skin	Spicy	August - December	Poaching, pickling

Although thousands of pear varieties have been identified, only a dozen or so are commercially significant. Pear varieties vary widely in size, color and flavor. They are generally eaten out of hand, baked, or poached. Pears are delicious with cheese, especially blue cheeses, and can be used in fruit salads, compotes or preserves. When selecting pears, look for fruits with smooth, unbroken skin and an intact stem.

Asian pears, also known as Chinese pears or apple-pears, are of a different species than common pears. They have the moist, sweet flavor of a pear and the round shape and crisp texture of an apple. They are becoming increasingly popular in the United States, particularly those known as Twentieth Century or Nijisseiki.

Pears will not ripen properly on the tree, so they are picked while still firm and should be allowed to soften before use. Under-ripe pears may be left at room temperature to ripen. A properly ripened pear should have a good fragrance and yield to gentle pressure at

the stem end. Pears can be prepared or stored in the same ways as apples.

Quince

Common quince resemble large, lumpy yellow pears. Their flesh is hard, with many pips or seeds, and they have a wonderful fragrance. While too astringent to eat raw, quince develop a sweet flavor and pink color when cooked with sugar. Quince are used in meat stews, jellies, marmalades and pies. They have a high pectin content and may be added to other fruit jams or preserves to encourage gelling.

Fresh quince, usually imported from South America or southeast Europe, are available from October through January. Select firm fruits with a good yellow color. Small blemishes may be cut away before cooking. Quince will keep for up to a month under refrigeration.



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12.3.4: Stone Fruits and Tropical Varieties

Stone Fruits

Stone fruits, also known as drupes, include apricots, cherries, nectarines, peaches and plums. They are characterized by a thin skin, soft flesh and one woody stone or pit. Although most originated in China, the shrubs and trees producing stone fruits are now grown in temperate climates worldwide.

The domestic varieties of stone fruits are in season from late spring through summer. They tend to be fragile fruits, easily bruised and difficult to transport, and have a short shelf life. Do not wash them until ready to use, as moisture can cause deterioration. Stone fruits are excellent dried and are often used to make liqueurs and brandies. (The kernel inside the pits of many stone fruits contains amygdalin, a compound that has a bitter almond flavor. Eating the raw kernel can cause digestive discomfort or more serious side effects and should be avoided. When cooked it is harmless and can add flavor to jams and creams.)

Apricots

Apricots are small, round stone fruits with a velvety skin that varies from deep yellow to vivid orange. Their juicy orange flesh surrounds a dark, almond-shaped pit. Apricots can be eaten out of hand, poached, stewed, baked or candied. They are often used in fruit compotes or savory sauces for meat or poultry, and are also popular in quick breads and fruit tarts or pureed for dessert sauces, jams, custards or mousses.

Apricots have a short season, peaking during June and July, and do not travel well. Select apricots that are well shaped, plump and firm. Avoid ones that are greenish-yellow or mushy. Fresh apricots will last for several days under refrigeration, but the flavor is best at room temperature. If fresh fruits are unavailable, canned apricots are usually an acceptable substitute. Dried apricots and apricot juice (known as nectar) are readily available.

From the northern states, particularly Washington, Oregon, Michigan and New York, come the two most important types of cherry: the sweet cherry and the sour (or tart) cherry. Sweet cherries are round to heart-shaped, about 1 inch (2.5 centimeters) in diameter, with skin that ranges from yellow to deep red to nearly black. The flesh, which is sweet and juicy, may vary from yellow to dark red. The most common and popular sweet cherries are the dark red Bings. Yellow-red Royal Ann and Rainier cherries are also available in some areas.

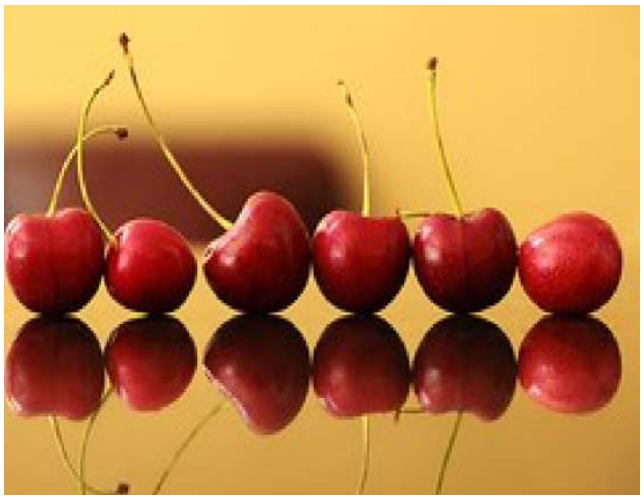


Cherries

Sweet cherries are often marketed fresh, made into maraschino cherries or candied for use in baked goods. Fresh sweet cherries have a very short season, peaking during June and July. Cherries will not ripen further after harvesting. Select fruits that are firm and plump with a green stem still attached. There should not be any brown spots around the stem. A dry or brown stem indicates that the cherry is less than fresh. Once the stem is removed, the cherry will deteriorate rapidly. Store fresh cherries in the refrigerator and do not wash them until ready to use.

Sour cherries are light to dark reel and are so acidic they are rarely eaten uncooked. The most common sour cherries are the Montmorency and Morello. Most sour cherries are canned or frozen, or cooked with sugar and starch (usually cornstarch or tapioca) and sold as prepared pastry and pie fillings.

Both sweet and sour varieties are available dried.



Peaches and Nectarines

Peaches are moderate-sized, round fruits with a juicy, sweet flesh. Nectarines are a variety of peach, the main difference between the two being their skin. Peaches have a thin skin covered with fuzz, while nectarines have a thin, smooth skin. The flesh of either fruit ranges from white to pale orange. Although their flavors are somewhat different, they may be substituted for each other in most recipes.

Peaches and nectarines are excellent for eating out of hand or in dessert tarts or pastries. They are also used in jams, chutneys, preserves and savory relishes, having a particular affinity for Asian and Indian dishes. Although the skin is edible, peaches are generally peeled before use. (Peaches peel easily if blanched first.)

Peaches and nectarines are either freestones or clingstones. With freestones, the flesh separates easily from the stone; free stone fruits are commonly eaten out of hand. The flesh of clingstones adheres firmly to the stone; they hold their shape better when cooked and are the type most often canned.

Select fruits with a good aroma; an overall creamy, yellow or yellow-orange color; and an unwrinkled skin free of blemishes. Red patches are not an indication of ripeness; a green skin indicates that the fruit was picked too early and it will not ripen further. Peaches and nectarines will soften but do not become sweeter after harvesting.

The United States, especially California, is the world's largest producer of peaches and nectarines. Their peak season is through the summer months, with July and August producing the best crop. South American peaches are sometimes available from January to May. Canned and frozen peaches are readily available.



Plums

Plums are round to oval-shaped fruits that grow on trees or bushes. Dozens of plum varieties are known, although only a few are commercially significant. Plums vary in size from very small to 3 inches (7.5 centimeters) in diameter. Their thin skin can be green, red, yellow or various shades of blue-purple.

Plums are excellent for eating out of hand. Plums can also be baked, poached or used in pies, cobblers or tarts; they are often used in jams or preserves, and fresh slices can be used in salads or compotes.

Fresh plums are widely available from June through October; their peak season is in August and September. When selecting plums, look for plump, smooth fruits with unblemished skin. Generally, they should yield to gentle pressure, although the green and yellow varieties remain quite firm. Avoid plums with moist, brown spots near the stem. Plums may be left at room temperature to ripen, and then stored in the refrigerator.



Tropicals

Tropical fruits are native to the world's hot, tropical or subtropical regions. Most are now readily available throughout the United States thanks to rapid transportation and distribution methods. All can be eaten fresh, without cooking. Their flavors complement each other and go well with rich or spicy meat, fish and poultry dishes.

Bananas

Common yellow bananas are actually the berries of a large tropical herb. Grown in bunches called hands, they are about 7 to 9 inches (17.5 to 22.5 centimeters) long, with a sticky, soft, sweet flesh. Their inedible yellow skin is easily removed. Baby bananas (Nino, Ladyfinger or Finger Bananas) measure 4 to 5 inches long (10 to 12.5 centimeters) with yellow or red skin. Their flesh is more dense and sweeter than larger banana varieties and their diminutive size makes them ideal for many dessert applications.

Properly ripened bananas are excellent eaten out of hand or used in salads. Lightly bruised or over-ripe fruits are best used for breads or muffins. Bananas blend well with other tropical fruits and citrus. Their unique flavor is also complemented by cherry, cinnamon, ginger, honey, and chocolate.

Fresh bananas are available all year. Bananas are always harvested when still green, because the texture and flavor will be adversely affected if the fruits are allowed to turn yellow on the tree. Unripe bananas are hard, dry and starchy. Because bananas ripen after harvesting, it is acceptable to purchase green bananas if there is sufficient time for final ripening before use. Bananas should be left at room temperature to ripen. A properly ripened banana has a yellow peel with brown flecks. The tip should not have any remaining green coloring. As bananas continue to age, the peel darkens and the starches turn to sugar, giving the fruits a sweeter flavor. Avoid bananas that have large brown bruises or a gray cast (a sign of cold damage).



Plantains

Plantains, also referred to as cooking bananas, are larger than but not as sweet as common bananas. They are frequently cooked as a starchy vegetable in tropical cuisines.



Dates

Dates are the fruit of the date palm tree, which has been cultivated since ancient times. Dates are about 1 to 2 inches (2.5 to 5 centimeters) long, with a paper-thin skin and a single grooved seed in the center. Most are golden to dark brown when ripe.

Although dates appear to be dried, they are actually fresh fruits. They have a sticky-sweet, almost candied texture and rich flavor. Dates provide flavor and moisture for breads, muffins, cookies and tarts. Additionally, they can be served with fresh or dried fruits, or stuffed with meat or cheese as an appetizer.

Pitted dates are readily available in several packaged forms: whole, chopped, or extruded (for use in baking). Whole un-pitted dates are available in bulk. Date juice is also available for use as a natural sweetener, especially in baked goods. Although packaged or processed dates are available all year, peak season for fresh domestic dates is from October through December. When selecting dates, look for those that are plump, glossy and moist.



Kiwis

Kiwis, sometimes known as kiwifruits or Chinese gooseberries, are small oval fruits, about the size of a large egg, with a thin, fuzzy brown skin. The flesh is bright green with a white core surrounded by hundreds of tiny black seeds.

Kiwis are sweet, but somewhat bland. They are best used raw, peeled and eaten out of hand or sliced for fruit salads or garnish. Although kiwis are not recommended for cooking because heat causes them to fall apart, they are a perfect addition to glazed fruit tarts and can be pureed for sorbets, sauces or mousses. Kiwis contain an enzyme similar to that in fresh pineapple and papaya, which has a tenderizing effect on meat and prevents gelling.



Mangoes

Mangoes are oval or kidney-shaped fruits that normally weigh between 6 ounces and 1 pound (180 and 500 grams). Their skin is smooth and thin but tough, varying from yellow to orange-red, with patches of green, reel or purple. As mangoes ripen, the green disappears. The juicy, bright orange flesh clings to a large, flat pit.

A mango's unique flavor is spicy-sweet, with an acidic tang. Mangoes can be pureed for use in drinks or sauces, or the flesh can be sliced or cubed for use in salads, pickles, chutneys or desserts. Mangoes go well with spicy foods such as curry and with barbecued meats.

Although Florida produces some mangoes, most of those available in the United States are from Mexico. Their peak season is from May through August. Select fruits with good color that are firm and free of blemishes. Ripe mangoes should have a good aroma, and should not be too soft or shriveled. Allow mangoes to ripen completely at room temperature, then refrigerate for up to 1 week. Ripe mangoes should have a good aroma, and should not be too soft or shriveled. Allow mangoes to ripen completely at room temperature, then refrigerate for up to one week.



Papayas

The papaya is a greenish-yellow fruit shaped rather like a large pear and weighing 1 to 2 pounds (500 to 1000 grams). When halved, it resembles a melon. The flesh is golden to red dish-pink; its center cavity is filled with round, silver-black seeds resembling caviar. Ripe papayas can be eaten raw, with only a squirt of lemon or lime juice. They can also be pureed for sweet or spicy sauces, chilled soups or sorbets.

Papayas contain papain, which breaks down proteins, and therefore papayas are an excellent meat tenderizer. Meats can be marinated with papaya juice or slices before cooking. Papain, however, makes fresh papayas unsuitable for use in gelatins because it inhibits gelling. Unripe (green) papayas are often used in pickles, or chutneys, and can be baked, or stewed, with meat or poultry.

Papaya seeds are edible, with a peppery flavor and slight crunch. They are occasionally used to garnish fruit salads or add flavor to fruit salsa s and compotes. Papayas are grown in tropical and sub-tropical areas worldwide. Although they are available year-round, their peak season is from April through June. Select papayas that are plump, with a smooth, unblemished skin. Color is a better determinant of ripeness than is softness: The greater the proportion of yellow to green skin color, the riper the fruit. Papayas may be held at room temperature until completely ripe, then refrigerated for up to 1 week.



Passion Fruits

Passion fruits have a firm, almost shell-like purple skin with orange -yellow pulp surrounding large, black, edible seeds. They are about the size and shape of large hen eggs, with a sweet, rich and unmistakable citrusy flavor. The pulp is used in custards, sauces and ice creams.

Select heavy fruits with dark, shriveled skin and a strong aroma. Allow them to ripen at room temperature, if necessary, then refrigerate. Passion fruits are now grown in New Zealand, Hawaii and California and should be available all year, although their peak season is in February and March. Bottles or frozen packs of puree are readily available and provide a strong, true flavor.



Pineapples

Pineapples are the fruit of a shrub with sharp spear -shaped leaves. Each fruit is covered with rough, brown eyes, giving it the appearance of a pinecone. The pale yellow flesh, which is sweet and very juicy, surrounds a cylindrical woody core that is edible but too tough for most uses. Most pineapples weigh approximately 2 pounds (1 kilogram), but dwarf varieties are also available.

Pineapples are excellent eaten raw, alone or in salads. Slices can be baked or grilled to accompany pork, or ham. The cuisines of Southeast Asia incorporate pineapple into various curries, soups and stews. Pineapple juice is a popular beverage often used in punch or cocktails. Canned or cooked pineapple can be added to gelatin mixtures, but avoid using fresh pineapple; an enzyme (bromelin) found in fresh pineapple breaks down gelatin.

Pineapples do not ripen after harvesting. They must be left on the stem until completely ripe, at which time they are extremely perishable. The vast majority of pineapples come from Hawaii. Fresh pineapples are available all year, with peak supplies in March through June. Select heavy fruits with a strong, sweet aroma and rich color. Avoid those with dried leaves or soft spots. Pineapples should be used as soon as possible after purchase. Pineapples are also available canned in slices, cubes or crushed, dried or candied.



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12.4: Fruits and Vegetables for the Marketplace

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12.4.1: Selecting, Purchasing, Storing and Preparing Fruits

Selecting Fresh Fruits

Fresh fruits have not been subjected to any processing (such as canning, freezing or drying). Fresh fruits may be ripe or unripe, depending on their condition when harvested or the conditions under which they have been stored. In order to use fresh fruits to their best advantage, it is important to make careful purchasing decisions. It is important to pay attention to the size of each piece of fruit, its grade or quality, its ripeness on delivery,and its nutritional content in order to serve fruit in an appropriate and cost-effective manner.

Grading

Fresh fruits traded on the wholesale market may be graded under the USDA's voluntary program. The grades, based on size and uniformity of shape, color,and texture as well as the absence of defects, are U.S. Fancy, U.S. No. 1, U.S. No. 2 and U.S. No. 3. Most fruits purchased for food service operations are U.S. Fancy. Fruits with lower grades are suitable for processing into sauces, jams, jellies or preserves.

Ripening

Several important changes take place in fruit as it ripens. The fruit reaches its full size; its pulp or flesh becomes soft and tender; its color changes. In addition, the fruit's acid content declines, making it less tart, and its starch content converts into the sugars fructose and glucose, which provide the fruit's sweetness, flavo, and aroma.

Unfortunately, these changes do not stop when the fruit reaches its peak of ripeness. Rather, they continue, deteriorating the fruit's texture and flavor and eventually causing spoilage. Depending on the species, fresh fruits can be purchased either fully ripened or unripened. Figs and pineapples, for example, ripen only on the plant and are harvested at or just before their peak of ripeness, then rushed to market. They should not be purchased unripened, as they will never attain full flavor or texture after harvesting. On the other hand, some fruits, including bananas and pears, continue to ripen after harvesting and can be purchased unripened.

Gas

With most harvested fruits, the ripening time as well as the time during which the fruits remain at their peak of ripeness can be manipulated. For instance, ripening can be delayed by chilling. Chilling slows the fruit's respiration rate (fruits, like animals, consume oxygen and expel carbon dioxide). The slower the respiration rate, the slower the conversion of starch to sugar. For quicker ripening, fruit can be stored at room temperature.

Ethylene

Ripening is also affected by ethylene gas, a colorless, odorless hydrocarbon gas. Ethylene gas is naturally emitted by ripening fruits and can be used to encourage further ripening in most fruits. Apples, tomatoes, melons, and bananas give off the most ethylene and should be stored away from delicate fruits and vegetables, especially greens. Fruits that are picked and shipped unripened can be exposed to ethylene gas to induce ripening just before sale. Conversely, to extend the life of ripe fruits a day or two, isolate them from other fruits and keep them well chilled.

Fresh fruits will not ripen further once they are cooked or processed. The cooking or processing method applied, however, may soften the fruits or add flavor.

Purchasing Specifications

Fresh fruits are sold by weight or by count. They are packed in containers referred to as crates, bushels, cartons, cases, lugs or flats. The weight or count packed in each of these containers varies depending on the type of fruit, the purveyor, and the state in which the fruits were packed. For example, Texas citrus is packed in cartons equal to 7/10 of a bushel; Florida citrus is packed in cartons equal to 1/s of a bushel. Sometimes fruit size must be specified when ordering. A 30-pound case of lemons, for example, may contain 96, 112, or 144 individual lemons, depending on their size.

Some fresh fruits, especially melons, pineapples, peaches, and berries are available trimmed, cleaned, peeled, or cut. Sugar and preservatives are sometimes added. They are sold in bulk containers, sometimes packed in water. These items offer a consistent

product with a significant reduction in labor costs. The purchase price may be greater than that for fresh fruits, and flavor, freshness, and nutritional qualities may suffer somewhat from the processing.

Purchasing and Storing Preserved Fruits

Preservation techniques are designed to extend the shelf life of fruits in essentially fresh form. These methods include irradiation, acidulation, canning, freezing, and drying. Except for drying, these techniques do not substantially change the fruits ' texture or flavor. Canning and freezing can also be used to preserve cooked fruits.

Irradiated Fruits

Some fruits can be subjected to ionizing radiation to destroy parasites, insects, and bacteria. The treatment also slows ripening without a noticeable effect on the fruits ' flavor and texture. Irradiated fruits must be labeled "treated with radiation," "treated by irradiation" or with the appropriate symbol.

Acidulation

Apples, pears, bananas, peaches, and other fruits turn brown when cut. Although this browning is commonly attributed to exposure to oxygen, it is actually caused by the reaction of enzymes. Enzymatic browning can be retarded by immersing cut fruits in an acidic solution such as lemon or orange juice. This simple technique is sometimes referred to as acidulation. Soaking fruits in water or lemon juice and water (called acidulated water) is not recommended. Unless a sufficient amount of salt or sugar is added to the water, the fruits will just become mushy. However, if enough salt or sugar is added to retain texture, the flavor will be affected.

Although most fruits are edible raw and typically served that way, some fruits can also be cooked. Commonly used cooking methods are broiling and grilling, baking, sautéing, deep-frying, poaching, simmering, and preserving.

When cooking fruits, proper care and attention are critical. Even minimal cooking can render fruits overly soft or mushy. To combat this irreversible process, sugar can be added. When fruits are cooked with sugar, the sugar will be absorbed slowly into the cells, firming the fruits. Acids (notably lemon juice) also help fruits retain their structure. (Alkalis, such as baking soda, cause the cells to break down more quickly, reducing the fruits to mush.)

There are so many different fruits with such varied responses to cooking that no one standard for doneness is appropriate. Each item should be evaluated on a recipe-by-recipe basis. Generally, however, most cooked fruits are done when they are just tender when pierced with a fork or the tip of a paring knife. Simmered fruits, such as compotes, should be softer, cooked just to the point of disintegration. Avoid overcooking fruits by remembering that some carryover cooking will occur through the residual heat contained in the foods. Always rely on subjective tests such as sight, feel, taste, and aroma-rather than cooking time.

Cooking Methods:

Broiling and Grilling

Fruits are usually broiled or grilled just long enough to caramelize sugars; cooking must be done quickly in order to avoid breaking down the fruits' structure. Good fruits to broil or grill are pineapples, apples, grapefruits, bananas, persimmons and peaches. The fruits may be cut into slices, chunks or halves as appropriate. A coating of sugar, honey or liqueur adds flavor, as do lemon juice, cinnamon and ginger.

When broiling fruits, use an oiled sheet pan or broiling platter. When grilling fruits, use a clean grill grate or thread the pieces onto skewers. Only thick fruit slices will need to be turned or rotated to heat fully. Broiled or grilled fruits can be served alone, as an accompaniment to meat, fish or poultry or as topping for ice creams or custards.

Procedure to Broil or Grill Fruit

1. Select ripe fruits and peel, core or slice as necessary.
2. Top with sugar or honey to add flavor and aid caramelization.
3. Place the fruits on the broiler platter, sheet pan or grill grate.
4. Broil or grill at high temperatures, turning as necessary to heat the fruits thoroughly but quickly.

Baking

After washing, peeling, coring or pitting, most pomes, stone fruits, and tropical fruits can be baked to create hot, flavorful desserts. Fruits with sturdy skins, particularly apples and pears, are excellent for baking alone, as their skin (peel) holds in moisture and flavor. They can also be used as edible containers by filling the cavity left by coring with a variety of sweet or savory mixtures.

Combinations of fruits can bake together successfully; try mixing fruits for a balance of sweetness and tartness (for example, strawberries with rhubarb or apples with plums).

Several baked desserts are simply fruits (fresh, frozen, or canned) topped with a crust (called a cobbler), strudel (called a crumple or crisp) or batter (called a buckle). Fruits, sometimes poached first, can also bake in a wrapper of puff pastry, flaky dough or phyllo dough to produce an elegant dessert.

Procedure for Baking Fruit

1. Select ripe but firm fruits and peel, core, pit or slice as necessary.
2. Add sugar or any flavorings.
3. Wrap the fruits in pastry dough if desired, or directed in the recipe.
4. Place the fruits in a baking dish and bake uncovered in a moderate oven until tender or properly browned.

Sautéing

Fruits develop a rich, syrupy flavor when sautéed briefly in butter, sugar and, if desired, spices or liqueur. Cherries, bananas, apples, pears and pineapples are good choices. They should be peeled, cored and seeded as necessary and cut into uniform-size pieces before sautéing.

For dessert, fruits are sautéed with sugar to create a caramelized glaze or syrup. The fruits and syrup can be used to fill crepes or to top sponge cakes or ice creams. Liquor may be added and the mixture flamed (flambéed) in front of diners.

For savory mixtures, onions, shallots or garlic are often added. In both sweet and savory fruit sautés, the fat used should be the most appropriate for the finished product. Butter and bacon fat are typical choices.

Procedure for Sautéing Fruits

1. Peel, pit and core the fruits as necessary and cut into uniform-size pieces.
2. Melt the fat in a hot sauté pan.
3. Add the fruit pieces and any flavoring ingredients. Do not crowd the pan, as this will ca use the fruit to stew in its own juices.
4. Cook quickly over high heat.

Deep-Frying

Few fruits are suitable for deep-frying. Apples, bananas, pears, pineapples and firm peaches mixed in or coated with batter, however, produce fine results. These fruits should be peeled, cored, seeded, and cut into evenly-sized slices or chunks. They may also need to be dried with paper towels so that the batter or coating can adhere.

Fruit fritters are also a popular snack or dessert item. Fritters contain diced or chopped fish, shellfish, vegetables, or fruits bound together with a thick batter and deep-fried. Because frying time is very short, the main ingredient is usually precooked. Fritters are spooned or dropped directly into the hot fat; they form a crust as they cook. Popular examples are clam fritters, corn fritters, artichoke fritters, and apple fritters.

Method for Deep-Frying Fruit Fritters

1. Cut, chop and otherwise prepare the food to be made into fritters.
2. Precook any ingredients if necessary.
3. Prepare the batter as directed.
4. Scoop the fritters into deep fat at 350°F (180°C), using the swimming method.
5. Cook until clone. The fritters should be golden brown on the outside and moist but set on the inside.

6. Remove the fritters from the fat and hold them over the fryer, allowing the excess fat to drain off. Transfer the food to a hotel pan either lined with absorbent paper or fitted with a rack. Serve hot.
7. If the fritters are to be held for later service, place them under a heat lamp.

Poaching

One of the more popular cooking methods for fruits is poaching. Poaching softens and tenderizes fruits and infuses them with additional flavors such as spices or wine. Poached fruits can be served hot or cold and used in tarts or pastries or as an accompaniment to meat or poultry dishes.

The poaching liquid can be water, wine, liquor or sugar syrup. (As noted earlier, sugar helps fruits keep their shape, although it takes longer to tenderize fruits poached in sugar syrup.) The low poaching temperature (185°F/85°C) allows fruits to soften gradually. The agitation created at higher temperatures would damage them.

Cooked fruits should be allowed to cool in the flavored poaching liquid or syrup. Most poaching liquids can be used repeatedly. If they contain sufficient sugar, they can be reduced to a sauce or glaze to accompany the poached fruits.

Procedure for Poaching Fruits

1. Peel, core and slice the fruits as necessary.
2. In a sufficiently deep, nonreactive saucepan, combine the poaching liquid (usually water or wine) with sugar, spices, citrus zest and other ingredients as desired or as directed in the recipe.
3. Submerge the fruits in the liquid. Place a circle of parchment paper over the fruits to help them stay submerged.
4. Place the saucepan on the stovetop over a medium-high flame; bring to a boil.
5. As soon as the liquid boils, reduce the temperature. Simmer gently.
6. Poach until the fruits are tender enough for the tip of a small knife to be easily inserted. Cooking time depends on the type of fruit used, its ripeness and the cooking liquid.

Simmering

Simmering techniques are used to make stewed fruits and compotes. Fresh, frozen, canned and dried fruits can be simmered or stewed. As with any moist heat cooking method, simmering softens and tenderizes fruits. The liquid used can be water, wine or the juices naturally found in the fruits. Sugar, honey and spices may be added as desired. Stewed or simmered fruits can be served hot or cold, as a first course, a dessert or an accompaniment to meat or poultry dishes.

Method for Simmering Fruit

1. Peel, core, pit and slice the fruits as necessary.
2. Bring the fruits and cooking liquid, if used, to a simmer. Cook until the fruit is tender.
3. Add sugar or other sweeteners as desired or as directed in the recipe.

Preserving

Fresh fruits can be preserved with sugar if the fruit-and-sugar mixture is concentrated by evaporation to the point that microbial spoilage cannot occur. The added sugar also retards the growth of, but does not destroy, microorganisms.

Pectin, a substance present in varying amounts in all fruits, can cause cooked fruits to form a semisolid mass known as a gel. Fruits that are visually unattractive but otherwise of high quality can be made into gels, which are more commonly known as jams, jellies, marmalades and preserves.

The essential ingredients of a fruit gel are fruit, pectin, acid (usually lemon juice), and sugar. They must be carefully combined in the correct ratio for the gel to form. For fruits with a low pectin content (such as strawberries) to form a gel, pectin must be added, either by adding a fruit with a high pectin content (for example, apples or quinces) or by adding packaged pectin.

Terms

- **Concentrate** - also known as a fruit paste or compound; a reduced fruit puree, without a gel structure, used as a flavoring
- **Jam** - a fruit gel made from fruit pulp and sugar
- **Jelly** - a fruit gel made from fruit juice and sugar
- **Marmalade** - a citrus jelly that also contains unpeeled slices of citrus fruit
- **Preserve** - a fruit gel that contains large pieces or whole fruits

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12.4.2: Vegetable Nutrition, Storage and Preparation

Nutrition

Most vegetables are more than 80 percent water; the remaining portions consist of carbohydrates (primarily starches) and small amounts of protein and fat. The relative lack of protein and fat makes most vegetables especially low in calories.

Much of a vegetable's physical structure is provided by generally indigestible substances such as cellulose and lignin, also known as fiber. This fiber produces the characteristic stringy, crisp or fibrous textures associated with vegetables.

Vegetables are also a good source of vitamins and minerals. Care must be taken during preparation to preserve their nutritional content, however. Once peeled or cut, vegetables lo se nutrients to the air or to any liquid in which they are allowed to soak. Vitamins are concentrated just under the skin, so peel vegetables thinly, if at all.

USDA Organic Designation

Great strides in agriculture have been made during the past two centuries. Pesticides, fungicides, and herbicides now eliminate or control pests that once would have devoured, ruined or choked crops. Chemical fertilizers increase the yields of many of the world's staples. However, not everyone has greeted these developments with open arms.

During the past few decades, scientific and medical investigators have documented, or at least suggested, health risks associated with certain synthetic pesticides, fertilizers, and other products. These findings have led to a renewed interest in a now multi-billion-dollar-a-year back-to-the-basics approach to farming organic farming. Specialty farms, orchards, and even wineries now offer organically grown products (or, in the case of wineries, wines made from organically grown grapes). These products come with few, if any, intentional additives and should be free of any incidental additives. Proponents argue that these products are better for you and better for the health of the farm workers.

The U.S. Department of Agriculture regulates the production and labeling of organically grown foods. It requires that any natural food labeled "100 percent organic" must contain only organic ingredients-that is, those grown and manufactured without the use of added hormones, pesticides, synthetic fertilizers, and so on; soil cannot have been treated with unapproved synthetics for three years for a crop to be called organic. To be labeled organic, or to display the USDA organic seal, processed foods must contain at least 95 percent organic ingredients by weight. Processed foods with 70 to 95 percent organic ingredients may be labeled "made with organic ingredients"; processed foods with less than 70 percent organic ingredients may list those ingredients on the information panel but may not use the term organic anywhere on the front of the package.

Purchasing and Storing Fresh Vegetables

Fresh vegetables should be selected according to seasonal availability. Using a vegetable at the peak of its season has several advantages: Price is at its lowest, selection is at its greatest and the vegetable's color, flavor and texture are at their best.

Grading

The USDA has a voluntary grading system for fresh vegetables traded on wholesale markets. The system is based on appearance, condition, and other factors affecting waste or eating quality.

Grades for all vegetables include, in descending order of quality, U.S. Extra Fancy, U.S. Fancy, U.S. Extra No. 1 , and U.S. No.1. There are also grades that apply only to specific vegetables, for example, U.S. No. 1 Boilers for onions. Consumer or retail grading is currently required only for potatoes, carrots, and onions. It uses alphabetical listings, with Grade A being the finest.

Purchasing

Fresh vegetables are old by weight or count. They are packed in cartons referred to as cases, lugs, bushels, flats or crates. The weight or count packed in each of these containers varies depending on the size and type of vegetable as well as the packer. For example, celery is packed in 55-pound cartons containing 18 to 48 heads, depending on the size of each head.

Some of the more common fresh vegetables (for example, onions, carrots, celery, and lettuce) can be purchased from wholesalers trimmed, cleaned, and cut according to your specifications. Although the unit price will be higher for diced onions than for whole

onions, for example, the savings in time, labor, yield loss and storage space can be substantial. Processed vegetables may suffer a loss of nutrients, moisture, and flavor.

Ripening

Although vegetables do not ripen in the same manner as fruits, they do continue to breathe (respire) after harvesting. The faster the respiration rate, the faster the produce ages or decays. This decay results in wilted leaves and dry, tough or woody stems and stalks.

Respiration rates vary according to the vegetable variety, its maturity at harvest and its storage conditions after harvest.

Ripening proceeds more rapidly in the presence of ethylene gas. Ethylene gas is emitted naturally by fruits and vegetables and can be used to encourage further ripening in some produce, especially fruit-vegetables such as tomatoes. Items harvested and shipped when mature but green (unripe) can be exposed to ethylene gas to induce color development (ripening) just before sale.

Storing

Some fresh vegetables are best stored at cool temperatures, between 40°F and 60°F (4°C and 16°C), ideally in a separate produce refrigerator. These include winter squash, potatoes, onions, shallots, and garlic. If a produce refrigerator is not available, store these vegetables at room temperature in a dry area with good ventilation. Do not store them in a refrigerator set at conventional temperatures. Colder temperatures convert the starches in these vegetables to sugars, changing their texture and flavor.

Most other vegetables benefit from cold storage at temperatures between 34°F and 40°F (2°C and 4°C) with relatively high levels of humidity. Greens and other delicate vegetables should be stored away from apples, tomatoes, bananas, and melons, as the latter give off a great deal of ethylene gas.

Preservation techniques are designed to extend the shelf life of vegetables. These methods include irradiation, canning, freezing, and drying. Except for drying, these techniques do not substantially change the vegetable's texture or flavor. Canning and freezing can also be used to preserve cooked vegetables.

Waxing

- Use the links bellow (including the image) to explore why produce is waxed.



"shiny fruit" by Bobbytee is licensed under CC BY-NC-SA 2.0.

1. **https://www.youtube.com/watch?v=n7_Yt5yhZSo&ab_channel=ArtIsInCakes**
2. **https://www.youtube.com/watch?v=tVvE-w0ycmU&ab_channel=superfreshgrowers**

Irradiated Vegetables

The irradiation process uses ionizing radiation (usually gamma rays of cobalt 60 or cesium 137) to sterilize foods. When foods are subjected to radiation, parasites, insects and bacteria are destroyed, ripening is slowed and sprouting is prevented. Irradiation works without a noticeable increase in temperature; consequently, the flavor and texture of fresh foods are not affected. Some nutrients, however, may be destroyed. Irradiated vegetables do not need to be sprayed with post-harvest pesticides, and they have an extended shelf life.

The FDA classifies irradiation as a food additive. Although irradiation is not yet approved for all foods, grains, fruits and vegetables may be treated with low-dose radiation. Irradiated foods must be labeled "Treated with radiation" or "Treated by

irradiation."

Hydroponics: Working Water

Hydroponics is the science of growing plants without soil in water. Plants are grown in an inert medium such as gravel, peat, sand, or other sterile material.
Nutrients are distributed in water that is circulated over the plant's roots. In a hydroponic farm, the temperatures and light are controlled to maximize production. Because hydroponic farms are indoors, plants can be grown in any climate; both Canada and Holland are major producers of vegetables grown under these conditions.

Canned Vegetables

Canned vegetables are the backbone of menu planning for many food service operations. In commercial canning, raw vegetables are cleaned and placed in a sealed container, then subjected to high temperatures for a specific period. Heating destroys the microorganisms that cause spoilage, and the sealed environment created by the can eliminates oxidation and retards decomposition. However, the heat required by the canning process also softens the texture of most vegetables and alters their nutritional content; many vitamins and minerals may be lost through the canning process. Green vegetables may also suffer color loss, becoming a drab olive hue.

Canned vegetables are graded by the USDA as U.S. Grade A or Fancy, U.S. Grade B or Extra-Select, and U.S. Grade C or Standard. U.S. Grade A vegetables must be top quality, tender, and free of blemishes. U.S. Grade C vegetables may lack uniformity or flavor but can be used in casseroles or soups if cost is a concern.

Canned vegetables are purchased in cases of standard-sized cans. Canned vegetables can be stored almost indefinitely at room temperature. Once a can is opened, any unused contents should be transferred to an appropriate storage container and refrigerated. Cans with bulges should be discarded immediately, without opening.

Frozen Vegetables

Frozen vegetables are almost as convenient to use as canned. However, they often require some cooking, and expensive freezer space is necessary if an inventory is to be maintained. Regardless, freezing is a highly effective method for preserving vegetables. It severely inhibits the growth of microorganisms that cause spoilage without destroying many nutrients. Generally, green vegetables retain their color, although the appearance and texture of most vegetables may be somewhat altered because of their high water content: Ice crystals form from the water in the cells and burst the cells walls.

Some vegetables are available individually quick-frozen (IQF). This method employs blasts of cold air, refrigerated plates, liquid nitrogen, liquid air or other techniques to chill the vegetables quickly. Speeding the freezing process can greatly reduce the formation of ice crystals.

Combinations of vegetables, as well as vegetables with seasonings and sauces, are available frozen. Some frozen vegetables are raw when frozen; others are blanched before freezing so that the final cooking time is reduced. Many others are fully cooked before freezing and need only to be thawed or heated for service. Frozen vegetables generally do not need to be thawed before being heated. Once thawed or cooked, they should be stored in the refrigerator and reheated in the same manner as fresh vegetables. Do not refreeze previously frozen vegetables.

Frozen vegetables are graded in the same manner as canned vegetables. They are usually pack d in cases containing 1- to 2-pound (450- to 900-gram) boxes or bags. All frozen vegetables should be sealed in moisture-proof wrapping and kept at a constant temperature of 0°F (-18°C) or below. Temperature fluctuations can draw moisture from the vegetables, causing poor texture and flavor loss. Adequate packaging also prevents freezer burn, an irreversible change in the color, texture and flavor of frozen foods.

Dried Vegetables

Except for beans peas, peppers, mushrooms, and tomatoes, few vegetables are commonly preserved by drying. Unlike other preservation methods, drying dramatically alters flavor, texture and appearance. The loss of moisture concentrates flavors and sugars and greatly extends shelf life.

Imitation Meats:

Use the images below to explore imitation meats:





***"Impossible Burger Plant-Based Meat" by Scott Beale is licensed under CC BY-NC-ND 2.0. ***"My Vegan 'Meat' Drawer" by valeehill is licensed under CC BY-ND 2.0.

Tofu vs Tempe:



"Raw tempeh" by SaucyGlo is licensed under CC BY 2.0.

Acid/Alkali Reactions

The acid or alkali content of the cooking liquid affects the texture and color of many vegetables. This is of greater concern with moist-heat cooking methods, but it is also a consideration with city-heat cooking methods, as they often call for blanched or parboiled vegetables.

Texture

The acidity or alkalinity of the vegetable's cooking liquid influences the finished product's texture. If an acid such as lemon juice, vinegar or wine is added to the liquid for flavoring, the vegetable will resist softening and will require a longer cooking time. On the other hand, an alkaline cooking medium will quickly soften the vegetable's texture and may cause it to become mushy. Alkalinity also causes nutrient loss (especially thiamin) and may impart a bitter flavor. Alkalinity can be caused by tap water, detergent residue on utensils or the addition of baking soda (a base) to the cooking liquid. (You could add, for example, 1/8 teaspoon [0.6 milliliter) baking soda per cup [225 milliliters] of beans to speed the softening of dried beans.)

Color

The acidity or alkalinity of the liquid also affects the plant's pigments, causing both desirable and undesirable color changes. There are three principal pigment categories: chlorophyll, carotenoid, and flavonoid. A plant's unique color is the result of a combination of these pigments. Chlorophyll pigments predominate in green vegetables such as spinach, green beans and broccoli. Carotenoid pigments predominate in orange and yellow vegetables such as carrots, tomatoes, reel peppers and winter squashes. Flavonoid pigments are predominate in purple and white vegetables such as red cabbage, beets and cauliflower.

Initially, as vegetables are cooked, their original colors intensify. Exposure to heat makes pigments, especially chlorophyll, appear brighter. Exposure to acids and bases affects both chlorophyll and flavonoid pigments. Acids will gradually turn green vegetables an olive-drab color, while a slight alkalinity promotes chlorophyll retention. The opposite occurs with vegetables containing flavonoids: They retain desirable colors in a slightly acidic environment while losing colors in an alkaline one. (Carotenoids are not affected by either acidity or alkalinity.) Color changes alone do not affect flavor, but the altered appearance can make the product so visually unappealing as to become inedible.

Colors also change as the naturally occurring acids in vegetables are released during cooking. If the cooking pan is kept covered, the acids can concentrate, creating richer flavonoid pigments but destroying chlorophyll pigments.

Thus, if color is the one and only concern, vegetables with a high amount of chlorophyll should be cooked in an alkaline liquid, and vegetables, with a high amount of flavonoids should be cooked in an acidic liquid. Remember, the improvement in color usually comes at the expense of texture and nutrients.

Acid & Alkali Reactions

			Effects of Acid on:		Effect of Alkali on:	
VEGETABLE	**PIGMENT FAMILY**	**COLOR**	**TEXTURE**	**COLOR**	**TEXTURE**	**COOK COVERED**
Spinach, broccoli	chlorophyll	drab olive green	firm	bright green	mushy	no
Carrots, rutabagas	carotenoid	no change	firm	no change	mushy	no difference
Cauliflower	flavonoid	white	firm	yellow	mushy	yes
Red cabbage	flavonoid	red	firm	blue	mushy	yes

*Alkalinity always causes a loss of thiamin and other nutrients

Guidelines for Vegetable Cookery

The following general guidelines for vegetable cookery should be considered regardless of the cooking method used:

1. Vegetables should be carefully cut into uniform shapes and sizes to promote even cooking and provide an attractive finished product.
2. Cook vegetables for as short a time as possible to preserve texture, color and nutrients.
3. Cook vegetables as close to service time as possible. Holding vegetables in a steam table continues to cook them.
4. When necessary, vegetables may be blanched in advance, refreshed in ice water and refrigerated. They can then be reheated as needed.
5. White and red vegetables (those with flavonoid pigments) may be cooked with a small amount of acid such as lemon juice, vinegar or white wine to help retain their color.
6. When preparing an assortment of vegetables, cook each type separately, and then combine them. Otherwise, some items would become overcooked in the time required to properly cook others.

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CHAPTER OVERVIEW

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Thumbnail: Wheat field. (Unsplash License; Melissa Askew via Unsplash)

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SECTION OVERVIEW

13.1: Cereals and Starches

The History of Wheat Flour

Archaeologists who did excavations in the region of the lake dwellers of Switzerland found grains of wheat, millet, and rye 10,000 years old. The Romans perfected the rotary mill for turning wheat into flour. Eventually, improved milling processes were needed because even when wheat was milled twice and bolted (sifted) through silk gauze, the result was still a yellowish flour of uneven texture and flecked with germ and bran.

In the second half of the 19th century, there were great changes in the flour milling process. An American inventor, Edmund LaCroix, improved the process with a purifier to separate the **middlings** (bran, germ, and other coarse particles) from the particles that form smooth-textured white flour. In recent years, the demand for whole grain milling has increased because whole grain food products have proved to be more nutritious than products made from white flour.

Today, the major wheat growing areas of North America are in the central part of the continent, in the Great Plains of the United States and the Canadian Prairies. From Nebraska south, winter wheat can be grown, while to the north through Saskatchewan spring wheat dominates. Many American states and some Canadian provinces grow both kinds. In fact, there are very few states that don't grow some wheat. Kansas, the site of the American Institute of Baking, could be said to be at the heart of the U.S. wheat growing area, while Saskatchewan is the Canadian counterpart.

13.1.1: Grains and Flours

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SECTION OVERVIEW

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13.1.1.1: Classification and Milling of Wheat

Classification of Wheat

Wheat can be classified in three ways:

- Color (e.g., red, yellow, white)
- Planting season: spring wheat, planted in the spring and harvested in early fall; winter wheat, planted in the fall, harvested the following summer
- Characteristics of the grain: durum, hard bread wheat, and soft wheat

The United States recognizes seven market classes of wheat. The first five, listed below, are the most important:

- Hard red winter (planted in the fall, harvested the following summer)
- Soft red winter
- Hard red spring (planted and harvested the same year)
- Durum
- Red durum

Characteristics of the Major Wheat Groups

The major wheat groups each have differing characteristics. This also determines their use in food production and baking. The following identifies the major characteristics of each of the three major wheat groups.

- Durum wheat: Durum wheat is generally high in gluten-producing proteins. In effect, durum is the “hardest” wheat. Durum wheat is used for making semolina flour, which is made into macaroni and other pasta and is the top choice due to the higher gluten content.
- Hard wheat: Hard wheat includes hard winter wheat and hard spring wheat. Hard Red Winter (HRW) and Hard Red Spring (HRS) are most common in the United States. They contain more gluten-producing proteins than soft wheat, and are used for making bread flours and all-purpose flours.
- Soft wheat: Soft wheat is low in gluten-producing protein. Soft Red Winter (SRW) is the most common in the United States. Soft wheat is milled into cake and pastry flour.

Milling of Wheat

Milling wheat is the process that turns whole grains into flour. The goal of the miller is to produce:

- A consistent product
- A range of flours suitable for a variety of functions
- Flours with predictable performance

The very first mill operation is analyzing the grain, which determines criteria such as the **gluten** content and amylase (an enzyme that breaks down carbohydrates) activity. It is at this point that decisions about blending are made.

Following analysis, milling may be divided into three stages:

1. Cleaning and conditioning – ridding the grain of all impurities and readying it for milling
2. Crushing or breaking – breaking down the grain in successive stages to release its component parts
3. Reduction – progressive rollings and siftings to refine the flour and separate it into various categories, called *streams*

Cleaning

Wheat received at the mill contains weeds, seeds, chaff, and other foreign material. Strong drafts of air from the aspirator remove lighter impurities. The **disc separator** removes barley, oats, and other foreign materials. From there, the wheat goes to the scourers in which it is driven vigorously against perforated steel casings by metal beaters. In this way, much of the dirt lodged in the crease of the wheat berry is removed and carried away by a strong blast of air. Then the magnetic separator removes any iron or steel.

At this point, the wheat is moistened. Machines known as *whizzers* take off the surface moisture. The wheat is then **tempered**, or allowed to lie in bins for a short time while still damp, to toughen the bran coat, thus making possible a complete separation of the

bran from the flour-producing portion of the wheat berry. After tempering, the wheat is warmed to a uniform temperature before the crushing process starts.

Crushing or Breaking

The objectives at this stage are twofold:

1. Separate as much bran and germ as possible from the endosperm
2. Maximize the flour from the resulting endosperm

Household grain mills create flour in one step — grain in one end, flour out the other — but the commercial mill breaks the grain down in a succession of very gradual steps, ensuring that little bran and germ are mixed with any endosperm.

Although the process is referred to as *crushing*, flour mills crack rather than crush the wheat with large steel rollers. The rollers at the beginning of the milling system are corrugated and break the wheat into coarse particles. The grain passes through screens of increasing fineness. Air currents draw off impurities from the **middlings**. *Middlings* is the name given to coarse fragments of endosperm, somewhere between the size of semolina and flour. Middlings occur after the “break” of the grain.

Bran and germ are sifted out, and the coarse particles are rolled, sifted, and purified again. This separation of germ and bran from the endosperm is an important goal of the miller. It is done to improve dough-making characteristics and color. As well, the germ contains oil and can affect keeping quality of the flour.

Reduction

In the reduction stage, the coarser particles go through a series of fine rollers and sieves. After the first crushing, the wheat is separated into five or six streams. This is accomplished by means of machines called **plansifters** that contain sieves, stacked vertically, with meshes of various sizes. The finest mesh is as fine as the finished flour, and some flour is created at an early stage of reduction.

Next, each of the divisions or streams passes through cleaning machines, known as *purifiers*, a series of sieves arranged horizontally and slightly angled. An upcurrent draught of air assists in eliminating dust. The product is crushed a little more, and each of the resulting streams is again divided into numerous portions by means of sifting. The final crushings are made by perfectly smooth steel rollers that reduce the middlings into flour. The flour is then bleached and put into bulk storage. From bulk storage, the flour is **enriched** (thiamine, niacin, riboflavin, and iron are added), and either bagged for home and bakery use or made ready for bulk delivery.

Extraction Rates

The extraction rate is a figure representing the percentage of flour produced from a given quantity of grain. For example, if 82 kg of flour is produced from 100 kg of grain, the extraction rate is 82% (82÷100×100). Extraction rates vary depending on the type of flour produced. A whole grain flour, which contains all of the germ, bran, and endosperm, can have an extraction rate of close to 100%, while white all-purpose flours generally have extraction rates of around 70%. Since many of the nutrients are found in the germ and bran, flours with a higher extraction rate have a higher nutritional value.

Whole Grain and Artisan Milling

Whole grain and artisan milling is the type of milling that was practiced before the consumer market demanded smooth white flours that are refined and have chemical additives to expedite the aging of flours. Artisan milling produces flours that are less refined and better suited to traditional bread, but also contain little to no additives and have higher nutritional content. For that reason, demand for these types of flour is on the rise.

Artisan millers (also known as micro millers) process many non-stream grains, including spelt, kamut, buckwheat, and other non-gluten grains and pulses. This offers bakers opportunities to work with different grains and expand their businesses. Artisan flours are readily available directly from millers or through a distributor. Knowing the origin of the grains and the quality of the ingredients in baking is important for artisan bakers.

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13.1.1.2: Flour Terms and Treatments

Flour Terms and Treatments

In addition to types of flour, you may come across various other terms when purchasing flour. These include some terms that refer to the processing and treatment of the flour, and others outlining some of the additives that may be added during the milling and refining process.

Bleached

Bleaching and maturing agents are added to whiten and improve the baking quality quickly, making it possible to market the freshest flour. Even fine wheat flours vary in color from yellow to cream when freshly milled. At this stage, the flour produces doughs that are usually sticky and do not handle well. Flour improves with age under proper storage conditions for up to one year, both in color and quality.

Because storing flour is expensive, toward the close of the 19th century, millers began to treat freshly milled flour with oxidizing agents to bleach it and give it the handling characteristics of naturally aged flour. Under the category of maturing agents are included materials such as chlorine dioxide, chlorine gas plus a small amount of nitrosyl chloride, ammonium persulfate, and ascorbic acid. No change occurs in the nutritional value of the flour when these agents are present.

There are two classes of material used to bleach flour. A common one, an organic peroxide, reacts with the yellow pigment only and has no effect on gluten quality. Chlorine dioxide, the most widely used agent in North America, neutralizes the yellow pigment and improves the gluten quality. It does, however, destroy the tocopherols (vitamin E complex).

Enriched

Replacing naturally occurring nutrients that may have been lost during the milling process. Iron and three of the most necessary B vitamins (thiamin, riboflavin, and niacin), which are partially removed during milling, are returned to white flour by a process known as enrichment. No change occurs in taste, color, texture, baking quality, or caloric value of the flour.

Fortified

Adding a nutrient that was not present before or adding in larger quantities. Folic acid (folate) is added to enriched grains in an effort to prevent neural tube defects in children. Another example is Vitamin D fortification which we discussed previously in the milk chapter.

Pre-sifted

During the milling process, flour is sifted many times through micro-fine silk. This procedure is known as pre-sifting. The mesh size used for sifting varies from flour to flour. There are more holes per square inch for cake flour than, for example, bread flour, so a cup of cake flour has significantly more minute particles than a cup of bread flour, is liable to be denser, and weighs slightly more. Sifted flour yields more volume in baked bread than unsifted flour, simply because of the increased volume of air.

Flour Additives

A number of additives may be found in commercial flours, from agents used as dough conditioners to others that aid in the fermentation process. Why use so many additives? Many of these products are complementary – that is, they work more effectively together and the end product is as close to “ideal” as possible. Nevertheless, in some countries the number of additives allowed in flour is limited. For instance, in Germany, ascorbic acid remains the only permitted additive.

Some of the additives that are commonly added to flour include those described below.

Bromate

Until the early 1990s, bromate was added to flour because it greatly sped up the oxidation or aging of flour. In the United States, bromate is allowed in some states but banned in others (e.g., California).

Azodicarbonamide (ADA)

Approved in the United States since 1962. ADA is a fast-acting flour treatment resulting in a cohesive, dry dough that tolerates high water absorption. It is not a bleach, but because it helps produce bread with a finer texture it gives an apparently whiter crumb. It

does not destroy any vitamins in the dough.

Bakers who want to know if their flours contain ADA or other chemical additives can request this information from their flour suppliers.

L-Cysteine

An amino acid, L-cysteine speeds up reactions within the dough, thus reducing or almost eliminating bulk fermentation time. In effect, it gives the baker a “no-time” dough. It improves dough elasticity and gas retention.

Ascorbic Acid

Ascorbic acid was first used as a bread improver in 1932, after it was noticed that old lemon juice added to dough gave better results because it improved gas retention and loaf volume. Essentially vitamin C (ascorbic acid) has the advantage of being safe even if too much is added to the dough, as the heat of baking destroys the vitamin component. The addition of ascorbic acid consistent with artisan bread requirements is now routine for certain flours milled in North America.

Calcium Peroxide

Calcium peroxide (not to be confused with the peroxide used for bleaching flour) is another dough-maturing agent.

Glycerides

Glycerides are multi-purpose additives used in both cake mixes and yeast doughs. They are also known as surfactants, which is a contraction for “surface-acting agents.” In bread doughs, the main function of glycerides is as a crumb-softening agent, thus retarding bread staling. Glycerides also have some dough-strengthening properties.

Sodium Stearoyl Lactylate

Approved for use in the United States since 1961, this additive improves gas retention, shortens proofing time, increases loaf volume, and works as an anti-staling agent.

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13.1.1.3: Flour Streams and Types of Wheat Flour

Flour Streams and Types of Wheat Flour

Modern milling procedures produce many different **flour streams** (approximately 25) that vary in quality and chemical analysis. These are combined into four basic streams of edible flour, with four other streams going to feed.

- Top patent flour: This stream is composed of only the purest and most highly refined streams from the mill. It is low in ash and is approximately 50% of the flour extracted. The term *ash* indicates the mineral content (e.g., phosphorus) of the flour. When flour is burned, all that is left is the burned mineral elements that constitute ash.
- Second patent flour: This flour is composed of streams with an intermediate degree of refinement. It has an average ash content of approximately 0.45% and represents about 35% of the total flour.
- First clear flour: This stream contains the balance of the flour that possesses baking properties, and is high in ash and protein content. It is usually about 15% of the total flour.
- Second clear flour: This grade contains the poorest flour streams. It is very high in ash (approximately 0.75%), and has little or no baking quality. It is about 2% of the total flour.
- Feed streams: The balance of the streams from the mill are classed as feed. Feeds are marketed as bran, **wheat shorts**, flour middlings, and wheat germ.

Within the streams of edible flours, there are a number of different types of flour used in food preparation. Each has different characteristics, and with those come different uses, as described below.

All-Purpose Flour

General purpose or home use flours are usually a blend of hard spring wheats that are lower in protein (gluten) content than bread flours. They are top patent flours and contain sufficient protein to make good yeast breads, yet not too much for good quick breads, cakes, and cookies.

Note: A word about gluten quality as opposed to gluten quantity: The fact that a particular flour contains a high quantity of protein, say 13% to 15%, does not necessarily mean that it is of high quality. It may contain too much ash or too much damaged starch to warrant this classification. High quality is more important in many bread applications than high quantity. All-purpose flour is an example of a high-quality flour, with a protein content of about 12%.

Graham Flour

A U.S. patented flour, graham flour is a combination of whole wheat flour (slightly coarser), with added bran and other constituents of the wheat kernel.

Bread Flour

Bread flour is milled from blends of hard spring and hard winter wheat. They average about 13% protein and are slightly granular to the touch. This type of flour is sold chiefly to bakers because it makes excellent bread with bakery equipment but has too much protein to be considered all-purpose. It is also called strong flour or hard flour.

Cake Flour

Cake flour is milled from soft wheat. The protein content is about 7% and the granulation is so uniform and fine that the flour feels satiny. An exception is a high-protein cake flour formulated especially for fruited pound cakes (to prevent the fruit from sinking).

Clear Flour

Clear flour comes from the part of the wheat berry just under the outer covering. Comparing it to first patent flour is like comparing cream to skim milk. It is dark in color and has a very high gluten content. It is used in rye and other breads requiring extra strength.

Gluten Flour

Gluten flour is made from wheat flour by removing a large part of the starch. It contains no more than 10% moisture and no more than 44% starch.

Pastry Flour

Pastry flour is made from either hard or soft wheat, but more often from soft. It is fairly low in protein and is finely milled, but not so fine as cake flour. It is unsuitable for yeast bread but ideal for cakes, pastries, cookies, and quick bread.

Self-Rising Flour

Self-rising flour has leavening and salt added to it in controlled amounts at the mill.

Wheat Germ Flour

Wheat germ flour consists entirely of the little germ or embryo part of the wheat separated from the rest of the kernel and flattened into flakes. This flour should be refrigerated.

Whole Wheat Flour

Whole wheat flour contains all the natural parts of the wheat kernel up to 95% of the total weight of the wheat. It contains more protein than all-purpose flour and produces heavier products because of the bran particles.

Whole Wheat Pastry Flour

Whole wheat pastry flour is milled from the entire kernel of soft wheat, is low in gluten, and is suitable for pastries, cakes, and cookies.

Triticale Flour

The world's first new grain, triticale is a hybrid of wheat and rye. It combines the best qualities of both grains.

Semolina

Semolina is the granular product consisting of small fragments of the endosperm of the durum wheat kernel (The equivalent particles from other hard wheat are called *farina*).

Blending Flours

The blending of flours is done at the mill, and such is the sophistication of the analysis and testing of flours (test baking, etc.) that when problems occur it is generally the fault of the baker and not the product. Today the millers and their chemists ensure that bakers receive the high grade of flour that they need to produce marketable products for a quality-conscious consumer. Due to the vagaries of the weather and its effect on growing conditions, the quality of the grain that comes into the mill is hardly ever constant. For example, if damp weather occurs at harvest time, the grain may start to sprout and will cause what is known as *damaged starch*. Through analysis and adjustments in grain handling and blending, the miller is able to furnish a fairly constant product.

Bakers do blend flours, however. A portion of soft flour may be blended with the bread flour to reduce the toughness of a Danish pastry or sweet dough, for example. Gluten flour is commonly used in multi-grain bread to boost the aeration.

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13.1.1.4: Other Grains

Cereal Grains

Use the links provided to explore cereal grains:

- https://www.glnc.org.au/resource/types-of-grains/
- https://www.fs.usda.gov/wildflowers/ethnobotany/food/grains.shtml

Pseudo grains:

- https://www.glnc.org.au/when-is-a-grain-not-a-grain-when-its-a-pseudo-grain/

Gluten Free Grains:

- https://gluten.org/2019/10/17/gluten-free-grains/
- https://celiac.org/gluten-free-living/gluten-free-foods/

Other Grains and Flours

Several other types of grains are commonly used in baking. In particular, corn and oats feature predominantly in certain types of baking (quick bread and cookies respectively, for instance) but increasingly rice flour is being used in baked goods, particularly for people with gluten sensitivities or intolerances. The trend to whole grains and the influence of different ethnic cultures have also meant the increase in the use of other grains and pulses for flour used in bread and baking in general.

Corn

Corn is one of the most widely used grains in the world, and not only for baking. Corn is used in bread and cereals, but also to produce sugars (such as dextrose and corn syrup), starch, plastics, adhesives, fuel (ethanol), and alcohol (bourbon for example). It is produced from the **maize** plant (the preferred scientific and formal name of the plant that we call *corn* in North America). There are different varieties of corn, some of which are soft and sweet (corn you use for eating fresh or for cooking),and some of which are starchy and are generally dried to use for baking, animal feed, and popcorn.

Varieties Used in Baking

- Cornmeal has a sandy texture and is ground to fine, medium, and coarse consistencies. It has most of the husk and germ removed, is used in recipes from the American South (e.g., cornbread) and can be used to add texture to other types of bread and pastry.
- Stone-ground cornmeal has a texture not unlike whole wheat flour, as it contains some of the husk and germ. Stone-ground cornmeal has more **nutrients**, but it is also more perishable. In baking, it acts more like cake flour due to the lack of gluten.
- Corn flour in North America is very finely ground cornmeal that has had the husk and germ removed. It has a very soft powdery texture. In the U.K. and Australia, corn flour refers to cornstarch.
- Cornstarch is the starch extracted from the maize kernel. It is primarily used as a thickener in baking and other cooking. Cornstarch has a very fine powdery consistency and can be dissolved easily in water. As a thickening agent, it requires heat to set and will produce products with a shiny, clear consistency.
- Blue cornmeal has a light blue or violet color and is produced from whole kernels of blue corn. It is most similar to stone-ground cornmeal and has a slightly sweet flavor.

Rice

Rice is another of the world's most widely used cereal crops and forms the staple for much of the world's diet.

Varieties Used in Baking

- Rice flour is prepared from finely ground rice that has had the husks removed. It has a fine, slightly sandy texture, and provides crispness while remaining tender due to its lack of gluten. For this reason, many gluten-free breads are based on rice flour or blends that contain rice flour.

- Short grain or pearl rice is also used in the pastry shop to produce rice pudding and other desserts.

Oats

Oats are widely used for animal feed and food production, as well as for making breads, cookies, and dessert toppings. Oats add texture to baked goods and desserts.

Varieties Used in Baking

- Bakers will most often encounter rolled oats, which are produced by pressing the de-husked whole kernels through rollers.
- Oat bran and oat flour are produced by grinding the oat kernels and separating out the bran and endosperm.
- Whole grain oat flour is produced by grinding the whole kernel but leaving the ground flour intact.
- Steel-cut oats are more commonly used in cooking and making breakfast cereals, and are the chopped oat kernels.

Other Grains and Pulses

A wide range of additional flours and grains that are used in ethnic cooking and baking are becoming more and more widely available. These may be produced from grains (such as kamut, spelt, and quinoa), pulses (such as lentils and chickpeas), and other crops (such as buckwheat) that have a grain-like consistency when dried. Increasingly, with allergies and intolerances on the rise, these flours are being used in bakeshops as alternatives to wheat-based products for customers with special dietary needs. (For more on this topic, see the chapter Special Diets, Allergies, Intolerances, Emergent Issues, and Trends in the open textbook *Nutrition and Labelling for the Canadian Baker*.)

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13.1.1.5: Wheat in Pasta

Pasta is made from an unleavened dough of wheat flour mixed with a liquid. The liquid is usually egg and/or water. The flour can be from almost any grain: wheat, buckwheat, rice or a combination of grains. The dough can be colored and flavored with pureed vegetables, herbs, or other ingredients, and it can be cut or extruded into a wide variety of shapes and sizes.

Pasta can be cooked fresh while the dough is still moist and pliable, or the dough can be allowed to dry completely before cooking. Pasta can be filled or sauced in an endless variety of ways. It can stand alone, or be used in salads, desserts, soups, or casseroles.

Pasta is widely used in the cuisines of Asia, North America and Europe. In Italy, pasta dishes are usually served as a separate course, often referred to as the minestre; in other European countries, Asia, and the United States, pasta dishes may be served as an appetizer, entree, or side dish.

Identifying Pastas

The better-known pastas are based on the Italian tradition of kneading wheat flour with water and eggs to form a smooth, resilient dough. This dough is then rolled very thin, and cut into various shapes before boiling in water, or dried for longer storage.

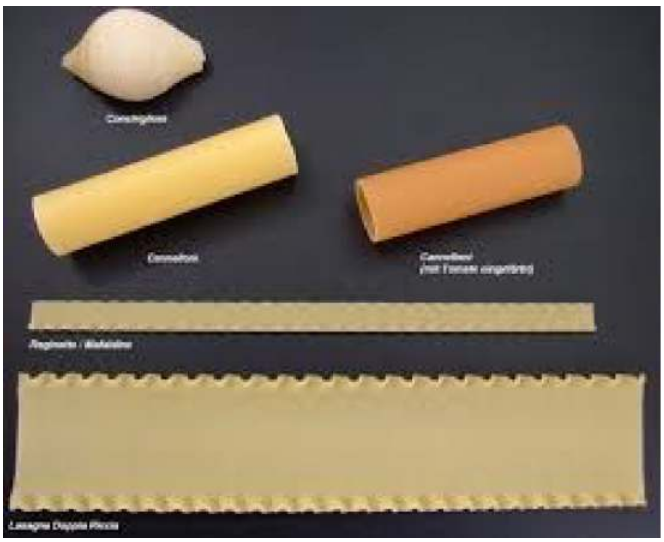
Commercially prepared dried pasta products are usually made with semolina flour. Semolina flour, ground from hard durum wheat and available from specialty purveyors, has a rich cream color and produces a very smooth, durable dough. Semolina dough requires a great deal of kneading, however, bread flour is an acceptable substitute when preparing fresh pasta by hand.

Asian pasta, generally known as noodles, is made from wheat, rice, bean, or buckwheat flour. It is available fresh or dried from commercial purveyors and at specialty markets.

Italian-Style Pasta

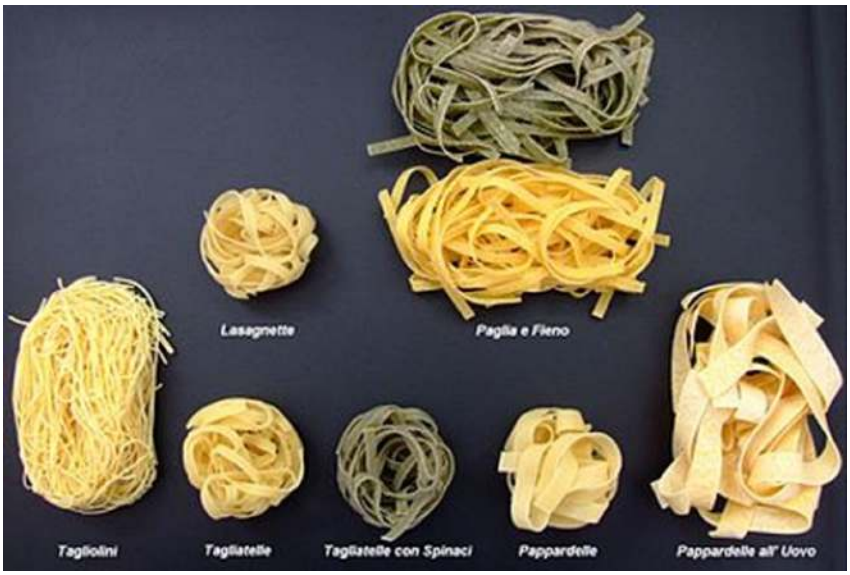
Although all Italian-style pasta is made from the same type of dough, the finest commercial pastas are those made with pure semolina flour, which gives the dough a rich, yellow color. Gray or streaked dough probably contains softer flours. Dried pasta should be very hard and break with a clean snap. The surface should be lightly pitted or dull. (A smooth or glossy surface will not hold or absorb sauces as well.)

Dried pasta, both domestic and imported, is available in a wide range of flavors and shapes. In addition to the traditional white (plain), green (spinach) and red (tomato) pastas, manufacturers are now offering flavor combinations such as lemon-peppercorn, whole wheat-basil and carrot-ginger. Small pieces of herbs or other flavorings are often visible in these products.



There are hundreds of recognized shapes of pasta, but only two or three dozen are generally available in the United States. When experimenting with unusual flavors and shapes, be sure to consider the taste and appearance of the final dish after the sauce and any garnishes are added.

Italian-style pasta can be divided into three groups based on the shape of the final product: ribbons, tubes, and shapes. There is no consistent English nomenclature for these pastas; the Italian names are recognized and applied virtually worldwide. (A specific shape or size may be given different names in different regions of Italy, however. These distinctions are beyond the scope of this text.)

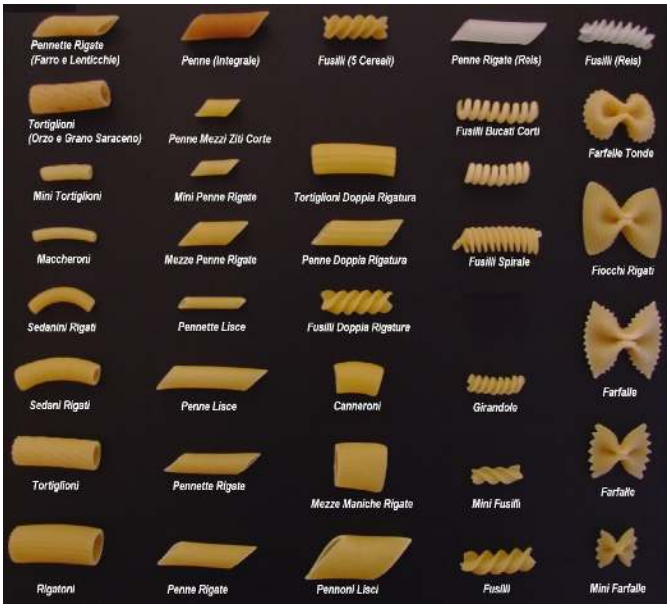


Ribbons

Pasta dough can be rolled very thin and cut into strips, or ribbons, of various widths. All ribbon shapes work well with tomato, fish, and shellfish sauces. Thicker ribbons, such as spaghetti and fettuccine, are preferred with cream or cheese sauces. Sheets of fresh pasta dough can be filled and shaped to create ravioli, cappelletti, and tortellini. Filled pasta is usually served with a light creamer tomato-based sauce that complements the filling's flavors.

Tubes

Cylindrical forms or tubes are made by extrusion. The hollow tubes can be curved or straight, fluted or smooth. Tubes are preferred for meat and vegetable sauces and are often used in baked casseroles.



Shapes - Additional Ribbons

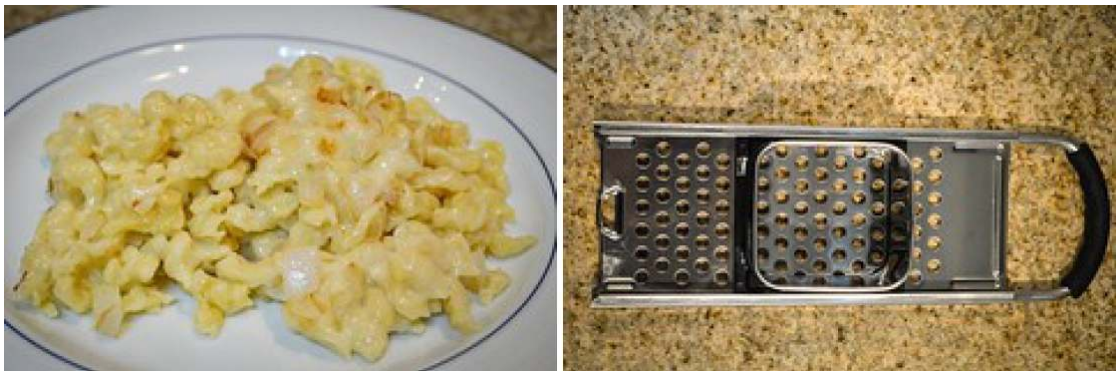


The extrusion process can also be used to shape pasta dough into forms. The curves and textures produced provide nooks and crevices that hold sauces well. Shaped pastas, such as conchiglie, farfalle and fusilli, are preferred with meat sauces and oil-based sauces such as pesto. Larger-shaped pastas can be cooked, then stuffed with meat or cheese fillings and baked or served as a casserole.

Gnocchi



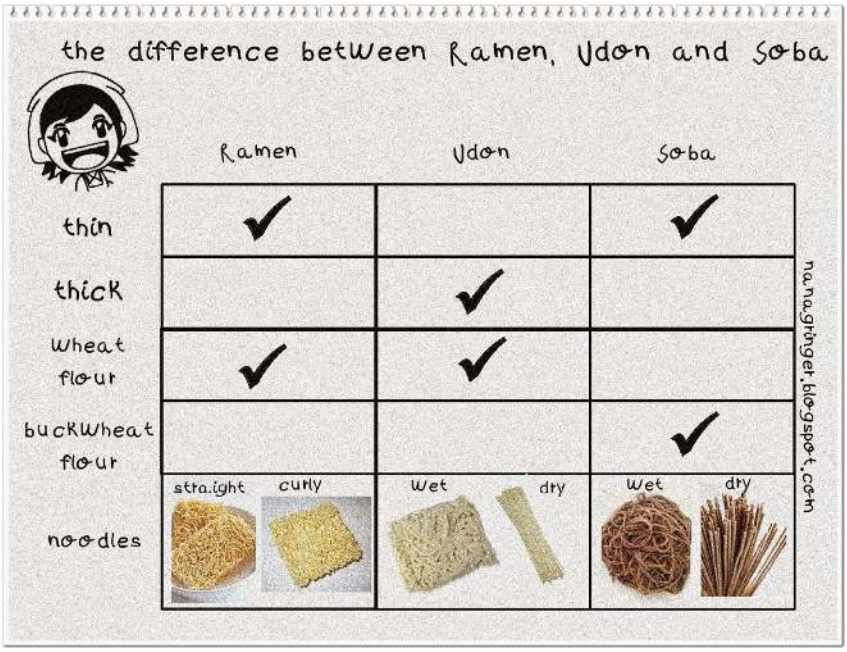
Spaetzle



Cooked Spaetzle Batter passes through device

Asian Noodles

Asian noodles are not cut into the same wealth of shapes and sizes as Italian-style pasta, nor are they flavored or colored with vegetable purees, herbs or other ingredients.



Virtually all Asian noodles are ribbons some thin, some thick-folded into bundles and packaged. Differences arise because of the flour used for the dough. Most dried Asian noodles benefit from soaking in hot water for several minutes before further preparation. The water softens the noodle strands; the bundles separate and the noodles cook more evenly.

Wheat Noodles

Wheat noodles, also known as egg noodles, are the most popular and most widely available of the Asian noodles. They are thin, flat noodles with a springy texture; they are available fresh or dried. Dried egg noodles can be deep-fried after boiling to create crisp golden noodles (chow mein) used primarily as a garnish. Japanese wheat noodles, known as somen (if thin) and udon (if thick), may be round, square or flat. They are eaten in broth or with a dipping sauce.

Rice Noodles

Rice noodles are thin dried noodles made with rice flour. They should be soaked in hot water before cooking and rinsed in cool running water after boiling to remove excess starch and prevent sticking. Rice noodles are often served in soups or sautéed.

Rice vermicelli, which has very fine strands, can be fried in hot oil without presoaking. In only a few seconds, the strands will turn white, puff up and become crunchy. Mounds of crunchy rice noodles can be used as a base for sautéed dishes or for presenting hors

d'oeuvre.

Bean Starch Noodles

Bean starch noodles are also known as spring rain noodles, bean threads, bean noodles or cellophane noodles. They are thin, transparent noodles made from mung beans. Dried bean noodles can be fried in the same manner as rice vermicelli. Otherwise, they must be soaked in hot water before using in soups, stir-fries or braised dishes.

Buckwheat Noodles

Buckwheat flour is used in the noodles of northern Japan and the Tokyo region, known as soba noodles. Soba noodles are available fresh or dried and do not need soaking before cooking. They are traditionally served in broth or with a dipping sauce, but may be substituted for Italian-style pasta if desired.

Dumplings

A **dumpling** is a small mound of dough cooked by steaming or simmering in a flavorful liquid. Dumplings are found in many cuisines: Italian gnocchi, Jewish matzo balls, German spaetzle, Chinese wontons, Belorussian pelmeni and Polish pierogi Dumplings can be sweet or savory, plain or filled.

Plain or **drop** dumplings are made with a bread-like dough, often leavened with yeast or chemical leavening agents. They should be light and tender, but firm enough to hold their shape when cooked. Drop dumplings may be served with stews or broths, or coated with butter or sauce as an appetizer or side dish. **Filled dumplings** are made by wrapping noodle dough around seasoned meat, vegetables, cheese or fruit. These parcels are then steamed, fried or baked and served as a snack food, appetizer or side dish.

Nutrition

Pastas are very low in fat and are an excellent source of vitamins, minerals, proteins and carbohydrates. In addition, the processed products are sometimes enriched with additional nutrients.

Purchasing and Storing Pasta Products

Pasta products are purchased by weight, either fresh or dried. Tubes and shapes are not generally available fresh. Dried products, by far the most common, are available in boxes or bags, usually in 1-, 10- and 20-pound units. They can be stored in a cool, dry place for several months. Fresh pasta can be stored in an airtight wrapping in the refrigerator for a few clays or in the freezer for a few weeks.

Preparing Fresh Pasta

Making Fresh Pasta

Fresh pasta is easy to make, requiring almost no special equipment and only a few staples. The basic form is the sfoglia, a thin, flat sheet of dough that is cut into ribbons, circles or squares.

Although pasta dough can be kneaded by hand, stretched and rolled with a rolling pin and cut with a chef's knife, pasta machines make these tasks easier. Pasta machines are either electric or manual. So me electric models mix and knead the dough, then extrude it through a cutting disk. An extrusion machine is most practical in a food service operation that regularly serves large quantities of pasta. The pasta machine more often encountered is operated manually with a hand crank. It has two rollers that knead, press and push the dough into a thin, uniform sheet. Adjacent cutting rollers slice the thin dough into various widths for fettuccine, spaghetti, capellini and the like.

Filling Pasta

Sheets of raw pasta dough can be filled or folded to create ravioli (squares), tortellini (round "hats" with a brim of dough), lunettes (circles of dough folded into half-moons), agnolotti (squares of dough folded into rectangles), cappelletti (squares of dough folded and shaped into rings) and other shapes. The filled pieces of dough are then cooked in boiling water using the procedure for cooking pasta ribbons discussed later. The filling can include almost anything cheese, herbs, vegetables, fish, shellfish, meat or poultry. It can be uncooked or precooked. Nevertheless, any meat filling should be fully cooked before the pasta is assembled, as the time it takes for the dough to cook may not be sufficient to cook the filling.

Cannelloni is a different type of filled pasta: A large square of cooked dough is wrapped around a meat or cheese filling and baked. Popular lasagna dishes are similar. Lasagna are wide, flat sheets of pasta that are cooked and then layered with cheese, tomato sauce and meat or vegetables as desired. The finished casserole is baked and cut into portions.

Some of the larger, commercially prepared pasta shapes such as large shells (conchigloni or rigate) or large tubes (manicotti) can be partially cooked in boiling water, then filled, sauced and baked as a casserole.

Asian noodle dough is also made into filled items such as dumplings, wontons, egg rolls (made with egg noodle dough) and spring rolls (made with rice paper). These items are usually steamed, pan-fried or deep-fried. When making filled pasta, consider the flavors and textures of the filling, dough and sauce. Each should complement the others.

Cooking Method

Determining Doneness

Italian - style pastas are properly cooked when they are al dente, firm but tender. Cooking times vary depending on the shape and quantity of pasta, the amount of water used ,the hardness of the water, and even the altitude. Fresh pasta cooks rapidly, sometimes in seconds. Noodles and dried pasta may require several minutes.

Although package or recipe directions offer some guidance, the only way to accurately test done-ness is to bite into a piece. When the pasta is slightly firmer than desired, remove it from the stove and drain. It will continue to cook through residual heat.

Unlike Italian pasta, Asian noodles are not served al dente. Rather, they are either boiled until very soft or stir-fried until very crisp.

Boiling

All Italian-style pasta and most Asian noodles are cooked by just one method: boiling. The secret to boiling pasta successfully is to use ample water. Allow 1 gallon (4 liters) of water for each pound (450 grams) of pasta.

Use a saucepan or stockpot large enough to allow the pasta to move freely in the boiling water; otherwise, the starch released by the dough will make the pasta gummy and sticky. The water should be brought to a rapid boil, then all the pasta should be added at once.

Salt should be added to the water. Pasta absorbs water and salt during cooking. Adding salt to the pasta after it is cooked will not provide the same seasoning effect.

Chefs disagree on whether to add oil to the cooking water. Purists argue against adding oil, on the theory that it makes the dough absorb water unevenly. Others think oil should be added to reduce surface foam. Another theory is that oil keeps the pasta from sticking, although this works only when added to cooked, drained pasta.

Asian noodles may be prepared by boiling until fully cooked, or they may be parboiled and then stir-fried with other ingredients to finish cooking.

Terms

- **cracking** a milling process in which grains are broken open
- **grinding** a milling process in which grains are reduced to a powder; the powder can be of differing degrees of fineness or coarseness
- **hulling** a milling process in which the hull or husk is removed from grains
- **pearling** a milling process in which all or part of the hull, bran and germ are removed from grains
- **extrusion** the process of forcing pasta dough through perforated plates to create various shapes; pasta dough that is not extruded must be rolled and cut
- **macaroni** any dried pasta made with wheat flour and water; only in the United States does the term refer to elbow-shaped tubes
- **al dente** Italian for "to the tooth"; used to describe a food, usually pasta, that is cooked only until it gives a slight resistance when one bites into it.

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13.1.1.6: Flour in Baking

Flour in Baking

Flour forms the foundation for bread, cakes, and pastries. It may be described as the skeleton, which supports the other ingredients in a baked product. This applies to both yeast and chemically leavened products.

The strength of flour is represented in protein (gluten) quality and quantity. This varies greatly from flour to flour. The quality of the protein indicates the strength and stability of the flour, and the result in bread making depends on the method used to develop the gluten by proper handling during the fermentation. Gluten is a rubber-like substance that is formed by mixing flour with water. Before it is mixed it contains two proteins. In wheat, these two proteins are **gliadin** and **glutenin**. Although we use the terms *protein* and *gluten* interchangeably, gluten only develops once the flour is moistened and mixed. The protein in the flour becomes gluten.

Hard spring wheat flours are considered the best for bread making as they have a larger percentage of good quality gluten than soft wheat flours. It is not an uncommon practice for mills to blend hard spring wheat with hard winter wheat for the purpose of producing flour that combines the qualities of both. Good bread flour should have about 13% gluten.

Storing Flour

Flour should be kept in a dry, well-ventilated storeroom at a fairly uniform temperature. A temperature of about 70°F with a relative humidity of 60% is considered ideal. Flour should never be stored in a damp place. Moist storerooms with temperatures greater than 74°F are conducive to mold growth, bacterial development, and rapid deterioration of the flour. A well-ventilated storage room is necessary because flour absorbs and retains odors. For this reason, flour should not be stored in the same place as onions, garlic, coffee, or cheese, all of which give off strong odors.

Flour Tests

Wheat that is milled and blended with modern milling methods produces flours that have a fairly uniform quality all year round and, if purchased from a reliable mill, they should not require any testing for quality. The teacher, student, and professional baker, however, should be familiar with qualitative differences in flours and should know the most common testing methods.

Flours are mainly tested for:

- Color
- Absorption
- Gluten strength
- Baking quality

Other tests, done in a laboratory, are done for:

- Albumen
- Starch
- Sugar
- Dextrin
- Mineral and fat content

Color

The color of the flour has a direct bearing on baked bread, providing that fermentation has been carried out properly. The addition of other ingredients to the dough, such as **brown sugar**, malt, molasses, salt, and colored margarine, also affects the color of the bread.

To test the color of the flour, place a small quantity on a smooth glass, and with a spatula, work until a firm smooth mass about 2 in. square is formed. The thickness should be about 2 cm (4/5 in.) at the back of the plate to a thin film at the front. The test should be made in comparison with a flour of known grade and quality, both flours being worked side by side on the same glass. A creamy

white color indicates a hard flour of good gluten quality. A dark or grayish color indicates a poor grade of flour or the presence of dirt. Bran specks indicate a low grade of flour.

After making a color comparison of the dry samples, dip the glass on an angle into clean water and allow to partially dry. Variations in color and the presence of bran specks are more easily identified in the damp samples.

Absorption

Flours are tested for absorption because different flours absorb different amounts of water and therefore make doughs of different consistencies. The absorption ability of a flour is usually between 55% and 65%. To determine the absorption factor, place a small quantity of flour (100 g/4 oz.) in a bowl. Add water gradually from a beaker containing a known amount of water. As the water is added, mix with a spoon until the dough reaches the desired consistency. You can knead the dough by hand for final mixing and determination of consistency. Weigh the unused water. Divide the weight of the water used by the weight of the flour used. The result is the absorption ability in percentage. For example:

Weight of flour used 100 g (4 oz.)

Weight of water used 60 g (2.7 oz.)

Therefore absorption = 6/10 or 60%

Prolonged storage in a dry place results in a natural moisture loss in flour and has a noticeable effect on the dough. For example, a sack of flour that originally weighed 40 kg (88 lb.) with a moisture content of 14% may be reduced to 39 kg (86 lb.) during storage. This means that 1 kg (2 lb.) of water is lost and must be made up when mixing. The moisture content of the wheat used to make the flour is also important from an economic standpoint.

Hard wheat flour absorbs more liquid than soft flour. Good hard wheat flour should feel somewhat granular when rubbed between the thumb and fingers. A soft, smooth feeling indicates soft wheat flour or a blend of soft and hard wheat flour. Another indicator is that hard wheat flour retains its form when pressed in the hollow of the hand and falls apart readily when touched. Soft wheat flour tends to remain lumped together after pressure.

Gluten Strength

The gluten test is done to find the variation of gluten quality and quantity in different kinds of flour. Hard flour has more gluten of better quality than soft flour. The gluten strength and quality of two different kinds of hard flour may also vary with the weather conditions and the place where the wheat is grown. The difference may be measured exactly by laboratory tests, or roughly assessed by the variation of gluten balls made from different kinds of hard flours.

For example, to test the gluten in hard flour and all-purpose flour, mix 9 oz. of each in separate mixing bowls with enough water to make each dough stiff. Mix and develop each dough until smooth. Let the dough rest for about 10 minutes. Wash each dough separately while kneading it under a stream of cold water until the water runs clean and all the starch is washed out. (Keep a flour sieve in the sink to prevent dough pieces from being washed down the drain.) What remains will be crude gluten. Shape the crude gluten into round balls, then place them on a paper-lined baking pan and bake at 420°F for about one hour. The gluten ball made from hard flour will be larger than the one made from all-purpose flour. This illustrates the ability of hard flour to produce a greater volume because of its higher gluten content.

Ash Content

Ash or mineral content of the flour is used as another measurement of quality. Earlier in the chapter, we talked about extraction rates as an indicator of how much of the grain has been refined. Ash content refers to the amount of ash that would be left over if you were to burn 100 g of flour. A higher ash content indicates that the flour contains more of the germ, bran, and outer endosperm. Lower ash content means that the flour is more highly refined (i.e., a lower extraction rate).

Baking Quality

The final and conclusive test of any flour is the kind of bread that can be made from it. The baking test enables the baker to check on the completed loaf that can be expected from any given flour. Good volume is related to good quality gluten; poor volume to young or green flour. Flour that lacks stability or power to hold during the entire fermentation may result in small, flatbread. Flour

of this type may sometimes respond to an increase in the amount of yeast. More yeast shortens the fermentation time and keeps the dough in better condition during the pan fermentation period.

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13.1.1.7: Rye Flour

Rye Flour

Rye is a hardy cereal grass cultivated for its grain. Its use by humans can be traced back over 2,000 years. Once a staple food in Scandinavia and Eastern Europe, rye declined in popularity as wheat became more available through world trade. A crop well suited to northern climates, rye is grown in the northern states such as the Dakotas and Wisconsin.

Rye flour is the only flour other than wheat that can be used without blending (with wheat flour) to make yeast-raised bread. Nutritionally, it is a grain comparable in value to wheat.

The brown grain is cleaned, tempered, and milled much like wheat grain. One difference is that the rye endosperm is soft and breaks down into flour much more quickly than wheat. The bran is separated from the flour by the break roller. It is then further rolled and sifted while being graded into chop, meal, light flour, medium flour, and dark flour:.

- Chop: This is the miller's name for the coarse stock after grinding in a break roller mill.
- Meal: Like chop, a meal is made of 100% extraction obtained by grinding the entire rye kernel.
- Light rye flour: This is obtained from the center of the rye kernel and is low in protein and high in starch content. It can be compared to white bread flour and is used to make light rye bread.
- Medium rye flour: This is straight flour and consists of all the kernels after the bran and shorts have been removed. It is light grey in color, has an ash content of 1%, and is used for a variety of sourdough bread.
- Dark rye flour: This is comparable to the first clear wheat flour. It has an ash content of 2% and a protein content of 16%. It is used primarily for heavier types of rye bread.

The lighter rye flours are generally bleached, usually with a chlorine treatment. The purpose of bleaching is to lighten the color, since there is no improvement on the gluten capability of the flour.

Extraction of Rye Flour

The grade of extraction of rye flour is of great importance to the yield of the dough and the creation of a particular flavor in the baked bread. Table 1 shows the percentage of the dry substances of rye flour by grade of extraction.

Table 1 Dry Substances of Rye Flour by Grade of Extraction

Substance	70% Extraction Rate	85% Extraction Rate
Ash	0.8%	1.4%
Fat	1.2%	1.7%
Protein	8.1%	9.6%
Sugar	6.5%	7.5%
Starch	72.5%	65.1%
Crude fiber	0.5%	1.3%

Note that ash and fiber are higher in the 85% extraction rate flour, and starch is lower. The starch level in rye flour is greater than that of wheat flour and is of more significance for successful rye bread baking.

Rye flours differ from wheat flour in the type of gluten that they contain. Although some dark rye flours can have a gluten content as high as 16%, this is only gliadin. The glutenin, which forms the elasticity in the dough is absent, and therefore doughs made only with rye flour will not hold the gas produced by the yeast during fermentation. This results in a small and compact loaf of bread.

Starches are far more important to the quality of the dough yield than gluten. Starch is the chief component of the flour responsible for the structure of the loaf. Its bread-making ability hinges on the age of the flour and the acidity. While rye flour does not have to be aged as much as wheat flour, it has both a "best after" and a "best before" date. Three weeks after milling is considered to be good.

When the rye flour is freshly milled, the starch gelatinizes (sets) quickly at a temperature at which amylases are still very active. As a result, bread made from fresh flour may be sticky and very moist. At the other extreme, as the starch gets older, it gelatinizes less readily, the enzymes cannot do their work, and the loaf may split and crack. A certain amount of starch breakdown must occur for the dough to be able to swell.

The moisture content of rye flour should be between 13% and 14%. The less water in the flour, the better its storage ability. Rye should be stored under similar conditions to wheat flour.

Differences between Rye and Wheat

Here is a short list of the differences between rye and wheat:

- Rye is more easily pulverized.
- Rye does not yield semolina.
- Gluten content in the rye is not a significant dough-making factor.
- Starch is more important for bread making in rye flour than in wheat flour.
- Rye flour has greater water-binding capability than wheat flour, due to its starches.

In summary, both wheat and rye have a long history in providing the “staff of life.” They are both highly nutritious. North American mills have state-of-the-art technology that compensates for crop differences, thus ensuring that the baker has a reliable and predictable raw material. Flour comes in a great variety of types, specially formulated so that the baker can choose according to product and customer taste.

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SECTION OVERVIEW

13.1.2: Leavening Agents

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13.1.2.2: Chemical Leavening

13.1.2.3: Physical Leaveners

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13.1.2.1: Biological Leavening

Biological Leavening

Yeast and certain bacteria may be used as leavening agents. Yeast plays an important role in leavening many bread products in that it can release $C0_2$ gas and allow doughs to rise.

Yeast

Yeast is naturally found in the environment and is thought to have been discovered by complete accident. Yeast feeds on starches and sugars and releases $C0_2$ gases which is why it is the preferred leavening agent in bread making. Yeast also lends a flavor to the final baked product.

Types of Yeast

Wild Yeast

Wild yeast spores are found floating on dust particles in the air, in flour, on the outside of fruits, etc. Wild yeasts form spores faster than cultivated yeasts, but they are inconsistent and are not satisfactory for controlled fermentation purposes.

Compressed Yeast

Compressed yeast is made by cultivating a select variety, which is known by experiment to produce a yeast that is hardy, consistent, and produces a fermentation with strong enzymatic action. These plants are carefully isolated in a sterile environment free of any other type of yeast and cultivated on a plate containing nutrient agar or gelatin. Wort, a combination of sterilized and purified molasses or malt, nitrogenous matter, and mineral salts is used to supply the food that the growing yeast plants need to make up the bulk of compressed yeast.

After growing to maturity in the fermentation tank, the yeast is separated from the used food or wort by means of centrifugal machines. The yeast is then cooled, filtered, pressed, cut, wrapped, and refrigerated. It is marketed in 454 g (1 lb.) blocks, or in large 20 kg (45 lb.) bags for wholesale bakeries.

Figure 7 illustrates the process of cultivating compressed yeast, and Table 9 summarizes its composition.

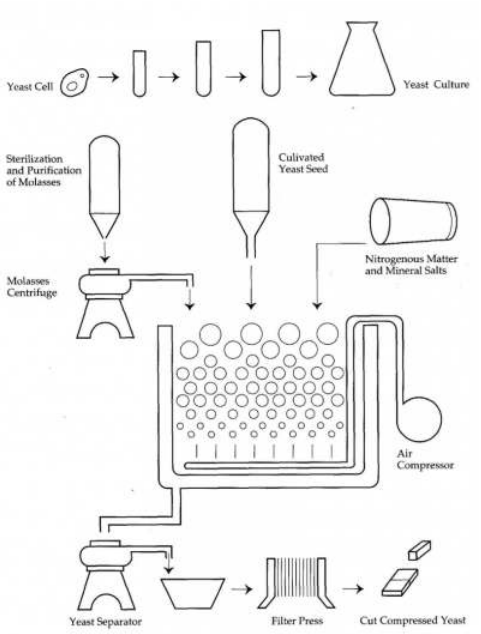


Figure 7. Production of compressed yeast. [Image Description]

Active Dry Yeast

Active dry yeast is made from a different strain than compressed yeast. The manufacturing process is the same except that the cultivated yeast is mixed with starch or other absorbents and dehydrated. Its production began after World War II, and it was used

mainly by the armed forces, homemakers, and in areas where fresh yeast was not readily available.

Even though it is a dry product, it is alive and should be refrigerated below 7°C (45°F) in a closed container for best results. It has a moisture content of about 7%. Storage without refrigeration is satisfactory only for a limited period of time. If no refrigeration is available, the yeast should be kept unopened in a cool, dry place. It should be allowed to warm up to room temperature slowly before being used.

Dry yeast must be hydrated for about 15 minutes in water at least four times its weight at a temperature between 42°C and 44°C (108°F and 112°F). The temperature should never be lower than 30°C (86°F), and dry yeast should never be used before it is completely dissolved.

It takes about 550 g (20 oz.) of dry yeast to replace 1 kg (2.2 lb.) of compressed yeast, and for each kilogram of dry yeast used, an additional kilogram of water should be added to the mix. This product is hardly, if ever, used by bakers, having been superseded by instant yeast (see below).

Instant Dry Yeast

Unlike instant active dry yeast that must be dissolved in warm water for proper rehydration and activation, instant dry yeast can be added to the dough directly, either by:

- Mixing it with the flour before the water is added
- Adding it after all the ingredients have been mixed for one minute

This yeast can be reconstituted. Some manufacturers call for adding it to five times its weight of water at a temperature of 32°C to 38°C (90°F to 100°F). Most formulas suggest a 1:3 ratio when replacing compressed yeast with instant dry. Others vary slightly, with some having a 1:4 ratio. In rich Danish dough, it takes about 400 g (14 oz.), and in bread dough about 250 g to 300 g (9 oz. to 11 oz.) of instant dry yeast to replace 1 kg (2.2 lb.) of compressed yeast. As well, a little extra water is needed to make up for the moisture in compressed yeast. Precise instructions are included with the package; basically, it amounts to the difference between the weight of compressed yeast that would have been used and the amount of dry yeast used.

Instant dry yeast has a moisture content of about 5% and is packed in vacuum pouches. It has a shelf life of about one year at room temperature without any noticeable change in its gassing activity. After the seal is broken, the content turns into a granular powder, which should be refrigerated and used by its best-before date, as noted on the packaging.

Instant dry yeast is especially useful in areas where compressed yeast is not available. However, in any situation, it is practical to use and has the advantages of taking up less space and having a longer shelf life than compressed yeast.

The Functions of Yeast

Yeast has two primary functions in fermentation:

- To convert sugar into carbon dioxide gas, which lifts and aerates the dough
- To mellow and condition the gluten of the dough so that it will absorb the increasing gases evenly and hold them at the same time

In baked products, yeast increases the volume and improves the flavor, texture, grain, color, and eating quality. When yeast, water, and flour are mixed together under the right conditions, all the food required for fermentation is present as there is enough soluble protein to build new cells and enough sugar to feed them.

Activity within the yeast cells starts when enzymes in the yeast change complex sugar into invert sugar. The invert sugar is, in turn, absorbed within the yeast cell and converted into carbon dioxide gas and alcohol. Other enzymes in the yeast and flour convert soluble starch into malt sugar, which is converted again by other enzymes into fermentable sugar so that aeration goes on from this continuous production of carbon dioxide.

Proper Handling of Yeast

Compressed yeast ages and weakens gradually even when stored in the refrigerator. Fresh yeast feels moist and firm, and breaks evenly without crumbling. It has a fruity, fresh smell, which changes to a sticky mass with a cheesy odor. It is not always easy to

recognize whether or not yeast has lost enough of its strength to affect the fermentation and the eventual outcome of the baked bread, but its working quality definitely depends on the storage conditions, temperature, humidity, and age.

The optimum storage temperature for yeast is around 30 degrees F. At this temperature, it is still completely effective for up to two months. Yeast does not freeze at this temperature.

Other guidelines for storing yeast include:

- Rotating it properly and using the older stock first
- Avoiding overheating by spacing it on the shelves in the refrigerator

Yeast needs to breathe, since it is a living fungus. The process is continuous, proceeding slowly in the refrigerator and rapidly at the higher temperature in the shop. When respiration occurs without food, the yeast cells starve, weaken, and gradually die.

Yeast that has been frozen and thawed does not keep and should be used immediately. Freezing temperatures weaken yeast, and thawed yeast cannot be refrozen successfully.

Using Yeast

Many bakers add compressed yeast directly to their dough. A more traditional way to use yeast is to dissolve it in lukewarm water before adding it to the dough. The water should never be higher than 122°F because heat destroys yeast cells. In general, salt should not come into direct contact with yeast, as salt dehydrates the yeast. (Table 10 indicates the reaction of yeast at various temperatures.)

It is best to add the dissolved yeast to the flour when the dough is ready for mixing. In this way, the flour is used as a buffer. (Buffers are ingredients that separate or insulate ingredients, which if in too close contact, might start to react prematurely.) In sponges where little or no salt is used, yeast buds quickly and fermentation of the sponge is rapid.

Never leave compressed yeast out for more than a few minutes. Remove only the amount needed from the refrigerator. Yeast lying around on workbenches at room temperature quickly deteriorates and gives poor results. One solution used by some bakeries to eliminate steps to the fridge is to have a small portable cooler in which to keep the yeast on the bench until it is needed. Yeast must be kept wrapped at all times because if it is exposed to air the edges and the corners will turn brown. This condition is known as air-burn.

Table 10 How Yeast Reacts at Different Temperatures

Temperature	Reaction
15°C–20°C (60°F–68°F)	slow reaction
26°C–29°C (80°F–85°F)	normal reaction
32°C–38°C (90°F–100°F)	fast reaction
59°C (138°F)	terminal death point

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13.1.2.2: Chemical Leavening

Baking Powder

Baking powder is a dependable, high-quality chemical leavening. To be effective, all baking powders rely on the reaction between one or more acids on sodium bicarbonate to produce carbon dioxide gas. Just as with yeast leavening, the presence of carbon dioxide gas creates air bubbles that cause the product to rise.

There are two main types of baking powders available on the market:

- Continuous or single-action baking powder
- Double- or multiple-action baking powder

The difference between continuous- and double-action baking powders is simply the rate of reaction:

- Continuous-action baking powder uses one acid, which continuously reacts with the soda to release gas steadily throughout the baking process until all the gassing power is spent.
- Double-action baking powder contains two different acids, which react with soda at different stages of the baking process. One acid reacts to give off a small amount of gas at low temperatures, and the other major acid reacts at baking temperatures to give off the bulk of the gas.

The Leavening Mechanism of Baking Powder

Before baking, approximately 15% of the CO_2 gas is released in the cold stage. Eighty-five percent of the CO_2 gas is released in the oven starting at approximately 105°F. Some leavening power is apparently lost in the cold stage, but there is usually still adequate gassing power in the remaining portion.

When the baking powder is activated through moisture and heat, the gas works its way into the many cells created by the mixing or creaming of the batter and starts to expand them. This process comes to a halt when the starch gelatinizes and the cells become rigid. This starts at about 140°F and is more or less complete at around 167°F. After this point, some gas may still be created, but it simply escapes through the porous structure of the product.

Using Baking Powder

For even distribution throughout the batter, the baking powder should be sifted with flour or other dry ingredients.

Sodium Bicarbonate

When sodium bicarbonate (baking soda) is moistened and heated, it releases carbon dioxide gas. If it is moistened and heated in the presence of sufficient acid, it will release twice as much gas as if it is moistened and heated without the presence of an acid.

Slightly acidic ingredients provide the mix with some of the necessary acids for the release of carbon dioxide gas. Examples are:

- Honey
- Molasses
- Ginger
- Cocoa
- Bran

For this reason, some of the mixes contain baking powder only while others contain a combination of baking powder and baking soda. If an excessive amount of baking soda is used in a cake batter without the presence of sufficient acid, the normally white cake crumb will have a yellowish-brown color and a strong undesirable smell of soda.

The gas evolves very fast at the beginning of baking when the **pH** level is still on the acidic side (pH of around 5 to 6). Once the soda neutralizes the acid, the dough or batter quickly becomes **alkaline** and the release of gas is reduced. Mixes and doughs leavened with baking soda must be handled without delay, or the release of the gas may be almost exhausted before the product reaches the oven.

The darker color of the crumb found on the bottom half of a cake or muffin is caused by the partial dehydration of the batter that is heated first during baking. In spiced honey cookies and gingerbread, baking soda is used alone to give them quick color during

baking and yet keep the products soft.

The level of baking soda depends on the nature of the product and on the other ingredients in the formula. Cookies, for example, with high levels of fat and sugar, do not require much, if any, leavening.

Cream of Tartar

Cream of tartar is a white crystalline compound that exists in grapes, tamarinds, and other fruits. It is prepared from the sediments in wine barrels and is called *argol*. The argol is dissolved in hot water, and the coloring matter is removed by means of clay or egg albumin. After being purified by crystallization, it is ready for the market.

Cream of tartar has no leavening capacity by itself, but can be used in combination with sodium bicarbonate to provide the acid necessary for leavening. It was formerly used for making baking powder but that practice has been largely discontinued because of cost and its too quick reaction time. In some recipes, it is used alone. Cream of tartar is also an excellent stabilizer for egg whites.

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13.1.2.3: Physical Leaveners

Leavening agents play an integral role in the development of flour mixtures into final baked products. Leaveners directly aid in the process of rise and give products their distinct shape and flavor. Leaveners can be physical, biological, or chemical and this section discusses physical leaveners.

Physical Leavening Agents

There are two types of physical leavening agents; air and steam.

Air

Air is regularly incorporated into flour mixtures during several preparation steps such as mixing, stirring, creaming fat and sugar, sifting dry ingredients, and whipping. Air becomes trapped in between protein matrixes aiding in the final lift (or rise) in the baked product.

Steam

Water that is incorporated into the flour mixtures will produce steam when heated or cooked. Steam expands to many times its original volume pushing out on the gluten or other protein structures as bread or other flour mixture bakes. Steam acts as the primary leavening agent in popovers, pie crusts, and pastries.

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13.1.3: Yeast Breads

Click on the link bellow to get a quick overview of yeast breads:

https://www.quakeroats.com/cooking-and-recipes/baking-101/yeast-breads/types-of-yeast-breads



"Italian Bread Rolls, Homemade" by Herman Saksono is licensed under CC BY-NC-ND 2.0.

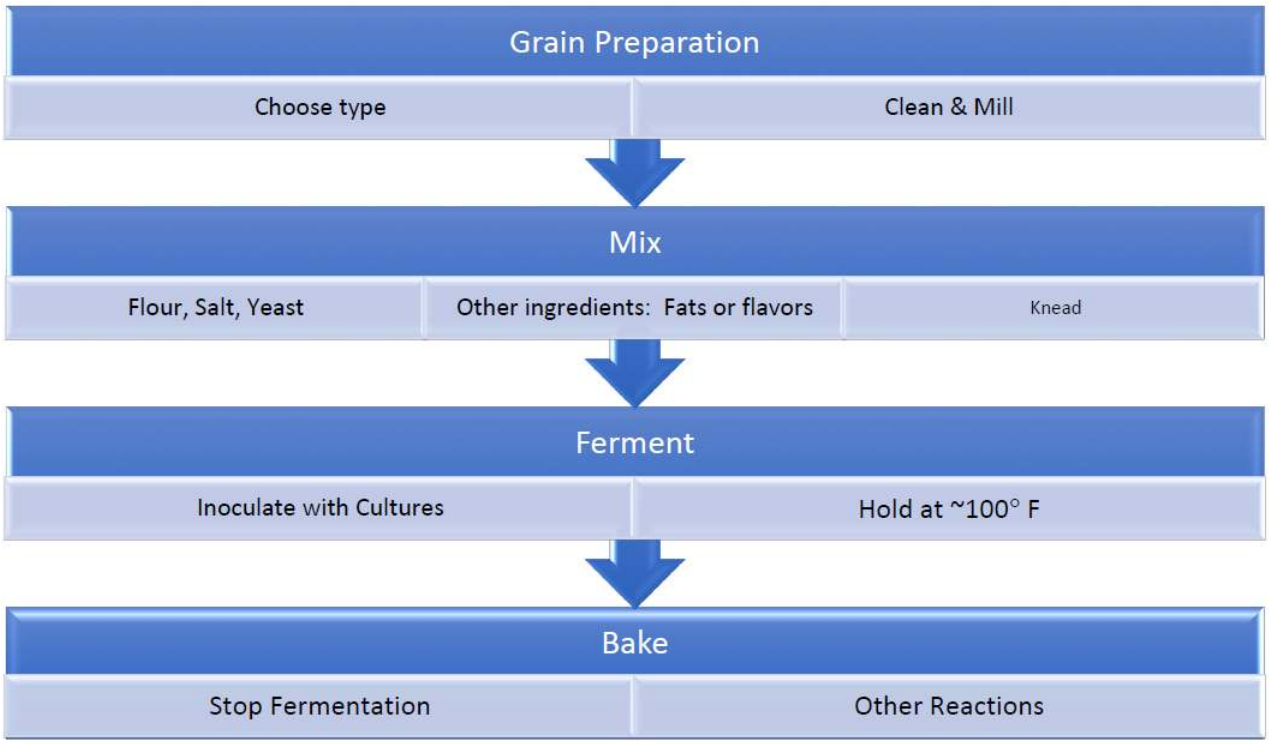
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13.1.3.1: Bread

Bread Production

Bread is a staple food in many cultures. The key ingredients are a grain starch, water, and a leavening agent. However, there are some breads without leavening agents (tortillas or naan), but these are flat breads.

Typical Steps in Bread Production:



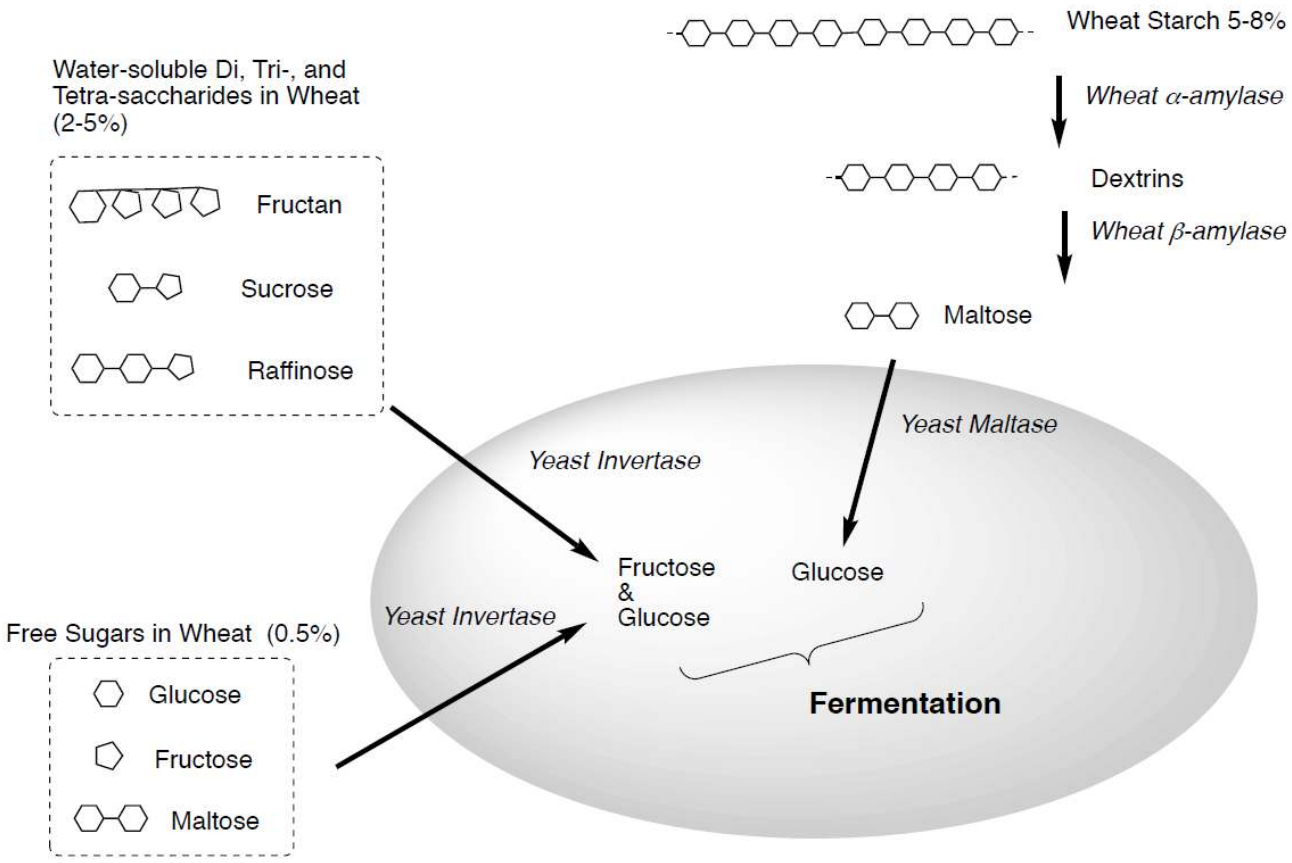
Leavening Organisms and Fermentation

Saccharomyces cerevisiae, also known as baker's yeast, is the primary leavening agent in the production of most breads. Yeast cells consume the sugars present in dough and generate carbon dioxide (CO_2) and ethanol that are responsible for dough leavening during the fermentation phase and the oven rise.

Fermentable Sugars

After flour, yeast and water are mixed, complex biochemical and biophysical processes begin, catalyzed by the wheat enzymes and by the yeast. These processes go on in the baking phase. The primary starches found in most cereal plants are the polymers amylose and amylopectin.

These starches in the flour provide most of the sugar for fermentation, but the starch must be broken down into monosaccharides before it can be fermented by the yeast. Here is an overview of the sugars utilized by the yeast for the fermentation process:



Amylases: Two types of amylases are present in wheat flour: alpha-amylases and beta-amylases.

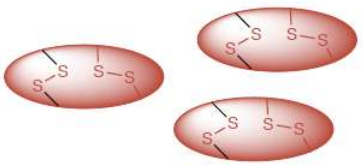
- alpha-Amylases hydrolyze the alpha-1,4 linkages inside the starch chain randomly, thereby generating shorter oligosaccharides.
- beta-Amylases cleave maltose from the non-reducing end of the starch chain.

Yeast Invertase and Maltase

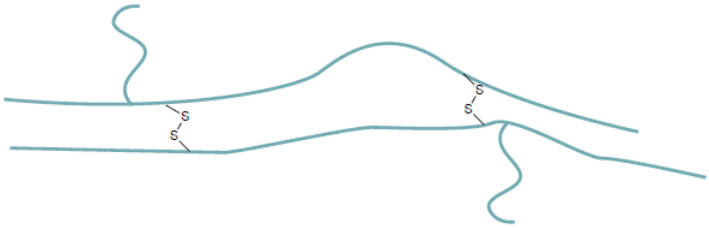
- Invertase hydrolyzes several small oligosaccharides.
- Maltase cleaves maltose into the 2 monosaccharides.

Gluten Formation

Amongst the most important components of the flour are proteins, which often make up 10-15% of the flour. These include the classes of proteins called glutenins and gliadins. **Gliadins** are globular proteins with molecular weights ranging from 30,000 to 80,000 kDa. Gliadins contain intramolecular disulfide bonds.

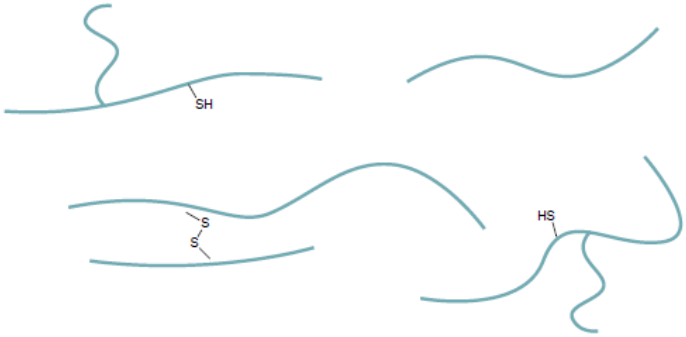


Glutenins consist of a heterogeneous mixture of linear polymers with a large molecular weight sections and low molecular weight branches (LMW). Disulfide bond cross-link the glutenin subunits.

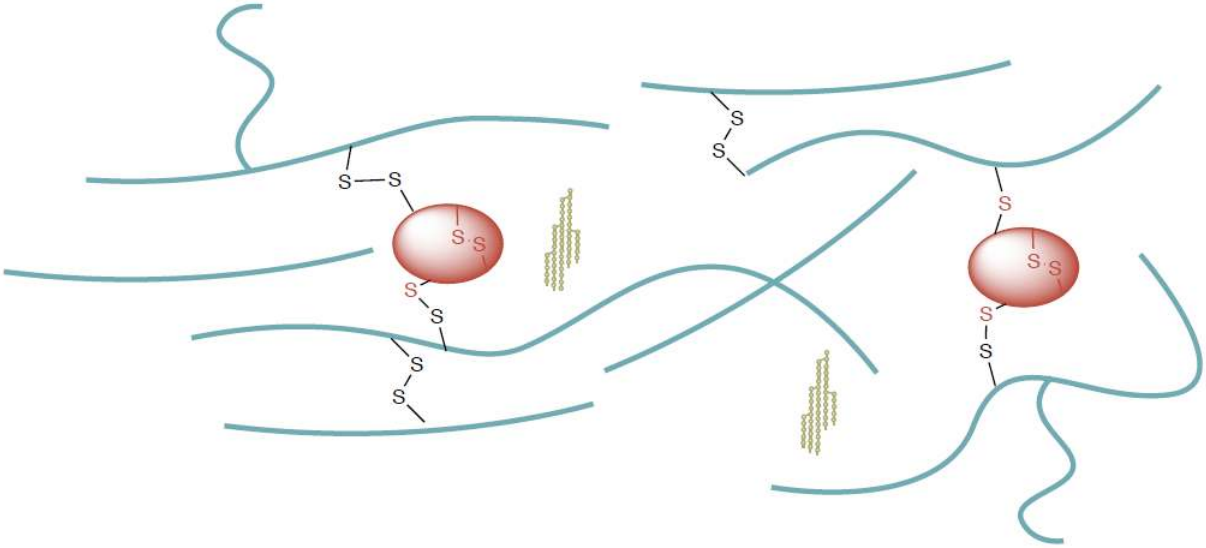


Prior to kneading, the two main protein types, gliadin, and glutenin, remain separate on a molecular level. However, as the dough is mixed and kneaded several things begin happening:

The protease enzymes from the wheat begin to break the glutenin into smaller pieces.



The glutenin and gliadin begin to form chemical crosslinks between the proteins. A complex network of proteins, ***gluten***, is formed.



Starch granules are trapped in the dough and air is incorporated into the dough during kneading. The dough needs to be elastic enough to relax when it rests and expand and hold CO_2 when it rises — while still maintaining its shape. Eventually, the heat of the baking will kill the yeast.

Effect of Other Ingredients on Gluten Formation

- Fat and emulsifiers coat proteins.
- Salts (table salt, NaCl, or hard water salts such as Ca^{+2} or Mg^{+2}) can strengthen the gluten network.

Cookie: Usually quite crumbly and doesn't rise very much.

Pizza: To pull dough as thin as a pizza without breaking, there must be a very strong gluten network.

Bread: A network is tight enough to trap the yeast's CO_2 allowing it to rise, but not so tight that it is free to expand.

Baking

Flavors and Aromas: Maillard Reactions

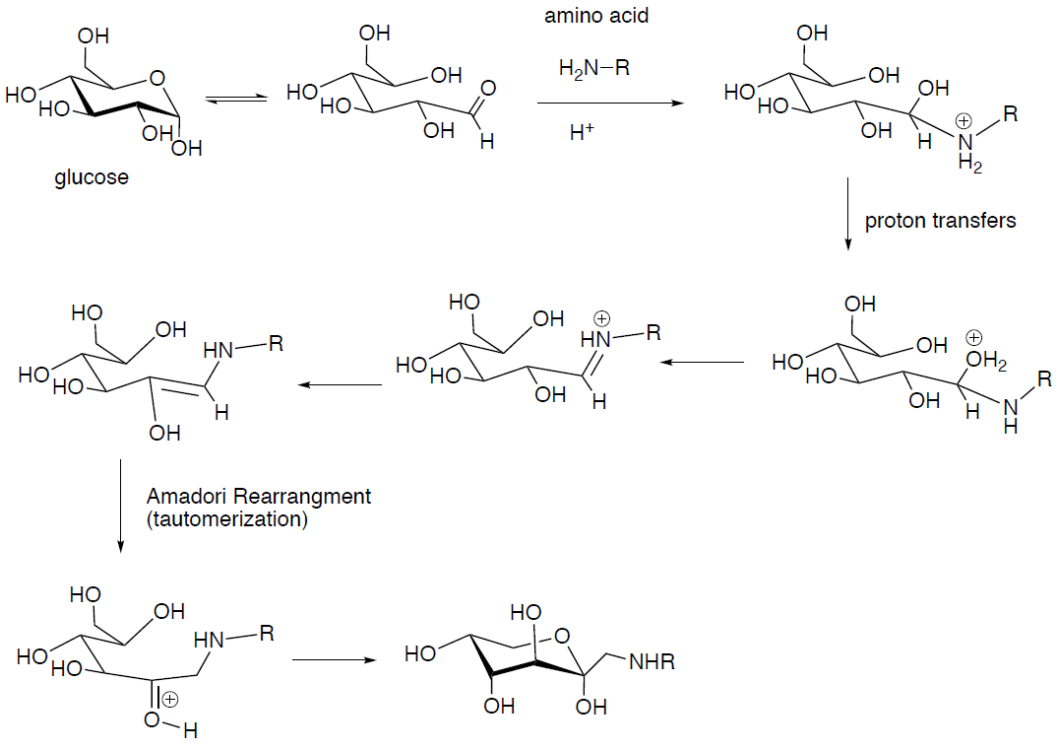
Brewer's Journal, Science/Maillard Reaction

In food chemistry, any heating steps involving the presence of sugars and amino compounds lead to a series of reactions called the Maillard reactions. These Maillard reactions are nonenzymatic 'browning reactions' that lead to the formation of a wide range of flavorful compounds which include; malty, toasted, bready and nutty flavors.

There are three stages to the Maillard Reactions:

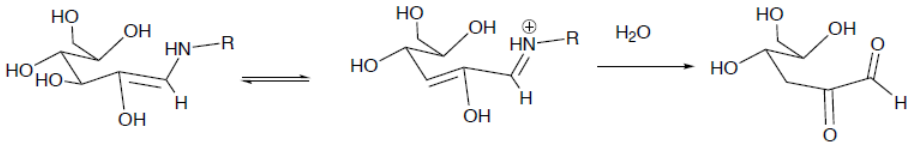
Stage I: A condensation between the sugar and amine followed by the Amadori rearrangement.
Stage II: Formation of Strecker Aldehydes
Stage III: Formation of heterocyclic nitrogen compounds.

Stage 1:

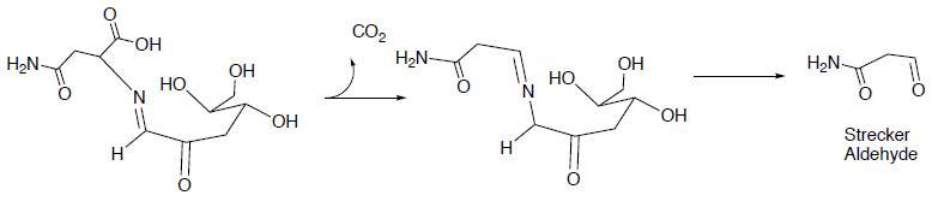


Stage 2:

Tautomerizations can convert the Amadori Product to a dicarbonyl.

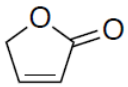
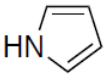
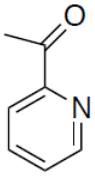
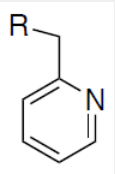
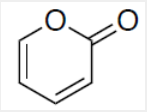
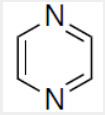
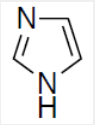


In the Strecker degradation, the imine product undergoes a decarboxylation and is hydrolyzed to an aldehyde.



Stage 3:

In this stage, the Strecker aldehydes form complicated heterocycles in a variety of molecular families.

 furanones ‘sweet, caramel’	 pyrroles ‘nutty’	 Acylpryidines ‘cracker’	 furans ‘meaty, burnt’	 thiophenes ‘meaty,roasted’
 Alkylpryidines ‘bitter, burnt’	 pyranones ‘maple, warm, fruity’	 pyrazines ‘roasted, toasted’	 oxazoles ‘nutty, sweet’	 imidazoles ‘chocolate, bitter, nutty’

The molecules can also form polymers and precipitates.

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13.1.3.2: Yeast Doughs

Bread is one of the simplest and yet most complicated of items to make. Most doughs consist of flour, water, salt, and yeast. The art of making simple and complex doughs is understanding the nature of the item and what affects the finished product – gluten development and the fermentation of the leavener, yeast.

Types of Doughs

Lean Doughs

These doughs are low in fat and sugar.

1. **Hard and crusty bread** – these are crust French bread, rolls, pizza doughs, and hard rolls. These are the leanest of all doughs made.
2. **White and Whole wheat bread** – these bread may contain some fats and sugar. They are softer doughs and usually have a soft texture and crust.
3. **Grain bread** - these types of bread are made from other types of flour and grains. They may contain additives that add acid and sweetness to the doughs i.e. rye, oat, flax seed, and sprouted grains.

Rich Doughs

These doughs contain great amounts of fats and sugars, and also eggs. These additions give the bread a softer feel and richer taste. These types of doughs can be sweet or non-sweet depending on the amount of sugar that is added or toppings. Such bread include brioche, coffee cake, and dinner rolls.

Laminated Doughs

These types of dough have the fat rolled into the dough to create layers. This is done by rolling or pinning in the fat and folding the dough to create the many layers that make up the dough. This process gives the dough a flaky and buttery texture. Although there is some sugar in the dough, the majority of the sweetness comes from the added fillings and toppings. The two main types are croissants and Danish however, some other bread can be finished in this style.

The production of bread

As with everything, there are specific steps to making bread. It is much more complex than just adding the ingredients to a bowl and stirring. The process is a building block of steps that cannot be rushed - or done out of order. Each step is necessary to insure that the bread comes out as desired. As seen below there are many steps in making the perfect yeast dough. For the purposes of this class, we have narrowed down the number of steps to 7 but understand that there may be additional steps that are required for the making of each individual bread and these steps do not incorporate the pre-step of measurement or the final stages of bread production such as storage.

Mixing

Kneading

Proofing

Punching down

Shaping/Decorating

Second proofing (optional)

Baking

Scaling (Measuring) Ingredients

The recipes or formulas used in baking are exact and getting the amount of each ingredient is necessary. This is done in the bakeshop by weighing out the ingredients. Liquid can be measured by volume but with large quantity, it is more accurate to scale out each and every ingredient. Pay special attention to spices and salt. Salt plays an important role in the fermentation of yeast.

Mixing

The purpose of mixing is to give an even distribution of the ingredients and to form a smooth dough. This is also the beginning of gluten formation. There are many ways to mix ingredients but we will highlight the 4 most common below:

Straight Method:

Dry and wet ingredients are mixed together until they come together, then kneaded until developed into a smooth non-sticky ball. This ball will be allowed to rise and then baked.

Sponge Method:

This method differs from straight dough method in that we allow some of the yeast to ferment before we mix together all of the dry ingredients in order to form a ball of dough. This helps the flavor develop. To makeyea st bread using this method 1/3rd of the flour is mixed with the wet ingredients and yeast. This yeast/flour mixture is allowed to sit for around 30 minutes and you should visibly see bubbles form on the surface. After the time has elapsed the rest of the dry ingredients are added and the straight dough method is followed where the dough is kneaded, allowed to rise, and baked.

Batter Method:

There is no kneading involved in the batter method of preparation which sets it apart from all of the others. The batter method involves combining all of the ingredients together until a batter is formed. The batter is then moved to a prepared loaf pan and allowed to proof. After proofing the batter is then baked.

Rapid Mix:

With rapid mixing, a bread machine does all of the work. The bread machine will mix, knead, proof, and bake a loaf of bread in around 2 hours without the need of elbow grease on the part of the baker. This is easy and convenient.

Proofing

This is the beginning of the fermentation of the yeast. The yeast will feed on the sugars and starches it will release carbon dioxide and alcohol. The gluten will work as a net to trap the gases and cause the dough to rise. Fermentation is part of the development of the dough. Improper fermentation time will affect the finished product. Over-fermented dough will become hard and tough whereas under-fermented dough will not have enough volume.

The dough is placed in a large container that will allow it to “grow” or expand. The dough is covered during this time to avoid air hitting it and forming a “skin” or crust that will ruin the texture of the dough. Some doughs can be oiled to avoid this.

Folding/Punching Down

As the dough ferments the yeast will releases gases. These gases are what cause the expansion of the dough. The purpose of punching down (or folding) is to control this process and help further develop the gluten. Many things can affect the feeding of the yeast and too much carbon dioxide is just one. The folding releases the gases and allows the yeast to continue its process. During this release, the dough is folded thus realigning the gluten strands similar to the kneading of the dough. It also helps to keep the temperature of the dough constant.

Decorating/ Shaping

Once the doughs are scaled out, they need to be pre-shaped into a form that will allow for the next stage. Most bakers choose to pre-shape their dough into round shapes. This round form allows for a smooth surface to the dough. The gluten strands are pulled tight and help for continued fermentation. This also gives the baker the chance to feel the dough for the texture and strength of the gluten strands. If the dough is slack or loose then you can give it a tighter shape. If the dough is tough and not too elastic give it a looser form. Try to get your pre-shaped dough as close to the final makeup shape as possible.

Second Proofing (also called bench proofing)

Once the dough has been shaped, it needs to rest. This step can be anywhere from 10 to 20 minutes. This allows the gluten strands to relax and get ready for the final stages of the process. This is done on the bench or work area. The dough is covered with plastic wrap but not tight. It will continue to ferment and rise.

Baking

This is the stage of cooking the bread. The oven is set for the conditions needed to produce the finished desired result. The ovens used in class are the convection oven and the deck oven. Each cooks differently due to the type of oven. Bread is finished in different ways before going into the oven. They can be washed with water, egg wash, heavy cream, as well as other types of washes. These will affect the finished products' crust and look. Both class ovens have the ability to inject steam to help with crust formation allowing for rapid expansion without splitting the crust. It also helps in heat distribution and helping with oven spring. Oven spring is the final rise that occurs in bread once it begins to cook. This then sets the structure of the bread as the temperature of the dough rises the yeast dies at 140 F. Scoring is another useful technique used to avoid the splitting of the dough as it rises in the oven. Slits are made to the top of the dough with a lame (curved razor tool) or sharp knife.

Cooling

Once the bread is cooked to the correct internal temperature (this varies for types of breads), then it is removed from the oven. The cooked bread is placed on a cooling rack. The cooling allows for many things to happen. Excess moisture is released from the bread as it cools and the alcohol created by the fermented yeast evaporates. Most bread are allowed to cool on the pan. Bread baked in loaf pans or other pans can be removed and set on its side so that moisture does not condense on the bottom causing the crust to become soggy.

Storing

The bread can be stored in moisture -proof bags to prevent staling or wrapped tightly with plastic wrap in their pans. Before either occurs, the bread must be cooled completely.

- Wrapping or bagging hot or warm bread will cause moisture to form and thus making the bread wet and soggy.
- Once properly bagged, bread can be kept at room temperature if used occurs within a few hours or days, or frozen for longer periods.
- Putting bread in the refrigerator will increase the staling of the bread as will leaving them unwrapped on the rack.
- Bread that has a hard crust should not be wrapped, this will affect the texture of the finished crust.

For transport or for longer storage time, freezing bread is an appropriate method of storage and will not result in changes to texture after thawing.

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13.1.3.3: Functions Affecting Baking

Functions of Fat in Baking

The following summarize the various functions of fat in baking.

Tenderizing Agents

Used in sufficient quantity, fats tend to “shorten” the gluten strands in flour; hence their name: shortenings. Traditionally, the best example of such fat was lard.

Creaming Ability

This refers to the extent to which fat, when beaten with a paddle, will build up a structure of air pockets. This aeration, or creaming ability, is especially important for cake baking; the better the creaming ability, the lighter the cake.

Plastic Range

Plastic range relates to the temperature at which the fatty acid component melts and over which shortening will stay workable and will “stretch” without either cracking (too cold) or softening (too warm). A fat that stays “plastic” over a temperature range of 4°C to 32°C (39°F to 90°F) would be rated as excellent. A dough made with such a fat could be taken from the walk-in cooler to the bench in a hot bakeshop and handled interchangeably. Butter, on the other hand, does not have a good plastic range; it is almost too hard to work at 10°C (50°F) and too soft at 27°C (80°F).

Lubrication

In dough making, the fat portion makes it easier for the gluten network to expand. The dough is also easier to mix and to handle. This characteristic is known as *lubrication*.

Moistening Ability

Whether in dough or in a cake batter, fat retards the product from drying out. For this purpose, a 100% fat shortening will be superior to either butter or margarine.

Nutrition

As one of the three major food categories, fats provide a very concentrated source of energy. They contain many of the fatty acids essential for health.

Major Fats and Oils Used in Bakeries

Lard

Lard is obtained from the fatty tissues of pigs, with a water content of 12% to 18%. Due to dietary concerns, lard has gradually lost much of its former popularity. It is still extensively used, however, for:

- Yeast dough additions
- Pie pastry
- Pan greasing

Lard has a good plastic range, which enables it to be worked in a pie dough at fairly low temperatures (try the same thing with butter!). It has a fibrous texture and does not cream well. It is therefore not suitable for cake making. Some grades of lard also have a distinctive flavor, which is another reason it is unsuitable for cake making.

Butter

Butter is made from sweet, neutralized, or ripened creams pasteurized and standardized to a fat content of 30% to 40%. When the cream is churned or overwhiped, the fat particles separate from the watery liquid known as buttermilk. The separated fat is washed and kneaded in a water wheel to give it plasticity and consistency. Color is added during this process to make it look richer, and salt is added to improve its keeping quality.

Sweet (or unsalted) butter is made from a cream that has a very low acid content and no salt is added to it. It is used in some baking products like French buttercream, where butter should be the only fat used in the recipe. Keep sweet butter in the refrigerator.

From the standpoint of flavor, butter is the most desirable fat used in baking. Its main drawback is its relatively high cost. It has moderate but satisfactory shortening and creaming qualities. When used in cake mixing, additional time, up to five minutes more, should be allowed in the creaming stage to give maximum volume. Adding an emulsifier (about 2% based on flour weight) will also help in cake success, as the butter has a poor plastic range of 18°C to 20°C (64°F to 68°F).

Butter and butter products may also be designated as "whipped" where they have had air or inert gas uniformly incorporated into them as a result of whipping. Whipped butter may contain up to 1% added edible casein or edible caseinates.

Butter and butter products may also be designated as "cultured" where they have been produced from cream to which a permitted bacterial culture has been added.

Margarine

Margarine is made primarily from vegetable oils (to some extent hydrogenated) with a small fraction of milk powder and bacterial culture to give a butter-like flavor. Margarines are very versatile and include:

- General-purpose margarine with a low melting point, suitable for blending in dough and general baking
- Cake margarine with excellent creaming qualities
- Roll-in margarine, which is plastic and suitable for Danish pastries
- Puff pastry roll-in, which is the most waxy and has the highest melting point

Margarine may be obtained white, but is generally colored. Margarine has a fat content ranging from 80% to 85%, with the balance pretty much the same as butter.

Oil content claims on margarine

The claim that margarine contains a certain percentage of a specific oil in advertisements should always be based on the percentage of oil by weight of the total product. All the oils used in making the margarine should be named. For example, if a margarine is made from a mixture of corn oil, cottonseed oil, and soybean oil, it would be considered misleading to refer only to the corn oil content in an advertisement for the margarine. On the other hand, the mixture of oils could be correctly referred to as vegetable oils.

It used to be that you could only buy margarines in solid form full of saturated and trans fat. The majority of today's margarines come in tubs, are soft and spreadable, and are non-hydrogenated, which means they have low levels of saturated and trans fat. Great care must be taken when attempting to substitute spreadable margarine for solid margarine in recipes.

Shortenings

Since the invention of hydrogenated vegetable oil in the early 20th century, *shortening* has come almost exclusively to mean hydrogenated vegetable oil. Vegetable shortening shares many properties with lard: both are semi-solid fats with a higher smoke point than butter and margarine. They contain less water and are thus less prone to splattering, making them safer for frying. Lard and shortening have a higher fat content (close to 100%) compared to about 80% for butter and margarine. Cake margarine and shortenings tend to contain a bit higher percentage of monoglycerides than margarine. Such "high-ratio shortenings" blend better with hydrophilic (attracts water) ingredients such as starches and sugar.

Health concerns and reformulation

Early in this century, vegetable shortening became the subject of some health concerns due to its traditional formulation from partially hydrogenated vegetable oils that contain trans fats. The apparent link between trans fats and adverse health effects has raised alarm bells. Consequently, a low trans-fat variant of Crisco brand shortening was introduced in 2004. In January 2007, all Crisco products were reformulated to contain less than one gram of trans fat per serving, and the separately marketed trans-fat free version introduced in 2004 was consequently discontinued. Since 2006, many other brands of shortening have also been reformulated to remove trans fats. Non-hydrogenated vegetable shortening can be made from palm oil.

Hydrogenated vegetable shortenings

Hydrogenated shortenings are the biggest group of fats used in the commercial baking industry. They feature the following characteristics:

- They are made from much the same oils as margarine.

- They are versatile fats with good creaming ability.
- Their hydrogenation differs according to the specific use for which the fat is designed.
- They are 100% fat – no water.
- They keep well for six to nine months.

Variations on these shortenings are: emulsified vegetable shortenings, roll-in pastry shortenings, and deep-frying fats.

Emulsified vegetable shortenings

Emulsified vegetable shortenings are also termed *high-ratio fats*. The added emulsifiers (mono- and Diglycerides) increase fat dispersion and give added fineness to the baked product. They are ideal for high-ratio cakes, where relatively large amounts of sugar and liquid are incorporated. The result is a cake:

- Fine in texture
- Light in weight and of excellent volume
- Superior in moisture retention (good shelf life)
- Tender to eat

This is also the fat of choice for many white cake icings.

Blending

It is probably safe to say that most fats are combinations or blends of different oils and/or fats.

They may be all vegetable sources. They may be combined with vegetable and animal sources. A typical ratio is 90% vegetable source to 10% animal (this is **not** a hard and fast rule). Formerly, blends of vegetable and animal oils and fats were termed *compound fats*. Nowadays, this term, if used at all, may refer also to combinations of purely vegetable origin.

Functions of Salt in Baking

Salt has three major functions in baking. It affects:

- Fermentation
- Dough conditioning
- Flavor

Fermentation

Fermentation is salt's major function:

- Salt slows the rate of fermentation, acting as a healthy check on yeast development.
- Salt prevents the development of any objectionable bacterial action or wild types of fermentation.
- Salt assists in oven browning by controlling the fermentation and therefore lessening the destruction of sugar.
- Salt checks the development of any undesirable or excessive acidity in the dough. It thus protects against undesirable action in the dough and effects the necessary healthy fermentation required to secure a finished product of high quality.

Dough Conditioning

Salt has a binding or strengthening effect on gluten and thereby adds strength to any flour. The additional firmness imparted to the gluten by the salt enables it to hold the water and gas better, and allows the dough to expand without tearing. This influence becomes particularly important when soft water is used for dough mixing and where immature flour must be used. Under both conditions, incorporating a maximum amount of salt will help prevent soft and sticky dough. Although salt has no direct bleaching effect, its action results in a fine-grained loaf of superior texture. This combination of finer grain and thin cell walls gives the crumb of the loaf a whiter appearance.

Flavor

One of the important functions of salt is its ability to improve the taste and flavor of all the foods in which it is used. Salt is one ingredient that makes bread taste so good. Without salt in the dough batch, the resulting bread would be flat and insipid. The extra palatability brought about by the presence of salt is only partly due to the actual taste of the salt itself. Salt has the peculiar ability

to intensify the flavor created in bread as a result of yeast action on the other ingredients in the loaf. It brings out the characteristic taste and flavor of bread and, indeed, of all foods. Improved palatability in turn promotes the digestibility of food, so it can be said that salt enhances the nutritive value of bakery products. The lack of salt or too much of it is the first thing noticed when tasting bread. In some bread 2% can produce a decidedly salty taste, while in others the same amount gives a good taste. The difference is often due to the mineralization of the water used in the dough.

Using Salt in Fermented Dough

The average amount of salt to use in the dough is about 1.75% to 2.25% based on the flour used. Some authorities recommend that the amount of salt used should be based on the actual quantity of water used in making the dough, namely about 30 g per L (1 oz. per qt.) of water.

During the hot summer months, many bakers find it advantageous to use slightly more salt than in the winter as a safeguard against the development of any undesirable changes in dough fermentation. Salt should never be dissolved in the same water in which yeast is dissolved. It is an antiseptic and dehydrates yeast cells and can even kill part of them, which means that less power is in the dough and a longer fermentation is needed. In bread made by the sponge dough method and in liquid fermentation systems, a small amount of salt included in the first stage strengthens the gluten.

Milk in Bread Baking

In the dough stage, milk increases water absorption. Consequently, dough made with milk should come softer from the mixer than dough made with water. Other aspects of milk in yeast doughs include:

- Dough may be mixed more intensively.
- Milk yields dough with a higher pH compared to water dough, and the fermentation will be slower.
- Fermentation tolerance (the ability of the dough to work properly in a range of temperatures) will be slightly improved.
- Bench time will be extended as the dough ferments more slowly at this stage. (Final proof times will be about the same, as by this time the yeast has adjusted to the condition of the dough.)

Bread made with milk will color faster in the oven and allowance should be made for this. If taken out too early after a superficial examination of crust color, it may collapse slightly and be hard to slice. The loaf should be expected to have a darker crust color than bread made without milk.

In the finished product, milk will make bread that has:

- Greater volume (improved capacity to retain gas)
- Darker crust (due to the lactose in the milk)
- Longer shelf life (due partly to the milk fat)
- Finer and more “cottony” grain
- Better slicing due to the finer grain

If skim milk or skim milk powder is used, some of the above benefits will not be so evident (e.g., longer shelf life, which is a result of the fat in the milk).

The type of sugar found in milk, lactose, has little sweetening power and does not ferment, so in dough made with skim milk powder, sugar has to be added or the fermentation will be very slow. While lactose is not fermentable, it caramelizes readily in the oven and produces a healthy crust color. The recommended amount of skim milk powder used in fermented dough is 2% to 8% based on flour, and up 15% in cakes.

Buttermilk and sour milk are used to make variety breads. They have a lower pH and require a shorter fermentation for good results.

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1. Table 7. Composition of typical fats by Wikipedia. © Creative Commons Attribution-ShareAlike 3.0 Unported Licence. ↵

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13.1.4: Quick Breads

Quick Breads:

These breads are an ideal solution to the bakers who love bread but do not have the time or resources to spend on yeast breads. These breads are relatively quick to makes as their name suggest. They are leavened with chemical leavenings that make them ready to bake in a short amount of time. These breads are usually tender with very little mixing time, which allows very little gluten formation. The mixing methods used for quick breads are usually just a few minutes and easy to do by hand.

Types of Doughs for Quick Breads:

1. **Liquid or pourable batters** – these are more fluid and not as thick. They can be poured into prepared pans. Drop batters are also part of this category they are not liquid but soft enough to be dropped with a spoon.
2. **Soft doughs -** this dough is soft and can be rolled out and cut into shapes. Biscuit dough is worked gently by hand and must be stiffer than what is need for muffins.

Quick breads are typically prepared using the muffin, creaming or biscuit mixing methods that you learned about previously.

The links bellow provides further explanation on quick breads as well as some examples:

- https://www.theflourhandprint.com/types-of-quick-bread/
- https://www.tasteofhome.com/article/what-is-quick-bread/

Examples of Quick Breads:

- Banana or zucchini breads



"Recipe: Homemade Banana Bread" by Smaku is licensed under CC BY-NC-ND 2.0.

- Corn Bread



"Vidalia Onion Upside Down Corn Bread 04" by Key West Wedding Photography is licensed under CC BY 2.0.

- Soda Bread



"Soda Bread with Rosemary & Raisins" by Migle Seikyte is licensed under CC BY-SA 2.0.

- Muffins



"Muffin - IMG_0246" by Nicola since 1972 is licensed under CC BY 2.0.

- Scones



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13.2.1: Sweeteners

Types:

- Sugars: All monosaccharides and disaccharides. Used for nutrition labelling purposes.
- Sweetening agent: Any food for which a standard is provided in Division 18 of the Food and Drug Regulation, or any combination of these. Includes sugar (sucrose), sugar syrups, and molasses derived from sugar cane or sugar beet, dextrose, glucose and syrups, honey and lactose. Excludes sweeteners considered to be food additives.
- Sweetening ingredient: Any sugar, **invert sugar**, honey, dextrose, glucose, or glucose solids, or any combination of these in dry or liquid form. Designed for sweetening fruits, vegetables, and their products and substitutes.
- Maple syrup: The syrup obtained by the concentration of maple sap or by the dilution or solution of a maple product, other than maple sap, in potable water.
- Sweetener: Any food additive listed as a sweetener. Includes both sugar alcohols and high intensity-sweeteners such as acesulfame-potassium, aspartame, and sucralose.
- Sugar alcohols: Food additives that may be used as sweeteners. Includes isomalt, lactitol, maltitol, maltitol syrup, mannitol, sorbitol, sorbitol syrup, xylitol, and erythritol.

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13.2.1.1: Sugar (sucrose)

Sugar (Sucrose)

For the remainder of this section, we will be referring to sugar generally to mean sucrose and its derivatives.

Sugar is a natural food. **Chlorophyll**, the green coloring matter in plants, is the key to the natural production of sugar. The process used by green plants is called **photosynthesis**. Plants build all other food substances, such as protein and oil, directly or indirectly from this sugar.

The two plants that yield the most sugar and are commercially grown are sugar cane and sugar beet. **Raw sugar** is made in large refineries by crushing cane sugar (*Sacchrum officinarum*) or beet root (*Beta vulgaris*) to obtain juice. Boiling the juice removes water, and with further processing, unrefined raw sugar is obtained (sometimes also known as *panela*). Generally, cane sugar is produced by tropical countries and the beet sugar by cooler, temperate areas.

Sugar cane is actually a giant grass that stores sugar in its stalk and is a renewable resource. In other words once it is planted it can be harvested again and again without replanting. It is grown in warm, moist countries, and cane accounts for approximately 80% of the world's sugar; the remaining 20% is produced from sugar beet. Brazil and India are the largest cane producers, with Brazil alone accounting for over 25% of the world's sugar. Other producing regions significant to North America's sugar supply are Thailand, China, Hawaii, the Caribbean, Philippines, and Australia.

Sugar beet was developed in the early 1800s. Since that time, sugar beet farming has spread to all parts of the temperate climatic zone. A root crop, it is more tolerant of northern climates and is grown as far north as Minnesota and Michigan in the United States.

- The link bellow provides more details on where sugar comes from:

https://www.agfoundation.org/news/where-does-sugar-come-from#:~:text=Sugar%20is%20made%20in%20the,crystalized%20into%20golden%2C%20raw%20sugar.

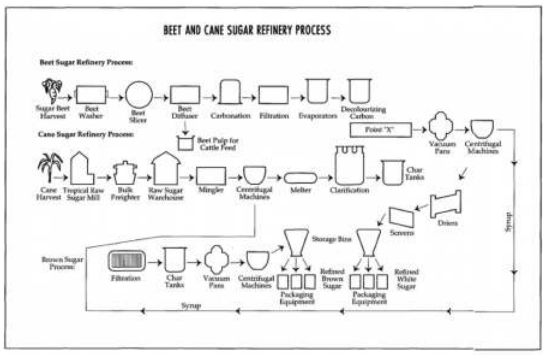


Figure 1. Sugar refining process.

Sugar Chemistry

Chemically, sugar consists of carbon (C), oxygen (O), and hydrogen (H) atoms, and is classified as a **carbohydrate**. There are three main groups of sugars, classified according to the way the atoms are arranged together in the molecular structure. These groups are the following:

- **Monosaccharides** or simple sugars. **Dextrose** (**glucose**) is the major monosaccharide. Others are **levulose** or **fructose** (found in **honey** and many fruits), and galactose, which is a milk sugar. Such sugars do not readily crystallize. (*Mono* means *one*, indicating that the sugar consists of only one molecule.)
- **Disaccharides** or complex sugars. Sucrose (common sugar) is the primary example of a disaccharide. Maltose, found in cereals, and **lactose**, found in milk, are others.
- **Polysaccharides**. Examples are starches, dextrins, and cellulose.

Sugar Refining

While some refining usually occurs at source, most occurs in the recipient country. The raw sugar that arrives at the ports is not legally edible, being full of impurities.

At the refinery, the raw brown sugar goes through many stages:

- Washing and boiling
- Filtering to remove impurities
- Evaporation to the desired crystal size under vacuum to avoid caramelization
- Centrifuging, in which the fluid is spun off leaving the crystals
- Drying in a rotating drum with hot air
- Packaging in various sizes, depending on the intended market

Sugar beet undergoes identical steps after the initial processing, which involve:

- Slicing the beets and extracting the sugar using hot water
- Removing impurities
- Filtration
- Concentration in evaporators

From here, the process is identical to the final steps in cane processing. See Figure 2 which illustrates the process.

Some of the sugar passes through a machine that presses the moist sugar into cubes and wraps and packages them; other sugar is made into icing sugar. The sugar refining process is completely mechanical, and machine operators' hands never touch the sugar.

Brown and yellow sugars are produced only in cane sugar refineries. When sugar syrup flows from the centrifuge machine, it passes through further filtration and purification stages and is re-boiled in vacuum pans such as the two illustrated in Figure 2. The sugar crystals are then centrifuged but not washed, so the sugar crystals still retain some of the syrup that gives the product its special flavor and color.

During the whole refining process almost 100 scientific checks for quality control are made, while workers in research laboratories at the refineries constantly carry out experiments to improve the refining process and the final product. Sugar is carefully checked at the mills and is guaranteed to have high purity.

Are animal ingredients included in white sugar?

Bone char — often referred to as natural carbon — is widely used by the sugar industry as a decolorizing filter, which allows the sugar cane to achieve its desirable white color. Other types of filters involve granular carbon or an ion exchange system rather than bone char.

Bone char is made from the bones of cattle, and it is heavily regulated by the USDA. Only countries that are deemed BSE-free (*bovine spongiform encephalopathy)* can sell the bones of their cattle for this process.

Bone char is also used in other types of sugar. Brown sugar is created by adding molasses to refined sugar, so companies that use bone char in the production of their regular sugar also use it in the production of their brown sugar. Confectioner's sugar — refined sugar mixed with cornstarch — made by these companies also involves the use of bone char. Fructose may, but does not typically, involve a bone-char filter.

If you want to avoid all refined sugars, there are alternatives such as sucanat and **turbinado sugar**, which are not filtered with bone char. Additionally, beet sugar — though normally refined — never involves the use of bone char.

Types of Sucrose:

Sugar in its various forms is the third most used ingredient in the bakery, exceeded only by flour and water. The following sections describe the forms of sugar available to bakers, and Table 2 shows the differences in composition of the leading types.

Cube Sugar

Cube sugar, or lump sugar, is made from the first refined syrup, which is the highest grade. It is formed in molds while the sugar is still moist, then dried in ovens and packed. Cube sugar is excellent for sugar boiling in caramel work.

Granulated Sugar

Refined granulated sugar is the most common form of sugar used. It is produced in various crystal sizes (fine, super fine, and berry are a few). Custom sizes are also available from some manufacturer, since any size crystal is possible at the factory depending on when the process is halted.

Liquid Sugar

Some food manufacturers prefer this mixture of water and sugar. Liquid sugar is metered into the manufacturing process. There are many grades and blends of liquid sugar tailored to suit food manufacturers' requirements.

Invert Sugar

When water and sugar are heated in the presence of a weak acid solution and/or enzymes, the sucrose breaks up into sweeteners of simpler chemical structure, creating **invert sugar**. A similar process occurs in the stomach. Like commercial glucose, invert sugar is a thick, colorless syrup and consists of 38% dextrose, 38% levulose, and 24% water. It is slightly sweeter than sucrose and is popular with some industrial users like soft drink bottlers and confectioners. Invert sugar is a good example of a monosaccharide — that is, despite the presence of a high concentration of sugar, it stays as a thick syrup.

Castor Sugar

Use the link below to learn more about castor sugar:

https://www.webstaurantstore.com/blog/2584/what-is-caster-sugar.html

Icing Sugar

Also known as confectionary or **powdered sugar**, icing sugar is produced by grinding high-grade crystals. This sugar passes through a series of sieves, yielding a selection of icing sugars. Icing sugar contains from 3% to a maximum of 5% starch (either cornstarch or wheat starch) to retard lumping or crystallization. Tricalcium phosphate may be added in the United States at a level of 1% for the same purpose.

Note: Icing sugar that contains wheat starch is not a gluten-free ingredient!

Sanding Sugar

Use the link bellow to learn more about sanding sugar:

https://www.bobsredmill.com/blog/baking-101/what-is-sanding-sugar/

Brown Sugar and Golden (Yellow) Sugar

Brown sugar, light brown sugar, and yellow sugar are refined products containing molasses flavored syrup giving the products a distinctive taste and color. They are available in a variety of grades and colors and are soft sugars.

Keep this sugar moist. If stored in dry conditions, the sugar becomes lumpy and hard. If the ambient humidity is high, the sugar can be left exposed. If the air is dry, it must be kept well covered.

Molasses

Molasses is a by-product of the cane and beet refining processes. Cane sugar molasses is edible and comes in many grades from fancy to black strap molasses. Sugar beet molasses is non-edible but has other industrial uses. Molasses is also available in dry form.

Turbinado Sugar

Use the link bellow to learn more about turbinado sugar.

https://www.masterclass.com/articles/turbinado-sugar-guide

Raw Cane Sugar

Visit the link below to learn more about raw cane sugar:

https://foodinsight.org/what-is-raw-sugar/

Sweetness in Sugar

Sweetness is influenced by many factors including temperature, pH, and the presence of other substances that need not themselves be sweeteners. The relative sweetness of sugar and other carbohydrate sweeteners is shown in Table 3. Note that sucrose is the reference standard to which all the other types of sugar are compared. This reference is called the **sweetness equivalent**.

Table 3 Relative Sweetness of Sugars

Type of Sugar	Sweetness Equivalent
Fructose/levulose	1.73
Invert sugar	1.30
Sucrose	1.00 (reference)
Glucose/dextrose	0.74 – 0.80
Sorbitol	0.60
Mannitol	0.50
Maltose	0.33-0.45
Galactose	0.32
Lactose	0.16

What this table tells us is that mannitol, for example, is only half as sweet as sucrose. Therefore, two level teaspoons of mannitol would be needed in a cup of coffee to obtain the same sweetness level as one teaspoon of sucrose.

Media Attributions

- Sugar refining process © Baking Association of Canada

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13.2.1.2: Syrups

Agave

Agave has gained popularity in the food industry due to some of its nutritional properties. The agave nectar is obtained from the sap of the heart of the agave plant, a desert succulent, which is also used to produce tequila. The syrup/sugar production process of agave is similar to that of sugar. The link bellow gives further explanation on agave.

- https://foodinsight.org/what-is-agave-syrup/

Glucose/Dextrose/Corn Syrup/High-Fructose Corn Syrup

The sugar known as glucose has two origins:

- In a natural form in most fruits
- In a processed form from corn (corn syrup)

In baking, we usually refer to industrially made glucose. It is made from corn and the resulting product, a thick syrup, is then adjusted to a uniform viscosity or consistency. The particular form of the syrup is defined by what is known as the *dextrose equivalent*, or DE for short. Corn syrup is the most familiar form of glucose.

In plant baking, high-fructose corn syrup (HFCS) is the major sweetening agent in bread and buns. It consists of roughly half fructose and half dextrose. Dextrose (chemically identical to glucose) is available in crystalline form and has certain advantages over sucrose:

- It is easily fermentable.
- It contributes to browning in bread and bun making.
- In crystalline form, it is often used in doughnut sugars as it is more inclined to stay dry and non-greasy.
- It is **hygroscopic** and valued as a moisture-retaining ingredient.
- It retards crystallization in syrups, candies, and fondant.

Corn syrup is made from the starch of maize (corn) and contains varying amounts of glucose and maltose, depending on the processing methods. Corn syrup is used in foods to soften texture, add volume, prevent crystallization of sugar, and enhance flavor.

Table 1 shows the amount of corn syrup or HFCS needed to replace sugar in a formula.

Table 1 Replacement Factor for Corn Syrup and High-Fructose Corn Syrup

Type of Sugar	Solids	Replacement Factor
Granulated sugar	100%	1.0
Regular corn syrup	80%	1.25
High-fructose corn syrup	71%	1.41

Glucose, HFCS, and corn syrup are not appropriate substitutions for sucrose in all bakery products. Certain types of cakes, such as white layer cakes, will brown too much if glucose or HFCS is used in place of sugar.

Honey

Honey is a natural food, essentially an invert sugar. Bees gather nectar and, through the enzyme invertase, change it into honey. Honey varies in composition and flavor depending on the source of the nectar. The average composition of honey is about 40% levulose, 35% dextrose, and 15% water, with the remainder being ash, waxes, and gum.

Blended honey is a mixture of pure honey and manufactured invert sugar, or a blend of different types of honey mixed together to produce a good consistency, color, and aroma. Dehydrated honey is available in a granular form.

Store honey in a tightly covered container in a dry place and at room temperature because it is hygroscopic, meaning it absorbs and retains moisture. Refrigeration or freezing won't harm the color or flavor but it may hasten granulation. Liquid honey crystallizes

during storage and is re-liquefied by warming in a double boiler not exceeding a temperature of 58°C (136°F).

Honey is used in baking:

- As a sweetener
- To add unique flavor
- In gingerbread and special cookies where a certain moistness is characteristic of the product
- To improve keeping qualities

There are several types of honey available:

- Comb honey is “packed by the bees” directly from the hive.
- Liquid honey is extracted from the comb and strained. It is the type used by most bakers.
- Creamed honey has a certain amount of crystallized honey added to liquid honey to give body to the final product.
- Chunk honey consists of pieces of comb honey as well as liquid.
- Granulated honey has been crystallized.

In the United States, honey categories are based on color, from white to dark amber. Honey from orange blossom is an example of white honey. Clover honey is an amber honey, and sage and buckwheat honeys are dark amber honeys.

Malt

Malt is the name given to a sweetening agent made primarily from barley. The enzymes from the germ of the seeds become active, changing much of the starch into maltose, a complex sugar. Maltose has a distinct flavor and is used for making yeast products such as bread and rolls. Malt is considered to be relatively nutritious compared to other sweeteners.

Malt is available as:

- Flour
- Malt syrup
- Malt extract
- Dried malt

The flour is not recommended since it can lead to problems if not scaled precisely. Malt syrup is inconvenient to work with, as it is sticky, heavy, and bulky. Dried malt is the most practical, though it must be kept protected from humidity.

Crushing malted grain in water produces malt syrup. This dissolves the maltose and soluble enzymes. The liquid is concentrated, producing the syrup. If the process is continued, a dry crystallized product called dried malt syrup is obtained.

Malt syrup has a peculiar flavor, which many people find desirable. It is used in candy, malted milk, and many other products. The alcoholic beverage industry is the largest consumer of malt by far, but considerable quantities are used in syrup and dried malt syrup, both of which are divided into diastatic and non-diastatic malt.

Malt sugar, which is fermented by the yeast in the later stages of fermentation is valuable in baking. Other sugars such as glucose and levulose are used up rapidly by fermenting yeast in the early stages of fermentation.

The main uses of malt in the bakery are to:

- Add nutritive value, as it is rich in vitamins and essential amino acids
- Lengthen shelf life through its ability to attract moisture
- Help fermentation by strengthening the gluten and feeding the yeast
- Make products more appealing through browning of the crust
- Add unique flavor to products when used in sufficient quantity

Table 5 shows the suggested use levels for malt.

Maple Syrup

Canada is responsible for 84% of the world’s maple syrup production, with the United States being responsible for the remaining 16%. Maple syrup is made by boiling and evaporating the sap of the sugar maple tree. Because sap is only 2% or 3% sugar, it takes almost 40 liters of sap to make 1 liter of syrup. This makes maple syrup a very expensive sweetener. It is prized for its unique

flavor and sweet aroma. Don’t confuse maple-flavored pancake or table syrup with real maple syrup. Table syrup is made from inexpensive glucose or corn syrup, with added caramel coloring and maple flavoring.

Darker maple syrups are better for baking as they have a more robust flavor. Using maple sugar is also a good way to impart flavor. Maple sugar is what remains after the sap of the sugar maple is boiled for longer than is needed to create maple syrup. Once almost all the water has been boiled off, all that is left is solid sugar. It can be used to flavor some maple products and as an alternative to cane sugar.

For a video on maple syrup production, see The Faces of Business: Mapleside Sugar Bush.

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13.2.1.3: Sugar Substitutes

Sugar Substitutes

Sugar Alcohols (Polyols, Sugar Replacers)

Sugar(s) can provide a lot of calories and contribute to tooth decay. Thus there are many other compounds that are used as alternatives to sugar that have been developed or discovered. We will first consider sugar alcohols and then the alternative sweeteners in subsequent sections.

Below you can see the structure of three common sugar alcohols: xylitol, sorbitol, and mannitol.

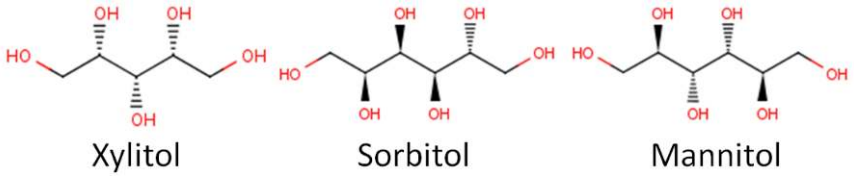


Figure 1: Structure of three commonly used sugar alcohols: xylitol, sorbitol, and mannitol3-5

Sugar alcohols are also known as "sugar replacers", because some in the public might get confused by the name sugar alcohol. Some might think a sugar alcohol is a sweet alcoholic beverage. Another name for them is nutritive sweeteners, which indicates that they do provide calories. Sugar alcohols are less sweet and provide about half the calories of sucrose as shown below. The name polyols also seems to be increasingly used to describe these compounds. It should be noted that consuming a large amount of sugar alcohols has a laxative effect.

Table 1: Relative sweetness of monosaccharides, disaccharides, and sugar alcohols6,7

Sweetener	Relative Sweetness	Energy (kcal/g)
Lactose	0.2	4*
Maltose	0.4	4
Glucose	0.7	4
Sucrose	1.0	4
Fructose	1.2-1.8	4
Erythritol	0.7	0.4
Isomalt	0.5	2.0
Lactitol	0.4	2.0

*Differs based on a person’s lactase activity

Sugars are fermented by bacteria on the surfaces of teeth. Acid is a product of this fermentation, which results in decreased pH (higher acidity) that leads to tooth decay and, potentially, cavity formation. The major advantage of sugar alcohols over sugars is that sugar alcohols are not fermented by bacteria on the tooth surface. There is a nice picture of this process in the link below as well as a video explaining the process of tooth decay.

Web Links

Sugar and Dental Caries

Tagatose

While not a sugar alcohol, tagatose is very similar to sugar alcohols. Tagatose is an isomer of fructose, that provides a small amount of energy (1.5 kcal/g). 80% of tagatose reaches the large intestine, where it is fermented by bacteria, meaning it has a prebiotic-type

effect6. Notice the similarity in structure of tagatose to sugar alcohols, the only difference being a ketone instead of an alcohol group.

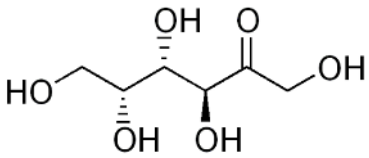


Figure 2: Structure of tagatose8

Alternative Sweeteners

Alternative sweeteners are simply alternatives to sucrose and other mono- and disaccharides that provide sweetness. Many have been developed to provide zero-calorie or low calorie sweetening for foods and drinks.

Because many of these provide little to no calories, these sweeteners are also referred to as non-nutritive sweeteners (FDA is using high-intensity sweeteners to describe these products10). Aside from tagatose (described in the sugar alcohol section), all sweeteners on the list below meet this criteria. Aspartame does provide calories, but because it is far sweeter than sugar, the small amount used does not contribute meaningful calories to a person's diet. Until the FDA allowed the use of Stevia, this collection of sweeteners were commonly referred to as artificial sweeteners because they were synthetically or artificially produced. However, with Stevia, the descriptor artificial can no longer be used to describe these sweeteners. More recently, Luo Han Guo Fruit extracts have also been allowed to be used as another high-intensity sweetener that is not synthesized or artificially produced. The table in the link below summarizes the characteristics of the FDA approved high-intensity sweeteners.

Web Link

Aspartame and Other Sweetener in Food

Saccharin

Saccharin is the oldest of the artificial sweeteners. However, it should be noted that both sweet and bitter taste receptors are triggered by it, so for some people it has an aftertaste that is off-putting11,12. It has been found that this bitter or metallic flavor can sometimes be masked by mixing alternative sweeteners13. It is a heat-stable alternative sweetener.

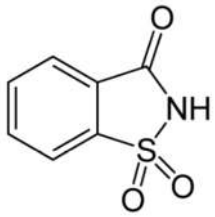


Figure 3: Structure of saccharin14

Aspartame

Aspartame is made up of 2 amino acids (phenylalanine and aspartate) and a methyl ($-CH_3$) group. The compound is broken down during digestion into the individual amino acids. This is why it provides 4 kcal/g, just like protein11. However, it is still considered noncaloric because it is so sweet that we use very small amounts that don’t provide any meaningful caloric value. Because it can be broken down to phenylalanine, products that contain aspartame contain the following message: "Phenylketonurics: Contains phenylalanine." Phenylketonuria (PKU) will be covered in greater detail in the protein section. When heated, aspartame breaks down and loses its sweet flavor7.

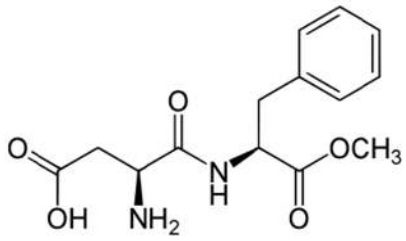


Figure 4: Structure of aspartame1

Neotame

Neotame is like aspartame version 2.0. Neotame is structurally identical to aspartame except that it contains an additional side group (bottom of the figure below, which is flipped backwards to make it easier to compare their structures). While this looks like a minor difference, it has profound effects on the properties of neotame. Neotame is much sweeter than aspartame and is heat-stable. It can still be broken down to phenylalanine, but such small amounts are used that it is not a concern for those with PKU7,11.

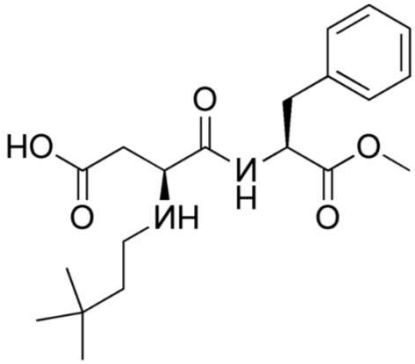


Figure 5: Structure of neotame16

Advantame

The newest, sweetest alternative sweetener approved by the FDA in 2014 is advantame. It is heat-stable and does not have a trade name yet10. Notice it also has a similar structure to aspartame and neotame. Like Neotame, it can be broken down to phenylalanine, but such small amounts are used that it is not a concern for those with PKU. However, it has a much higher acceptable daily intake than Neotame11, meaning there is less concern about adverse effects from consuming too much.

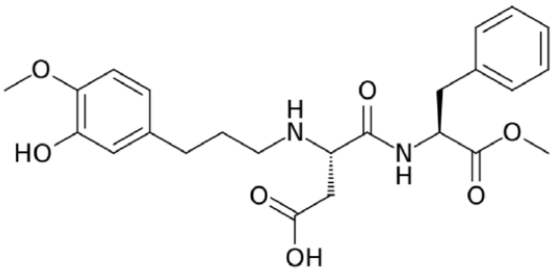


Figure 6: Structure of advantame17

Acesulfame-Potassium (K)

Acesulfame-potassium is not digested or absorbed, therefore it provides no energy or potassium to the body7. It is a heat-stable alternative sweetener.

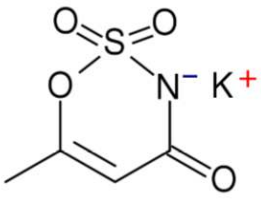


Figure 7: Structure of acesulfame-potassium (K)18

Sucralose

Sucralose is structurally identical to sucrose except that 3 of the hydroxyl groups are replaced by chlorine molecules. This small change causes sucralose to not be digested and as such is excreted in feces7,11. It is a heat-stable alternative sweetener.

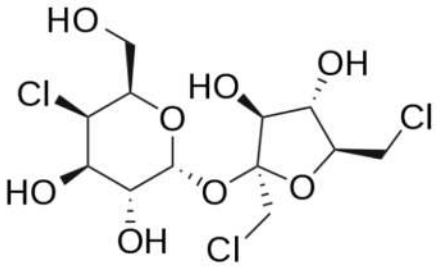


Figure 8: Structure of sucralose19

Stevia

Stevia is derived from a South American shrub, with the leaves being the sweet part. The components responsible for this sweet taste are a group of compounds known as steviol glycosides. The structure of steviol is shown below.

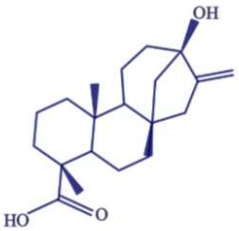


Figure 9: Structure of steviol20

The term glycoside means that there are sugar molecules bonded to steviol. The two predominant steviol glycosides are stevioside and rebaudioside A. The structure of these two steviol glycosides are very similar21. The structure of stevioside is shown below as an example.

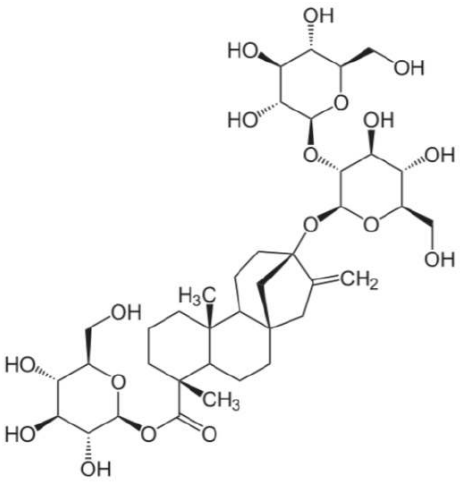


Figure 10: Structure of stevioside22

The common name for a sweetener containing primarily rebaudioside A is rebiana. Stevia sweeteners are heat-stable and have been marketed as a natural alternative sweeteners, something that has been challenged by lawsuits as described in the following link.

Web Link

What is natural and who decides?

Stevia is a heat-stable alternative sweetener.

Luo Han Guo Fruit Extracts

Luo Han Guo (aka Siraitia grosvenrii Swingle, monk) fruit extracts are a newer, natural heat-stable alternative sweetener option derived from a native Chinese fruit. These extracts are sweet because of the mogrosides that they contain10. The structure of a mogroside is shown below.

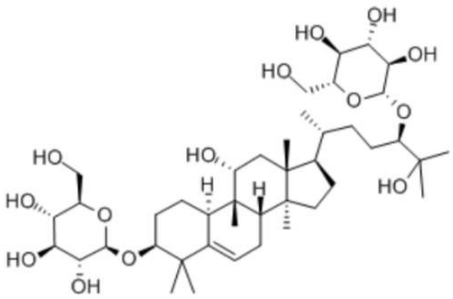


Figure 11: Structure of a mogroside23

We must be careful when replacing sugar (sucrose) with these sugar substitutes in recipes. Even though the sweetness comparison levels may be similar (or less), it is generally not possible to do straight 1-for-1 substitution. Sugar (sucrose) plays many roles in a recipe:

- It is a bulking agent.
- It absorbs moisture.
- It is a tenderizer.
- It adds moisture and extends shelf life.
- It adds color (caramelization).

Sugar substitutes may not work in a recipe in the same way.

More information on sugar substitutes and their relative sweetness can be found online.

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- **2.1: Carbohydrates - Simple Carbohydrates & Alternative Sweeteners** by Brian Lindshield is licensed CC BY-NC-SA 4.0. Original source: http://goo.gl/vOAnR.

13.2.1.4: Functions of Sugar

As mentioned, sugar is the third most used ingredient in the bakeshop. Sugar has several functions in baking. The most recognized purpose is, of course, to sweeten food, but there are many other reasons sugar is used in cooking and baking:

- **Maillard reaction:** It can be used for browning effect on everything from breads to cookies to cakes. Browning gives a pleasant color and flavor to the finished product. Caramelization results from the action of heat on sugars. At high temperatures, the chemical changes associated with melting sugars result in a deep brown Color and new flavors. The Maillard reaction results from chemical interactions between sugars and proteins at high heat. An amino group from a protein combines with a reducing sugar to produce a brown colors in a variety of foods (e.g., brewed coffee, fried foods, and breads).
  - https://www.seriouseats.com/what-is-maillard-reaction-cooking-science
- **Tenderizing:** It acts as the most important tenderizing agent in all baked goods, and one of the factors responsible for the spread in cookies. It helps delay the formation of gluten, which is essential for maintaining a soft or tender product.
- **Texture:** It makes an important contribution to the way we perceive the texture of food. For example, adding sugar to ice cream provides body and texture, which is perceived as smoothness. This addition helps prevent lactose crystallization and thus reduces sugar crystal formation that otherwise causes a grainy texture sometimes associated with frozen dairy products.
- **Preservative:** It preserves food when used in sufficient quantity. Use the link bellow to learn more.
  - https://www.sugarnutritionresource.org/news-articles/sugar-as-a-preservative
- **Leavening:** In baking, it increases the effectiveness of yeast by providing an immediate and more usable source of nourishment for the yeast's growth. This hastens the leavening process by producing more carbon dioxide, which allows the dough to rise at a quicker and more consistent rate. Use the link bellow to learn more.
  - https://serenalissy.com/the-function-of-sugar-in-baking/#:~:text=Sugar%20as%20a%20Leavening%20Agent&text=Sugar%20makes%20the%20yeast%20more,creating%20bubbles%20and%20dough%20rises.
- **crystallization:** Use the link bellow to learn about crystalization:
  - https://www.wekivaculinary.org/working-with-sugar-the-magic-of-crystallization/
- **Solubility:** Use the link bellow to learn about solubility:
  - https://chestofbooks.com/food/science/Experimental-Cookery/The-Solubility-Of-The-Sugars.html
- **Hygroscopicity:** Use the link bellow to learn about hygroscopicity:
  - https://www.seriouseats.com/the-serious-eats-guide-to-sugar-syrup-honey-natural-sweetners#:~:text=Moistens%3A%20Sugar%20is%20hygroscopic%2C%20which,of%20sugar's%20water%2Dattracting%20property.
- **Fermentation:** Use the link bellow to learn about fermentation:
  - https://www.nordzuckerireland.ie/ie/about-sugar/functional-properties-of-sugar/fermentation#:~:text=In%20baking%2C%20sugar%20feeds%20the,when%20no%20sugar%20is%20added.

Just as there are many functions of sugar in the bakeshop, there are different uses for the various types of sugar as well:

- Fine granulated sugar is most used by bakers. It generally dissolves easily in mixes and is pure enough for sugar crafters to boil for "pulled" sugar decorations.
- Coarse granulated sugar may be used for a topping on sugar cookies, puff pastry, and Danish pastries as it doesn't liquefy or caramelize so readily. In some European countries, an extra coarse sugar (called *hail* — a literal translation) is used for this purpose.
- Icing or powdered sugar is used in icings and fillings and in sifted form as a top decoration on many baked goods.
- Brown or yellow sugars are used where their unique flavor is important, or in bakeries where an old-fashioned or rustic image is projected. Brown sugar can usually be substituted for white sugar without technical problems in sugar/batter mixes such as cakes and muffins, and in bread dough.

The link bellow provides a full overview of all functions of sugar:

https://www.sugar.org/blog/sugar-in-baking-what-bakers-need-to-know/

***Calories:** There is 4 kcal/gram of sugar/carbohydrate.

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13.2.2: Cakes, Cookies

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13.2.2.1: Cookies

One of the most varied items in the pastry world is the cookie. They are made into various shapes, sizes and textures. From chewy to soft batch, crunch to bite size bits. Depending on where you are in the world the name cookie will not mean anything. Only in North American do we consider a cookie a cookie!

As with cakes, the word cookie translates in “little cake” there are different methods used to make them. The most popular is the creaming method.

Creaming Method

1. Accurately scale ingredients at room temp
2. Sugar and fat are added to bowl with paddle attachment on low speed.
3. Scrape down bowl before each addition of ingredients
4. Cream fat and sugar. Amount of air will affect cookie texture.
5. Add liquid and eggs.
6. Sift dry ingredients and add. Mix until just combined. Over mixing will cause gluten formation.

Different types of cookies

1. **Pipped** – this dough is soft enough to be put into a piping bag fitted with a tip and piped out. The dough will hold its shape once piped.
2. **Dropped** – using a scoop or spoon this dough onto a prepared cookie sheet. These can usually have additions such as chocolate chips, nuts, and candies added.
3. **Rolled** – the dough is pinned out with a rolling pin onto a lightly floured surface. Cookie cutters are used to stamp them out.
4. **Molded** – the dough is molded either by hand or with a stamp into the desired shape.
5. **Icebox -** this dough is a bit stiffer. The dough is rolled into a log and then refrigerated. When ready to bake it is cut into equal sizes and placed on the prepared cookie sheet.
6. **Bar -** the dough is pined into a sheet pan, baked and cut into the desired shape. Another method is to make the dough into a log and bake.

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13.2.2.2: Cake and Buttercreams

To make a great cake the baker must take great care in creating the batter. The cake itself is a base for which the rest of the ingredients are built upon. The process starts with high quality ingredients. The rest is an art from that follows specific formulas and mixing methods to produce a light and delicious finished product.

There are three main goals you to making a good batter:

1. Combining the ingredients into a smooth homogeneous batter.
2. Incorporating air into the batter.
3. Having the proper texture in a finished product.

The Batter

All cake batters are a basic emulsion of fat and water. As the two ingredients are mixed, the fat molecules encase the water droplets. Then, as the other ingredients are added, this emulsion can break. If so the batter will looked curdled. This happens when the fat separates from the water and they are then just mixed together with the other ingredients in the batter.

Issues that can lead to curdled batters:

1. **Using the wrong type of fat** – each recipe is formulated for a specific fat. Do not substitute fats. High ratio shortening cannot hold the same amounts as butter. Also butter has water in it so formulas that contain butter limit the water to what that product can hold and remain emulsified.
2. **Temperature of the ingredients** – the best emulsification happens at room temperature, which is about 70 F.
3. **Mixing process** – do not rush the process. The formation of the emulsification must be done correctly for it to hold. Higher speeds do not speed up the process. Air cell formation is accomplished at a lower speed.
4. **Adding ingredients** – if liquids are added to quickly, the other ingredients cannot adequately absorb them. They are usually added in stages and alternate with dry. This helps to keep a smooth homogeneous mix.

Air Cells

Proper procedure needs to be followed to obtain proper air cell formation. This is done by slowly incorporating the butter and sugar in the creaming method. Too high a speed will cause the mix to become warm and not allow for proper formation. In addition, the temperature of the ingredients play a part in this as well. Butter and granulated sugar combinations at low speed create the best air cells for a good cake texture.

Texture of the Batter

The finished texture of the baked cake depends on the ingredients, and how well they were put together. If the air cells were formed small and uniform, the crumb will be smooth and fine. A coarse crumb will be because of large or irregular formation of the air cells. Unlike bread, you do not want a lot of gluten formed in the cake. Gluten will give a tough product. Cake flour, which is low in protein, is used to insure gluten formation is minimal. Also, the way the ingredients are mixed together.

Mixing Methods for Cakes

I. Creaming Method

1. All of the ingredients are scaled out accurately and at room temperature.
2. The fat is placed into the mixing bowl fitted with the paddle attachment. On low begin to mix until it is smooth and creamy. There should be no lumps.
3. Scrape down the sides of the bowl and add the sugar. On a low/medium speed, you will begin the process of creaming the fat and sugar together. You will cream them until they are white, light and fluffy. This will take anywhere from 5 to 10 minutes. Notice the color change of the butter.
4. Stop and scrape down the bowl. The eggs will be added a little at time depending on how many you have. Before you add the next egg, make sure that each addition is completely absorbed into the mix. The mix will return to a light and fluffy texture.
5. The addition of the dry and liquid ingredients will begin once all the eggs have been added. Scrap down the bowl continuously to ensure proper mixing.

6. You will start with the dry and end with the dry. The pattern for adding dry in liquid is:
    - ¼ of the dry is added. The mixer is turned on, and you will mix until JUST incorporated. Turn off and scrape the down the bowl.
    - 1/3 of the liquid is added. This is mixed until just blended. Again, scrape down the bowl.
    - These steps are repeated until all the ingredients have been added. Scraping and alternating the ingredients ensure an even mixing of the batter.

NOTE: Vanilla and other spices can be added once the fat and sugar is creamed or to the liquid ingredients. Some bakers prefer to sift the spices into the dry ingredients. If adding melted chocolate to a batter it can be added to the creaming method paying attention to the temperature of the chocolate.

II. Chiffon Method

1. Scale out all ingredients accurately. All should be at room temperature.
2. Sift all dry ingredients into the bowl of the stand mixer fitted with the paddle attachment. Add part of the sugar at this time as well.
3. With the mixer on low slowly steam in the oil. Next you will add the egg yolks, followed by water and any flavorings. As this is being added you should stop the mixer and scrape down the bowl to ensure proper mixing of the batter.
4. In another bowl, you will begin to whip the egg whites to soft peak. Then add the cream of tartar and remaining sugar. Whip to stiff peak.
5. Fold the whipped egg whites into the batter.
6. Cake pans should only be greased, and lined on the bottom. If the sides are greased the cake will not rise. It needs to cling to the side of the pan to rise.

Types of Cakes

1. **Shortened Cakes (Butter Cakes)** – these are high fat cakes. The fat used for these cakes is butter. This gives the cake a better mouth feel. Butter melts at body temperature whereas shortening does not. Some bakers will prefer to use shortening because it is cheaper and easier to emulsify.
2. **Unshortened Cake (Sponge or Foam Cakes)** - these cakes have little to no fat.
3. **Chiffon Cake** - hybrid of shortened and unshortened cakes. There is fat from vegetable oil and egg yolks, flour, and leavening agents.

Baking and Handling of Cake

The method of baking will ensure that your cake is at its best. To ensure this following the right guidelines are essential.

- Always preheat your oven.
- The oven and its shelves should be level. If they are not the batter will bake unevenly.
- Make sure the pans are spaced evenly apart. Proper air circulation will ensure even baking of each cake.
- Bake at the right temperature. Each cake requires different baking temperatures. This will affect the way the cake sets.
    - **Too high a temperature** will cause the top to set before it has risen enough.
    - **Too low a temperature** can lead to it not rising enough and falling
- Some ovens have steam. This can help delay the crusting of the layer and allow for a more even rise in some cakes: creamed, two-stage and one-stage cakes.
- Do not open the oven until the cake has fully risen and the structure has set. This can cause the cake to fall.

Signs of Doneness

- If the cake appears to be pulling away from the sides of the pan.
- When the top is lightly touched, it springs back.
- If you stick a cake tester in the center, it comes out clean.

Cooling and Removing from Pans

- Cakes should be cooled in their pans for 15 to 20 minutes or until warm to the touch. Removing the cake before can cause it to crack. Remember that they are fragile and soft.
- Remove cakes from the pan and place on a cooling rack to finish cooling.
- Sheet cakes can be turned out onto cake boards or another sheet pan. Top the cake with parchment, then the cake board. Flip the pan leaving the cake on the cake board. Another cake board is now put on the bottom and both are inverted leaving the bottom of the cake on the board. Remove the parchment and let cool.

NOTE: **Angel Food and Chiffon cakes need to be cooled completely in their pans. The pan should be inverted but not touching the tabletop. There needs to be room for air circulation.** This prevents the cake from falling in on itself. The cake will not fall out of the pan because it is clinging to the sides. Once they are cooled you can turn them over and with a knife remove them from the pan.

Buttercreams

Once the cake is baked and cooled it's time to finish it. From the simple to the extravagant cakes can be finished in a variety of ways. Simple buttercreams, fondant, marzipan or poured ganache can be used to turn something simple into works of art.

Buttercreams

Light and fluffy frosting that can be used in decorating a cake. They range in simple to complex formulas that differ in texture and taste depending on the type you make.

3 Classical Butter Creams

These buttercreams all have a base that begins with a meringue. Each is done in a different style. These buttercreams are soft and smooth in texture.

1. **Swiss Buttercream** – the base for this is Swiss meringue. The egg whites and sugar are heated over a warm bain marie until the sugar melts. Once this happens whip on high speed until the meringue cools and doubles in size. Slowly the cold butter/shortening combination is incorporated. As this happens the mixture will get to a stage that it looks broken. Keep adding the butter. It will come together. Any flavorings can be added at this time.
2. **Italian Buttercream** – the base for this is Italian meringue. The sugar and water are cooked to 240 F. While this is happening whip the eggs whites to soft peaks. Pour the sugar into the whipping egg whites and whip until cool. Cut the butter into the mixture until it is all added. It will look curdled but continue to add the butter and mix until it is smooth and creamy.
3. **French Buttercream** - this buttercream has an egg yolk base. The sugar and water are cooked to 240 F. Egg yolks are whipped to ribbon stage (thick and light in color). Pour the cooked sugar into the whipping yolks. Continue whipping until the mixture has cooled off and is thick. The butter is added slowly allowing the mixture to absorb the butter before the next addition is added. Flavorings can be added at this time.

American Buttercream

This is a popular buttercream frosting that is primarily used in North American and "frosting" of choice for most people in the South. This buttercream is simple to make and requires no cooking. It has a sweet taste with a fluffy and creamy texture. It is easily flavored and when set has a dry sugar "crust" exterior. The recipes for it vary depending on the baker/user but main ingredients are the same.

- **Plain American Buttercream** – butter (shortening) is added to the bowl of a stand mixer fitted with the paddle attachment. It is creamed until smooth and fluffy. Powdered sugar is added and mixed in. Flavorings are added at this time. The mixture is thick and will be thinned out with cream or water to the desired consistency. This buttercream has a very low melting temperature. It is not a good use for outdoor cakes in the summer months.

Royal Icing

This type of frosting is used in decorative decorating of cakes, cookies and other edible pastries. It can be used as a thick frosting for drop string, outlines of shapes and for making edible flowers. When thinned out it can be used to fill in outlined shapes for a beautiful finishing touch. This frosting dries hard to the touch.

- **Royal Icing** – egg whites are added to the bowl of a stand mixer fitted with the paddle attachment. The whites are mixed to just break them up. Next cream of tartar is added along with powdered sugar. The mixture is mixed until it is stiff and fluffy with soft peaks. To keep this useable while working it needs to be covered with a damp cloth.

Glazes

Some cakes are finished with a glaze a thin almost see through coating. This is a mixture of ingredients that is poured over a finished product to leave it with a beautiful shiny surface. The purpose is twofold in that it serves as a finish and protection to avoid the drying out of the product.

There are primarily two types of glazes:

1. **Chocolate glazes** – these consist of chocolate melted by pouring heated cream over mixed with either butter, glucose or corn syrup. Once cool to the touch it is poured over a cake. If cooled correctly, it can be whipped into a frosting to finish a cake as well.
2. **Gelatin glazes** - these are done with a combination of ingredients but the primary setting of the glaze is done with gelatin. Bloomed gelatin is melted, then added to other ingredients, mixed, and immediately used. If it is allowed to sit and cool, it will set.

Other Cake Coatings

1. **Rolled fondant** – can be made, or purchased commercially. A thick edible sugar paste that can be used to cover and decorate cakes. It can be molded into shapes, flowers, animals etc. It can be used as is, or colored for added garnish. This gives the outer layer protection and keeps it from drying out.
2. **Marzipan** – a decorative coating made from almond paste, sugar and corn syrup. It has a very sweet taste and can be used to make accent garnishes as well. It is also used to make marzipan candy, and used as a filling for truffles.
3. **Modeling Chocolate** – a paste that is made from melted chocolate and corn syrup. When done it is thick and easily molded. Texture is similar to thick playdough.

Cake Syrup

From-scratch cakes, differ from box mix cakes. They lack the preservatives that are added to keep those moist as they sit. To add some moisture to your cake a cake syrup is used. It is brushed onto layers and allowed to soak it. It is a basic 1:1 ratio of water to sugar. Flavoring can be added as well as liquors or spirits.

Cake Decorating

One of the most important things you need to begin the decorating of a cake is the design of the cake. Nothing can really be done without this. The planning of how it is assembled, frosting, filling,s and garnishes are all done based on the initial plan. Proper planning of the cake lends to easy assembly and a beautifully finished product.

The Cake Layers

Once your layers are baked, de-panned, and cooled they need to be prepped for assembly.

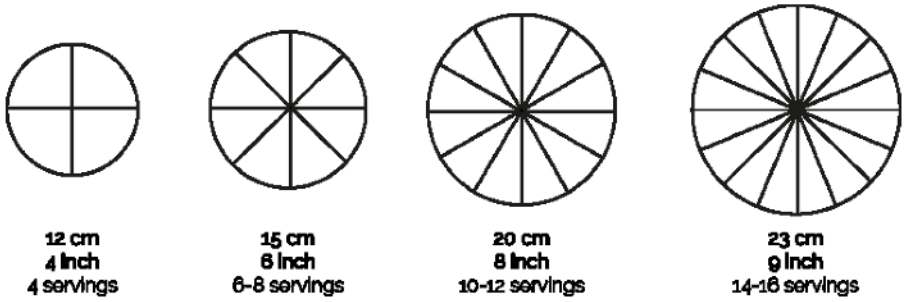
1. All excess crumbs are removed with a dry pastry brush.
2. If tops are slightly mounded, they can be made even with the addition of buttercream. If there is a high rounded top, it needs to be leveled by cutting the top even.
3. Proper cake board is added under the layer.
4. Cake layers are cut in half. This increases the amount of filling and frosting adding additional height to your finished cake as well as increasing the cake to filling/frosting ratio.
5. Cake layers are brushed with cake syrup excluding the top layer.
6. If there is a filling other than buttercream, a dam is created to lock the filling it. This is a circle of frosting piped around the perimeter of the layer.
7. The bottom of the cake is the straightest piece. It should always be used as the last layer added to the cake. This gives a straight and level surface to the finished cake.

8. Once the layers are assembled, the crumb coat is added. This is a very thin layer of frosting. Its purpose to lock in any extra crumbs that are on the cake. Once this is done, place it in the refrigerator to set.
9. Once the crumb coat is set, the finishing frosting is added. This addition is the final buttercream coating unless a rolled coating will be used. Once finished this should not contain any crumbs. The cake is now ready for decorating.

Cake Cuts

There are three main cake cuts that see the most use for round cakes or pies are the **‘8’ cut**, the **‘12’ cut** and the **‘16’ cut**.

1. **The ‘8’ cut**: The cake is cut in half. Each half is then cut in half. From there each quarter is then cut in half. Each slice should be the same size.
2. **The ‘12’ cut**: is a little more difficult. The cake is cut in half. Each quarter piece is then cut evenly into 3 pieces. Each piece should be the same size.
3. **The ‘16’ cut**: is the most difficult. Each cake is cut in half. Each quarter is then cut in half. Each eight is then cut in half. Each slice should be the size.



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13.2.2.3: Dry Ingredients

Wheat Flour

One of the most important ingredients in the baking process is flour. Almost every item made has some type of flour added. It is the main building block of breads, pastries and most cakes. The production of flour can be traced through the centuries to the beginning of civilization. An important fact for a baker to know is the difference between hard and soft wheat. This gives the baker the ability to know which type of flour to use for the application needed.

There are six different types of wheat grown in North America.

1. **Hard Red Winter** - This versatile wheat can be used in a variety of baking applications as well as making Asian style noodles. The protein content of this milled wheat is between 10 to 15 %. This is a good choice for all purpose flour, hard rolls and flatbreads.
2. **Hard Red Spring** - this wheat has a higher protein content 12 to 18 % and is primarily used to mix into flours. As a standalone flour, it the gluten formed is very strong and often difficult to form into bread. It is often added to improve bread flours and is used in making the high-end breads such as: artisan breads, pizza crust, croissants and rolls.
3. **Soft Red White** - this flour has a weaker gluten formation due to a low protein content of only 8 to 11%. The weaker gluten makes this an excellent wheat for items such as cookies, crackers and pastries.
4. **Soft White** - this a wheat has a low moisture content as well as low protein content 8 to 11 %. It also produces a whiter product, which makes it ideal for cakes, pastries, and some Middle Eastern flatbreads.
5. **Hard White** - this is a newer type of wheat grown in the United States. It is used for making whiter wheat breads as well as Asian noodles, and flatbreads.
6. **Durum** - this is the hardest of all wheats. It has the highest protein content 14 to 16 % as well as the high gluten content. It is primarily used in the production of pastas, couscous and Mediterranean breads.

The Wheat Kernel

The wheat kernel is made up of three parts: bran, endosperm, and germ. During the milling process, the kernel is broken up and each part is milled and used.

1. **Bran** - this is the hard outer casing of the kernel. It is darker in color than the inside. When looking at flour the brown specks present is the milled bran. It is removed from white flour. The bran is high in fiber, vitamins, minerals, proteins and fat.
2. **Germ** - this is from where new wheat plants sprout. It has a very high fat content thus is will become rancid quickly. This leads to a very short shelf life of any flour that contains the germ.
3. **Endosperm** - this is the inside part of the kernel. It makes up about 83% of the kernel. This is the part that white flour is derived. It is also the starchiest part of the kernel with about 68 to 76% starch. It contains protein and carbohydrates alone with vitamin B, iron, minerals and soluble fiber.

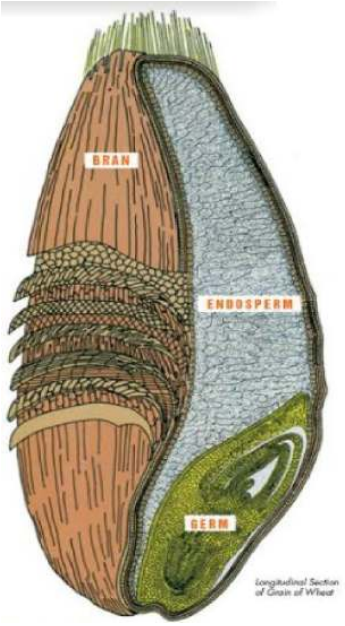


Image Wheat Foods Council

Milling Process

The purpose for milling to separate the parts of the wheat kernel into usable material. Thus, the endosperm has to be separated from the bran and germ. The endosperm is the part that becomes flour that we use in baking. All parts can be purchased for use in today's market.

In the early years of milling, the wheat kernels were milled by smashing or rolling them between two large stones. This process gave a course grind to the stone but allowed the parts to be sifted and separated. This was a very laborious process. You can still find stone ground products today in some European markets but most flours in the US are no longer process this way. The most common stone ground products are stone ground grits and cornmeal.

Modern milling of wheat occurs by way of the *break system*.

Types of Flour used in Bakery

Bread Flour - this is a strong flour made from hard wheat. It offers a good amount of protein and thus offers a good gluten formation. You can purchase this bleached or unbleached. This type is usually reserved for commercial bakeries.

High-Gluten – We use this flour in class. It is a high protein flour that offers a good gluten formation also.

Cake Flour – this is weak flour made from soft wheat. It is normally pure white. It has a soft and silky feel to it. The gluten formation is low with this flour, which makes it an excellent flour for delicate pastries.

Pastry Flour - a weak flour that is also low in protein and thus low in gluten formation. It is stronger than cake flour however. The color is a creamy yellowish color.

All-purpose – this flour is a general use flour. It can be used in the place of each of the above flour. Its protein content is lower but has enough form a good gluten structure for bread making. Usually this is the home baker's flour of choice.

Self-rising - this flour has the leavener added to it. Baking powder and salt. This is not used in the professional kitchen. Leavener tend to weaken over time so this can be an issue also when scaling recipes most have a leavener added and the amounts vary so not enough could ruin the product.



Meals

Corn meal – this is made from the endosperm of the corn kernel. It can be purchased in a variety of styles. It contains no gluten.

Nut meals - various nuts are ground into “flours” that can be used in baking. Almond and Hazelnut are the two most common. These also contain no gluten due to the absent of wheat in the product.

Sweeteners

Sugar - refined graduated sugar is a common item in the bake shop. It is used in almost every recipe as the main sweeter ingredient. It can also act as a tenderizer in products. This has no molasses left in it after refining.



Sugar is **hydroscopic** which means it absorbs moisture in the air and its surrounding.

Light brown sugar - this is sugar that has not been refined as much. It still has some molasses left in it. This gives it a slight addition of acidity. It will feel a bit wet when touched. When measuring this sugar you want to make sure you pack in into the measuring cup tight. If done correctly it will hold its shape when removed.



Dark Brown Sugar - this is sugar that has the highest amount of molasses left in it during the refining process. This has a slightly higher acid content than light brown sugar.



Molasses - a byproduct from the process of refining sugar. It is a thick darn brown liquid. It added moisture to baked goods helping then stay fresher longer.

Honey - a natural sugar syrup made by bees. The type of honey varies depending on the diet of the bees and the area in which they are kept. It is the only food that does not spoil. It may crystalize as it sits but it can be put into warm water, or heated to melt the crystals.

Invert Sugars - These are liquid sugars that are used in the baking kitchen. They can be added to recipes as sweeteners, or used to prevent crystallization of the granulated sugar. Corn syrup and glucose are two of the most common we use.

Fats

Butter - is made from the processing of heavy cream. As the cream is agitated, the fat molecules pull together and separates from the whey. It can be purchased in stores salted and unsalted. In the kitchen, unsalted butter is preferred so that salt can be measure into the recipes in the correct amounts. Butter will become solid when cold but soft at room temperature. It also has a very low melting point (90 to 95oF).

Margarine - This is a fabricated product from hydrogenated animal and vegetable fats. It also contains flavorings, emulsifiers and dyes to give it color. There are different types that can be purchase. It is cheaper than butter while still maintaining some flavor of butter.

Shortening

Regular – this is the shortening are referred to as plastic shortenings. They have a tough waxy texture with small fat particles. They have a good creaming ability and work well in flaky pie doughs because of their texture. Crisco is an example.

High-ratio - they spread easily through a batter. They are creations for use in recipes that have a high ratio of liquid and sugar to flour.

High-ration liquid - they have less hydrogenation which makes them pourable. This add moisture to cakes and batters. It also allows for easy air incorporation, which will give cakes a better rise and texture.

Dairy

Milk - this can be purchased in whole, 2 %, low fat, and skim. Each of these describes the amount of fat this is in the product. Milk today is sold as homogenized which means it has been through a process that keeps the fat and liquid from separating.

Heavy Cream - this has a higher percentage of fat in it. It can be used as is or whipped up and sweetened to make whipped cream. As with milk you can buy heavy cream with different fat percentages.

Butter Milk – this is used often in recipes but contains an acid that is countered by the addition of Baking soda.

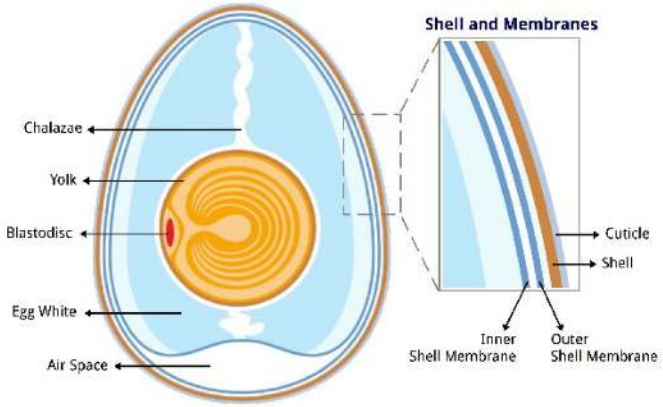
Evaporated Milk - also known as “pet “milk. Evaporated milk is milk that has a percentage of the water removed. It is sold in cans unrefrigerated due to sterilization.

Fat Amounts in Various Dairy Products	
Whole Milk	8%
Skim Milk	< 1%
Heavy Cream	30% to 40%
Half and Half	10% to 18%

Eggs

The egg is an essential ingredient used in the bake shop.

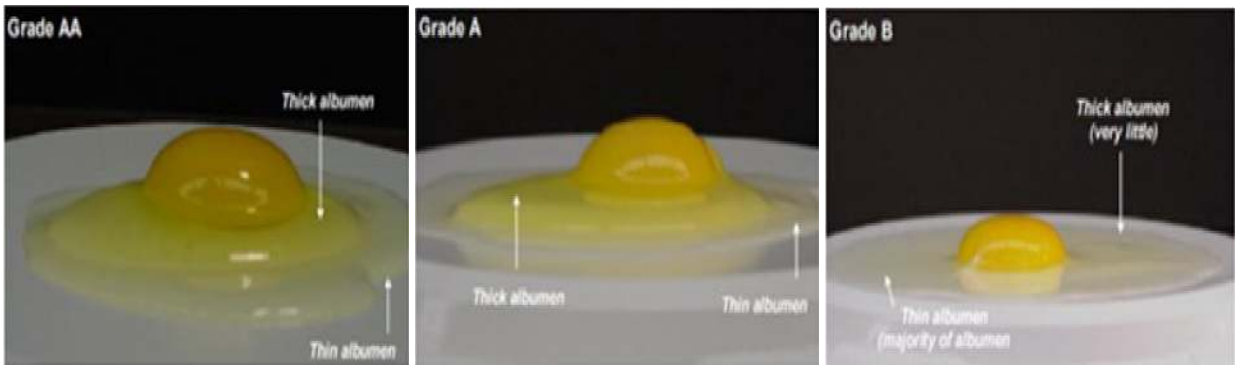
- The make of the egg is simple – yolk, white and shell. In the diagram you see how each in connected in the shell.
- The chalazae is the stringy white part you see when you crack the egg.
- The yolk is high in fat and protein. Lecithin is also found in the yolk and aid in thickening and emulsification of ingredients.
- The white is the lean part of the egg. It is used for meringues and coagulates when heated.



Grading and Weight of Eggs

The United States grading system for eggs is based on their quality but also size. There are 3 types of grades given to eggs AA, A and B.

Approximate of Weights of a Large Egg	
One whole egg	1.67 oz
One egg white	1 oz.
One egg yolk	.67 oz.
9 ½ whole eggs	1 lb.
16 egg whites	1 lb.
24 yolks	1 lb.



Yeast

The leavening agent in yeast doughs. It is a single cell fungi however there are many species and well as types. When fed the yeast will produce carbon dioxide and alcohol.

Types of Yeast

1. **Fresh or Cake** - this is sold in bricks similar to butter. It is moist and perishable. If treated properly it will last about 2 week in the refrigerator. It can be froze to extend the life if not used right away.
2. **Active Dry** - this must be rehydrated with warm water that is 4 times its weight. Yeast will die if the water temperature is 140oF or higher. Major issue with this yeast is that many of the yeast cells in the packet are dead and activing the rest can be problematic.
3. **Instant dry yeast** - this yeast does not need to be dissolved in water to use it. It can be added to the dry ingredients and mixed due to its ability to absorb water quickly. This makes it the preferred yeast product of most bakers today.

Chemical Leaveners

These leaveners work by releasing gases caused by a chemical reaction.

Types of Chemical leaveners

1. **Baking Soda** – sodium bicarbonate. The reaction for baking soda is done once liquid is added. Products that contain baking soda must be baked as soon as they are assembled. If allowed to sit the chemical reaction will take place and end causing the product to not rise once in the oven. They are generally used when acids are added to a recipe such as molasses, brown sugar, and some fruit juices and cocoa powder.
2. **Baking Powder** – this is a combination of baking soda and an acid. This allows for the majority of the leavening to take place in the oven. Heat is need to leaving products that contain baking powder. The preferred type found in stores and bakeries is double acting baking powder.

Cocoa Powder

This is the powder that is left once the cocoa butter has been removed during the production of chocolate.

Types of Cocoa Powder

1. **Dutch-processed** - the acid in this has been neutralized through a washing process. This gives the cocoa powder with a dark color, and smoother flavor.
2. **Cocoa powder** – this is somewhat acidic and lighter in color.

Vanilla

This is the fruit of the orchid plant Vanilla. The fruit is cut, and cured which dries the pod allowing for the intense flavor due to minimal loss of the essential oils.

- Vanilla extract is made from soaking the cut vanilla beans in alcohol. It is allow to macerate until the desired flavor profile is reached. The beans are then removed and the product is bottle.

- Once you use a bean, it can be dried and used to make vanilla sugar. This is done by enclosing the bean and sugar in a container and allowing the sit. The vanilla flavor is permeate through the sugar.
- Dried Vanilla beans can also be ground and made into vanilla powder.





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13.2.3: Pastries, Pies

Click here to learn more about pies and Pastries as well as their differences and similarities.





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13.2.3.1: Types of Pastry and Storage

These doughs differ from the previous doughs in that they are not leavened. They have a more tender crumb and are usually used as a base to be filled such as tarts. The names are derived from the French and give indication to the texture of the finished product.

Non-Laminated:

This link Provides some insight on non-laminated doughs.

Plain pastry

Shortcrust (Pie) – These doughs are tender as well and that is because little gluten is formed during the making of the dough. ***This link*** gives further details on this pastry dough.

The types of dough are included bellow:

- **Pie Crust:** use ***this link*** to learn more.

The first recorded pie recipe was found to be written by the Romans. The first popular pies were traditionally meat pies. Today pies are filled with a variety of fillings such as meat, fruit, and custards. The first pies were not baked in the crust that we associate with pies. They were baked in "reeds" and only the fillings were made. Pies gains popularity through out Europe with the first Cherry Pie credit going to Queen Elizabeth I. Pies came to the Americas with the English settlers but the thick crust was seen as a vessel for the fillings. As the pie evolved the crust went from vessel to part of the dish. Today Pies are a traditional American dessert.

The Ingredients for Pie Crust

There are two types of pie crust flaky and mealy. Both use the same simple ingredients flour, fat, salt and water. The difference between the two are the way the fat and flour are put together.

1. *Flour* – the ideal flour for pie crust is pastry flour. It has just enough proteins to form a gluten structure that will give the dough structure but keep the gluten low enough to keep the dough flaky. Pie dough should be mixed until the ingredients are just combined.
2. *Fat* – hydrogenated shortening is the most popular fat to use for pie dough. It is soft enough to mix in but strong enough to produce a workable dough. Butter is also used but it has two down falls – it is expensive and has a low melting point. What makes it ideal is the mouth feel and flavor it adds to the curst.
3. *Liquid* – the cheapest and best liquid to add is water. Ice water is normally used because it keeps the fat at a stable temperature and helps prevent it from melting. Milk can be used but it will cause the crust to brown quickly.
4. *Salt* – this adds to the flavor of the crust. It is best to mix it with the flour or dilute in liquid to ensure even distribution.

Flaky Pie Dough

The fat for this dough is rubbed, or cut into the flour, until the pieces of butter are the size of a pea or hazelnut. This allows for some gluten formation when the water is added. As the dough comes together, the pieces of fat are flatten out with the dough thus giving it the flaky texture. Used often in pies that call for blind baking as well as the top for covered pies.

Mealy Pie Dough

The fat for a mealy dough is completely cut into the flour until the mix resembles a coarse cornmeal. There should be no lumps of fat in the mixture. The flour particles have been completely encased in fat and there less liquid is used to bind this one because the flour cannot absorb it. This type of dough has a few advantages over the flaky crust.

- This is a softer crust because gluten development is kept low due to the low absorption of water with the flour.
- Once baked this dough does not absorb much liquid so it will not become soggy from its filling.

NOTE: This is a popular crust for fruit and custard pies because it does not become soggy.

- **Galettes:** use ***this link*** to learn more.
- **Tarts:** Tarts are made in shallow fluted pans. The doughs that are used have a tender crust, are made with butter and add to the overall flavor of the tart.

The three main types are discussed below. ***This link*** also provides more clarification and some helpful tips on how to remember the different types.

1. *Pâté Brisée* - the French translation is broken dough. This name is based on how the dough is put together. The fat is combined with the flour in the same fashion that you would put together a mealy pie dough. The fat is rubbed into the flour until the mixture resembles a coarse meal. There should be visible pieces of butter. This allows the flour particles to be surrounded by fat thus hampering the formation of gluten resulting in a tender pastry.
2. *Pâté Surcée* – the French translation is sugared dough. This dough has more sugar the pâté brisée. The extra sugar helps to keep this dough tender thus making it softer and harder to handle. It can be made using either the above method or the creaming method. The finished dough can be used for smaller tarts and pastries as well as a stand-alone cookie.
3. *Pâté Sablée* – the word sablée in French means 'sand', which describes the finished texture of this dough. The recipes usually have more fat than the brisée and less egg, which lends it its finished texture. The most common method for this dough today is the creaming method.

Hot-Water Crust

Use ***this link*** to learn more about hot-water crust.

Brioche

Use ***this link*** to learn more about brioche pastry.

Choux (Éclair Paste)

In the industry it is referred to by the French name pâte a choux which means "cabbage paste" because once baked they resemble little cabbages. This is a cooked pastry dough that can be used in a variety of ways to create both sweet and savory baked goods. The way they are piped out will determine the name given to the finished product. The dough can be made in a few minutes and is usually used as soon as made. It will form a skin if allowed to sit without being covered with a damp cloth. Once made it should not sit without being used for longer than an hour. ***This link*** will provide you with more information and some helpful images.

Pastries made from pâte a choux:

1. *Cream puffs* – small or large pastries piped out using a round tip. The size is determined by the dessert you want to make.
2. *Eclairs* – can be made with the round tip also. They are piped out in a line and the size will depend on the tip and what they are needed for.
3. *Paris-Brest* – they are piped using a star tip. The shape represents a bicycle wheel. The shape was created to honor the bicycle race from Paris to Brest which begun in 1891.
4. *Gougères* – these are savory "cream puffs" while making the dough you can add herbs, spices and cheese to make it savory.

Laminated:

This link helps you to better understand lamination.

Puff Pastry

This dough is a versatile dough that is made in the same fashion as Danish and croissants meaning that is it a laminated dough. The main difference is that this dough has no leavening agent. This dough is cooked at a high temperature thus creating steam from the layers of fat and dough. The steam causes the dough to rise at least an inch more than is normal size. The preferred fat for puff pastry is butter due to its mouth feel and flavor. There are different methods to make puff pastry but the more layers added as well as higher fat content of the recipe will give you a better rise and product. ***This link*** provides further insight on this type of dough. It is important to know the proper use of the dough. If you do not handle it properly the dough will not rise nor will it give you the desired finish.

Quick (blitz) Puff

This link provides you with helpful information on quick puff as well a video.

Strudel

This dough is made from flour, water and eggs. It is then stretched thin over a floured cloth. The dough is so thin that you can see through it. Learning to stretch the dough take time, patience and skill.

Phyllo

This is the Greek version of strudel dough. It is usually purchased commercially. The thin sheets of pastry are rolled together in a thin plastic covering. When working with you it is best to keep a slightly damp cloth over it to prevent it from drying out. The thin sheet is placed and then melted butter is gently brushed on covering the entire sheet. Another sheet then added and brushed with butter. This continues until the desired amount is reached.

Croissant

This link provides information on croissants.

Danish

This link provides information on Danishes.

Storage:

Use ***this link*** to learn about pastry storage.

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13.2.4: Candy and Chocolate

Syrup-Phase Candy:

This category of candy contains the majority of candies made. All of these candies are made with simple syrup (1:1 ratio of sugar and water boiled together) and flavorings.

- Hard candy
- Nougats
- Caramels
- Marshmallows
- Jelly beans
- Gums
- Fudges
- Fondants

Fat-Phase Candy:

This phase is when there is a form of fat introduced to a candy like chocolate or peanut butter. The two phases can be combined.

Crystaline VS. Non-Crystaline:

The info-graphic provided in this link gives a good outline of this topic.

Determining Doneness With Texture:

This link will provide some examples of the textures that you can look for in each stage of candy using either a thermometer or the water test.

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13.2.4.1: Types of Candies

6.5.01: Types of Candies

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13.2.4.2: Types of Chocolate

From the Cocoa Bean to the Finished Chocolate

In North America, chocolate manufacturing started in Massachusetts in 1765. Today, in the factory, the beans get cleaned, and magnets take out metallic parts, and then sand, dust, and other impurities are removed. Some starch will be changed into dextrins in the roasting process to improve flavor. Machines break the beans and grind them fine until a flowing liquid is produced, called chocolate liquor. Through hydraulic pressure, cocoa butter is reduced from 55% to approximately 10% to 24% or less, and the residue forms a solid mass called *press cake.*

The press cake is then broken, pulverized, cooled, and sifted to produce commercial cocoa powder. The baking industry uses primarily cocoa powders with a low fat content.

At the factory, chocolate is also subject to an additional refining step called **conching.** Conching has a smoothing effect. The temperature range in this process is between 131°F and 149°F. Sugar interacts with protein to form amino sugars, and the paste loses **acids** and moisture and becomes smoother.

Watch this video on the chemistry of chocolate to learn about the chemical reactions related to heat, melting point, and formation of crystal structures in chocolate.

Types of Chocolate Commonly Used:

True chocolate contains cocoa butter. The main types of chocolate, in decreasing order of cocoa liquor content, are:

- Unsweetened (bitter) chocolate
- Dark chocolate
- Milk chocolate
- White chocolate - contains no chocolate liquor at all.

Unsweetened Chocolate

Unsweetened chocolate, also known as bitter chocolate, baking chocolate, or cooking chocolate, is pure cocoa liquor mixed with some form of fat to produce a solid substance. The pure ground, roasted cocoa beans impart a strong, deep chocolate flavor. With the addition of sugar in recipes, however, it is used as the base for cakes, brownies, confections, and cookies.

Dark (Sweet, Semi-Sweet, Bittersweet) Chocolate

Dark chocolate has an ideal balance of cocoa liquor, cocoa butter, and sugar. Thus it has the attractive, rich color and flavor so typical of chocolate, and is also sweet enough to be palatable. It does not contain any milk solids. It can be eaten as is or used in baking. Its flavor does not get lost or overwhelmed, as in many cases when milk chocolate is used. It can be used for fillings, for which more flavorful chocolates with high cocoa percentages ranging from 60% to 99% are often used. *Dark* is synonymous with semi-sweet, and *extra dark* with bittersweet, although the ratio of cocoa butter to solids may vary.

- Sweet chocolate has more sugar, sometimes almost equal to cocoa liquor and butter amounts (45% to 55% range).
- Semi-sweet chocolate is frequently used for cooking. It is a dark chocolate with less sugar than sweet chocolate.
- Bittersweet chocolate has less sugar and more liquor than semi-sweet chocolate, but the two are often interchangeable when baking. Bittersweet and semi-sweet chocolates are sometimes referred to as *coverture* (see below). The higher the percentage of cocoa, the less sweet the chocolate is.

Coverture

The usual term for top quality chocolate is **coverture**. Coverture chocolate is a very high-quality chocolate that contains extra cocoa butter. The higher percentage of cocoa butter, combined with proper tempering, gives the chocolate more sheen, firmer “snap” when broken, and a creamy mellow flavor. Dark, milk, and white chocolate can all be made as coverture.The total percentage cited on many brands of chocolate is based on some combination of cocoa butter in relation to cocoa liquor. In order to be labeled as coverture by European Union regulations, the product must contain not less than 35% total dry cocoa solids, including not less than 31% cocoa butter and not less than 2.5% of dry non-fat cocoa solids. Coverture is used by professionals for dipping,

coating, moulding, and garnishing. What the percentages don't tell you is the proportion of cocoa butter to cocoa solids. You can, however, refer to the nutrition label or company information to find the amounts of each. All things being equal, the chocolate with the higher fat content will be the one with more cocoa butter, which contributes to both flavor and mouth-feel. This will also typically be the more expensive chocolate, because cocoa butter is more valuable than cocoa liquor. But keep in mind that just because two chocolates from different manufacturers have the same percentages, they are not necessarily equal. They could have dramatically differing amounts of cocoa butter and liquor, and dissimilar flavors, and substituting one for the other can have negative effects for your recipe. Determining the amounts of cocoa butter and cocoa liquor will allow you to make informed decisions on chocolate choices.

Milk Chocolate

Milk chocolate is solid chocolate made with milk, added in the form of milk powder. Milk chocolate contains a higher percentage of fat (the milk contributes to this) and the melting point is slightly lower. It is used mainly as a flavoring and in the production of candies and moulded pieces.

White Chocolate

The main ingredient in white chocolate is sugar, closely followed by cocoa butter and milk powder. It has no cocoa liquor. It is used mainly as a flavoring in desserts, in the production of candies and, in chunk form in cookies.

Dutch Process Cocoa

This Dutch process is a treatment of the chocolate product with alkali, usually potassium carbonate. Cocoa beans have a pH of approximately 5.2. The treatment with alkali raises the pH of the finished product to 6.8 and higher. The process affects the flavor and color of the chocolate product. Alkaline solution is generally applied to the raw beans or nibs but not to the liquor. If alkali is used in the cocoa liquor, it tends to react and leaves a soapy flavor.

Dutch cocoa is generally more expensive than natural cocoa. Whether or not the cocoa powder is Dutch process has some importance for some recipes. The Dutch process:

- Lowers acidity
- Increases solubility
- Enhances color
- Smooths flavor

Because Dutch cocoa has a neutral pH and is not acidic like natural cocoa, it cannot be used in recipes that use baking soda as the leavening agent, which relies on the acidity of the cocoa to activate it. Rather, Dutch process cocoa can be used in recipes that use baking powder for leavening.



Figure 1. Dutch process and natural cocoa.

Compound Chocolate

Compound chocolate is the most commonly used chocolate in the baking industry today. It is also referred to in the trade as coating chocolate, confectionary coating, non-temper coatings, or baker's chocolate. **Note:** It should not be confused with the Baker's brand chocolate, easily obtained in supermarkets, which is generally pure chocolate.

A typical chocolate coating contains approximately 35% to 40% fat, which is a type of hard fat (usually hydrogenated palm kernel oil), 8% to 18% cocoa, approximately 2% milk solids, and a small amount of lecithin and flavor; the remainder is pulverized sugar. Since there is no cocoa butter (generally) present in compound chocolate, it offers a cost savings, and it eliminates the time spent needed in tempering.

Because of the replacement of cocoa butter, compound chocolates are not appropriate to use in moulding applications. With the other oils and fats in compound chocolate, it will not set as firmly as a cocoa butter chocolate, making it difficult if not impossible to remove from a mould. Another factor to consider is that properly tempered cocoa butter chocolate will shrink slightly, and this aids in the removal from molds.

Compound chocolate melts at approximately 95°F to 99°F and is best for coating at approximately 104°F. If any liquefying agent is needed, palm kernel oil can be used. Most compound chocolate is thin enough for coating.

The shelf life of fresh bakery goods enrobed with compound coating does not present any problems with **bloom** because hard fat is used to adjust the melting point and carries enough seed to make tempering unnecessary. While temperature control is not as critical as when using true chocolate, heating coating to 122°F and higher could destroy seed crystals and reduce the coating's viscosity.

Coatings that are well adapted to freezing are produced. Here, ability to withstand the freeze/thaw cycle without brittleness and cracking is important. In any case, products going into the freezer should be tightly enclosed in plastic wrap. The wrap should not be removed until the product is defrosted.

Viscosity

Viscous means "sticky"' and the term *viscosity* refers to the way in which the chocolate flows. Chocolate comes in various Viscosities, and the confectioner chooses the one that is most appropriate to his or her needs. The amount of cocoa butter in the chocolate is largely responsible for the viscosity level. Emulsifiers like lecithin can help thin out melted chocolate, so it flows evenly and smoothly. Because it is less expensive than cocoa butter at thinning chocolate, it can be used to help lower the cost of chocolate.

Moulded pieces such as Easter eggs require a chocolate of less viscosity. That is, the chocolate should be somewhat runny so it is easier to flow into the molds. This is also the case for coating cookies and most cakes, where a thin, attractive and protective coating is all that is needed. A somewhat thicker chocolate is advisable for things such as ganache and flavoring of creams and fillings. Where enrobers (machines to dip chocolate centres) are used, the chocolate may also be thinner to ensure that there is an adequate coat of coverture.

Viscosity varies between manufacturers, and a given type of chocolate made by one manufacturer may be available in more than one viscosity. Bakers sometimes alter the viscosity depending on the product. A vegetable oil is sometimes used to thin chocolate for coating certain squares. This makes it easier to cut afterwards.

Chips, Chunks, and Other Baking Products

Content and quality of chocolate chips and chunks vary from one manufacturer to another. This chocolate is developed to be more heat stable for use in cookies and other baking where you want the chips and chunks to stay whole. Ratios of chocolate liquor, sugar, and cocoa butter differ. All these variables affect the flavor.

Chips and chunks may be pure chocolate or have another fat substituted for the cocoa butter. Some high-quality chips have up to 65% chocolate liquor, but in practice, liquor content over 40% tends to smear in baking, so high ratios defeat the purpose.

Many manufacturers package their chips or chunks by count (ct) size. This refers to how many pieces there are in 1 kg of the product. As the count size number increases, the size of the chip gets smaller. With this information, you can choose the best size of chip for the product you are producing.

Other chocolate products available are chocolate sprinkles or “hail,” used as a decoration; chocolate curls, rolls, or decorative shapes for use on cakes and pastries; and chocolate sticks or “batons,” which are often baked inside croissants.

Storing Chocolate

Chocolate will keep for up to a year at a temperature of 18°C to 20°C (64°F to 68°F) with a relative humidity level of 60%. These are the ideal storage conditions. It is not always possible in bakeries to meet the ideal, but in general, room temperature is all right. Chocolate must be kept safe from odours and humidity, and therefore the refrigerator is not the ideal place to store it.

These guidelines apply also to all pure chocolate products, such as chocolate chips, hail, and sticks. All must be protected from humidity and odours and kept cool and dry at room temperature in sealed containers or in the original packaging.

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13.2.5: Frozen Desserts

Frozen Desserts

Frozen desserts have been popular for just about as long as humans have tried to find cool relief from scorching temperatures. The first known frozen dessert is thought to have been consumed by the Roman emperor Nero who is famously reported to have requested ice be brought from the mountain tops for his enjoyment with sweet fruit syrups and honey. Other notables throughout history are known for enjoying a frozen treat and there has been an evolution of treats, varieties, flavors over time. To learn more about history please visit here.

With seemingly endless flavor combinations frozen desserts come in a wide variety.

For more information on types of frozen desserts and their distinct differences please visit this site:

Types of Frozen Desserts

One of the most distinguishable differences between the type of frozen desserts comes down to the type and amount of milk fat that the item contains. For a full view on milk-fat and how it is used in various types of frozen desserts please visit this All About Frozen Dessert webpage for a greater idea.

Ice Cream

Ice cream is simply a mixture of milk, cream, sugar, eggs, and flavorings that are combined and frozen in a machine that spins the mixture into a smooth and creamy dessert. There are various names for the delectable treat but all are churned and frozen. The constant movement of the machine ensures that the mixture does not freeze into a solid block. Most ice cream machines whether commercial or home-style consist of a tube with a paddle that spins. A cooling system surrounds the tube freezing the mixture. As the paddle turns, it keeps the forming ice crystals in motion incorporating air into the ice cream, which leads to its texture.

Overrun is the name given to the air that is added to ice cream as it is mixed. This added air will increase the amount of the finished product. Overrun is listed on packing in a percentage of the finished product. If you begin with a gallon of ice cream base and once spun, you finish with 2 gallons of ice cream then your overrun percentage is 100%.

Understanding the science behind how ice cream is made and the resulting texture, body, and melting properties is particularly important. The combination of ingredients and their ratio can help alter the final product but sometimes that means that our final product isn't actual ice cream. Remember ice cream must contain at least 10% milk fat. Milk fat, sugar, milk solids nonfat, and air are all incorporated together in order to get the final texture and taste we come to expect. To learn how ice cream is made please visit: How Ice Cream is Made.

Texture and body are two properties to consider when thinking about the final product. Read this informative page Ice, Cream, and Chemistry to get the full picture.

In the process, lots of things can go wrong. Learn about defects here and consider how to best overcome these challenges.

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14.1: Meat

Meat is defined as the flesh of animals (usually mammals) used as food, that can be part of a healthful diet. Meat is a major source of key nutrients, such as high-quality protein, iron, and B vitamins for many Americans.

There are many different types of meats but for the purposes of this course, we will be focusing on beef, pork, and lamb. Other meats include but are not limited to horses, squirrels, llamas, etc.

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14.1.1: Meat Identification

There are many definitions of meat but one of the most widely used definitions is " the flesh of an animal (usually a mammal) used as food." In this section we will explore common types of meat in the United States with emphasis on red meat. While some definitions of meat include poultry, we will be discussing poultry in the next section.

In the United States the two most commonly consumed red meats are beef and pork. While lamb is not eaten in the same volume as beef and pork it will be discussed in this section.

Beef Classification:

Beef originates from cattle that are classified by age and gender:

Steers: male cattle that are castrated while young. This is so that they will gain weight quickly

Bulls: uncastrated males that are used for breeding purposes. The consumer does not see meat sold at the grocery store that comes from bulls as this meat tends to be tougher and less palatable. Meat that comes from bulls may be used in processed meats or pet foods.

Heifers/Cows: Heifers are females that have not borne a calf while cows are female cattle that have borne calves. The meat from cows is seen as less desirable than that of heifers or steers.

Calves: calves 3-8 months old are too old for veal but too young for beef. If they go to market between 8-12 months they are referred to as "baby beef"

Veal comes from the young calves that are slaughtered between the ages of 3 weeks to 3 months. These calves may be either male or female and have been fed a diet primarily of milk. This results in tender, lighter colored meat.

Pork Classification:

Most pork sold in stores is from young swine of either male or female gender that is slaughtered between 5-7 months of age. **Pigs** are less than 4 months old while **hogs** are older than 4 months of age. These terms are often used interchangeably.

Lamb Classification:

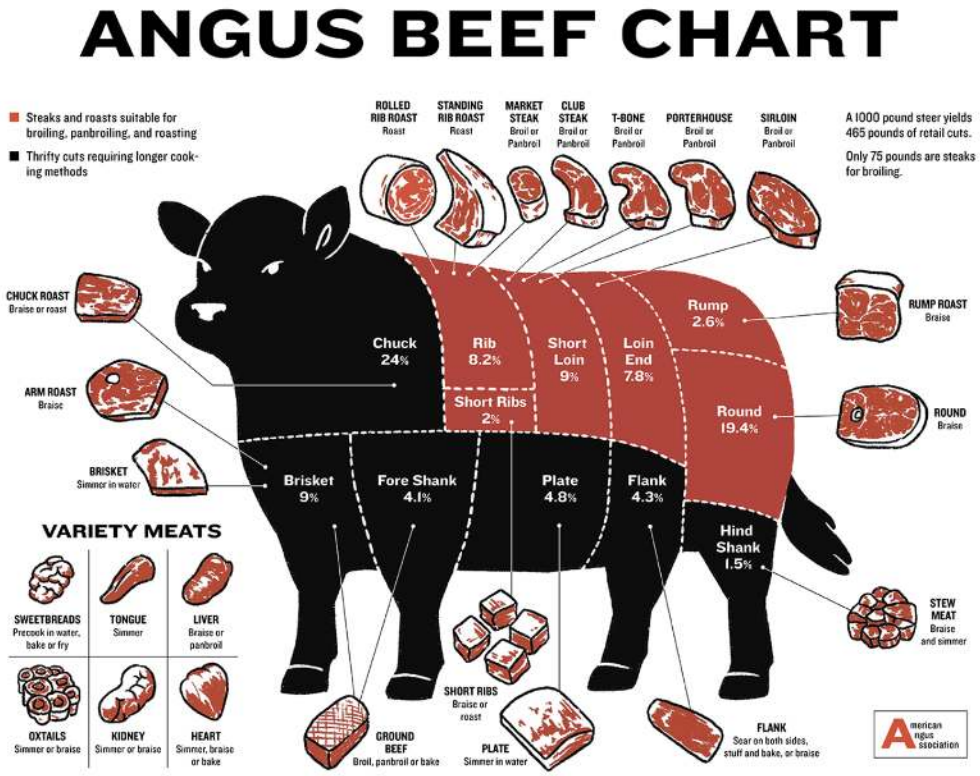
Lamb and **mutton** meat both come from sheep. However, the difference in the two terms comes down to the age at which the animal was at slaughter. Sources differ on the age at which the meat derived from sheep goes from lamb to mutton it is usually noted to at the 12 month mark. In other words a sheep slaughtered before it is 12 months old yields lamb, and older than 12 months yields mutton. Lamb is typically more tender and lighter in flavor compared to mutton due to being fed a primarily milk based diet and having had restricted movements.

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14.1.1.1: Cuts and Preparation Methods

Retail Cuts of Beef

There are four basic (primal) cuts into which beef is separated: chuck, loin, rib and round. It is important to know the location of bones when cutting or working with meats. This makes meat fabrication and carving easier and aids in identifying cuts. An entire beef carcass can range in weight from 500 to more than 800 pounds (225 to 360 kg). It is recommended that packages of fresh beef purchased in the supermarket be labeled with the primal cut as well as the product, such as "chuck roast" or "round steak". This helps consumers know what type of meat is best for cooking the product. Generally, chuck and round are less tender and require moist heat such as braising; loin and rib can be cooked by dry heat methods such as broiling or grilling.



FOREQUARTER

Cuts from the forequarter of the animal tend to be less tender than other cuts. The toughness is due to increased amounts of collagen found in these muscles from use and exercise of the animal. To overcome the natural toughness of the meat, moist heat preparations are recommended to increase tenderness by breaking down the collagen in a process of gelation.

Chuck

The primal chuck is the animal's shoulder; it accounts for approximately 28 percent of carcass weight. It contains a portion of the backbone, five rib bones and portions of the blade and arm bones. Because an animal constantly uses its shoulder muscles, chuck contains a high percentage of connective tissue and is quite tough. This tough cut of beef, however, is one of the most flavorful.

The primal chuck is used less frequently than other primal cuts in food service operations. If cooked whole, the chuck is difficult to cut or carve because of the large number of bones and relatively small muscle groups that travel in different directions. The primal chuck produces several fabricated cuts: cross rib pot roast, chuck short ribs, cubed or tenderized steaks, stew meat and ground chuck.

Because the meat is less tender, the fabricated cuts usually benefit from moist-heat cooking or combination cooking methods such as stewing and braising. There are exceptions, however. The beef industry is developing new products from underutilized cuts of

meat. Flat iron comes from the top shoulder of the chuck and is one such cut gaining in popularity as an alternative steak suitable for dry-heat cooking.

BRISKET and SHANK

The brisket and shank are located beneath the primal chuck on the front half of the carcass. Together, they form a single primal that accounts for approximately 8 percent of carcass weight. This primal consists of the steer's breast (the brisket), which contains the ribs and breastbone, and its arm (the fore shank), which contains only the shank bone.

The ribs and breastbone are always removed from the brisket before cooking. The boneless brisket is very tough and contains a substantial percentage of fat, both intermuscular and subcutaneous. It is well suited for moist-heat and combination cooking methods such as simmering or braising. It is often pickled or corned to produce corned beef brisket, or cured and peppered to make pastrami. Beef fore shanks are very flavorful and high in collagen. Because collagen converts to gelatin when cooked using moist heat, fore shanks are excellent for making soups and stocks. Ground shank meat is often used to help clarify and flavor consommés because of its rich flavor and high collagen content.

RIB

The primal beef rib accounts for approximately 10 percent of carcass weight. It consists of ribs 6 through 12 as well as a portion of the backbone. This primal is best known for yielding roast prime rib of beef. Prime rib is not named after the quality grade USDA Prime. Rather, its name reflects the fact that it constitutes the majority of the primal cut. The eye meat of the rib (the center muscle portion) is not a well-exercised muscle and therefore is quite tender. It also contains large amounts of marbling compared to the rest of the carcass and produces rich, full- flavored roasts and steaks. Although roasting the eye muscle on the rib bones produces a moister roast, the eye meat can be removed to produce a boneless rib eye roast or cut into ribeye steaks. The rib bones that are separated from the rib eye meat are quite meaty and flavorful and can be served as barbecued beef ribs. The ends of the rib bones that are trimmed off the primal rib to produce the rib roast are known as beef short ribs. They are meaty and are often served as braised beef short ribs.

SHORT PLATE

The short plate is located directly below the primal rib on a side of beef; it accounts for approximately 9 percent of the overall weight of the carcass. The short plate contains rib bones and cartilage and produces the short ribs and skirt steak. Short ribs are meaty, yet high in connective tissue, and are best when braised. Skirt steak is often marinated and grilled as fajitas. Other, less meaty portions of the short plate are trimmed and ground.

HIND QUARTER

Short Loin

The short loin is the anterior (front) portion of the beef loin. It is located just behind the rib and becomes the first primal cut of the hindquarter when the side of beef is divided into a fore-quarter and hindquarter. It accounts for approximately 8 percent of carcass weight. The short loin contains a single rib, the 13th, and a portion of the backbone. With careful butchering, this small primal can yield several sub primal and fabricated cuts, all of which are among the most tender, popular and expensive cuts of beef

The loin eye muscle, a continuation of the rib eye muscle, runs along the top of the I-shaped bones that form the backbone. Beneath the loin eye muscle on the other side of the backbone is the tenderloin, the tenderest cut of all.

When the short loin is cut in cross-sections with the bone in, it produces - starting with the rib end of the short loin club steaks (which do not contain any tenderloin), T-bone steaks (which contain only a small portion of tenderloin), and porterhouse steaks (cut from the sirloin end of the short loin, and contain a large portion of tenderloin).

The whole tenderloin can also be removed and cut into chateaubriand, filet mignon, and tournedos. A portion of the tenderloin is located in the sirloin portion of the loin. When the entire beef loin is divided into the primal short loin and primal sirloin, the large end of the tenderloin (the butt tenderloin) is separated from the remainder of the tenderloin and remains in the sirloin; the smaller end of the tenderloin (the short tenderloin) remains in the short loin. If the tenderloin is to be kept whole, it must be removed before the short loin and sirloin are separated. The loin eye meat can be removed from the bones, producing a boneless strip loin, which is very tender and can be roasted or cut into boneless strip steaks.

Sirloin

The sirloin is located in the hindquarter, between the short loin and the round. It accounts for approximately 7 percent of carcass weight and contains part of the backbone as well as a portion of the hipbone.

The sirloin produces bone-in or boneless roasts and steaks that are flavorful and tender. With the exception of the tenderloin portion, however, these subprimals and fabricated cuts are not as tender as those from the strip loin are. Cuts from the sirloin are cooked using dry-heat methods such as broiling, grilling or roasting.

Flank

The flank is located directly beneath the loin, posterior to (behind) the short plate. It accounts for approximately 6 percent of carcass weight. The flank contains no bones.

Although quite flavorful, it is a less tender cut with a good deal of fat and connective tissue. Flank meat is usually trimmed and ground, with the exception of the flank steak or London broil. The flank also contains a small piece of meat known as the hanging tenderloin. Although not actually part of the tenderloin, it is very tender and can be cooked using any method.

ROUND

Meat from the round is flavorful and tender. Steaks cut from the round are less tender, but because they have large muscles and limited intermuscular fat, the top round and knuckle make good roasts. The bottom round is best when braised. The hind shank is prepared in the same fashion as the fore shank.

Organ Meats

Several organ meats find use in food service operations. This group of products is known as offal. It includes the heart, kidney, tongue, tripe (stomach lining) oxtail, and pigs feet. Offal benefit from moist-heat cooking and are often used in soup, stew or braised dishes.

PRIMAL	FABRICATED CUT	COOKING METHODS	SERVING SUGGESTIONS
Chuck	Top blade (flat iron)	Dry heat (broil or grill)	Steak; fajitas
	Chuck roll, tied	Combination (braise; stew)	Pot roast; beef stew
	Stew meat	Combination (stew) Beef stew	
	Ground beef	Dry heat (broil or grill; roast)	Hamburgers; meat load
		Combination (braise; stew)	Chili con came; beef stews
Brisket and dinner	Brisket	Moist heat (simmer)	Corned beef; New Eng. boiled
Shank		Combination (braise)	Pot Roast
	Shank	Combination (braise)	Shredded beef for tamales or hash
Rib	Oven-ready rib roast	Dry heat (roast)	Roast prime rib
	Rib eye roll	Dry heat (roast)	Roast prime rib
Short Plate	Skirt steak	Dry heat (broil or grill)	Steak; fajitas
	Short ribs	Combination (braise)	Braised short ribs

Forequarter Above / Hindquarter Below			
Short loin	Porterhouse	Dry heat (broil or grill)	Steak T-bone steaks
	Strip loin	Dry heat (broil or grill; sauté)	New York steak; minute steak; roast; borderlaise
	Tenderloin	Dry heat (broil or grill; roast)	Tournedos Rossini; Beef Wellington
Sirloin	Top sirloin butt	Dry heat (broil or grill; roast)	Steak; roast beef
	Tri tip	Dry heat (broil or grill; roast)	Steak; stir-fry; fajitas
Flank	Flank Steak	Dry heat (broil or grill)	London broil
		Combination (braise)	Braised stuffed flank steak
Round	Steamship round	Dry heat (roast)	Roast beef
	Top (inside) round	Dry heat (roast)	Roast beef
		Combination (braise)	Braised beef roulade

Sources:

https://www.taylordesign.com/2021/06...-to-beef-cuts/

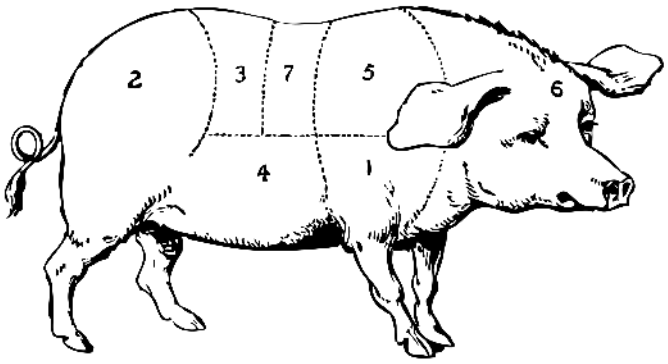
https://ask.usda.gov/s/article/What-are-the-retail-cuts-of-fresh-beef

Retail Cuts of Pork

Hogs are bred specifically to produce long loins; the loin contains the highest- quality meat and is the most expensive cut of pork. Pork is unique in that the ribs and loin are considered a single primal. They are not separated into two different primals, as are the ribs and loin of beef, veal and lamb. As with all meats, it is important to know the location of bones when cutting or working with pork. This makes meat fabrication and carving easier and aids in identifying cuts. A hog carcass generally weighs in a range of 120 to 210 pounds (55 to 110 kg)

Because all pork comes from hogs slaughtered at a young age, the shoulder is tender enough to be cooked by any method. It is, however, one of the least tender cuts of pork. It is available smoked or fresh. The shoulder is fairly inexpensive and, when purchased fresh, it can be cut into shoulder butt steaks or boned and cut into smaller pieces for sautéing or stewing. Whole pork shoulder is the cut preferred by many barbecue pit masters throughout the American South.

The foreshank is called the shoulder hock and is usually smoked. Shoulder hocks are often simmered for long periods in soups, stews and braised dishes to add flavor and richness.



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LOIN

The loin is cut from directly behind the Boston butt and includes the entire rib section as well as the loin and a portion of the sirloin area. The primal loin accounts for approximately 20 percent of the carcass weight. It contains a portion of the blade bone on the shoulder end, a portion of the hipbone on the ham end, all the ribs and most of the backbone.

The primal pork loin is the only primal cut of pork not typically smoked or cured. Most of the loin is a single, very tender eye muscle. It is quite lean but contains enough intramuscular and subcutaneous fat to make it an excellent choice for a moist-heat cooking method such as braising, or it can be prepared with dry-heat cooking methods such as roasting or sautéing. The loin also contains the pork tenderloin, located on the inside of the rib bones on the sirloin end of the loin. The tenderloin is the tenderest cut of pork; it is very versatile and can be trimmed, cut into medallions and sautéed, or the whole tenderloin can be roasted or braised. The most popular cut from the loin is the pork chop. Chops can be cut from the entire loin, the choicest being center-cut chops from the primal loin after the blade bone and sirloin portions at the front and rear of the loin are removed. The pork loin can be purchased boneless or boned and tied as a roast. A boneless pork loin is smoked to produce Canadian bacon. The rib bones, when trimmed from the loin, can be served as barbecued pork back ribs.

Although not actually part of the primal loin, fatback is the thick layer of fat - sometimes more than an inch (2.5 centimeters) thick - between the skin and the lean eye muscle. It has a variety of uses in the kitchen, especially in the preparation of charcuterie items.

FRESH HAM

The primal fresh ham is the hog's hind leg. It is a rather large cut accounting approximately 24 percent of the carcass weight. The ham contains the aitch, and hind shank bones. Fresh ham, like the legs of other meat animals, contains large muscles with relatively small amounts of connective tissue. Like many other cuts of pork, hams are often cured and smoked. However, fresh hams also produce great roasts and can be prepared using almost any cooking method. When cured and smoked, hams are available in a variety of styles; they can be purchased bone-in, shankless or boneless, partially or fully cooked. Fully cooked hams are also available canned. There is a specific ham for nearly every use and desired degree of convenience. The shank portion of the ham is called the ham hock. It is used in the same manner as the shoulder hock.

PRIMAL	SUBPRIMAL OR FABRICATED CUT	COOKING METHODS	SERVING SUGGESTIONS
Shoulder	Picnic shoulder	Dry heat (roast or bake)	Smoked picnic shoulder
Boston Butt	Boston butt	Dry heat (broil or grill; sauté)	Broiled Boston butt steaks
		Moist heat (simmer)	Choucroute
Belly	Bacon	Dry heat (sauté)	Breakfast meat
		Moist heat (simmer)	Seasoning
		Combination (braise)	Seasoning
	Spareribs	Combination (steam, then grill)	Barbecued spareribs
Loin	Pork Loin	Dry heat (roast)	Roast pork
		Combination (braise)	Braised pork chops
	Pork tenderloin	Dry heat (broil; grill; sauté; roast)	Roast pork tenderloin
	Pork back ribs	Combination (steam, then grill)	Barbecued back ribs
	Pork loin chops	Dry heat (broil or grill)	Broiled loin chop with leeks and fennel
		Combination (braise)	Braised loin chop with leeks and fennel
Fresh Ham	Fresh ham	Dry heat (roast)	Roast pork with apricots and almonds

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14.1.1.2: Composition of Meat

Meat muscle, which is what we eat, is made of **fibres**, bound together with connective tissue, that are mainly linked to other groups of muscles or directly to the animal's bone structure. Muscle contains 60% to 70% moisture, 10% to 20% protein, 2% to 22% fat, and 1% ash, depending on type and species.

On larger bones (such as the shanks of larger animals), it is easy to see the muscle groups in bundles (if cut on the cross-section) surrounded by **collagen** fibres and a much heavier connective tissue (**elastin**) that forms a thin covering (called **silverskin**) separating muscle groups or a **tendon** at the ends of the muscle group (Figure 1). The tendon is attached to the bone at or near a bone joint (Figure 2).



Figure 1. Crosscut of beef shank showing muscle fibres.



Figure 2. Bone with tendon attached (left) and muscle removed (right).

The muscle fibres are known as **myofibrils**, which are composed of thick and thin filaments arranged in a repeating pattern alongside the other myofibrils (Figure 3). One unit of a bundle is called a **sarcomere**, or little muscle. The thick filaments are the contractile protein **myosin**. The thin filaments, known as **actin**, contain two other proteins called **troponin** and **tropomyosin** that help regulate muscle contraction.

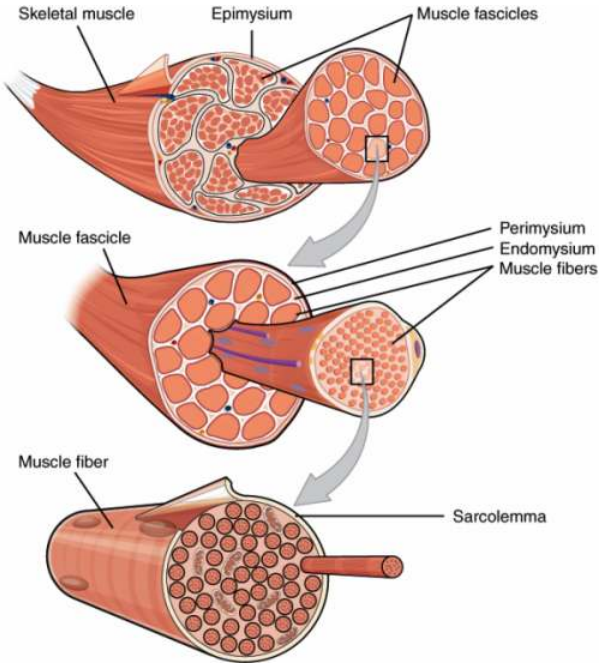


Figure 3. 1007 Muscle Fibres (large) by OpenStax College – Anatomy & Physiology, Connexions Website. June 19, 2013. Licensed under CC BY 3.0 via Wikimedia Commons

The amount of connective tissue in meats and its **solubility** (the degree to which it is dissolved during the cooking process) can directly influence the tenderness of meat muscle. For example, as an animal ages, it has more connective tissue and therefore experiences **cross-linking**, an increase in connective tissue that becomes highly insoluble. This is why older animals are usually tougher and younger animals are more tender.

The most tender cuts from a beef animal, such as tenderloin, strip loin, and top sirloin from the beef hind quarter, can be prepared using a **dry heat cooking method**. In contrast, tougher cuts from the front quarter of beef that have more collagen connective tissue, such as the blade, shoulder, and shank, require a **moist heat** or **combination cooking method**, which breaks down collagen into a **gelatin** form when cooked in water at temperatures of over 80°C (176°F). The collagen dissolves in the water, which is why stocks made from animal bones and connective tissue have body and thicken when cooled. (We discuss cooking potential and tenderness in more detail later in the book.)

Heavy collagen, such as tendons at the ends of muscle groups and the protein elastin, does not break down under this cooking process and is therefore insoluble in water. In addition to silverskin and tendons, there is a specific piece of heavy collagen (also known as the **backstrap)** that is yellow in colour and located along the upper backbone from the base of the skull to the end of the rib cage in all meat animals (Figure 4).



Figure 4. Backstrap location on lamb rack.

Fats are deposited all over certain parts of the animal and contribute to the shelf life, flavour, and colour of dry aged meats. Fat in beef meat muscle is called **intramuscular fat** and appears as a pattern of wavy lines, commonly known as **marbling** (Figure 5).

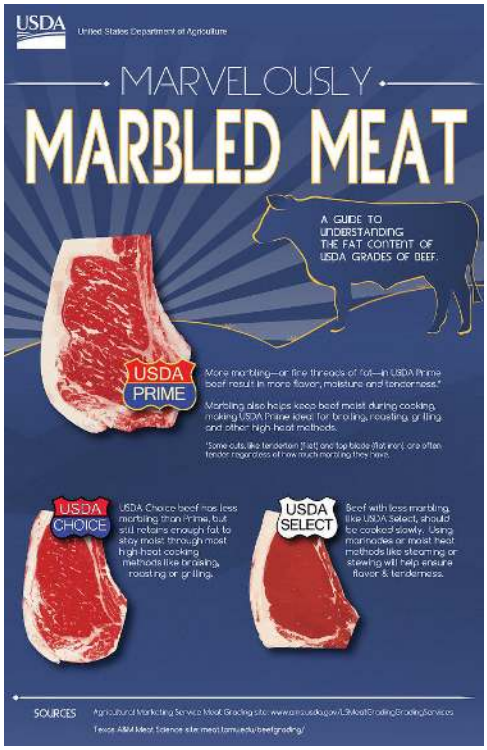


Figure 5. Poster indicating marbling in USDA Beef grades. [image description]

Well-marbled meat usually indicates that the cooked meat will be juicy and tender, and the amount of marbling is a factor that is used to determine the grade of beef, specifically for the A grades. Beef grading is discussed in detail later in the book.

Image descriptions

Figure 5. Poster indicating marbling in USDA Beef grades.

A guide to understanding the fat content of USDA grades of beef.

- USDA Prime: More marbling—or fine threads of fat—in USDA Prime beef result in more flavor, moisture and tenderness. Marbling also helps keep beef moist during cooking, making USDA Prime ideal for broiling, roasting, grilling and other high-

heat methods. Some cuts like tenderloin (filet) and top blade (flat iron) are often tender regardless of how much marbling they have.

- USDA Choice: USDA Choice beef has less marbling than Prime, but still retains enough fat to stay moist through most high-heat cooking methods like braising, roasting or grilling.
- USDA Select: Beef with less marbling, like USDA Select, should be cooked slowly. Using marinades or moist heat methods like steaming or stewing will help ensure flavor & tenderness.

Return to Figure 5

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14.1.1.3: Meat Fibers and Tenderness Factors

Under cross-sectional inspection, muscles from different parts of the animal's body display bundles of fibers that appear as irregularly shaped polygons. The bundle size and thickness of the **connective tissue septa** determine the texture of the muscles: those with small bundles and thin septa have a fine texture, and those muscles with larger bundles and more connective tissue with thick septa have a coarser texture.

The finer the texture the more precision of movement from the muscle, such as tenderloin (Figure 7). The coarse-textured muscles, such as shanks and shoulders (Figure 8), are the heavy working muscles of the body that support the full weight of the animal and therefore require less precision of movement.



Figure 7 Fine-textured meat shown on beef tenderloin.



Figure 8 Coarse-textured meat shown on beef shoulder pot roast.

Science can help explain why some muscles on a beef animal are more tender than others. There are actually three types of skeletal muscle, known as **twitch fibres**, with differing speeds of movement and with different colours:

1. Fast glycolytic (white): These are fast twitch fibers; they are found in skeletal muscle, such as shanks, shoulders, and hips, and are known as "voluntary muscles." They require no oxygen and they move faster.

2. Fast oxidative (red): These are slow twitch fibers; they are found in the diaphragm, heart, arteries, and veins, and are known as “involuntary muscles.” They require oxygen to operate and they move slowly.
3. Slow oxidative (red/white intermediate): These are slow/fast twitch fibers; they are found in precision muscles, such as the tenderloin and strip loin, that don’t need to move as fast as skeletal muscles.

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- Coarse-textured meat shown on beef shoulder pot roast © Jakes and Associates is licensed under a CC BY-NC (Attribution NonCommercial) license

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14.1.1.4: Meat Color

The post mortem color development of meat varies greatly from one species to another, with variations in fresh beef being very prominent. Beef shows a range of color from first being cut to the end of its shelf life (about three days). Typical meat color for different species is shown in Table 3.

Table 3 Typical color of meat from different species

Species	Color
Beef	Bright cherry red
Fish	Pure white to grey-white or pink to dark red
Lamb and mutton	Light red to brick red
Pork	Greyish pink
Poultry	Grey-white to dull red
Veal	Brownish pink

Meat color is significant to consumer acceptance of products. The bright red color of good quality beef, sockeye salmon, and young lamb are naturally appealing, whereas the paler colors of veal and other fish species are sometimes less appealing to some. Dark meats such as horse are more popular in Quebec, Canada and some European countries. Mutton (sheep over 12 months of age with darker flesh) appeals to an even smaller range of customers.

Factors Affecting Color

Use of Muscles

Poultry provides a good opportunity to see and learn about the differences in meat color. Meat cutters and cooks may often be asked why different parts of a chicken have **white meat** and other parts have **dark meat**, or why duck or game birds have mostly dark meat.

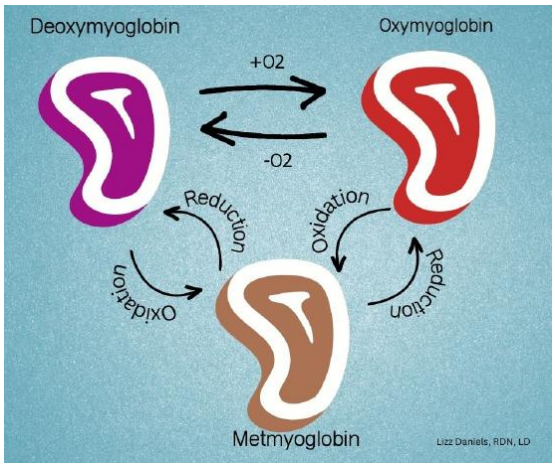
The color of the meat is determined by how the muscle is used. Game birds that fly only short bursts, such as **partridges** and grouse, have white breast meat. In contrast, ducks and geese and most other game birds that fly long distances have exclusively dark meat. In domestic poultry (chickens and turkeys), there is a difference between breasts (white meat) and thighs and drumsticks (dark meat).

Note: Chicken thighs, even when fully cooked, may have a reddish tinge and blood seepage from the thigh bone. This is normal; however, inexperienced customers may interpret this as a sign of not being cooked properly.

Proteins

Meat color is associated with two proteins: **myoglobin** (in the muscle) and **hemoglobin** (in the blood). When animals are no longer alive and air comes in contact with the meat, myoglobin reacts with oxygen in an attempt to reach a state of equilibrium, at which point no further changes occur. As this process happens, the meat color goes through three stages and three colours that are easy to see, especially on freshly cut beef meats.

1. Purplish red (myoglobin): occurs immediately after a **steak** is sliced.
2. Cherry red (oxymyoglobin): occurs several minutes after cutting and after exposure to oxygen.
3. Brown (metmyoglobin): occurs when the iron in the myoglobin is oxidized, which usually takes about three days after cutting. (You may see steaks with this color in the discount bin at a supermarket. The brown color doesn't mean there is anything wrong with the product; in fact, purchasing meat at this stage is a great way to stock up on cheaper steaks for the freezer.)



Oxygen

Oxygen plays two important roles, which affect the color in opposite ways. As soon as meat is cut, oxygen reacts with the myoglobin and creates the bright red color associated with oxymyoglobin. This will continue to develop until the iron in the myoglobin oxidizes to the point of the **metmyoglobin** stage.

Oxidation can also occur when iron in the meat binds with oxygen in the muscle. This can often occur during the processing of round steak from the hip primal and can be identified by the rainbow-like colours that appear from the reflection of light off the meat surface. The condition will remain after the product is cooked and can often be seen on sliced roast beef used in sandwich making. This condition does not alter the quality of the meat; however, it is generally less attractive to consumers.

Age

The pale muscles of veal carcasses indicate an immature animal, which has a lower myoglobin count than those of more mature animals. Young cattle are fed primarily milk products to keep their flesh light in color. However once a calf is weaned and begins to eat grass, its flesh begins to darken. Intact males such as breeding bulls have muscle that contains more myoglobin than females (heifers) or steers (castrated males) at a comparable age.

Generally, beef and lamb have more myoglobin in their muscles than pork, veal, fish, and poultry. Game animals have muscles that are darker than those of domestic animals, in part due to the higher level of physical activity, and therefore they also have higher myoglobin.

Preventing Discoloration

Maintaining the temperature of fresh meat near the freezing point (0°C/32°F) helps maintain the bright red color **(bloom)** of beef meats for much longer and prevents discoloration.

Meat should be allowed to bloom completely (the bloom usually reaches its peak about three or four days after cutting) or be wrapped on a meat tray with a **permeable** wrapping film as in supermarket meat displays. If portioned steaks are to be vacuum packed, doing so immediately after cutting (but before the bloom has started) will allow the steaks to bloom naturally when removed from the vacuum packaging.

Certain phases of meat processing can also trigger discoloration. Oxidation browning (metmyoglobin) can develop more rapidly than normal if something occurs to restrict the flow of oxygen once the bloom has started but has not been allowed to run its full course. The two most common examples are:

- Cut meat surfaces stay in contact too long with flat surfaces such as cutting tables, cutting boards, or trays.
- Meat is wrapped in paper (which means there is no further exposure to air and therefore no oxygen, which speeds up the browning effect).

The browning effect will occur naturally once the meat is exposed to oxygen.

There are two other types of discoloration that commonly occur with beef and pig meat. Although the cause of both types occurs before death (**ante mortem**), the actual change does not show up until after death (post mortem). The discoloration is a result of chemical reactions in the animal's body due to stresses, known as **pre-slaughter stress syndrome (PSS)**.

PSS can result in two different types of discoloration: PSE and DFD.

PSE (pale, soft, and exudative) occurs mainly in pigs (and in some cases has been found to be genetic). PSE is brought about by a sudden increase of lactic acid due to the depletion of glycogen before slaughter, which in turn causes a rapid decline in the pH post slaughter. The visible signs of PSE can be detected by the trained eye in the pork loin primal, where the flesh appears much paler than normal. The muscle meat is softer and may be very sloppy and wet to the touch and leaking meat juices, a result of a high proportion of free water in the tissues.

Although product with PSE is safe to eat, its shelf life is limited and it may become tougher sooner if overcooked. Products with PSE have limited use as fresh products but are used to manufacture cooked products such as formed ham and certain sausage varieties with a recommended limit of 10% (i.e., one part PSE to nine parts of regular meat), due to the high water content.

DFD (dark, firm, and dry) occurs mainly in beef carcasses but sometimes in lamb and turkey. In the meat industry, these carcasses are referred to as **dark cutters**. Unlike PSE meat, DFD meat shows little or no drop in the pH after slaughter. Instead, there may be an increase of stress hormones, such as **adrenaline**, released into the bloodstream. Consequently, **glycogen** (muscle sugar) is depleted before slaughter due to stresses. This decreases the lactic acid, which in turn affects the pH, causing it to not drop fast enough after slaughter. Therefore, the muscle meat, typically in the hip area of the carcass, may become very dry and dark.

Even after the carcass is aged and the meat has been processed and displayed, the dark appearance remains and bloom will not occur. In addition, the meat may also feel sticky to the touch, which limits shelf life. DFD meat is generally considered unattractive to the consumer; however, the meat remains edible and is still suitable for use in cooked products and sausage emulsions but should be limited to 10% (one part DFD to nine parts of regular meat).

Listed below are some causes of DFD that should be avoided:

- Transferring animals to strange surroundings (kill plant) and holding them for too long
- Treating animals roughly prior to and during transport (e.g., using cattle prods)
- Overcrowding cattle during shipping
- Mixing cattle with other animals they are not used to
- Preventing animals from having sufficient rest at the slaughterhouse prior to harvesting
- Dehydrating animals (not giving them enough water) prior to slaughter
- Causing over-excitement, pain, hunger, excessive noise, smell of blood
- Exposing animals to temperature extremes during transportation
- Shipping stress-susceptible animals, such as intact males (bulls), during severe weather

Note: DFD can occur anywhere between 12 and 48 hours prior to an animal's slaughter.

Imperfections and Abnormalities in Meat

Even though meats arriving at their final destination (point of sale) have usually been approved and inspected, the product still requires further checks prior to sale and eating in case abnormal meat inconsistencies were missed in the inspection process. Some of these are caused by injuries or disease that occurred while the animal was alive, while others are naturally occurring parts of the animal's body (glands in particular) that are removed prior to or during the cutting process.

Some examples are given here.

- **Abscesses** and **cysts**: infected or non-infected tumors from old injuries that are imbedded in muscles and sometimes close to bones (Figure 9).



Figure 9. Cyst in beef short loin.

- **Blood spots and clots**: usually from more recent injuries and also found imbedded in muscles or between muscle seams or on or near bone joints.
- **Fibrous tissue**: scar tissue, usually from very old injuries, with the appearance of white fatty seams or thin strands tightly bound together, making the muscle tough and unsightly.
- **Lymph nodes** and **glands**: lymph nodes are glands in the throat and back of the tongue that give a good indication of the general health of the animal; these are inspected on the animal carcass at the harvesting plant prior to being sold, but internal or intermuscular glands are not examined unless further inspection is recommended by a veterinarian. Consequently, three major glands are removed from beef, pork, and lamb during processing to ensure the public do not see them. They are the **prescapular gland**, located in the neck and blade sub-primals below the junction of the fifth cervical vertebra (Figure 10); the **prefemoral gland**, located at 90 degrees to the round bone on the hip on the exterior of the sirloin tip imbedded in the cod fat pocket (Figure 11); and the **popliteal gland**, located in the outside round sub-primal in the hip primal between the eye of the round and the outside round flat under the heel of round, imbedded in a fat pocket (Figure 12).



Figure 10. Prescapular gland.



Figure 11. Prefemoral gland.



Figure 12. Popliteal gland.

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14.1.1.5: Inspection and Grading of Meat Products

The inspection and grading of meat and poultry are two separate programs within the U.S.Department of Agriculture (USDA). Inspection for wholesomeness is mandatory and is paid for with public funds. Grading for quality is voluntary, and the service is requested and paid for by meat and poultry producers/processors.

Mandatory Federal Inspection

American consumers can be confident that the Food Safety and Inspection Service (FSIS), the public health agency in the USDA, ensures that meat and poultry products are safe, wholesome, and correctly labeled and packaged.

Under the Federal Meat Inspection Act and the Poultry Products Inspection Act , FSIS inspects all raw meat and poultry sold in interstate and foreign commerce, including imported products. The Agency monitors meat and poultry products after they leave federally inspected plants.

Prior to the creation of the FSIS inspection of animal production and slaughter relied almost exclusively on visual inspection of animals, products, and plant operations. This was referred to as the "poke and sniff" method of inspection which did not take into account microbiological activity that could cause illness. However, refinements in animal production reduced disease and created a more homogeneous animal population. Thus, the concerns of today's inspectors are broader and include unseen hazards such as microbiological and chemical contamination.

As discussed in previous sections on prevention of Foodborne illness, measures in food production such as monitoring time and temperature and creating standards of food production in restaurants are designed to minimize the likelihood of harmful bacteria contaminating raw meat and poultry products. However, some bacteria could be present and might become a problem if meat and poultry are not handled safely. To assist food handlers, the USDA requires that safe handling instructions be put on all packages of raw and not fully cooked meat and poultry.



Inspection mark on raw meat from beef, pork, lamb or goat.



Inspection mark on poultry that is raw or processed.



Inspection mark on packaged and processed meat containing beef, pork, lamb and/or goat.

Grading

After meat and poultry are inspected for wholesomeness, producers and processors may request that they have products graded for quality by a licensed Federal grader. The USDA's Agricultural Marketing Service (http://www.ams.usda.gov) is the agency responsible for grading meat and poultry. Those who request grading must pay for the service. Grading for quality means the evaluation of traits related to tenderness, juiciness, and flavor of meat; and, for poultry, a normal shape that is fully fleshed and meaty and free of defects.

USDA grades are based on nationally uniform Federal standards of quality. No matter where or when a consumer purchases graded meat or poultry, it must have met the same grade criteria. The grade is stamped on the carcass or side of beef and is usually not visible on retail cuts. However, retail packages of beef, as well as poultry, will show the U.S. grade mark if they have been officially graded.

The grade symbol and wording are no longer copyrighted; however, according to the Truth in Labeling Law, it is illegal to mislead or misrepresent the shield or wording.

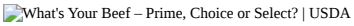
USDA Grades for Meat and Poultry

Beef

Beef is graded as whole carcasses in two ways:

- quality grades - for tenderness, juiciness, and flavor; and
- yield grades - for the amount of usable lean meat on the carcass. There are eight quality grades for beef. Quality grades are based on the amount of marbling (flecks of fat within the lean), color, and maturity.

Quality Grades:



1. Prime grade is produced from young, well-fed beef cattle. It has abundant marbling and is generally sold in restaurants and hotels. Prime roasts and steaks are also excellent for dry-heat cooking due to the age of the animal, and less connective tissue (broiling, roasting, or grilling).
2. Choice grade is high quality, but has less marbling than Prime. Choice roasts and steaks from the loin and rib will be very tender, juicy, and flavorful and are, like Prime, suited to dry-heat cooking. Many of the less tender cuts, such as those from the rump, round, and blade chuck, can also be cooked with dry heat if not overcooked. Such cuts will be most tender if "braised" — roasted, or simmered with a small amount of liquid in a tightly covered pan.
3. Select grade is very uniform in quality and normally leaner than the higher grades. It is fairly tender, but, because it has less marbling, it may lack some of the juiciness and flavor of the higher grades. Only the tender cuts (loin, rib, sirloin) should be cooked with dry heat. Other cuts should be marinated before cooking or braised to obtain maximum tenderness and flavor.
4. Standard and Commercial grades are frequently sold as ungraded or as "store brand" meat.
5. Utility, Cutter, and Canner grades are seldom, if ever, sold at retail but are used instead to make ground beef and processed products.



Note: Grades such as Prime, Choice and Select are not acceptable terms for raw cuts of pork or poultry

Yield grades range from "1" to "5" and indicate the amount of usable meat from a carcass. Yield grade 1 is the highest grade and denotes the greatest ratio of lean to fat; yield grade 5 is the lowest yield ratio. Though yield grades are not something consumers normally see, they are most useful when purchasing a side or carcass of beef for the freezer.

Veal/Calf

There are five grades for Veal/Calf: prime, choice, good, standard, and utility.

Prime and choice grades are juicier and more flavorful than the lower grades. Because of the young age of the animals, the meat will be a light grayish-pink to light pink, fairly firm, and velvety. The bones are small, soft, and quite red. Cuts such as chops can be cooked by the dry- heat methods of roasting, grilling or broiling.

Lamb

There are five grades for lamb. Normally only two grades are found at the retail level — prime and choice. Lower grades of lamb and mutton (meat from older sheep) — good, utility, and cull — are seldom marked with the grade. Lamb is produced from animals less than a year old. Since the quality of lamb varies according to the age of the animal, it is advisable to buy lamb that has been USDA graded.

1. Prime grade is very high in tenderness, juiciness, and flavor. Its marbling enhances both flavor and juiciness.
2. Choice grade has slightly less marbling than prime, but still is of very high quality. Most cuts of prime and choice grade lamb (chops, roasts, shoulder cuts, and leg) are tender and can be cooked by the dry-heat methods (broiling, roasting, or grilling). The less tender cuts — breast, riblets, neck, and shank — can be braised to make them tenderer.

Pork

Pork is not graded by USDA quality grades as it is generally produced from young animals that have been bred and fed to produce more uniformly tender meat. Appearance is an important guide in buying fresh pork. Look for cuts with a relatively small amount of fat over the outside and with meat that is firm and grayish pink in color. For best flavor and tenderness, meat should have a small amount of marbling.

Poultry

The USDA grades for poultry are A, B, and C.



- Grade A is the highest quality and the only grade that is likely to be seen at the retail level. This grade indicates that the poultry products are virtually free from defects such as bruises, discolorations, and feathers. Bone-in products have no broken bones. For whole birds and parts with the skin on, there are no tears in the skin or exposed flesh that could dry out during cooking, and a good covering of fat under the skin. Also, whole birds and parts will be fully fleshed and meaty. The U.S. grade shield for poultry may be found on the following chilled or frozen ready- to-cook poultry products: whole carcasses and parts, as well as roasts, tenderloins, and other boneless and/or skinless poultry products that are being marketed. There are no grade standards for necks, wing tips, tails, giblets, or ground poultry.
- Grades B and C poultry are usually used in further-processed products where the poultry meat is cut up, chopped, or ground. If sold at retail, they are usually not grade identified.

Carcass Grading Criteria

Defects	A Grade	B Grade	C Grade	NG (nongradable)
Missing Parts	one or both wing tips and tail	wing tips, wing portions, and tail back area IF not wider than base of the tail or more than halfway to hip joints	any parts beyond wing portion (drumette, entire wing, etc.)	meaty parts (legs, thighs, back, breast portions)
Broken Bones	none	only one if non-protruding	any protruding or more than one non-protruding	no limit
Disjoints	only one	two with no breaks or one with a non-protruding break	more than two	no limit
Exposed Flesh	less than 0.25" on breast and legs less than 1.5" everywhere else	less than 1/3 of the entire part	over 1/3 of the entire part	no limit

Mix up the cards to create classes for practice then grade or place based on the standard criteria. The chicken carcasses pictured weigh between two and six pounds. **More than one carcass of the same quality grade may be in the class at the contest.**

For more information about meat and poultry grading, go to USDA's Agricultural Marketing Service (AMS) Web site at www.ams.usda.gov/

United States Department of Agriculture

Summary of Federal Inspection Requirements for Meat Products

Source: https://www.fsis.usda.gov/wps/wcm/co...df?MOD=AJPERES

https://www.canr.msu.edu/resources/o...spection_e3114

https://www.nicksolares.com/post/usd...ding-explained

https://www.flickr.com/photos/usdagov/10926871984

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14.1.1.6: Types of Beef and US Consumption

Types of Cattle:

Cattle is the collective name for all domesticated oxen (genus Bos). Cattle are classified as follows:

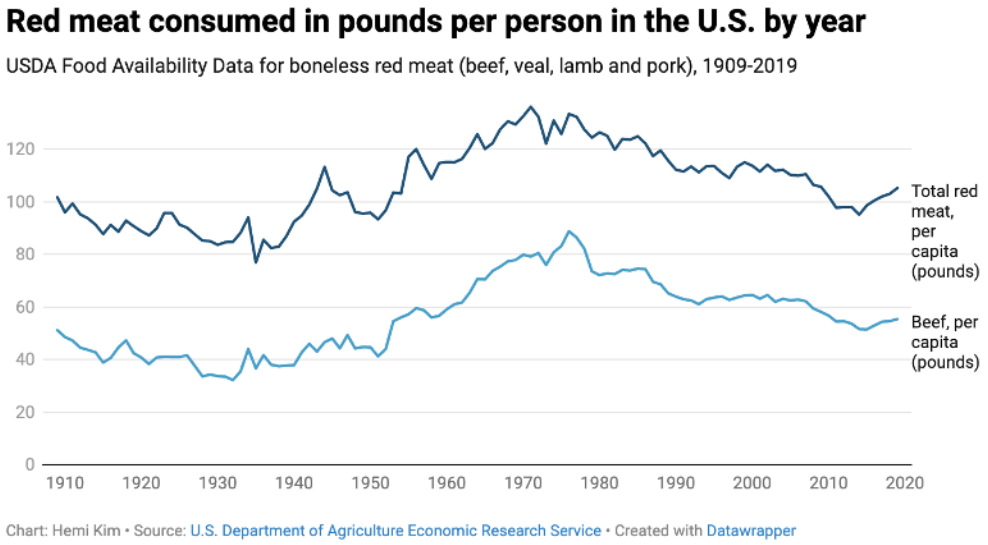
1. **Bulls** - male cattle, usually not raised to be eaten.
2. **Calves** - young cows or bulls prized for their meat.
3. **Cows** - female cattle after their first calving raised in this country principally for milk and calf production. In France, cows are used for beef when they are no longer needed for milk.
4. **Heifers** - young cows or cows before their first calving. Heifer meat and organs are becoming increasingly popular as a food source.
5. **Stags** - male cattle castrated after maturity, principally used for dog food.
6. **Steers** - male cattle castrated prior to maturity and principally raised for beef.
7. **Veal** - a calf or young beef animal. A veal calf is raised until about 16 to 18 weeks of age, weighing up to 450 pounds. Male dairy calves are used in the veal industry.

Veal is the meat of young, usually male, calves that are by- products of the dairy industry. Dairy cows must calve before they begin to give milk. Calves that are not used in the dairy herds are used in today's veal industry. Although veal may come from any calf under the age of nine months, most comes from calves slaughtered when they are 8 to 16 weeks old. Veal is lighter in color than beef, has a more delicate flavor and is generally tenderer. Young veal has a firm texture, light pink color and very little fat. As soon as a calf starts eating solid food, the iron in the food begins to turn the young animal's meat red. Meat from calves slaughtered when they are older than five months is called a calf. It tends to be a deeper red, with some marbling and external fat.

Beef Consumption in the United States

Meat consumption in the U.S. has roughly mirrored the rise and fall of beef consumption in the last century, with a low of 76.9 pounds of red meat per person in 1935 rising to a high of 136.1 pounds in 1971. From 1971 to 2019 Americans reduced their red meat intake to about 105.2 pounds per person.

The graph below shows the per capita consumption of beef and red meat in the U.S. from 2009 to 2019, using data from the USDA

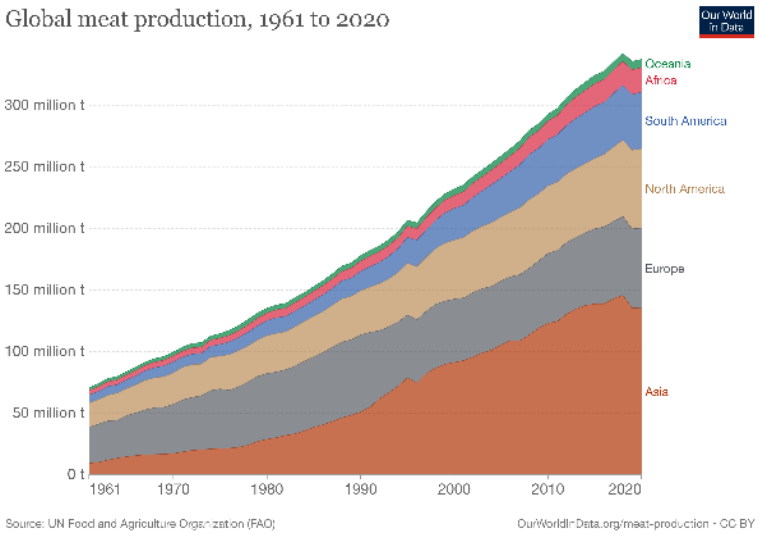


Since the late 1970s, beef consumption in the U.S. has declined, in part due to consumer concerns about **the health** impacts of eating too much red meat. Instead, Americans **are eating** the more affordable chicken.

Beef Consumption After the Pandemic

As COVID-19 spread—and **killed** at least 20 workers from **meatpacking plants** in the Spring of 2020 before ultimately causing the deaths of a further **600,000 people in the U.S.**—beef consumption **seems to have fallen** to 13.2 billion pounds nationally,

down from 13.9 billion in 2019. People also began purchasing more of their beef from the grocery store than from restaurants and other foodservice venues.



USDA ERS - Chart Detail

For more information on meat consumption, visit https://www.ers.usda.gov/publications/pub-details/?pubid=104507.

Sources:

-https://www.fsis.usda.gov/food-safet...eal-farm-table

-https://fullofsteak.com/wp-content/u...nal_edited.jpg

-https://www.ers.usda.gov/publication.../?pubid=104507

-https://www.ers.usda.gov/data-produc...chartId=103767

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14.2: Poultry

The word poultry refers to all domesticated birds raised for their meat. Although chickens are the most popular poultry consumed, other species include turkeys, ducks, geese, guinea fowls, and pigeons (squabs). Game birds such as pheasant, wild duck, and quail are also consumed, but few of them reach the marketplace. Emus and ostriches, though not yet readily available in all parts of the country, are being bred for their lower-fat meat. Despite the variety of poultry, chickens, raised by humans for over 4,000 years (11), remain the most common poultry consumed. Chickens are especially useful because both their meat and their eggs are consumed. Th e popularity of chicken and turkey continues to increase at the expense of beef (18). In the last 40 years, production of broilers (young chickens) in the United States has increased from about 34 million to over 6 billion (3). Poultry is important to the diet, and the purpose of this chapter is to discuss poultry classification, composition, purchasing, preparation, and storage.

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14.2.1: Introduction to Poultry Identification

Market Forms of Poultry

Poultry, regardless of type, is organized for the consumer in 4 categories that get progressively more specialized and specific in meaning as they go.

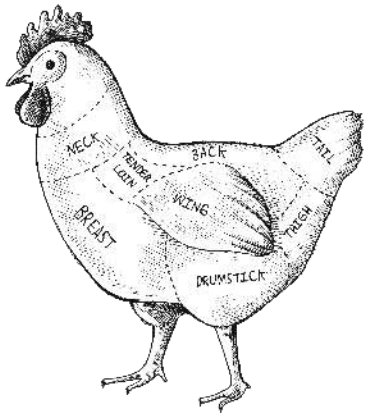
Kind: This term refers to the species of bird, e.g. turkey, chicken, squab, ostrich

Class: This is a subgroup of kind for example chickens have the greatest variety of classes e.g. cornish game hen, broiler, roaster, capon, and stag to name a few.

Style: This is the term that refers to the amount of cleaning or processing the bird has undergone. E.g. live, dressed (killed, bled, plucked), ready to cook (completely processed).

Type: Fresh or frozen?

When it comes to the style of poultry, this can also indicate the degree to which the bird has been **broken down.** Broken down references to what degree the bird has been cut up into portions. These portions are what the consumer sees when they purchase poultry at the store. Common cuts include breast, thigh, wing, and whole.



Chicken

The muscle composition of chicken is approximately 72% water, 20% protein, 7% fat, and 1% minerals. Chicken has no marbling of the meat therefore no intramuscular fat. The fat of a chicken is stored under its skin and in the abdominal cavity. Chicken fat has a lower melting point than other animal fats which can be cooked at lower temperatures. Rendered chicken fat is easy to keep refrigerated and sealed in containers for a flavorful cooking fat that can positively affect the food budget. Dark meat is found in the leg and thigh, and contains myoglobin, an oxygen binding protein for muscle use. Dark meat also contains more fat and connective tissue than light meat, therefore it requires longer cooking time than white meat and leans itself well to roasting and braising.

Classifications:

- Game hens - raised five weeks or less.
- Broiler/fryer - raised 10 weeks or less.
- Roaster - raised between 8 and 12 weeks.
- Capon – 4 - 8 months
- Hens/ stewing - over ten months

Game Hens

Game hens are the young or immature progeny of Cornish chickens and white Rock chickens. They are very flavorful and weight one to two pounds. French refer to these as ‘Poussin’. These little hens can be split and broiled, grilled or trussed and roasted whole. A friend of mine from Idaho once prepared a delicious roasted Cornish Game Hen with Amaretto that was superb.



Game Hens from commons. Wikimedia.org

Broilers and Fryers

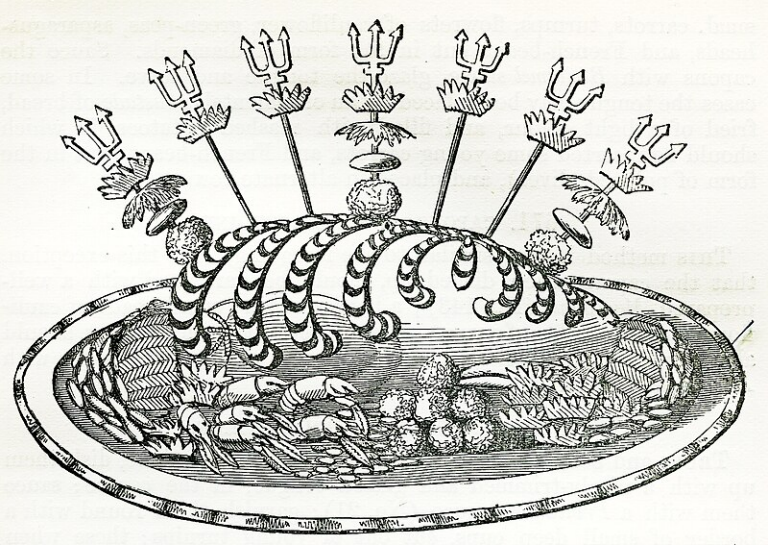
These birds are young with soft, smooth textured skin, and are relatively lean. They generally weigh three and a half pounds or less. You may use any method to cook broilers and fryers. One popular method for the recent resurgence in grilling is “spatchcocking” which is a way of cutting out the back bone, breaking the breast bone, and removing the breast cartilage. The bird is then seasoned and grilled under a brick and turned to complete the cooking.



Grilled Spatchcocked Chicken - commons.wikimedia.org

Capon

These can be difficult to find and once were the darling of the Garde Manger for cold platter use with Chaud Froid. Capons are the surgically castrated male chickens (roosters) which are fattened for consumption. They are bred for flavor and have a high proportion of light to dark meat. They weigh between 5-7 pounds and are often roasted.



"Capon a la Godard". Engraving from Charles Elmé Francatelli's
The Modern Cook. 28th edition, 1886



Capons- commons.wikimedia.org

Duck

Ducks can be harvested from the wild when the lawful hunting season is in, but today we have year round access to beautifully farm raised duck products from whole birds to specialty pates. Ducks are exclusively dark meat but we must treat the breast meat and leg meat as if they are two different animals.

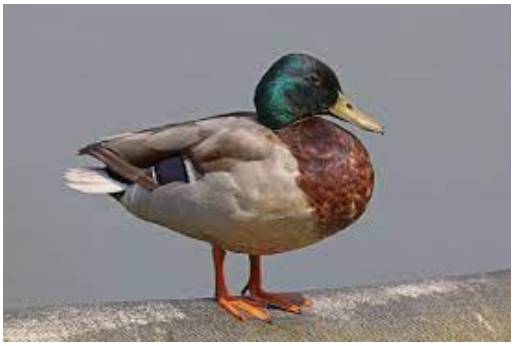
Duck have a tremendous amount of fat as nature's buoyancy device to keep this waterfowl afloat. The fat is referred to as "white gold" and is always rendered to use as cooking fat for confit of duck and Pommes de Terre Sarladaises. They also have a high 'bone-to-meat' ratio, which makes for making great stock once fabricated. The three primary ducks we eat are **Muscovy**, **Mallard**, and **Pekin**.



Muscovy Duck - commons.wikimedia.org



Pekin ducks - commons.wikimedia.org



Mallard duck - commons.wikimedia.org

Geese

Goose is a wonderful bird often roasted for popular holidays with acidic fruit based sauces known as a gastrique. This type of sauce offsets the fattiness of this succulent waterfowl. Geese are divided into two classes of young and mature. They as do duck only contain dark meat.



Canadian goose - commons.wikimedia.org



Roasted Christmas Goose - Fen. wikimedia.org

Guinea Fowl

These birds, like geese, are divided into young and mature classifications. They are the descendants of a game bird and have both light and dark meat. The breasts are tender enough to sauté, but the bird is so lean that it helps to lard or bard the bird when roasting.



Guinea Fowl - commons.wikimedia.org

Pigeon

Though pigeons can be eaten at any size or age, we usually refer to the young pre-flight pigeons as **squab**. They are very popular in Persian restaurants. Pigeons only contain dark meat and is very tender even



Chinese Fried Pigeon- thewoksoflife.com

Turkey

Turkey has four classifications.

- Fryer/roaster
- Young

- Yearling
- Mature

Turkey is the second most popular category of poultry in the U.S. behind chicken. It contains both light and dark meat and relatively low in fat. Turkey can be roasted and young turkeys can be prepared with a variety of methods. Many people make ‘pillards’ of turkey to bread and sauté as you would veal for schnitzel. I like to make tornedoes from the tenders for turkey mignons. Braised turkey potpies are a comforting dish in the fall and winter. Wild and farm raised turkeys are different in appearance and flavor.



Wild Gobbler - commons.wikimedia.org Farm Raised Turkeys - www.publicdomainfiles.com

Ratites

Ratites are a family of flightless birds with small wings and flat breast bones. They include the Ostrich, Emu, and Rhea. Each are classified as a red meat and are low in fat and cholesterol. The most delicious of the three is Ostrich and they can be prepared in any way that you would prepare the lean delicate meat of veal.



Ostrich - commons.wikimedia.org. Emu - commons.wikimedia.org Rhea - commons.wikimedia.org

Poultry Offal

Also known as giblets, these parts of the bird include the gizzards, hearts, livers, and necks. Livers are often sautéed, broiled, or used in pates. Gizzards are the second stomach and act as a grinding mechanism for their food; they are often fried as are livers in the South. Hearts are sometimes sautéed or creamed. The Garde Manger sometimes confits these parts and uses them to inlay as a garnish within pate. The necks are used for stock with the remaining carcasses. Sometimes southern cooks pick the meat form the neck to add into cornbread dressing or to make a cornstarch thickened giblet gravy with stock, giblets, and boiled eggs



Duck Giblets - neck, liver, heart, and gizzard - www.simplyrecipes.com

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14.2.2: Poultry Grading and Standards

The USDA Food Safety and Inspection Service (FSIS) inspects all poultry products that cross state lines. The Wholesome meat and Poultry Act extends to cover the inspection of poultry that is processed and sold within state lines. The USDA marks products that have passed inspection with a seal. Modernization to the poultry inspection system called the New Poultry Inspection System (NPIS) is currently voluntary but includes certain measures that extend to all facilities that are inspected by FSIS. For example, facilities are now mandated to collect their own biological samples and test for salmonella and campylobacter. This testing is required regardless if the processor opts in to the new system. Other changes and updates can be read about here:https://www.fsis.usda.gov/inspection/inspection-programs/inspection-poultry-products/modernization-poultry-slaughter

Similarly to that of the grading of red-meats, the USDA offers a voluntary grading system for poultry. It should be noted that, while many think that the color of the skin plays a role in the grading scale, this is not true. The color of the skin is highly dependent on the type of plant pigments found in the birds diet.

U.S. Grade A. A lot of ready-to-cook poultry, parts, or poultry food products consisting of one or more ready-to-cook carcasses or parts, or individual units of poultry food products of the same kind and class, each of which conforms to the requirements for A quality may be designated as U.S. Grade A.

U.S. Grade B. A lot of ready-to-cook poultry or parts consisting of one or more ready-to-cook carcasses or parts of the same kind and class, each of which conforms to the requirements for B quality or better may be designated as U.S. Grade B.

U.S. Grade C. A lot of ready-to-cook poultry or parts consisting of one or more ready-to-cook carcasses or parts of the same kind and class, each of which conforms to the requirements for C quality or better, may be designated as U.S. Grade C.



Source: https://www.fsis.usda.gov/inspection...dance/labeling

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14.2.3: Cooking Poultry

Cooking Methods:

Poultry can be cooked in many ways but the main dry and wet methods are detailed below:

Dry:

- **Roasting/Baking**: this method requires that the poultry (whole or in pieces) be placed in a roasting pan. If the bird is whole, it can be placed breast up in order for juices to collect in the pan or breast down in order for the breast to be cooked in the juice and will lead to juicier breast meat. Another method is to use a V rack to elevate the bird away from the juices (rotisserie). To prep the bird, the cavity can be seasoned and coating the surface with butter or temperature appropriate oil will prevent sticking and the surface drying out. Butter will add flavor while oil does not. The pan drippings can then be used a gravy or sauce. If a bird is stuffed, add 5 extra minutes to the cooking time. Check the table bellow for exact times per poundage.
    - *Trussing*: this method is used mostly on turkeys or any birds that may require more time to prepare. The metal clips that normally hold the legs of the bird are removed before baking, the wings are tucked under the back (this is done to avoid overcooking or burning), a butcher string is used (measure 3 times the the length of bird) to wrap around the legs and the ends are then brought over to the breastbone. the bird is then turned over to allow the strings to go under the wings and over the neck. The video bellow shows the exact steps on how to truss a bird.



-
    - *Basting:* This step is needed to avoid drying out the bird as it cooks. Basting can be done using a wide spoon or brush or a baster to pour the liquid and drippings over the bird as it cooks. If the sauce used contains sugar (barbeque or honey glaze), there will be more browning. It is important to note that duck and goose do not need to basted due to their high fat content.
    - *Stuffing vs Dressing*: Stuffing is anything that is placed in the cavity of the bird to absorb the juices as it cooks. Dressing is only different in that it is cooked separately from the bird and is generally served as a side dish. Both stuffing and dressing start with a base of stale bread and a mix of mirepoix.
- **Broiling**: this method is mostly used on portioned out pieces of a bird (wings, thigh, breast, etc) unless the bird is being cooked on a spit over hot coals. To prep the meat, use a marinade to add some flavor and moisture (done under refrigeration) and place the pieces skin side up on a broiling pan. The pan should be place in the oven 6 inches away from the heat source. If a sugary sauce is being used, ensure that it is only added towards the last 15 minutes of the cook time to avoid burning. The table bellow shows exact cook times per pound.
- **Grilling**: similar to broiling in that a whole bird should not be grilled unless a spit is being used. A marinade is also Recommended when grilling to prep the chicken. Once prepped, the pieces should be placed skin side down. If a sugary sauce is being used, ensure that it is only added towards the last 15 minutes of the cook time to avoid burning. The table bellow shows exact cook times per pound.
- **Frying**: smaller pieces of poultry can be fried in the following ways:

- *Pan-Fry*: poultry can be breaded in this step to add texture and keep in moisture and flavor. Poultry needs about 1/4 inches of fat/oil (appropriate smoke point). If breading is not used, the bird should be fried skin side down first and then can be flipped over using kitchen tongs.
- *Deep Fry*: this step requires poultry to be breaded, floured, or battered in order to be fully submerged in hot oil (325 F - 350 F).
  - steps of breading: *Always assign a wet and dry hand when breading to avoid breading your hands and fingers and making the process more difficult.*
- *Tools*: Using tongs to flip/turn avoids puncturing a hole and leaking juices.

1. **Dredge:** This can be done using flour or starch and is vital in helping the moistening agent stick. Roll the food in the dredge to thinly coat and allow excess to fall away.
2. **Moisten:** this is commonly done using egg wash (eggs + milk/water) but other things like mustard can also be used incase of an allergy. This step provides the adhesive for the breading to stick to the food being fried. Roll the food in the moistening agent being used and allow excess to drip off.
3. **Breadcrumbs or Panko**: This is what gives fried food it's texture and flavor. Press the food into the breading and coat evenly. It is Recommended to place breaded foods in the fridge to chill for 10-15 minutes before frying to allow the breading to fully stick.

Wet:

- Braising: this method is mainly used on birds that are older or tougher because it requires the meat to be cooked very slowly over a longer period of time in a liquid or brine of some sort to allow the collagen and other proteins to break down. To do this, the bird can be cut into smaller segments and then browned in a pan to add and retain flavor. Then the liquid is added along with any desired flavorings and the pan is covered and allowed to simmer until the meat is tender.

Table 1. Chicken Roasting Time (Oven temp set to 325 F)

Weight	Cook Time Per Pound	Total Cook Time
1-2 lb	30-40 min	30-80 min
2-3 lb	30-40 min	60-120 min
3-4 lb	30-40 min	90-100 min
4-10 lb	30-40 min	-
10-14 lb	Approx. 20 min	-
14-20 lb	Approx. 18 min	-
20-30	Approx. 15 min	-

DO NOT use to determine doneness

Cook Time For Cook Method

Oven	Pressure Cook	Deep Fry	Boil
90-120 min	40 min	25 min	90 min

Always take the internal temperature to determine if your poultry is safe to remove from heat (165 F)!

Source:

-https://www.chefjamie.com/index.php/...fic%20texture!).

-Understanding Food

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14.3: Fish/Shellfish

- Click on the image bellow to learn more about fish and shellfish.



"Fishing" by RachelC is licensed under CC BY-NC 2.0.

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14.3.1: Fish Classifications and Composition

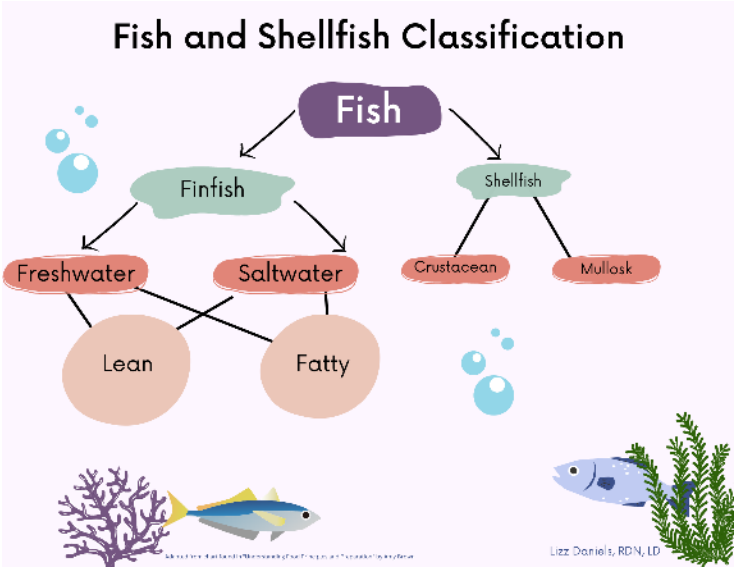
Fish Classification:

Fish are classified in several ways. To distinguish major groups of animals that live in waters they broader category may be broken down in two major ways: finfish vs. shellfish, vertebrates vs. invertebrates, or fresh vs saltwater.

Simply put, finfish have fins and shellfish do not (and not all shellfish have shells!) So often times, the presence of a backbone is used to classify these creatures. Fish that have them are called vertebrates and those that lack a backbone are called invertebrates. The last of which, fresh vs saltwater is used in describing finfish and is described below.

Finfish:

Found in the fresh waters of rivers, lakes, and streams as well as the salt water of oceans and seas. The most popular finfish in North America include tuna, cod, pollock, and salmon.



Freshwater:

Freshwater fish are found within the worlds less salty waterways such as streams, rivers, and ponds. Freshwater fish tend to be less "fishy" in flavor. Top freshwater fish are listed below:

1.) Catfish - known for a mild taste with a slightly denser texture making it less flaky and more versatile to cook.

2.) Largemouth Bass - white flaky meat and extremely popular due to its mild flavor.

3.) Trout - Referred to as "chicken of fish" because of its unoffensive and mild flavors.

4.) Salmon- most notable for its orange/red color and high omega-3 fatty acid content. Mild flavor with rich texture.

5.) Walleye- Soft and flaky white fish that is easy to de-bone.

6.) Pike- Known to be more "fishy" than other freshwater fish and harder to de-bone.

Freshwater fish can either be considered lean or fatty which is described in more detail below.

Saltwater:

Saltwater fish are found in oceans or in the areas of water that mix with fresh and salt water. Some fish, such as salmon, are considered **anadromous**, meaning they live their lives in both fresh and salt water.

Top saltwater fish are listed below:

1.) Salmon (see above)

2.) Tuna: commonly canned, fresh high grade tuna has a dark red color and may be consumed raw.

3.) Anchovies: small fish that are often used as a pizza topping in the U.S.

4.) Sardines: Small fish, typically sold in the U.S. in cans are a staple in Mediterranean cuisine.

5.) Snapper: Rosey colored skin distinguishes this one from the others. This is a white fish that has a firm texture and sweet/nutty flavor.

6.) Swordfish: Large fish, that may have high levels of methylmercury. The flsh can have an orangy tint to it due to their diet but the color of the flesh may vary.

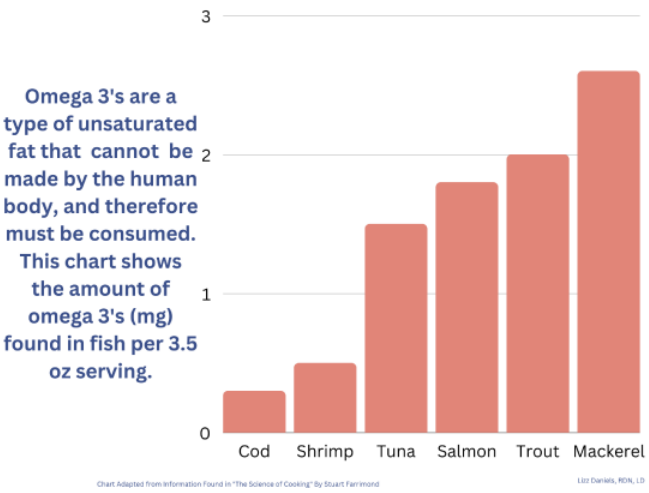
7.) Grouper: Two main types, red and black. Red is most frequently found in the marketplace for its value and flavor. The flavor is mild and the red grouper is sometimes described as sweet.

8.) Cod: Appreciated for its mild flavor and flaky white flesh cod is used to make cod liver oil as it is a source of omega-3's and fat soluble vitamins A, D, and E.

9.) Hake: Similar to cod (and sometimes classified as being in the same family) with a mild flavor and flaky skin.

Fatty Fish (Oily Fish)

Fatty fish, also referred to as oily fish, are fin fish that have a higher amount of fat than other more leaner fish species. The fat in the fish is typically found along the sides, closest to the skin, or deep inside the fish around organs. The fat found in fish is mostly unsaturated in nature which are described to be a healthy fat and one that is required for overall good health. See image below for amounts of omega 3 fatty acids that are found in some common fish species. Common fatty fish include: salmon, mackerel, lake trout, butterfish, whitefish, and herring.



Lean Fish

A fish that contains < 2.5% fat is considered to be lean. Due to the lower fat content of these fish, they tend to be lower in calories as well. Examples of lean fish include: cod, pike, haddock, flounder, sole, whiting, red snapper, and halibut.

Structure and Muscle Composition (Finfish)

Whether the fish comes from fresh or salt water finfish are composed similar to that of edible land animals with muscle, connective tissue, and fat. However, unlike land animals the structure of muscle and composition of fat make fish much more delicate which requires different cooking techniques and care. Naturally occurring oils and unstable fleshy tissue make spoilage a real concern and fish will spoil at a faster rate than red meats or poultry. However, fish tend to be lower in saturated fats, higher in polyunsaturated

fats, and are good sources of protein. Fish is a high protein, low-fat food that is rich in vitamin D and great source of other vitamins and minerals such as phosphorus, potassium, zinc, iodine, and magnesium.

The muscle structure of fish differs from land animals in that the muscles are arranged in sheets rather than in elongated bundles of fiber-like structures. In fish, these sheets are arranged in myotomes that are separated by a thin later of connective tissue. The connective tissue is made of collagen that is not as strong as the collagen found in land meats and will gel at a lower temperature. This characteristic is what allows fish to cook at lower temperatures and frankly- fall apart or "flake" while cooking.

Fish get their color from the protein myoglobin (that should sound familiar!) but the over-all color of the fish is greatly dependent on the daily activity of the fish. Fish that swim long distances rely predominately upon "slow twitch fibers" which function best in the presence of oxygen. In contrast, fish that do lots of quick movements have more "fast twitch fibers". These muscle fibers work in the absence of oxygen and are; therefore less pigmented and appear white.

More myoglobin (unfortunately) leads to greater rancidity.



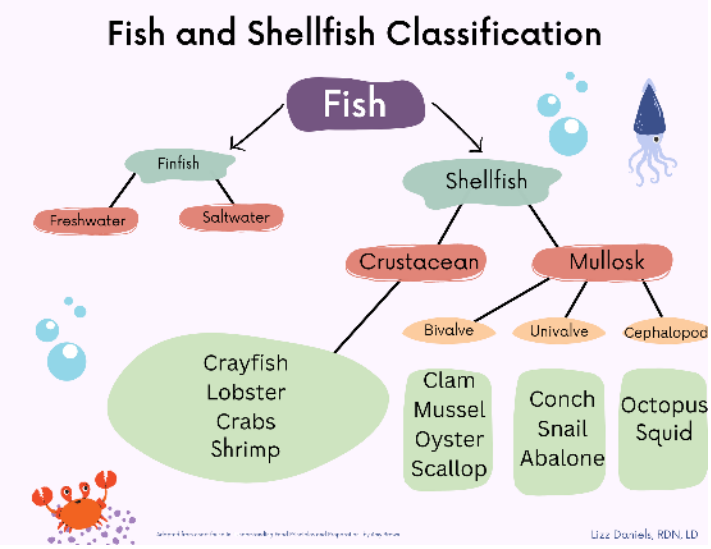
Thanks to salmons' distinct color, the contrast between the color of the muscle and connective tissue between the myotomes is highly visible. In this photograph, you can see the distinct shape that the myotomes have that look almost wave-like and the thin sheets of white connective tissues (made of mostly collagen) that is holding the thin sheets together.

Photo from Pexels

Shellfish:

The term shellfish is a commercial rather than scientific classification and are considered invertebrates which also includes crustaceans and mollusks. Vertebrates are distinguished from invertebrates by the presence of a skeletal structure or in other words a backbone.

Shellfish are often more expensive and less widely available to the general public. Special cooking techniques are often required which makes cooking these types of fish more complicated for the average at home chef.



Structure and Muscle Composition (Shellfish)

Mollusks are shellfish characterized by soft, unsegmented bodies with no internal skeleton. Most mollusks have hard outer shells. Single-shelled mollusks such as abalone are known as **univalves**. Those with two shells, such as clams, oysters and mussels, are known as **bivalves**. Squids and octopuses, which are known as **cephalopods**, do not have a hard outer shell. Rather, they have a single thin internal shell called a pen or cuttlebone.

Crustaceans are also shellfish. They have a hard outer skeleton or shell and jointed appendages. Crustaceans include lobsters, crabs and shrimp.

The flesh of fish and shellfish consists primarily of water, protein, fat and minerals. Fish flesh is composed of short muscle fibers separated by delicate sheets of connective tissue. Fish, as well as most shellfish, are naturally tender, so the purpose of cooking is to firm proteins and enhance flavor. The absence of the oxygen-carrying protein myoglobin makes fish flesh very light or white in color. (The orange color of salmon and some trout comes from pigments found in their food.) Compared to meats, fish do not contain large amounts of intermuscular fat. However, the amount of fat a fish does contain affects the way it responds to cooking. Fish containing a relatively large amount of fat, such as salmon and mackerel, are known as fatty or oily fish. Fish such as cod and haddock contain very little fat and are referred to as lean fish. Shellfish are also very lean.

Mollusks

Univalves

Univalves are mollusks with a single shell in which the soft-bodied animal resides. They are actually marine snails with a single foot, used to attach the creature to fixed objects such as rocks.

Conch are found in warm waters off the Florida Keys and in the Caribbean. Beachcombers prize the beautiful peachy-pink shell of the queen conch. Conch meat is lean, smooth and very firm with a sweet-smoky flavor and chewy texture. It can be sliced and pounded to tenderize it, eaten raw with lime juice or slow-cooked whol

Snails. Although snails (more politely known by their French name, escargots) are univalve land animals, they share many characteristics with their marine cousins. They can be poached in court bouillon; removed from their shells and boiled; or baked briefly with seasoned butter, or sauce. They should be firm but tender; overcooking makes snails tough and chewy. The most popular varieties are the large white Burgundy snail and the small garden variety called petit gris.

Fresh snails are available from snail ranches through specialty suppliers. The great majority of snails, however, are available canned; most canned snails are the product from France or Taiwan.

Bivalves

Bivalves are mollusks with two bilateral shells attached by a central hinge.

Clams are harvested along both the East and West Coasts, with Atlantic clams being more significant commercially. Atlantic Coast clams include hard-shell, soft-shell, and surf clams. Clams are available all year, either live in the shell or fresh - shucked (meat removed from the shell). Canned clams, whether minced, chopped, or whole, are also available.

Atlantic hard-shell clams or quahogs have hard, blue-gray shells. Their chewy meat is not as sweet as other clam meat. Quahogs have different names, depending upon their size. Littlenecks are generally under 2 inches (5 centimeters) across the shell and usually are served on the half shell or steamed. They are the most expensive clams.

Soft-shell clams, also known as Ipswich, steamer ,and long-necked clams, have thin, brittle shells that do not completely close because of the clam's protruding black-tipped siphon. Their meat is tender and sweet. They are sometimes fried but are more often served steamed.

Surf clams are deep-water clams that reach sizes of 8 inches (20 centimeters) across. They are most often cut into strips for frying or are minced, chopped, processed and canned.

Mussels are found in waters worldwide. They are excellent steamed in wine or seasoned broth and can be fried or used in soups or pasta dishes.

Oysters have a rough gray shell. Their soft, gray, briny flesh can be eaten raw directly from the shell. They can also be steamed or baked in the shell or shucked and fried, sautéed or added to stews or chowders. Most oysters available in the United States are commercially grown and sold either live in the shell or shucked. There are four main domestic species.

Scallops contain an edible white adductor muscle that holds together the fan-shaped shells. Because they die quickly, they are usually shucked and cleaned on board the ship. The sea scallop and the bay scallop, both cold-water varieties, and the calico scallop, a warm-water variety, are the most important commercially. Sea scallops are the largest, with an average count of 20 to 30 per pound. Larger sea scallops are also available.

Bay scallops average 70 to 90 per pound; calico scallops average 70 to 110 per pound. Fresh or frozen shucked, cleaned scallops are the most common market form, but live scallops in the shell and shucked scallops with roe attached (very popular in Europe) are also available. Scallops are sweet, with a tender texture. Raw scallops should be a translucent ivory color and non-symmetrically round and should feel springy. They can be steamed, broiled, grilled, fried, sauteed, or baked. When overcooked, however, scallops quickly become chewy and dry. Only extremely fresh scallops should be eaten raw.

Cephalopods

Cephalopods are marine mollusks with distinct heads, well-developed eyes, a number of arms that attach to the head near the mouth, and a saclike fin-bearing mantle. They do not have an outer shell; instead, there is a thin internal shell called a pen or cuttlebone.

Octopus is generally quite tough and requires mechanical tenderization or long, moist-heat cooking to make it palatable. Most octopus is imported from Portugal, though fresh ones are available on the East Coast during the winter. Octopus is sold by the pound usually fresh, frozen, or whole. Octopus skin is gray when raw, turning purple when cooked. The interior flesh is white, lean, firm, and flavorful.

Squid, known by their Italian name, calamari, is becoming increasingly popular in the United States. Similar to octopuses but much smaller, they are harvested along both American coasts and elsewhere around the world, (the finest are the East Coast loligo or winter squid). They range in size from an average of 8 to 10 per pound to the giant South American squid, which is sold as tenderized steaks. The squid's tentacles, mantle (body tube), and fins are edible. Squid meat is white to ivory in color, turning darker with age. It is moderately lean, slightly sweet, firm and tender, but it toughens quickly if overcooked. Squid is available either fresh or frozen and packed in blocks.

Crustaceans

Crustaceans are found in both fresh and salt water. They have a hard outer shell and jointed appendages, and they breathe through gills.

Crayfish generally called crayfish in the North and ‘crawfish’ or ‘crawdad’ in the South, are freshwater creatures that look like miniature lobsters. They are harvested from the wild or aqua-farmed in Louisiana and the Pacific Northwest. They are from 3 1/2 to 7 inches (8 to 17.5 centimeters) in length when marketed and may be purchased live or precooked and frozen. The lean meat, found mostly in the tail, is sweet and tender. Crayfish can be boiled whole, and served hot or cold. The tail meat can be deep-fried, or used in soups, bisque or sauces. Crayfish are a staple of Cajun cuisine, often used in gumbo, etouffee and jambalaya. Whole crayfish become brilliant red when cooked, and used as a garnish

Crabs are found along the North American coast in great numbers and are shipped throughout the world in fresh, frozen and canned forms. Crab meat varies in flavor and texture and can be used in a range of prepared dishes, from chowders to curries to casseroles. Crabs purchased live should last up to five days; dead crabs should not be used.

King crabs are very large crabs (usually around 10 pounds [4.4 kilograms] caught in the very cold waters of the northern Pacific. Their meat is very sweet and snow-white. King crabs are always sold frozen, usually in the shell. In-shell forms include sections or clusters legs and claws or split legs. The meat is also available in "fancy" packs of whole leg and body meat, or shredded and minced pieces.

Lobsters have brown to blue -black outer shells and firm, white meat with a rich, sweet flavor. Lobster shells turn red when cooked. They are usually poached, steamed, simmered, baked or grilled, and can be served hot or cold. Picked meat can be used in prepared dishes, soups or sautés. Lobsters must be kept alive until just before cooking. Dead lobsters should not be eaten. The Maine, also known as American or clawed lobster, and the spiny lobster are the most commonly marketed species.

Maine lobsters have edible meat in both their tails and claws; they are considered superior in flavor to all other lobsters. They come from the cold waters along the northeast coast and are most often sold live. Maine lobsters may be purchased by weight (for example, 1 1/4 pounds [525 grams], 1 1/2 pounds [650 grams] or 2 pounds [900 grams] each), or as 'chix' (that is, a lobster weighing less than 1 pound [450 grams]). Maine lobsters may also be purchased as ‘culls’ (lobsters with only one claw) or ‘bullets’ (lobsters with no claws). They are available frozen or as cooked, picked meat

Shrimp are found worldwide and are widely popular. Gulf whites, pinks, browns, and black tigers are just a few of the dozens of shrimp varieties used in food service operations. Although fresh, head-on shrimp are available, the most common form is raw, head-off (also called green headless) shrimp with the shell on. Most shrimp are de-headed and frozen at sea to preserve freshness.

Shrimp are available in many forms: raw, peeled and deveined; cooked, peeled and deveined; and individually quick-frozen, as well as in a variety of processed, breaded or canned products. Shrimp are graded by size, which can range from 400 per pound to 8 per pound (extra-colossal), and are sold in counts per pound. For example, shrimp marketed as "21- 26 count" means that there is an average of 21 to 26 shrimp per pound; shrimp marketed as "U-10" means that there are fewer than 10 shrimp per pound.

Prawn is often used interchangeably with the word shrimp in English speaking countries. Although it is perhaps more accurate to refer to fresh-water species as prawns, and saltwater species as shrimp, in commercial practice, prawn refers to any large shrimp. Equally confusing, scampi is the Italian name for the Dublin Bay prawn (which is actually a species of miniature lobster), but in the United States scampi refers to shrimp sautéed in garlic butter

Nutrition

Fish and shellfish are low in calories, fat and sodium, and are high in protein and vitamins A, Band D. Fish and shellfish are also high in minerals, especially calcium (particularly in canned fish with edible bones), phosphorus, and potassium and iron (especially mollusks). Fish are high in a group of polyunsaturated fatty acids called omega-3, which may help combat high blood cholesterol levels and aid in preventing some heart disease. Shellfish are not as high in cholesterol as was once thought. Crustaceans are higher in cholesterol than mollusks, but both have considerably lower levels than red meat or eggs.

The cooking methods used for fish and shellfish also contribute to their healthfulness. The most commonly used cooking methods are broiling, grilling, poaching and steaming-add little or no fat.

Sources:

Understanding Food Principles and Preparation by Amy Brown 4th edition.

https://www.boatsafe.com/best-tastin...r-fish-to-eat/

The Science of Cooking By Stuart Farrimond

https://www.ehow.com/list_6463496_na...h-can-eat.html

https://en.wikipedia.org/wiki/Swordfish#As_food

https://en.wikipedia.org/wiki/Cod#As_food

https://www.fortunefishco.net/groupe...lack%20Grouper.

https://www.thespruceeats.com/about-...snapper-334338

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14.3.2: Inspection and Grading

Inspection/Grading:

Use the links bellow to explosre the diffrent agencies that handle the inspection and grading of fish and shelfish:

- https://www.usa.gov/federal-agencies/seafood-inspection-program
- NOAA Fisheries Seafood Inspection Program
- https://www.fda.gov/food/resources-you-food/seafood



https://www.ecfr.gov/current/title-50/chapter-II/subchapter-G/part-260

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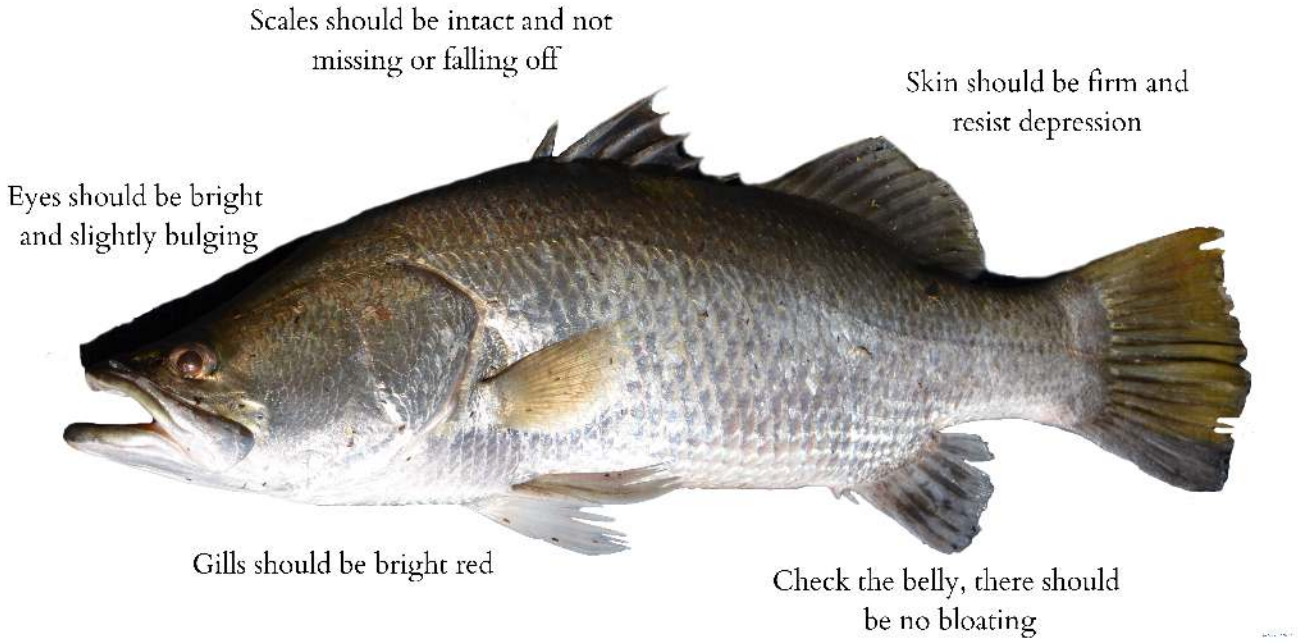
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14.3.3: Fish and Cooking Methods

Finfish Selection:

The poke and sniff method was an actual technique that meat inspectors used to use to inspect meats and prevent dangerous meats that had undergone spoilage from entering the main food supply. Before we knew more about microorganisms and foodborne illness meat inspectors would literally poke, prod, and sniff meat and poultry as their final inspection method. That system, as we know, was wildly flawed and has since been discontinued but when it comes to inspection of fish to ensure freshness this old timey method is a reasonable way for the average consumer to assess the freshness of seafood at the time of purchase.

For whole fish, look for fish that is still shiny and bright and have eyes that have not dulled or sunken in. Fish, that smells overly "fishy" has begun the decomposition process and is no longer fresh. Fish should not appear bloated and the body should feel somewhat stiff and firm. Fresh fish markets, often keep live fish inside large water tanks to ensure peak freshness at the time of purchase, while others will keep fish "on ice". While keeping fish frozen or chilled can slow down the process of decomposition it is not as protective against the unsaturated fats becoming rancid and therefore, is not a sure thing in ensuring freshness. Best judgement should be used in the purchasing of seafood.



Rigor Mortis:

When selecting fish, a stiff body is a particularly important characteristic to look for because this is a good indication that the fish is still in rigor mortis. Rigor mortis occurs quickly after death but lasts a shorter period of time than the rigor mortis process explained previously in the meat section. The timeline of this process varies greatly however on size and species of fish. This natural process of muscles stiffening and then relaxing increases the water holding capacity of the muscle proteins which translates to a juicier, more tender fish with better flavor.

Maintaining a colder temperature can prolong this process however due to the unsaturated fats found in fish rancidity can still occur. Rancid fats have a distinct aroma, which is another reason to do your due diligence in assessing the freshness of fish.

Cuts of Fish:

Before a fish makes its way to your plate, it is first prepared. There are cuts of finfish that are outlined below with their best cooking methods or uses.

Cut	Description	Cooking Methods
Whole Fish	Fish is left in its whole state including head, tail, fins, scales, and eyes.	Less risk of fall apart because the flesh is protected by the tough outer skin. May be barbequed, roasted, broiled, pan fried, poached and deep fried.
Drawn Fish	Fish has had entrails (internal organs) removed, but remain intact otherwise including its head, tail, scales, fins and eyes.	Prepare in same ways as whole fish or can be further prepped. May stay fresh longer because entrails can quickly decay.
Dressed Fish	Fish has had entrails, head and tail removed. Typically scales and fins are also removed.	Completely ready to be cooked and prepared. Any cooking methods may be used because the flesh is still mostly protected by outer skin.
Steak	Prepared when a dressed fish is cut at a 90-degree angle so there is bone present in it.	Typically, a thicker cut, sautéing, baking, broiling and poaching are good options. Depending on how much skin and how thick, grilling may be possible if additional measures like aluminum foil and non-stick spray.
Fillet/Butterfly Fillet	Slice form side of fish and contain no bones (although checking is still a good idea).	Delicate portions that care needs to be taken so they do not fall apart during cooking. En papillote, pan searing/frying, baking, and broiling are good methods. Some fish may also be battered and fried.
Fish Stick	Sliced from fish steaks or fillets in strips or are pressed and molded from minced meat before being breaded.	Care should be taken if cut from stakes or fillets following fillet cooking methods. Breading and frying these are common, especially if molded from minced meat.



Methylmercury Concerns:

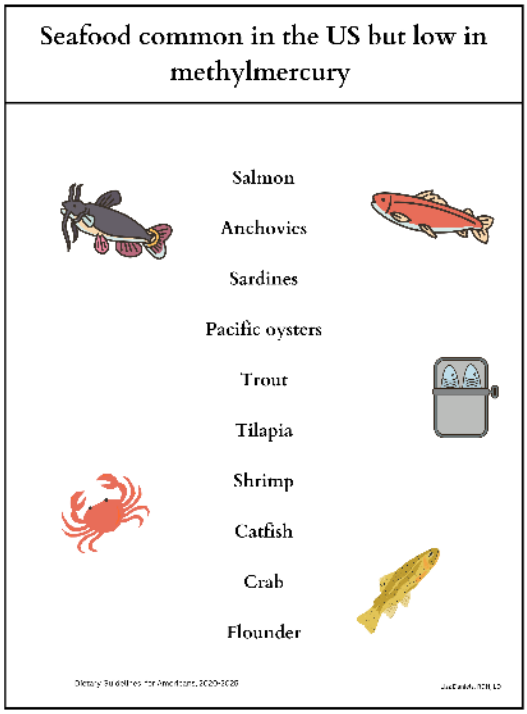
While it has been a standard recommendation per the Dietary Guidelines for Americans, a document published every 5 years to guide the nutrition goals for Americans, to consume 2 servings of fatty fish per week there have been concerns about methylmercury concentration in fish and the dangers that may pose to human health.

Methylmercury, often referred to as simply mercury, is an organic compound that is a byproduct of the coal burning industry. When coal is burned, the naturally present mercury in that coal is released into the atmosphere where it is eventually returned to the earth by rain or snowfall. Bacteria convert the element of mercury into the organic compound known as methylmercury which bioaccumulate and biomagnify in the animals that live within waterways and oceans.

For that reason, smaller fish tend to be safer to consume while larger fish, who have consumed the smaller fish as apart of their own diets, will have higher concentrations of methylmercury.

Methylmercury is known as a neurotoxin and can cause impaired neurological development which is why it is of particular interest for those who are pregnant to avoid excessive sources of it.

According to the Dietary Guidelines for Americans, most of the U.S. population is not consuming the recommended amount of seafood and so their potential for risk is low. However, fish is a good source of omega 3's which is known to have antiinflammatory properties and emerging evidence suggests that it can work together with other factors to delay the onset of Alzheimers Disease among other neurodegenerative disorders. Due to the health benefits associated with regular consumption of seafood, it is recommended to choose low-methylmercury fish sources.



Heated (Dry and Moist) Methods:

When cooking shellfish, it is believed that the "well done" rule should be observed, however with clams and oysters cooking actually destroys their flavor and they are often consumed raw for this reason. Foodborne illness is still a threat in this case so it is advised that pregnant people or those who are immune compromised not consume these foods.

When thinking about the best cooking method for fin fish, consider the texture of the fish that you are preparing. If it has a firmer texture grilling or other dry heat methods are possible, but if it is a delicate fish that may easily fall apart during these types of heating methods consider a moist method such as en papillote.

To prevent sticking, lean fish should be cooked in plenty of fat. Fatty fish do not often make for good deep fried fish due to the risk of their natural oils breaking down in the process and creating unpleasant smells and flavors.

High heat for a shorter cooking period is often permitted when using dry heat methods due to the quick cooking time of the muscle fibers found in fish and the quick breakdown of the collagen that holds them together. Cooking at lower temperatures for a longer period of time often results in over-cooked outside and raw inside. It is again for that reason that cooking from frozen is not recommended and fish that has been frozen should be thawed to avoid frozen centers and overcooked outsides.

Review cooking methods discussed previously and see how they may relate to cooking a delicate food such as fish.

Raw Fish:

Raw fish is commonly consumed and has grown in popularity with the introduction of sushi in the U.S. over the last 20 years. Seafood that is sold for the purposes of being sold for uncooked consumption undergoes careful handling and inspections to ensure the safest product possible. Raw fish warnings exist for pregnant people and immune compromised individuals.

Shellfish Selection:

Shellfish are highly perishable and are sold frequently alive and still in their shells. To maintain quality they must be kept alive until they are cooked. Some shellfish are consumed raw, such as oysters, however- consuming raw shellfish poses the risk of foodborne illness.

Since shellfish are sold while still alive, it is typically easy to assess activity. However, some shellfish are more tricky to due to the tightness of their shells or decreased activity level of the species. In the case of **mollusks,** if the shell is left open (without movement) than the mollusk is most likely dead and should be discarded. This same rule does not apply to mussels or clams that normally have slight gaps in their shells. Looking for signs of damage or decay as well as evoking the "poke and sniff" method of odor may be helpful.

Scallops are a type of mollusk where the only part that is consumed is the creamy white abductor muscle that is responsible for the movement of the shell. These shells are unable to close tightly and so to prevent early spoilage they are immediately shucked and either sold fresh, frozen, or in a can.

Other shellfish such as **oysters** are not always sold alive but may be already shucked (removed from shell) and then chilled or frozen. Live oysters will have tightly closed shells so discard any that are gaping open or have defects. Shucked oysters should look and feel plump. **Clams** are sold and bought in the same forms as oysters and their shells should not indicate opening or defects.

Clams come in two variety, soft or hard shell. These distinctions are misleading because the shells of soft shell clams are not in fact soft but thin and brittle. Soft shell clams should be eaten within the day of purchase.

The largest of all the crustaceans, **lobsters** are considered a delicacy with preference towards consuming females. Most of the meat of the lobster is found in the large tail but the most sweet and tender portion of meat is found within the small claw. Lobsters are sold alive or may be frozen or canned. When cooked lobsters turn from a blue-grey color to a distinctive red-orange.

Shrimp Sizing Chart

Common Size Name	Shrimp Per Pound
Small	51/60
Medium	41/50
Large	31/35
Jumbo	21/25

Shrimp are sold raw with shell on or may have their shell removed and frozen. Shrimp must be deveined which is the removal of a dark "sand vein" that runs the length of the shrimps back. The sand vein also known as the alimentary canal is where bodily wastes, including sand, pass through the shrimp which is why it should be removed. In tiny shrimp this line is nearly undetectable and therefore does not need to be removed.

Shrimp are sold according to size and how many shrimp weigh a pound.

Determining Doneness

Unlike most meats and poultry, nearly all fish and shellfish are inherently tender and should be cooked just until done. Indeed, overcooking is the most common mistake made when preparing fish and shellfish. Variables such as the type and the form of fish and the exact cooking method used suggest that one or more of the following methods of determining doneness are more appropriate for determining doneness:

- **Translucent flesh becomes opaque** - The raw flesh of most fish and shellfish appears somewhat translucent. As the proteins coagulate during cooking, the flesh becomes opaque.
- **Flesh becomes firm** - The flesh of most fish and shellfish firms as it cooks. Doneness can be tested by judging the resistance of the flesh when pressed with a finger. Raw or undercooked fish or shellfish will be mushy and soft. As it cooks, the flesh offers more resistance and springs back quickly.
- **Flesh separates from the bones easily** - The flesh of raw fish remains firmly attached to the bones. As the fish cooks, the flesh and bones separate easily.
- **Flesh begins to flake** - Fish flesh consists of short muscle fibers separated by thin connective tissue. As the fish cooks, the connective tissue breaks down and the groups of muscle fibers begin to flake, that is, separate from one another. Fish is done when the flesh begins to flake. If the flesh flakes easily, the fish will be overdone and dry.

Remember, fish and shellfish are subject to carryover cooking. Because they cook quickly and at low temperatures, it is better to undercook fish and shell- fish and allow carryover cooking or residual heat to finish the cooking process.

Sources:

https://www.pbs.org/wgbh/pages/front...0food%20supply.

https://www.who.int/news-room/fact-s...0as%20foetuses.

https://www.dietaryguidelines.gov/si...-2020-2025.pdf

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14.4: Milk

Milk is a white liquid food that is produced by mammals through mammary glands. This liquid is produced for the primary purpose of feeding the offspring of the mother animal. However, for thousands of years animal milk has been a staple of the human diet and continues to offer nutrient benefits even in modern times. Milk contains 13 essential nutrients, of which 6 are considered "nutrients of concern" in the American diet. While cow's milk is the primary source of milk in the United States other sources of milk are consumed globally. Examples include camel, sheep, and goat.



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14.4.1: Pasteurization and Homogenization

Homogenization:

Homogenized milk is fresh milk in which the fat particles are so finely divided and emulsified mechanically that the milk fat cannot separate on standing. The milk fat is forced into tiny droplets. As soon as the droplets form, milk proteins and emulsifiers form a protective film around each one, preventing the fat from reuniting. The tiny droplets stay suspended indefinitely, and milk fat no longer separates and rises to the top as a cream layer. In other words, homogenized dairy products are stable emulsions of fat droplets suspended in milk. It is also said that homogenized milk is more readily digestible.

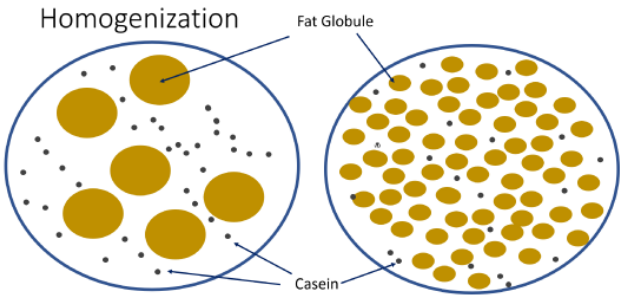


Image: Lizz Daniels, RDN, LD

Prior to the process of homogenization, milk had to be shaken prior to consumption to give it a desirable taste and consistency. This process, which became standard in the 19th century, is a completely mechanical process and does not use any chemicals or additives to achieve. The goal is to evenly distribute the fat that is naturally found in milk to create a homogenous mixture that will not separate when left to stand.

Pasteurization:

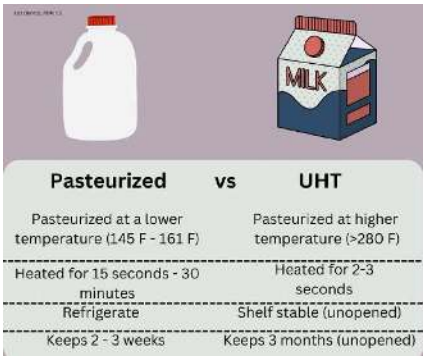
Pasteurization of milk was developed in 1859 by the French chemist Louis Pasteur. This video is provides a brief overview of the history of development of the process in a humorous yet factual way:



Milk can be pasturized using a combination of either high or low temperatures with varying time controls. Given the growth of technology and market desires for milk that lasts longer there are two main types of pasteurization used today. Below is a outline of the two types which also include Ultra High Temperature (UHT).

The two main types of pasteurization used today are high-temperature, short-time (HTST, also known as “flash”) and higher-heat, shorter time (HHST). Ultra-high-temperature (UHT) processing is also used.

- High-temperature, short-time (HTST) pasteurization is done by heating milk to 161°F (72°C) for 15 seconds. Milk simply labeled “pasteurized” is usually treated with the HTST method.
- Higher-heat, shorter time (HHST) milk and milk products are pasteurized by applying heat continuously, generally above 212°F (100°C) for such time to extend the shelf life of the product under refrigerated conditions. This type of heat process can be used to produce dairy products with extended shelf life (ESL).
- Ultra-high-temperature (UHT) processing holds the milk at a temperature of 284°F (140°C) for four seconds. During UHT processing, milk is sterilized rather than pasteurized. This process allows milk or juice to be stored several months without refrigeration. The process is achieved by spraying the milk or juice through a nozzle into a chamber that is filled with high-temperature steam under pressure. After the temperature reaches 281°F (140°C) the fluid is cooled instantly in a vacuum chamber and packed in a pre-sterilized, airtight container. Milk labeled UHT has been treated in this way.



Please watch this short video on the two processes. Please note that this is a branded video and I do not endorse any particular product. This video however, is a clear and concise explanation of pasteurization:



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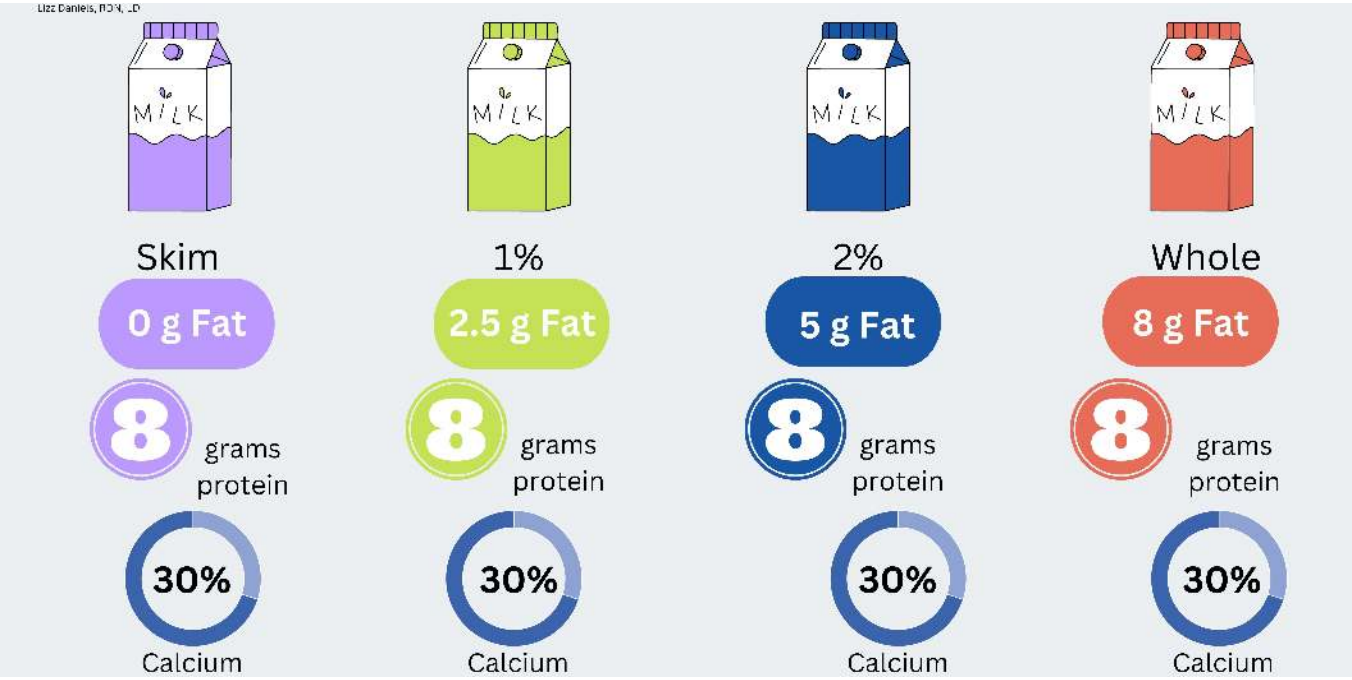
14.4.2: Fluid Milk Products

Milk Products

It is estimated that only about half of the milk that is consumed in the United States is in the form of fluid milk and cream. Milk is used as the base for many other food products such as: butter, cheese, yogurt, and ice cream.

Milk

There are 4 major forms of liquid milk sold in U.S. stores whole, reduced fat, low fat, and fat free/nonfat.



Whole milk: to be whole milk, the milk must contain a minimum of 3.25% milk fat and at least 8.25% milk solids not fat (MSNF). Fortification of whole milk is an optional practice but many kinds of milk currently on the market are fortified with vitamins A and D.

Reduced fat and low-fat milk: this milk has had some of the fat removed. The percentage of fat found in these products can be on a range but are around 2% and 1% respectively. Similar to whole milk 8.25% MSNF must be present. These milk solids contribute to the consistency, taste, and nutrient profile of the product. Fortification with vit D is an optional practice while fortification with vitamin A is a mandated standard.

Fat-free or nonfat: Also referred to as skim milk, this milk has almost all of the milk fat removed (<.5%). Like other forms of milk 8.25% of MSNF is required to be present in the product. Fortification of vitamin A is a requirement for fat-free milk but fortification with vitamin D is optional.

Homogenized milk is fresh milk in which the fat particles are so finely divided and emulsified mechanically that the milk fat cannot separate on standing. The milk fat is forced into tiny droplets. More on this topic is discussed in the "Pasteurization and Homogenization" section of LibreText.

Pasteurization of milk was developed in 1859 by the French chemist Louis Pasteur. One method of pasteurization is to heat milk to above 71°C (160°F), maintain it at this temperature for a set time, then cool it immediately to 10°C (50°F) or lower. This kills all harmful bacteria that carry the potential threat of bovine tuberculosis and fever from cows to humans. More on pasteurization will be discussed in the "Pasteurization and Homogenization" section of LibreText.

Cream

The usual minimum standard for cream is 10% fat content, though it ranges between 10% and 18%. Cream in this range may be sold as light cream, half-n-half, heavy cream, or whipping cream. In order to produce these products, the cream is often removed and separated from the non-fat portion also known as skim milk and then various amounts of skim milk are added back to the cream to reach the desired fat percentage.

	Fat Content	Whip it?	Uses
Light Cream	18%	✗	Will not whip and susceptible to curdling with heat. Use as creamer for coffee or tea, or as a garnish for soups and salads
Whipping Cream	35%	✓	Whipping for use as a topping on desserts or beverages or as an ingredient in some pies and cake frostings
Heavy Cream	48%	✓	Won't likely curdle under heat, may be added to thicken soups, because it can also be whipped may be used as substitute for whipping cream

Evaporated Milk

Produced by evaporating about 60% of the water found in whole milk. Because the milk is canned, often time stabilizers are added to prevent the separation of the fat in the liquid.

Also sold in a fat free version.

To reconstitute combine equal parts water.

Another canned milk product similar to evaporated milk is **sweetened condensed milk.** Often used in dessert preparation due to its high sugar content, condensed milk is produced by the evaporation of about 50% of the water and the addition of sugar. Due to the high sugar content this product does not have to be sterilized. Additionally, the high percentage of sugar, when heated in the canning process, produces a darker caramel-color.



https://www.thespruceeats.com/canned...g-tips-1808225

Milk Powder

Dried milk is often easier and more affordable to ship and has an extended shelf-life due to the removal of fat and water from the milk product. Powdered (dry milk) can be made from any of the forms of milk discussed previously (e.g. whole, reduced fat, skim). Vitamins A and D are required to be added in dry milk product that has been made using whole, or reduced fat liquid milk but remains optional in non-fat milk varieties.

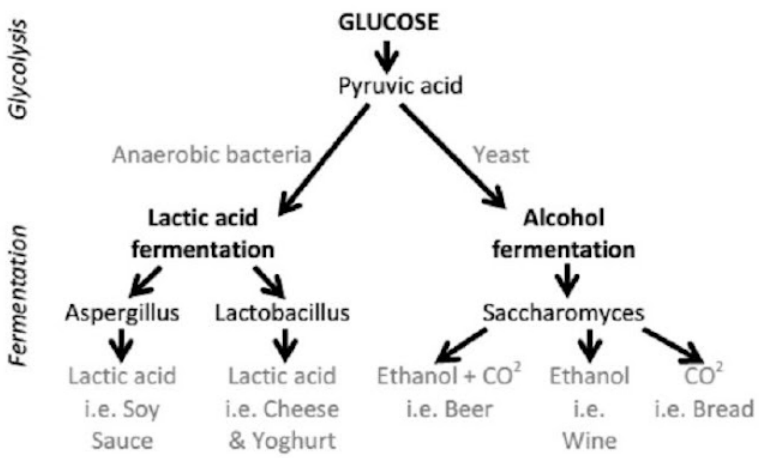
Dried milk has a similar nutrient profile to liquid milk but vitamins may be reduced in the final product.

Instant milk is sometimes confused with powdered milk but they are not the same. Unlike powdered (dried) milk instant milk has the ability to **agglomerate** which means it can easily dissolve in water. It is made by taking non-fat dried milk and exposing it to steam which is then re-dried. Through this process it gains the ability to dissolve easily in water.

To use, mix approximately 1/3 cup instant milk to 1 cup of water.

Cultured Milk Products

Cultured milk products also known called fermented milk products have been a part of the human diet for just as long as milk has. It is often thought to have increased health benefits due to the addition of probiotics. Common products sold and consumed in North America include: buttermilk, yogurt, kefir, and sour cream. Bacterial cultures have been added in order to ferment the lactose (sugar found in milk) to lactic acid. The acid causes the casein (milk protein) to precipitate out of the product.

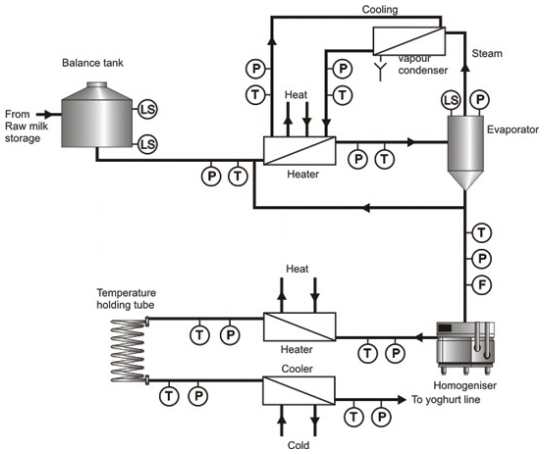


Cultures added differ and are not consistent in the production of all fermented foods. Food cultures include bacteria, mold, and yeast. These microorganisms can be present or added in the production process. There are no clear regulatory practices for the different microorganisms that are added to foods with the exception of yogurt which must have lactobacillus bulgaricus and streptococcus thermophilus added. When microorganisms are added they must appear on the nutrition label. If using naturally present bacteria or other organisms they are not required to be listed as an ingredient on the label.

http://www.foodpreserving.org/2016/0...n-process.html

Yogurt Production:

Yogurt has been around for several millennia. The mythological story about the discovery of yogurt suggests that sheepherders stored their milk in bags made of the intestinal gut of the animals. The intestines contain natural enzymes that cause the milk to curdle and sour. This soured milk lasted longer so they continued making it. Today, the FDA defines yogurt as a milk product fermented by two bacterial strains: a lactic acid-producing bacteria: *Lactobacillus bulgaricus* and *Streptococcus thermophiles*.



https://wiki.ubc.ca/Course:FNH200/2013w_Team07_Yogurt

Probiotics

Yogurt cultures in the intestinal tract have been shown to release the enzyme lactase which continues to break down lactose in the dairy product. This makes yogurt edible for people who are lactose-intolerant.

Kefir

Kefir is a carbonated fermented milk drink. The microbes involved in the production of kefir are a symbiotic culture of lactic acid bacteria and yeasts embedded in a matrix of proteins, lipids, and polysaccharides, ‘kefir grains’.

Sour Cream

Sour cream is made from cream soured by adding lactic acids and thickened naturally or by processing. The lactic acid causes the proteins in sour cream to coagulate to a gelled consistency.

Buttermilk

There are two methods to produce buttermilk:

- Inoculating milk with a specific culture to sour it
- Churning milk and separating the liquid left over from the butter

The second method is where buttermilk gets its name, but today, most of what is commonly called buttermilk is the first type. Buttermilk has a higher acid content than regular milk (pH of 4.6 compared with milk’s pH of 6.6).

The fermented dairy product known as *cultured buttermilk* is produced from cow’s milk and has a characteristically sour taste caused by lactic acid bacteria. This variant is made using one of two species of bacteria — either *Lactococcus lactis* or *Lactobacillus bulgaricus*, which creates more tartness in certain recipes.

The acid in buttermilk reacts with the sodium bicarbonate (baking soda) to produce carbon dioxide, which acts as the leavening agent.

Source: Understanding Food Principles and Preparations Amy Brown 4th edition

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14.5: Cheese



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Cheese is a preserved product made from the curd, or solid portion, of milk. Adding certain enzymes or acid to any type of milk causes casein proteins and fat to coagulate and separate from the liquid portion, or whey. Visit https://www.chhs.colostate.edu/fsi/food-articles/animal-products/cheese/ in order to learn all about cheese.

Sources:

Brown, Amy C., et al. *Lab Manual: Understanding Food, Principles and Preparation*. Cengage Learning, 2014.

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14.6: Eggs

What is an egg?

There are many types of eggs and many animals that can lay them such as fish, birds, and amphibians but in this chapter we will be looking specifically at bird eggs. Bird eggs are laid by females and are incubated for a varying time based on species. A single young hatches from each egg. Hens lay eggs even when not fertilized and those are the eggs that we get from the store.

The egg is made up of 5 Components going from the outside in:

- **Shell:** Made up of calcium carbonate and acts as the the protection for the egg. It contains thousands of pores which allow gas to escape. Shell color is due to the type of hen and does not have any correlation with nutrient content. The shell accounts for about 12% of total egg weight.
- **Air cell:** This is at the larger end of the egg, between the two shell membranes. This occurs because the inner contents of eggs contract after the egg is first laid due to their temperature dropping and allows this gap to form.
- **Albumen:** this is commonly referred to as the egg white and contains mostly water and protein (majority of that protein is albumin). Egg whites also contain the protein avidin which when consumed raw can inhibit biotin absorption and in large amounts it can cause deficiency. While the albumen can appear as one homogenous fluid, it is actually separated out by different Viscosities. Egg whites account for about 58% of total egg weight.
- **Yolk membrane:** This layer is made of up albumin and the vitelline membrane which help to keep the yolk contained.
- **Yolk:** this is the bright yellow or orange center of the egg and contains most of the egg's nutrients. A white germinal disk can be seen attached to the yolk, however it appears much darker when fertilized. There are many lipoproteins in the yolk which make it a great emulsifying agent. The color and nutrients of the yolk are a direct result of diet and feed. The yolk accounts for 30% of total egg weight.
    - *Chalazae:* Located at the top and bottom of the egg, chalazae act as the anchor for the yolk which allow it to be suspended in the middle of the egg white. These appear opaque.

Table 1.1 Egg Nutrients

Nutrient	Amount Per Large Egg	Examples
Protein	7 g (4g from white and 3g from yolk)	• Albumin • Avidin
Fat	5 g	• Triglycerides • Phospholipids • Cholesterol • Omega-3 • Lecithin
Cholesterol	213 mg	~
Vitamins and Minerals	~	• Fat soluble vitamins (ADEK) • B vitamins • Selenium • Iodine • Zinc • Iron

Uses in cooking and in industry.

Eggs are used for cooking in many different ways ranging from dressings to baked goods or even on their own. The table bellow explains some of the many functions and uses of eggs:

Table 1.2 Functions of Eggs

Functions	Explanation	Examples
Emulsify	The *lipid* lecithin is a natural Emulsifying agent found in egg yolks. This molecule is amphiphilic meaning it attracts both water and lipids because it contains both a Hydrophobic and hydrophilic section. This structure gives the yolk the ability to mix fats and water together and stabilizes them to reduce separation.	• Salad dressings • Hollandaise • Bearnaise • Mayonnaise • Ice cream • Choux pastry
Bind	The *protein* in eggs allow them to be great binding agents. Many foods are not able to stick together on their own and egg is used because when the proteins are heated, they coagulate and create a food adhesive and will give stability and keep structure.	• Meatballs • Breaded foods • Meatloaf • Lasagna • Manicotti
Foam	When air is beaten or incorporated into egg whites, they are very good at holding their shape and building foams due to the proteins. When air is being incorporated into egg whites, the proteins unwind and stretch to allow as much air as possible to get in and stay there. Acids can help this foaming ability and lipids inhibit it. The quality of the foam can also depend on temperature, age of the egg, the equipment, duration and other ingredients like salt/sugar.	• Meringue • Souffle • Macaroons
Interfere	When making frozen desserts, egg yolks are used to inhibit the formation of large and grainy ice crystals to result in a smoother product.	• Ice cream • Gelato
Clarify	This is when the egg white protein albumen is dissolved in a cold liquid and heated in order to clarify the solution. This happens because as these proteins denature through the heating process, they also attach to any other debris that may be making the liquid to be cloudy and will cause them to rise to the top of the liquid to be strained out and removed.	• Clear soups

Preparation:

Eggs are one of the most versatile foods in a kitchen. It is important to note that depending on what the recipe calls for, eggs can be cooked at different times and temperatures to achieve different results.

Table 1.3 Coagulation Temperatures

Type	Initial Coagulation Temperature	Complete Coagulation Temperature
Egg white	140°F (60°C)	149°F–158°F (65°C–70°C)
Egg yolk	144°F (62°C)	158°F (70°C)
Mixed	156°F (69°C)	~

Dry Heat:

Frying: This can be done on a frying pan or griddle. Some form of fat is heated in the pan and the eggs is gently cracked in, carefully so as to not break the yolk. The eggs can then be cooked until the desired results are reached:

Table 1.4 Egg Frying Methods

Frying Method	Result
Sunny Side Up	Cooked until the whites are set but the yolk is still soft and runny.
Over Easy	Cooked on one side until the whites are about 75% set and then flipped over to cook but the yolk is still soft.
Over Medium	Cooked on one side until the whites are about 75% set and then flipped over to cook but the yolk is partially set.
Over Hard	Cooked on one side until the whites are about 75% set and then flipped over to cook but the yolk fully set.

Scrambled Eggs: The egg is beaten while still raw along with any seasonings and some form of liquid like milk or cream. This mixture is then poured into a heated skillet and the heat is reduced. Then the eggs are stirred very gently to move the cooked egg aside and make way for the remaining raw liquid until the whole mixture is cooked.

Omelets: Eggs are beaten and cooked, then rolled or folded over either with or without fillings.

Baking: Eggs can be baked in many different ways. A shirred egg is an egg that is cracked into a small container and baked until fully cooked. A meringue is also a baked egg dish and is the combination of air, sugar and egg whites beaten to form a foam and the baked. Souffles are also a result of baked eggs which are a combination of egg white foam and egg yolk foam folded together with other ingredients and baked, resulting in a light and fluffy dish.

Moist Heat:

Hard or Soft "Boiled" : This method calls for the eggs to be submerged under simmering or boiling water (depending on the type of boiled egg desired) with the shells still on. Eggs should be simmered for hard boiled eggs to avoid the reaction of iron to ferrous sulfide and to avoid a rubber egg white. Timing is as follows:

- Soft: 3 to 4 minutes
- Medium: 5 to 7 minutes
- Hard: 12 to 15 minutes

Coddling: This is when an egg is broken into a small dish called a coddler which is made of ceramic or heatproof glass and a screw on lid. This is then submerged in simmering water until the egg is fully cooked. Other ingredients can be added to this (bell pepper, onions, ham, etc.)

Poaching: This is when an egg is cracked into either plain water or a mixture of water and vinegar/salt (this is done to speed up coagulation of the egg whites) and allows the eggs to "boil" without the shell. This is usually done for more runny eggs to be used on top of other foods like toast or an English muffin.

Custards: This is a mixture of milk, cream, sugar and egg. As the mixture is cooked (can be in a water bath in the oven or over a double boiler for a loose custard) the egg coagulates and begins to set the rest of the ingredients as well.

***Note:* DO NOT microwave whole eggs with their shell as air can expand which will lead to pressure build up and can burst the egg even after it is taken out of the microwave.

Safety:

The chance of an egg being contaminated internally are very low and usually the culprit if salmonella outbreaks can be traced back to improper handling and Preparation after the contents of the egg have already been separated from the shell. Regardless, individuals (especially at risk populations) should always handle eggs with care just in case there is internal contamination due to the hen carrying the bacteria and passing it along through the egg. By understanding and adhering to the following guidelines, you can minimize the chances of contracting a Foodborne illness from eggs such as salmonella:

- Purchasing: Always purchase refrigerated eggs and double check to make sure that there are no cracks present and that the eggs are clean.
- Cooking: Always make sure to fully cook eggs and to reduce contact with any other raw eggs after the cooking process is complete.
- Storage: Always keep eggs and egg products refrigerated.

Inspection and grading

"The Egg Products Inspection Act (EPIA), passed by Congress in 1970, sets forth requirements to ensure that eggs and egg products are wholesome, otherwise not adulterated, and properly labeled and packaged to protect the health and welfare of consumers of these products." (USDA)

Grading:

Once eggs have passed the inspection step, they can be graded by a USDA official. The best-quality eggs are graded USDA Grade AA and the next level is USDA Grade A. USDA Grade B is the lowest grade and is only is available to food service establishments. There are three methods used to grade eggs:

- Candling: candling when a light is shone directly into an egg in order to expose it's contents and determine it's quality. This used to be done using candles (hence the name) but is now done using a mechanically rotating surface where the eggs will be run through with a light underneath it.
- Appearance: this is exactly what it sounds like because the egg is rated based on external shell appearance as well as internal by breaking the egg and actually looking at the albumen, yolk and other Components outside of the shell.
- Haugh Units: This method requires an egg to be broken onto a flat surface in order to determine freshness. Eggs are randomly selected from the line using a micrometer and broken over the flat surface. The Haugh unit is then calculated by mathematically adding the thick portion of the albumen's height with the egg's weight, and then converting the result into a Haugh unit using a formula/table. As Haugh units and egg quality are directly correlated so as the unit decreases the quality also decreases:
    - Grade AA: Haugh unit of 72 or higher
    - Grade A: Haugh unit of 60 to 71
    - Grade B: Haugh unit of 31 to 59

Sources:

- https://www.eggs.ca/eggs101/view/95/food-science
- Understanding Food: Principles and Preparation, Fourth Edition Amy Brown
- https://www.ams.usda.gov/rules-regul...ese%20products.

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Thumbnail: The new Nutrition Facts label, in use since 2016. (Public Domain; U.S. Food and Drug Administration via Wikipedia)

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15.1: Federal Food Laws in the United States of America

Introduction

The United States has a robust system of federal laws and regulations in place to ensure the safety, quality, and integrity of the nation's food supply. Laws are enforced by various federal agencies and cover a wide range of areas, including: food safety, labeling, additives, and inspections. This section provides an overview of the key federal food laws in the United States.

I. Food Safety Modernization Act (FSMA): The FSMA, signed into law in 2011, is one of the most significant reforms in food safety legislation. It aims to shift the focus from responding to foodborne illness outbreaks to preventing them. The FSMA mandates preventive controls for food facilities, including: hazard analysis, risk-based preventive controls, and a supply chain program. It also enhances the FDA's authority to conduct inspections, issue recalls, and establish science-based safety standards. For more information please click here: https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/food-safety-modernization-act-fsma

II. Federal Food, Drug, and Cosmetic Act (FD&C Act): The FD&C Act is the foundational legislation governing food, drugs, and cosmetics in the United States. It provides the legal framework for ensuring the safety and proper labeling of food products. The act prohibits the introduction of adulterated or misbranded food into inter-state commerce, establishes requirements for food labeling, and grants the FDA the authority to set and enforce standards for food safety. For more information please click here: https://www.fda.gov/regulatory-information/laws-enforced-fda/federal-food-drug-and-cosmetic-act-fdc-act

III. Food Labeling Laws:

   a. Nutrition Labeling and Education Act (NLEA): The NLEA requires most packaged food products to bear standardized nutrition facts labels, providing information on serving size, calories, nutrients, and ingredients. It also regulates health claims, nutrient content claims, and allergen labeling. For more information please click here: https://www.fda.gov/nutrition-labeling-and-education-act-nlea-requirements-attachment-1

   b. Food Allergen Labeling and Consumer Protection Act (FALCPA): FALCPA mandates that food labels clearly identify major food allergens, such as: milk, eggs, fish, shellfish, peanuts, tree nuts, wheat, and soy. Manufacturers must list these allergens in a specific format to help consumers with food allergies make informed choices. For more information please click here: https://www.fda.gov/food/food-allergensgluten-free-guidance-documents-regulatory-information/food-allergen-labeling-and-consumer-protection-act-2004-falcpa

IV. Food Additive Regulation: The Food Additives Amendment to the FD&C Act requires pre-market approval of food additives before they can be used in food. The FDA evaluates the safety of additives based on scientific data and sets maximum allowable levels. Substances generally recognized as safe (GRAS) based on a long history of common use or expert consensus do not require pre-market approval. For more information please click here: https://www.fda.gov/food/food-additives-petitions/food-additive-status-list

V. Hazard Analysis and Critical Control Points (HACCP): HACCP is a science-based system used to identify and control food safety hazards. The FDA and the U.S. Department of Agriculture (USDA) require HACCP plans for certain food industries, such as seafood, juice, and meat products. HACCP involves identifying critical control points (where dangers may arise), establishing monitoring procedures, and implementing corrective actions to ensure food safety. For more information please click here: https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

VI. Food Inspections and Enforcement: The FDA and USDA conduct inspections of food facilities to verify compliance with federal regulations. They have the authority to seize adulterated or misbranded products, issue warning letters, and enforce compliance through recalls and/or legal actions. The USDA also regulates meat, poultry, and egg products, ensuring their safety and accurate labeling. For more information please click here: https://www.fda.gov/food/compliance-enforcement-food/inspections-protect-food-supply

Conclusion

The federal food laws in the United States of America play a critical role in safeguarding public health, ensuring food safety, and promoting consumer confidence. These laws address various aspects of the food industry, including safety, labeling, additives, and inspections. Compliance with these laws is essential for food producers, processors, distributors, and retailers to maintain the integrity of the nation's food supply.

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15.2: Food laws for the State of California

Introduction

The state of California in the United States is renowned for its diverse agricultural industry, robust food production, and commitment to consumer safety. To ensure the quality, safety, and integrity of the food supply, California has established a comprehensive framework of laws and regulations governing: food production, processing, distribution, and sale. This section will provide an overview of the key laws and regulations that govern the food industry in the state of California.

I. California Department of Food and Agriculture (CDFA): The California Department of Food and Agriculture is the primary regulatory agency responsible for enforcing food laws and regulations in the state. CDFA plays a crucial role in safeguarding public health and promoting the competitiveness of California's agricultural industry.

II. Food Safety Laws:

   a. California Retail Food Code (CalCode): The CalCode is a comprehensive set of regulations that establishes food safety standards for retail food facilities in California. It covers a wide range of areas, including: food handling, storage, employee hygiene, sanitation, and equipment maintenance. The CalCode is designed to protect consumers from foodborne illnesses and ensure that food establishments operate in a safe and sanitary manner.

   b. Hazard Analysis and Critical Control Points (HACCP): HACCP is a systematic approach to food safety that focuses on identifying, evaluating, and controlling hazards throughout the food production process. In California, certain food processors, including those that produce seafood, juice, and dairy products, are required to implement HACCP plans to ensure the safety of their products.

III. Labeling and Packaging Laws:

   a. California Sherman Food, Drug, and Cosmetic Law: The Sherman Law regulates the labeling and packaging of food, drugs, and cosmetics in California. It requires accurate and truthful labeling, including the listing of ingredients, allergens, nutrition facts, and net quantity. The law also prohibits deceptive practices, such as false advertising or misbranding.

   b. California Organic Products Act (COPA): COPA establishes standards for the production, labeling, and certification of organic products in California. It requires organic food producers to comply with the U.S. Department of Agriculture (USDA) National Organic Program (NOP) standards and obtain certification from approved certifying agents. COPA also prohibits the use of genetically modified organisms (GMOs) in products labeled as organic.

IV. Food Additive and Contaminant Regulations:

   a. California Safe Drinking Water and Toxic Enforcement Act (Proposition 65): Proposition 65 requires businesses to provide a clear and reasonable warning before exposing individuals to chemicals known to cause cancer, birth defects, or other reproductive harm. Food producers and retailers must ensure that their products comply with Proposition 65 requirements and provide appropriate warnings if necessary.

   b. Maximum Residue Limits (MRLs) and Pesticide Regulation: The California Department of Pesticide Regulation (DPR) establishes MRLs for pesticides used on food crops. MRLs represent the maximum allowable pesticide residues in or on food products. Food producers must adhere to these limits to ensure consumer safety and compliance with state regulations.

V. Food Facility Registration and Inspection: Food establishments operating in California must register with the local enforcement agency, which may be a county health department or a city agency, depending on the location. These agencies conduct regular inspections to ensure compliance with food safety regulations. Non-compliant facilities may face penalties or closure until corrective actions are taken.

Conclusion

California's food regulations are designed to protect public health, maintain the integrity of the food supply, and promote consumer confidence. The state's comprehensive framework covers various aspects of food safety, labeling, and contamination prevention. By complying with these laws and regulations, food producers, processors, distributors, and retailers contribute to the overall safety and quality of California's food

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15.3.1: Food Labeling

When it comes to food advertising, many of us can be of two minds: We generally believe that sellers have the right to build up their products. On the other hand, food is important to health, and we don't like to be misled.

Oh, how easily we've been misled. We reached for salad oil labeled "Cholesterol Free!" even though it never contained cholesterol in the first place. And we thought "90% Fat-free!" meant a low-fat product. We've generally come to feel that more regulation has been needed, particularly as our society has come to rely more and more on processed foods.

The basic question of labeling is, what does the food contain? Just the facts, please. But given the facts and even drawing a line on huckstering, there's still the very challenging question of how to meaningfully inform consumers about the many individual nutrients provided by specific products—both those nutrients for which we are at risk for too little and those we are at risk for too much.

The Federal labeling laws have become increasingly complicated and sophisticated, and now require a substantial amount of well-defined information—for those who care enough to do a bit of homework.

Armed with the knowledge that there are nutrient requirements to fill and certain excesses to avoid, choosing healthy foods seems simple enough. But once we get to the grocery store, we're faced with a huge array of choices. The information sources that could help us choose—advertising and label information—can be more confusing than helpful. It isn't so easy to choose.

Labels and advertising purport to tell us whether we want something or not, whether the price is right, and whether or not we will really get what we're led to expect. We know that the main goal of advertising is to sell. We are told that we can rely on labels for much of the information we need. However, we need to know how to interpret what labels tell us.

Shoppers are forced to rely heavily on labels, if they are to make wise choices. To make intelligent nutrition decisions, we must know how to interpret them correctly—the focus of this chapter.

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15.3.2: Supermarket Conflict

In some ways, the food supplier and the nutritionist are at odds. The former is, after all, a business that must make a profit. Foods which have received the most processing and packaging—and typically have a longer shelf-life—are usually shelved in the inner aisles of grocery stores.

Nutritionists encourage us to do most of our shopping along the far sides and back wall of the grocery store, where fresh produce, bread, dairy, and meat sections are usually located. These sections generally hold the foods which are minimally processed and packaged—foods which tend to have a shorter shelf-life.

Often what beckons most at the supermarket tends to be the least nutritious, and the allocation of prime shelf space may be inversely related to nutritional value. One sees the likes of soft-drink 12-packs, not bags of fresh produce, stacked prominently at the front-of-the-aisle promotion sites.

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15.3.3: The Food Label

The food label is the one theoretically objective source of product information in the grocery store. How well it serves this function has been a matter of differing opinion, but the potential is there, particularly as government regulations have required more and more useful information on food labels.

All food labels must identify the product, give the net weight of the food, the name and address of the manufacturer, packer, or distributor, and a listing of ingredients. Not much more than this was required until the 1973 law regarding nutrition information on food labels was implemented.

This law required that nutrition information be given on the label of foods to which nutrients had been added and/or about which nutrition claims were made, either on the label or in advertising. Nutrition information on the label of other foods was optional.

But in the years since 1973, scientific evidence of the relationship between diet and chronic disease has increased dramatically, and there has been increasing consumer interest in nutrition. As consumers have become more concerned about the healthfulness of their diets, food processors have responded by including nutrition labeling on more foods and, at the same time, making more nutrition claims—often misleading ones—on their labels.

As a practical matter, packages with less than 12 square inches for labeling aren't required to carry nutrition information. But the label must give a way (e.g., website) for consumers to get the information.

Advertisers have found that nutrition claims make potent sales pitches. Sales of Kellogg's All-Bran cereal, for example, rose dramatically when the label began suggesting in 1984 that eating this cereal would help prevent colon cancer. Other claims, like "cholesterol-free" and "33% less fat" also proliferated—as did consumer confusion.

Does fiber protect against colon cancer? Does "cholesterol-free" salad oil mean that cholesterol was removed from this particular brand? Does "33% less fat" really designate a low-fat product? Many claims did more to mislead than to educate.

Partly for this reason, Congress passed the Nutrition Labeling and Education Act in 1990, mandating that nutrition labels educate about nutrition and health, and that only specified health claims, ones founded on established scientific evidence, be allowed.

Figure 22-1: The Food Label

Serving size is an amount customarily eaten at one time. It's not a recommended amount.

The general goal is to choose foods that add up to 100% of the Daily Value for total carbohydrate, fiber, vitamins, and minerals, and add up to less than 100% of the Daily Value for total fat, saturated fat, cholesterol, sodium, and added sugars.

Many women, teenage girls, and less active men use about 2000 calories/day. (Many men, teenage boys, and very active women use about 2500 calories/day.)

Nutrition Facts

8 servings per container

Serving size **2/3 cup (55g)**

Amount per serving

Calories **230**

	% Daily Value*
Total Fat 8g	**10%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**13%**
Dietary Fiber 4g	**14%**
Total Sugars 12g	
Includes 10g Added Sugars	**20%**
Protein 3g	
Vitamin D 2mcg	10%
Calcium 260mg	20%
Iron 8mg	45%
Potassium 240mg	6%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

As a rough guide, 100 calories per serving is considered to be a moderate amount; 400 or more calories per serving is considered to be high-calorie.

There's no % Daily Value for *Trans* Fat, since the goal is to consume as little as possible.

20% Daily Value of Calcium means that 1 serving gives you 260 mg (20%) of the 1300 mg (100%) daily goal.

Figure 22-1: The Food Label

Nutrition information is now required on most food labels (see Fig. 22-1), except for fresh produce, and fresh and frozen seafood, meat, and poultry. For these exempted foods, nutrition labeling is voluntary.

Some food products, e.g., food produced by small businesses, are exempt from the nutrition labeling requirement.

The regulations came about after much discussion about the best ways to present nutrition information on a label. They aimed to enlarge the amount of required information. But more than this, they also sought to require that this information be presented in a way that showed which facts were the most important in making healthy choices.

Switching the Emphasis

As we have seen, our nutrition priorities have switched dramatically. It used to be that deficiency diseases were our biggest nutrition problems. So it is that white flour is enriched with iron and B-vitamins, milk is vitamin-D-fortified, and table salt is iodized. When pellagra, rickets, and goiter were common, enriched flour, vitamin-D-fortified milk, and iodized salt were unquestionably the more healthful choices.

Today, our biggest nutrition problems are related to excess calories, saturated fats, sodium, and added sugars, and inadequate fiber. This has been discussed in early chapters. So nutrition information on food labels now emphasize these nutrients.

The goal is to draw attention to the nutrients of greatest concern for today's consumer—so that a product low in added sugars, for example, will come to have more "draw" for consumers than one heavily fortified with vitamins and minerals.

Serving Size—A Key to Practical Comparison

The number of servings in a package must be given on the label. Consumers need to know what is in a "typical" serving so they can compare nutrient values between brands. To serve their purpose, it's important that these "typical servings" be well-standardized and reasonable.

Labeling regulations require standard serving sizes for similar foods. For example, one tablespoon must be the serving size for both margarine and butter, so that their nutrition values can be easily compared. But if a package has less than two standard servings or is packaged to be consumed as an individual serving (e.g., snack-sized yogurt and instant ramen, ice cream bars, 12-oz. cans of soft drinks), the entire package must be listed as a serving. (Previously, the label on a 12-oz. can of soft drink or a 8.45-oz. box of juice would list one serving as 6 oz.)

Nutrient Content

Adding nutrition information to food labels would seem to be a simple matter. One had only to analyze the food and then set out the results on the package, in terms of so many grams, milligrams, or micrograms. Consumers would then know what's in the food. Or would they?

For most people, the simple statement that the product has 9 mg of a nutrient is meaningless. Is this a negligible amount or a lot? How were labelers to suggest the importance of a food as a nutrient source? We can't expect the shopper to carry an RDA table and a calculator for every purchase. To be useful, nutrition labeling must convey information simply.

Could the label simply show the nutrient content in terms of percentage of the RDAs? But there are 22 sets of RDAs for the U.S. population (based on age, gender, pregnancy, breastfeeding)—and very little space on the label. Imagine trying to show on a can of soup the percentage of need for more than 20 nutrients for as many population groups.

It was to meet this challenge that the Daily Values (DVs) were created back in 1973 (though they weren't called Daily Values back then).

The Daily Values were generally established by taking, for each nutrient, the highest RDA for those over age 4 (excluding those for pregnant and nursing women). Thus, some Daily Values can be quite different than the RDAs for your group.

For example, the DV for iron is 18 mg. This is right-on if you're a 19-50 year-old female who isn't pregnant or nursing. But if you're a male over age 18 or a post-menopausal female, your iron RDA is only 8 mg—only 44% of that DV of 18 mg gives you that 8 mg (100% of your RDA).

The nutrient content of a particular food is given as a percentage of the Daily Value for that nutrient. A food that has 9 mg of iron, for example, is listed as having 50% of the Daily Value (i.e., 50% of 18 mg of iron), but if you're a man, this 50% DV is over 100% of your RDA of 8 mg.

The Daily Values were expanded to include reference values for dietary components for which there are no RDAs, e.g., total fat, saturated fat, cholesterol, fiber, and sodium. One intent was to give more emphasis to dietary components known to be related to risk of chronic disease (e.g., the increased risk for susceptible people of high blood pressure from a high-sodium diet). The dietary components for which information is given are listed in Table 22-1.

Again, the simple statement that a product has so many grams or milligrams of fat or sodium is meaningless to most people. So the amounts are also given as percentages of the recommended amount, based on a 2,000-calorie diet. Women in this country need about 2,000 calories a day; children about 1,800, and men about 2,500.

The food label shown in Figure 22-1, for example, says that a serving has 1 gram saturated fat and 5% Daily Value (1 gm fat = 5% of the recommended 20-gram limit for a 2,000 calorie diet).

The goal is less than 10% of total calories from saturated fat: 10% of 2,000 cal = 200 calories, which is equivalent to 22 gm saturated fat (200 cal/9 cal/ gm = 22 gm), which has been rounded to 20 gm.

Health Claims

Only certain nutrition-related health claims are allowed on food labels. For example, a claim can be made on a package of frozen vegetables that a diet rich in fruits and vegetable may lower the risk of some cancers. It has been found that populations who eat a diet rich in fruits and vegetables have a lower risk of certain cancers.

Required*	**Optional****
Calories per serving	
Total fat	
Saturated fat	
Trans fat	Polyunsaturated fat
Cholesterol	Monounsaturated fat
Sodium	
Total carbohydrate	Potassium
Dietary fiber	
Total sugars	Soluble fiber
Added sugars	Insoluble fiber
Protein	Sugar alcohol (e.g., sorbitol)
Vitamin D	
Calcium	
Iron	Other vitamins and minerals
Potassium	

*Exceptions allowed in certain circumstances, e.g., soft drink labels don't have to list cholesterol, fiber, etc.

**Exception: required if they've been added, or if label makes claims about them; e.g., zinc's %DV must be given if zinc has been added to the food. Daily Values (DV) for the nutrients are given in Appendix A.

Table 22-1: Dietary Components Listed in the "Nutrition Facts Panel" of Food Labels

The Food and Drug Administration (FDA) maintains an updated list of *Authorized Health Claims that Meet Significant Scientific Agreement* that are allowed on labels of food and dietary supplements.[1]

There are strict guidelines for making these health claims. For example, the claim can only use "***may***" or "***might***" in discussing the relationships and must state that other factors play a role, e.g., "While many factors affect heart disease, diets low in saturated fat may reduce the risk of this disease."

Also, the health claim can't be made if the food contributes a significant amount of saturated fat or sodium ("significant amount" is defined in the regulations). For example, the health claim relating calcium to osteoporosis can't be made on an ice cream label. Ice cream is a source of calcium, but it's also high in saturated fat.

Descriptions like “low-fat” and “sugar-free” have often been used to imply that particular foods are healthier than competing products. Therefore, these descriptions have been standardized and given clear definitions (see Table 22-2), and can’t be used in a misleading manner. For example, if the box of margarine says “cholesterol-free,” it must also say that all margarine is cholesterol-free, e.g., “margarine, a cholesterol-free food.”

As another example, a muffin might be high in both fiber and fat. If its label describes the muffin as high in fiber, it must also indicate that it’s also high in fat. (It might add “see nutrition information about fat content.”)

What Ingredient Lists Can Say About Nutrition

Among the oldest labeling rules are those which require that the ingredients of most foods be listed on the package, in decreasing order of their weight. From this, the consumer can make a number of deductions.

Looking at a package of frozen macaroni and cheese, the ingredients list begins with cooked macaroni, followed by water, followed by cheese. How much cheese can there be? Cheese is the high-priced ingredient in the product—Is the price of the product reasonable?

There are federal regulations about what processed foods can be called. For example, “Chicken and Gravy” must be at least 35% chicken, whereas “Gravy and Chicken” need be only 15% chicken.

In the same freezer case, we see a dish labeled as “gravy and sliced turkey.” Water is listed as the first ingredient, turkey as the second. This means that less than half of the dish consists of turkey meat.

A combination of ingredient lists and nutrition labeling can help us to evaluate some other products. Consider fruit “drinks,” which may contain as little as 10% fruit juice, but which may boast of high vitamin content. (Juice labels are required to list the percent of juice content). We can see a distorted nutrition profile, often with a lot of one vitamin, such as vitamin C, and little else. Compare these labels with those for real fruit juice, and you can see the difference.

Or take breakfast cereals with high percentages of Daily Values of “essential vitamins and minerals.” The list of cereal ingredients, which may read like a pharmaceutical shopping list, can quickly tell us that we’re being offered a kind of vitamin pill combined with some grain and sugar.

Foods fortified with 50% or more of the Daily Value for any nutrient must be called a diet supplement, e.g., Total™ breakfast cereal is labeled as a “multi-vitamin supplement cereal with iron and zinc.”

One-hundred percent of some of the day’s micronutrients may sound good, but we must remember what it actually is—a serving of “regular cereal” plus a pumped in vitamin pill. If that’s what we want, okay—but we should understand that comparison shopping can show that the price of the heavily fortified cereal is more than the combined price of a less expensive cereal and a vitamin pill.

Slipping Sugar Down the List

Prior to the implementation of the 1990 labeling law, what was known as “sugar splitting” became a popular way for manufacturers to avoid the scrutiny of ingredient lists. In selecting cookies, for example, consumers often looked for those with lesser amounts of sugar. Even though the amounts of individual ingredients needn’t be given, consumers could see whether sugar or flour was the first ingredient listed, and select the cookies which had flour listed first.

But consumers could still be kept in the dark when the manufacturer used more than one sugar (sugar, honey, corn syrup, etc.) to sweeten the product. Even when sugar was the principal ingredient, it wouldn’t appear first in the ingredient label, so long as no one sugar was the principal ingredient. Flour could be listed first and the sugars listed separately (e.g., sugar, high-fructose corn syrup), further down the list.

Sucrose is listed as sugar in an ingredient list; other sugars (e.g., high-fructose corn syrup, honey) are specified.

To thwart this sleight of hand, the regulations now require that the sugars (“sweeteners”) be grouped together.

Enriched Flour

Enriched grain is common on ingredient lists for grain products. It refers specifically to the addition of iron and the B-vitamins thiamin, riboflavin, niacin, and folic acid to refined grains.

Pellagra (the niacin-deficiency disease) was common in the U.S. in 1942. The enrichment program increased niacin intake and lessened pellagra's prevalence and severity. The pellagra death rate was 1 in 100,000 in 1943, and fell to 1 in 500,000 by 1952.

In 1942, enrichment was made mandatory for white flour sold across state lines. At that time, the diets of many Americans were low in thiamin, riboflavin, niacin, and iron, largely because consumers preferred the refined to the whole grain products which would have provided more of the deficient nutrients.

In 1998, folic acid was included in the B-vitamins added to refined grains. Folic acid (folate) deficiency in pregnant women can lead to birth defects in the spine ("neural tube defects"), and these defects have indeed fallen since 1998.[2] Canada has also had a fall in these birth defects since folic acid fortification.[3] Virtually all of the white flour found in our grocery stores is enriched, as is food made from enriched flour (e.g., bread, pastas, cereals).

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15.3.4: What Do the Grades Given to Foods Mean?

Many people believe that grades like *Grade A* or *Choice* on a food label have nutritive significance. In general, this isn't true. Mainly, such ratings show esthetic (e.g., appearance, texture), not nutritive values. As such, the government gradings (given by government graders) are optional and paid for by the processor or packer. (In contrast, food inspection for safety and healthfulness is required, and paid for by the government.)

Sometimes packers and stores use labels with terms like Super or Excellent. Don't confuse these "grades" with official government grades.

Many of these grades are given under U.S. Dept. of Agriculture (USDA) standards, recognizable by the appearance of the grade designation in the shield of the USDA (see Fig. 22-2).

A USDA poultry "wing tag" shows three marks at once. First, it shows the age of the bird (a frying chicken is younger than a stewing chicken). Second (lower left), it shows the inspection mark for all poultry, fresh, frozen, canned or dried, indicating cleanliness and safety. Third (lower right) is the mark for quality, showing meatiness, for example.

The high-fat content of "Prime" beef, for example, is in large part responsible for its increased tenderness, juiciness, and flavorfulness, giving it its "Prime" grade. Each succeeding lower grade is generally lower in fat and price. People who need to restrict fat intake do well to buy the cheaper grades of beef.

The lower grades of beef are generally lower in fat, so it could be said that in this case, the grades have nutritional significance. But this isn't the intent. If it were, the lower fat meats would be given the higher grades, since these would be the healthier choice.

Practically speaking, we don't have much choice among grades of meat, so it's not something we really need to consider in our shopping. The top grade of meat is mostly sold to fancy restaurants; the next two grades are what we're most commonly offered at the meat counter. The lowest grades are commonly sold to food processors.

The grade mark appears in a purple USDA shield, stamped on the cut (usually a side) of meat delivered to the butcher. But we seldom see even a glimpse of the stamp, since most of the meat we buy has been subdivided by the butcher into steaks, chops, etc., and the edges trimmed of some of the fat.

Choosing Eggs By Size and Grade

The USDA sets three grades for eggs AA, A, and B. AA eggs look prettier. If you break one into a hot skillet, it will stay in a smaller space, instead of spreading out. Eggs graded A cover a moderate area when broken, and are fine for all purposes. B eggs aren't as attractive, spreading thinly over the pan, and so are commonly used when they're to be beaten or mixed into a recipe. The nutritive values for all three grades of eggs are the same. (The nutritive value of brown-shelled eggs and white-shelled eggs are also the same.)



Figure 22-2: Government Grade Marks. a) Fresh fruits/vegetables; packed under supervision of U.S. government grader; shows quality, but not nutritional, differences. (b) Fresh and cured meat; health inspection of food and packing plant. (c) Butter, cheddar cheese grading mark, (d) Meat quality stamps. (e) Food can't meet its standard; reason why; still good nutrition. (f) USDA grade for canned, frozen, dried fruits and vegetables; also for jam, jelly, honey, similar items. (g) Egg grading mark. (h) Canned, frozen, dried or packaged meat products passed sanitation inspection. (j) USDA poultry "wing tag" (see text).

When egg prices are between one and two dollars per dozen, a general rule of thumb is: If the price difference is less than 20¢ per dozen between neighboring sizes in the same grade, you get more for your money by buying the bigger ones.

Egg sizes are based on minimum weight, and vary by a quarter-ounce per egg as follows: Jumbo (2.5 oz); Extra-large (2.25 oz); Large (2 oz); Medium (1.75 oz); and Small (1.5 oz).

Free (e.g., sugar-free, cholesterol-free): The amount of the substance in a serving is nutritionally and physiologically trivial. If free is used to describe a food normally free of the substance, the label must say so (e.g., "vegetable oil, a cholesterol-free food").
Fresh (e.g., fresh orange juice): Unprocessed, uncooked foods. (Approved treatments for fresh fruits and vegetables, such as washing or coating, are allowed.) Food can't have been previously frozen. But recently harvested foods that are quickly frozen can be described as fresh frozen or frozen fresh (e.g., fresh-frozen fish).
Freshly (e.g., freshly squeezed orange juice, freshly roasted peanuts): Recently prepared from fresh (i.e., hasn't been previously frozen, or processed).
Good Source (e.g., good source of vitamin E): A serving has 10 to 19% of the Daily Value of a beneficial nutrient.
High (e.g., high-calcium): A serving has 20% or more of the Daily Value of a beneficial nutrient.
Less (e.g., less fat, less sodium): Has at least one-fourth less of this nutrient than the stated food to which it's compared (e.g., has less sodium than regular cheddar cheese).
Low (e.g., low-fat, low-sodium): Eating the food frequently won't increase the amount of this substance to more than the Daily Values specify. If low is used to describe a food normally low in the substance, the label must state this (e.g., milk, a low-sodium food). Maximum amounts per serving are specified (e.g., low-fat means 3 gm fat or less, low-sodium means less than 140 mg, low-calorie means 40 calories or less, etc.)
More (e.g., more vitamin C): A serving has at least 10% more of the Daily Value of a beneficial nutrient than the stated food to which it's compared (e.g., more vitamin C than orange juice).

Table 22-2: Some Labeling Terms, Definitions

Fruits and Vegetables

There are standards of quality for canned and frozen fruits and vegetables: *Grade A* or *Fancy*, *Grade B* or *Extra Standard*, and *Grade C* or *Standard*. But nutritive quality is again not the issue; the grading is for esthetic quality. Knowing this, there isn't much point in paying for perfect shape and appearance if you're going to puree the fruit or vegetable.

When grades appear on labels, many consumers are suspicious of anything that doesn't sound absolutely tops in quality, but such suspicion can cheat you of good buys in canned and frozen produce.

Fresh fruits and vegetables are easier for most people to judge, so there isn't as much grading. When government grades are given, they're put on the crates, so we don't usually see them (the top grades are *U.S. Fancy* or *U.S. No. 1*). But this doesn't matter much. We select fresh produce by price, sight, feel, and smell, and when the produce deteriorates, the store throws it out.

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15.3.5: Changing Labels for Changing Times

What's in a Name?

There was once a time when unscrupulous food companies would add water to cheeses. Or they'd mix a bit of fruit with a lot of water and pectin and artificial color and flavor—and a bit of grass seed—and call it jam. So in the late 1930s, certain foods (e.g., ice cream, mayonnaise, jelly) were given *standards of identity*, which specified amounts of mandatory ingredients. Cheddar cheese, for example, could have no less than a certain amount of milk fat and no more than a certain moisture content. Add water beyond this limit, and you could no longer label it cheddar cheese.

In those days, a lot of people still made many of these foods at home. They were familiar with their recipes, and when they bought any of these foods ready made, they expected them to contain the ingredients they had used.

Beat up a bit of egg and vinegar with a lot of oil, and you have mayonnaise. Buy it in a store, and that's what you expected it to be. The content of these foods was so commonly agreed upon that their labels required an ingredient list only if optional ingredients were added.

Today, there aren't many people who make their own mayonnaise, ice cream, cheese, and such. In fact, many are quite surprised to learn that mayonnaise is mostly salad oil, and that cheese is so high in fat. Today's typical consumer needs an ingredient list on the labels of these "standard foods," and unlike before, the law requires it.

Recent times have also brought a consumer awareness that many of us are eating more fat and calories than is good for us. So food makers responded by giving us lower-fat and lower-calorie versions of ice cream, cheddar cheese, and the like. They provided healthier food options, but created marketing problems for themselves.

A low-fat cheddar cheese could no longer be labeled cheddar cheese, since it didn't conform to its standard of identity. It could be called "cheese food," "cheese substitute," "imitation cheddar cheese," etc., but it couldn't be called cheddar cheese. And these new descriptions weren't attractive to consumers.

Consumers were torn, particularly because so many have become enthusiastic about anything "natural," and repelled by "unnatural." What could sound more "unnatural" or "chemical" than an "imitation"? The consumer was lured by the lower-fat concept, yet repelled by the idea that these must not be "real foods."

Lower fat versions of familiar foods are the more healthful choices for most of us. In fact, now we want water added to cheeses, to replace some of the fat! Thus the regulations designed to prevent consumer deception in the 1940s became a problem of consumer perception in the 1980s.

As a result, the 1990 law did away with standards of identity, allowing low-fat versions of cheese, mayonnaise, ice cream, sour cream, and such, to be called "low-fat sour cream," "cholesterol-free mayonnaise," etc.

What About the Unprocessed Foods?

The irony of the major revamping of food-labeling regulations is that nutrition information isn't required on fresh vegetables and fruits—foods that are generally low in saturated fat, and sodium, and high in fiber—the very foods that nutritionists encourage us to eat. Wasn't getting us to make more healthful choices an aim of the 1990 law?

Of course, it isn't that fresh fruits, vegetables, meat, poultry, and fish (and alcoholic beverages) were purposely overlooked in the labeling reform. Guidelines are given for voluntary labeling of these foods, and labeling may become mandatory. Mandatory or not, there are unique challenges.

For one, the labeling of most of these foods aren't under the jurisdiction of the Food and Drug Administration (as most other foods are). Fresh fruits and vegetables and fresh and frozen meat and poultry are regulated by the Dept. of Agriculture, fresh and frozen fish by the Dept. of the Interior, and alcoholic beverages (except for wine beverages with less than 7% alcohol) by the Bureau of Alcohol, Tobacco, and Firearms. This is but a minor hurdle. There have already been some coordinating efforts by these organizations to establish a system for consistent labeling.

The biggest hurdle is the most obvious one. How do you label a bunch of grapes? Do you change the label of a banana as the sugar content increases as it ripens? Is the 5-oz. steak one serving, and the 7-oz. steak in the package underneath also one serving (each

is, after all, packaged as an individual serving)? If so, which do you use to compare the nutrient content of a serving of steak to a 6-oz. chicken leg? Should they be compared cooked or uncooked? If cooked, how cooked? Trimmed of fat or not?

Clearly, the likes of Oreo cookies are much easier to label—they're consistent in size, weight, and composition, and stay the same for a long time. The same is true of the many drinks that are essentially water, to which precise amounts of sugar, vitamins, flavor, and color have been added before bottling.

What about comparative shopping? We already know "you can't compare apples and oranges." But we can't conveniently compare fresh apples with canned apples either. In comparing sour creams, the various brands of regular sour cream are there next to the low-fat and fat-free versions.

We can compare prices and nutrient content, and even factor in our taste or distaste for various versions. In comparing peaches, those canned in syrup are shelved next to those canned in juice—but a long way from the fresh peaches. Some stores do provide nutrition information for these foods on leaflets and the like—portable information that facilitates comparative shopping.

As part of the trend towards less cooking "from scratch," we eat out more often. Restaurant chains with 20 or more restaurants must provide nutrition information on their menu items on-site and/ or on their websites, and an increasing number of restaurants provide some general nutritional guidelines, such as putting a heart symbol ("heart healthy") next to low-salt items on their menus.

Organic Foods

Labeling a food as *Organic* has marketing value, and so it was that many foods were labeled *Organic* without a uniform definition of what that meant. This led to a push for national standards, enacted in 2002 as the National Organic Program of the U.S. Dept. of Agriculture (USDA).[4]

Products labeled as USDA Organic must meet specific production and processing requirement, and specific substances are prohibited, e.g., synthetic pesticides and GMOs (Genetically Modified Organisms). Products labeled as USDA Organic are precisely defined:[5]

- **100% Organic**: contains only organically produced ingredients, not counting added water and salt.
- **Organic**: contains at least 95% organically produced ingredients by weight, not counting added water and salt; remaining ingredients are ones not commercially available as organic and/or other allowed substances. Can't contain sulfites.
- **Made with organic ingredients**: contains at least 70% organic ingredients, not counting added water or salt; remaining ingredients are ones not commercially available as organic and/or other allowed substances. Can't contain sulfites, except sulfur dioxide in wine, as specified.
- **Has some organic ingredients**: contains less than 70% organic ingredients, not counting added water or salt; remaining ingredients are ones not commercially available as organic and/or other allowed substances.



Products that are 95-100% organic can display the *USDA Organic* seal. Organic farms must comply with USDA standards, as must organic meat, poultry, eggs, and dairy products.

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15.3.6: Realities of Nutrition Labeling

When labeling was voluntary for a food product, nutrition information wasn't expected, unless it helped sell the product. Thus voluntary labeling appeared most often on such "nutritious" foods as bread and canned fruits and vegetables.

But there were some surprises—surprises to nutritionists, anyway. Nutrition labeling started appearing voluntarily on such foods as potato chips and cookies. Fig Newtons, one can understand, but Oreos?

The food makers realized that nutrition labeling might not affect the popularity of Oreos. One's mind is usually made up before the package is taken from the market shelf. Oreo buyers probably don't read labels carefully. Even if they ordinarily do and are generally concerned about nutrition, one expects that if they want their Oreo fix, they wouldn't look in this instance. The nutrition information might spoil their pleasure.

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15.3.7: Ultimately, Wise Food Selection is a Personal Matter

Ah, pleasure! Let's not forget that a healthful diet doesn't mean giving up favorite, not-so-nutritious foods. Individual foods aren't good or bad. As with individual nutrients, it's the amount that matters most.

Nutrient labeling of foods focuses on the nutritional merits and demerits of individual foods. So it's perhaps ironic that we should circle around to say that individual foods aren't necessarily good or bad. It's one's overall diet that counts.

For all that's been said about nutrition labeling, and all the healthier choices nutritionists hope consumers will make because of them, we know all too well that consumers first need to be motivated to make the changes.

What good is nutrition information on a label if it isn't read? Moreover, the information is only useful in the hands of a nutritionally literate consumer. Only if there's some real understanding of the roles of the various nutrients will nutrient content be meaningful.

As consumers become more knowledgeable about food and nutrition, there's less of a need to read labels. One develops a comfortable familiarity with foods, and is able to choose wisely without having to rely much on labels. Also, the most nutrition-conscious are those who tend to eat fewer processed foods and more fresh foods—foods without much labeling.

The hope is that those who have read this book are now more knowledgeable about food and nutrition, and will increasingly find pleasure in diets they know to be healthy. As we're freed from the spell of food rumor and fantasy, we can confidently choose from the wonderful variety of foods—fresh and processed—available in the marketplace.

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15.3.8: Summary

Food labels can help informed consumers make wise nutrition choices. Until 1973, little more than the product name, weight, manufacturer, and list of ingredients were required on the labels. A 1973 law required nutrition information if nutrients had been added or where claims had been made about the food's nutritive value. But the nutrition information and claims were often confusing and misleading, and many foods didn't carry any nutrition information at all.

The 1990 Nutrition Labeling and Education Act was enacted to require nutrition information on almost all food labels, and to make the information more consistent and relevant to current nutritional concerns. For example, Serving size and Calories head the list of Nutrition Facts on the label. Whereas nutritional deficiencies used to be our biggest dietary problem, our main concern now is with excesses, e.g., excess calories, sugar, sodium.

Among the other food-label changes, standard serving sizes have been established (nutrition information is given per serving), terms such as *low-fat* are precisely defined, and only certain health claims are permitted. As before, ingredients must be listed in decreasing order of weight. Nutrition labeling is voluntary for many raw foods, such as fresh fruits, vegetables, meat, poultry, and fish.

"Enriched" refers to the addition of iron and the B-vitamins thiamin, riboflavin, niacin, and folic acid to refined grain. Virtually all of our white flour is enriched, as would be the pasta, cereal, etc., made from enriched flour. Enrichment is indicated in the ingredient list (e.g., enriched flour).

Grading of food by the U.S. Dept. of Agriculture refers to the esthetic appearance and texture of food, not the nutritive value. A lower grade of meat, for example, may not be as tender but may be "healthier," because of a lower fat content. Similarly, canned peaches that are less firm and are unevenly cut can be just as nutritious as those of a higher grade.

Consumers knowledgeable in nutrition can use the nutrition information on food labels to choose a healthful diet. As informed consumers, we know that we don't have to exclude foods high in saturated fat, salt, sugar, etc. Rather, we know that food labels help us identify these foods more easily, so that we can eat them in smaller amounts or not as often. The food labels help us select a diet that's both healthy and pleasurable.

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15.3.9: Guest Lecturer

***Guest Lecturer**: Judy Fitzgibbons, MS, RD, LD*

Nutrition Label Zone: Thinking Required

Nutrition labels give us the facts about the foods, but we still must make the buy or not-buy decision, based on the information provided and our knowledge of our nutritional needs and goals. Here are three ways you can use your nutrition knowledge to be a wise consumer:

1. Develop your sense of the nutritional value of basic, minimally processed foods
2. Beware of decision-making based on single nutrients
3. Control the "problem potential" of "fun foods"

Learning About the Nutrients in Foods

Knowing the nutrients we should expect in foods guides us over the first decision hurdle of whether a food will help meet our basic nutrient needs or whether to relegate it to the "fun food" category that adds mostly calories.

For example, snack crackers are basically flour and shortening or oil. "Multi-grain" or "wheat" crackers in yellow or brown packaging give the impression they're made from whole grain flour and so would seem to be a good snack choice. By checking the ingredient list and reading the nutrient content on the label, we can tell whether or not they are the nutritious snack we expect.

A slice of whole wheat bread, containing a little more than 2 grams of fiber, as well as contributing B-vitamins and iron, gives us a reference point. We should expect about the same from an ounce or so of whole grain crackers. If the ingredient label shows that whole wheat (or other whole grain flour) is in the top two ingredients and the nutrition facts label shows the nutrients we expect, the crackers offer a healthy choice. On the other hand, if the fiber content looks acceptable, but there is no whole grain flour listed (or it falls low on the list), you will probably find a refined fiber, such as oat fiber, listed. This increases the fiber content, but doesn't bring along with it the other nutrients we expect from oats. High fiber in foods does not guarantee whole grain.

Learning what to expect from basic foods improves our ability to make smart food choices.

Beware of Single-Nutrient Decision-Making

Table A shows the most frequent nutrition and ingredient claims consumers said they look for on food packages (generally the front of packages) according to a 2020 survey conducted by FMI-The Food Industry Association, a supermarket industry organization. Interestingly, the majority of concerns are food factors to avoid rather than what to include.

Various foods and nutrients go in and out of favor, running the gamut from "miracle cures" to "evil curses." In the late 1980's, oat bran was the miracle cure, and fat became the evil curse. In the mid-2000's, the antioxidant-rich value of blueberries and pomegranates (along with major marketing efforts) catapulted these fruits and their products into shoppers' carts for their purported potential to prevent heart disease, cancer and diabetes. Trans fat, the by-product of the hydrogenation of vegetable oils, became the "evil curse" of the 1990s and was banned from most foods by the Food and Drug Administration (FDA) in 2018. Hydrogenated oils have now been replaced by the once-feared palm and coconut oils. Now, extra protein makes snack food look healthy, while low-carbohydrate and gluten-free claims promise weight loss and healthy intestines.

Although the underlying facts are valid, the problem with the cure-or-curse mindset is that we can become so focused on obtaining or avoiding a certain nutrient that we lose perspective.

Claim	% Consumers Seek Claim
Low sugar	35
Low sodium	32
Natural	27
Whole grain	24
High fiber	24
Low calorie	23
No trans fat	22
Low carbohydrate	20
No fat/low fat	19

Table A. Top-ranked Nutrition and Food Claims Consumers Seek

Source: FMI. 2020. U.S. Grocery Shopper Trends, p. 48.

For example, you can now find dozens of foods made with pomegranate and blueberry. Yogurts are flavored with pomegranate juice and cereals contain dried blueberries. If you decide to substitute pomegranate juice for a daily serving of orange juice, you've just dropped an important source of vitamin C and folic acid from your diet. Pomegranate juice contains neither in significant amounts.

How about avoiding gluten, the protein in wheat? There are plenty of breads, cereals, cookies and crackers with "gluten-free" labels. However, in order to create acceptable flavor and texture, manufacturers must use an assortment of highly refined, non-wheat flours which contribute little nutritional value besides calories. If you have a true gluten-intolerance, including celiac disease, a healthy diet must include other non-wheat whole grains to replace healthy fiber, B-vitamins, and several minerals wheat flours contribute. Some gluten-free cereals are now enriched, like wheat flour, but the selection is limited.

Balancing our choices over several meals, even over several days, protects us from the single nutrient focus. Blueberries are a great fruit, but so are oranges, kiwi fruit, and bananas. Palm oil is a problem, but we can handle a little of it in a commercial oatmeal cookie when we choose to use an olive oil-based dressing on a salad.

Table B. Estimating Fat and Sugar Budgets

To calculate the maximum fat and sugar recommendations in grams, first decide what would be a "healthy" weight for you. To estimate your grams of sugar limit, divide your weight by 3. To estimate your grams of fat limit, divide your healthy weight by 2. If you lead a sedentary life, subtract 10 grams from the fat total.

For example:

150 lbs = 50 grams of sugar per day

3 (approximately 10% of calories)

150 lbs = 75 grams of fat per day

2 (approximately 30% of calories)

If sedentary, 75 grams - 10 = 65 grams fat per day

Dealing with "Fun Foods"

The preparation and eating of a good diet can and ought to be fun and pleasurable. The trick is to control what I like to call the "problem potential" of foods such as candy, pastries, soft drinks—"fun foods."

Fat and sugar are the chief contributors to the “problem potential.” Both can either add excessive calories or fill us up so we don’t feel like eating foods that make important nutrient contributions. Excess calories from any source promote the development of obesity, cardiovascular disease, and cancer.

Current recommendations call for fat to contribute about 30% of our total calories. The Dietary Guidelines for Americans 2020-2025 recommends that added sugar contribute no more than 10% of total calories. Other health experts say it should be no more than 6%. For the typical adult, these translate to 50 to 70 grams of fat per day and 40 to 60 grams of added sugar (see Table B for how to estimate your personal fat/sugar limits).

Once you have a perspective on your fat and sugar “targets,” you’re equipped for comparison-shopping. Knowing these numbers allows you to decide whether the Hershey’s Milk Chocolate bar staring you down in the grocery checkout line is really “worth” the 13 grams of fat and 24 grams of sugar it will take out of your fat and sugar targets.

Another factor in controlling the “problem potential” is to consider how much of a food you will eat over a period of time. The special sale on the 15-ounce Party Size bag of Doritos from the end-of-aisle display brings 120 grams of fat into your household (grams of fat or sugar/serving x servings per container). If your daily fat target is 60 for the day and you single-handedly eat the whole bag in a couple of days, its “problem potential” is high. If, on the other hand, you stretch the chips out over several days or share them with others, their “problem potential” is greatly reduced.

There are of course many issues relating to nutrition labeling. But the concepts of evaluating nutrient value, avoiding single nutrient decision-making, and assessing “problem potential” will provide good starting places for nutritionally sound shopping.

Judy Fitzgibbons is a retired registered dietitian living in Cedar Rapids, Iowa. She has worked in the field of nutrition for 40 years, spending 10 of those writing the syndicated column On the Label, and 16 years as an in-store dietitian for Hy-Vee, Inc., an Iowa-based regional supermarket chain. She helped customers find foods that fit their individual nutrition concerns through supermarket tours, nutrition workshops, and personal nutrition coaching. She also helped store departments showcase their healthy food options with recipes and food demonstrations.

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16.1: The Future of Food in the United States of America

16.1.1: Innovations in Farming and Agriculture

16.1.2: Reducing Food Waste

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16.2: A Fresh Perspective- Sustainable Food Systems

Thumbnail: Farmer spraying pesticide on crops. (Unsplash License; Teo Sticea via Unsplash)

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16.1: The Future of Food in the United States of America

Introduction:

The future of food in the United States of America is poised to undergo transformative changes as the nation confronts the challenges of sustainability, food security, and public health. In this chapter, we will explore the emerging trends and innovations that are shaping the future of farming and agriculture, reducing food waste, and promoting health in the United States.

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16.1.1: Innovations in Farming and Agriculture

Vertical Farming

Vertical farming is revolutionizing agriculture by enabling the cultivation of crops in vertically stacked layers or in vertically inclined surfaces, such as walls or towers. With the efficient use of space, controlled environment agriculture techniques, and advancements in LED lighting technology, vertical farming provides opportunities for year-round crop production in urban areas. This approach reduces the distance between farms and consumers, minimizing transportation costs and environmental impact. For more information please visit: https://www.usda.gov/media/blog/2018/08/14/vertical-farming-future

Hydroponics and Aeroponics

Hydroponics and aeroponics are soil-less farming methods that rely on nutrient-rich water or air to grow plants. These techniques conserve water, reduce pesticide usage, and allow for higher crop yields compared to traditional farming. Hydroponics involves growing plants in a nutrient solution, while aeroponics involves misting the plant roots with a nutrient solution. These methods are particularly well-suited for urban agriculture and can be integrated into vertical farming systems. For more information please visit: https://www.nal.usda.gov/farms-and-agricultural-production-systems/hydroponics

Precision Agriculture

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16.1.2: Reducing Food Waste

Food Recovery and Redistribution

Improved Packaging and Storage

Food Waste Recycling

The future of food waste management lies in recycling and converting organic waste into valuable resources. Anaerobic digestion and composting systems break down food waste to produce biogas, which can be used for energy generation, and nutrient-rich compost, which improves soil health. These processes not only reduce greenhouse gas emissions but also contribute to the circular economy by closing the nutrient loop.

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16.1.3: Promoting Health

Nutrient-Dense and Functional Foods

The future of food in the United States emphasizes the development and consumption of nutrient-dense and functional foods. Nutrigenomics, the study of how food affects gene expression, informs the creation of personalized diets and functional foods tailored to individuals' genetic profiles. Additionally, advancements in food science and technology enable the fortification of foods with essential nutrients, bioactive compounds, and probiotics, promoting overall health and well-being.

Plant-Based and Alternative Proteins

As concerns over the environmental impact of animal agriculture and the health implications of excessive meat consumption rise, plant-based and alternative proteins are gaining popularity. Innovative companies are developing plant-based meat substitutes, cultured meat grown in laboratories, and protein-rich

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16.2: A Fresh Perspective- Sustainable Food Systems

Learning Objective

- Discuss some approaches to building a sustainable food system in your community.

The science of nutrition includes the study of how organisms obtain food from their environment. An ecosystem is defined as the biological and physical environments and their interactions with the community of organisms that inhabit those environments as well as the interactions among the organisms. Human nutrition and the health of the world's ecosystem are interdependent, meaning that what we eat and where we get it from affects the world. In turn, the health of the earth influences our health. The term sustainability is used to indicate the variety of approaches aimed at improving our way of life. Sustainability promotes the development of conditions under which people and nature can interact harmoniously. It is based on the principle that everything needed for human survival depends upon the natural environment.

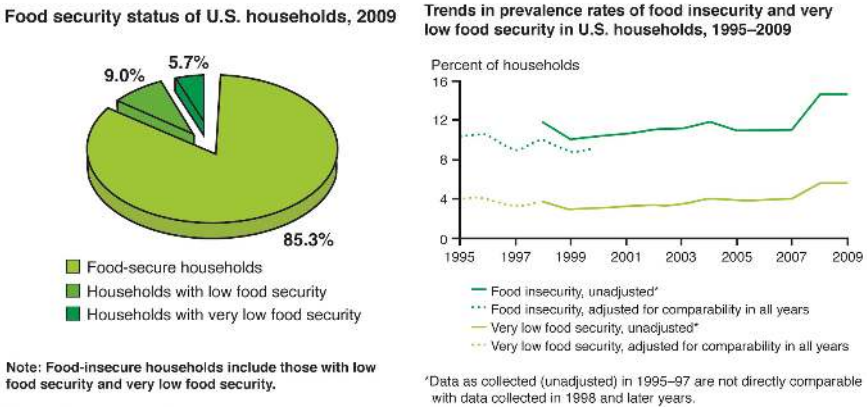


Figure 16.5.1: Food Security Status in the United States. Building a sustainable food system will help enforce measures to ensure that everyone on the planet has enough food to eat. Source: Calculated by ERS using data from the December 2009 Current Population Survey Food Security Supplement.

A major theme of sustainability is to ensure that the resources needed for human and environmental health will continue to exist. A healthy ecosystem, one that is maintained over time, is harmonious and allows for social and economic fulfillment for present and future generations. Nutritious foods come from our ecosystem and to ensure its availability for generations to come, it must be produced and distributed in a sustainable way. The American Public Health Association (APHA) defines a sustainable food system as "one that provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come with minimal negative impact to the environment."American Public Health Association. "Towards a Healthy, Sustainable Food System." *Policy Statement Database*. Policy no. 200712 (November 6, 2007). www.apha.org/advocacy/policy/policysearch/default.htm?id=1361 It also states that the attributes of a sustainable food system are:

- availability
- accessibility
- affordability to all
- humane
- just

A sustainable food system does not just include the food and those who consume the food, but also those that produce the food, like farmers and fishermen, and those who process, package, distribute, and regulate food. Unfortunately, we have a long way to go to build a sustainable food system.

The Challenges

The most prominent challenge to building a sustainable food system is to make food available and accessible to all. The Food and Agricultural Organization of the United Nations (FAO) states the right to food is a fundamental human right and its mission is to assist in building a food-secure world. Food security in America is defined as the "access by all people at all times to enough food for an active, healthy life."US Department of Agriculture, Economic Research Service. "Food Security in the United States: Key Statistics and Graphics." Last updated June 4, 2012. www.ers.usda.gov/Briefing/FoodSecurity/stats_graphs.htm#food_secure As of 2009, 14.9 percent of households, or 17.4 million people in the United States, had very low or low food security and these numbers have risen in recent years (Figure 1.7.2).Food and Agricultural Organization of the United Nations. "Food Security: Concepts and Measurement." In *Corporate Document Repository*, ID: 144369. 2003. http://www.fao.org/docrep/005/y4671e/y4671e06.htm

Food security is defined by the FAO as existing "when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food which meets their dietary needs and food preferences for an active and healthy life."Food and Agriculture Organization of the United Nations. "How Does International Price Volatility Affect Domestic Economies and Food Security? In *The State of Food Insecurity in the World*. 2011. http://www.fao.org/publications/sofi/en/ The FAO estimates that 925 million worldwide were undernourished in 2010. Although there was a recent

decline in overall food insecurity (attributable mostly to a decline in undernourished people in Asia), the number of undernourished people worldwide is still higher than it was in 1970, despite many national and international goals to reduce it.

Another challenge to building a sustainable food system is to supply high-quality nutritious food. The typical American diet does not adhere to dietary guidelines and recommendations, is unhealthy, and thus costs this country billions of dollars in healthcare. The average American diet contains too many processed foods with added sugars and saturated fats and not enough fruits, vegetables, and whole grains. Moreover, the average American takes in more kilocalories each day than ever before. This shift of the population toward unhealthy, high-calorie diets has fueled the obesity and diet-related disease crisis in this nation. Overall the cost of food for the average American household has declined since the 1970s; however, there has been a growth of "food deserts." A food desert is a location that does not provide access to affordable, high-quality, nutritious food. One of the best examples of a "food desert" is in Detroit, Michigan. The lower socioeconomic status of the people who live in this city does not foster the building of grocery stores in the community. Therefore, the most accessible foods are the cheap, high-caloric ones sold in convenience stores. As a result, people who live in Detroit have some of the highest incidences of obesity, Type 2 diabetes, and cardiovascular disease in the country.

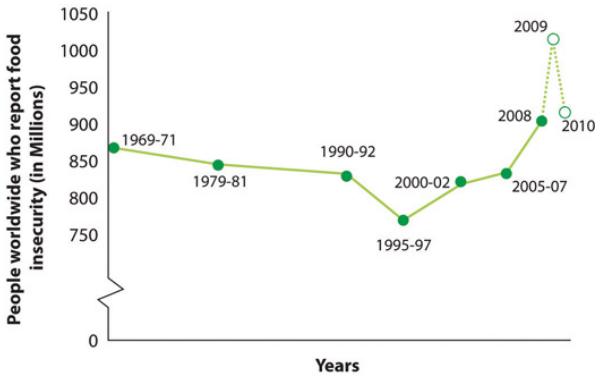


Figure 16.5.2: *Food Insecurity: A Global Perspective. Source: Calculated by ERS based on Current Population Survey Food Security Supplement data.*

A fourth challenge to building a sustainable food system is to change how we produce, process, and distribute food. Large agribusiness, complex industrial processing, and massive retail conglomerations distort the connection we have between the food on our plate and where it came from. More food is being produced in this nation than ever before, which might sound good at first. However, some factors that have contributed to higher food production include using genetically engineered plants, excessive use of herbicides and pesticides, and the selective promotion of only a few crops by the policy of crop-specific subsidies (money given to farmers by the federal government). The subsidies are given toward the support of only about eight crops, most notably corn and soybeans. This policy diminishes the variety of crops, decreases biodiversity among crops, and supports large agribusiness while disadvantaging small- and medium-sized farms. Additionally, the whole system of food production, processing, and distribution is lengthy, requiring a great deal of energy and fossil fuels, and promotes excessive use of chemicals to preserve foods during transportation and distribution. In fact, the current US food system uses approximately 22 percent of the energy in this country and is responsible for at least 20 percent of greenhouse gas emissions. Canning, P. et al. "Energy Use in the US Food System." US Department of Agriculture, *Economic Research Report, no. ERR-94* (March 2010).

Solutions to the Challenges

While these challenges are daunting there are many potential solutions that are gaining momentum in the United States. The APHA advocates expanding the infrastructure for locally grown food, improving access to healthy and local food for low-income Americans, providing education on food origin and production, building up the livelihoods of local farmers, and using sustainable farming methods. Detroit is currently a "food desert," but there is a fantastic example of how to positively impact the growth of a sustainable food system within the city. It is called the Eastern Market and it is a six-block inner city market with over 250 vendors marketing local produce, meat, seafood, plants, fresh-cut flowers and much, much more. Unlike many urban farmers' markets, it sells foods that are better quality and lower prices than grocery stores. Its forty-thousand visitors every Saturday demonstrate its success as a community-based way to foster good nutrition, good health, and social interaction.

Tools for Change

Ten Steps You Can Take to Help Build a Sustainable Food System in Your Community

1. Eat a "low-carbon diet." This is one where the foods that you eat require less energy and fuel to produce, process, and distribute than other foods.
2. Join a community-based farmers' market.
3. Have a garden at home and join a network of home gardeners. Find out how by visiting the USDA website on gardening: www.usda.gov/wps/portal/usda/usdahome?navid=GARDENING &parentnav=CONSUMER_CITIZEN&navtype=RT and the National Garden Association, http://www.garden.org/.
4. Compost your food and garden waste. Learn some of the essentials of composting by visiting "Composting at home," a fact sheet provided by Ohio State University (http://ohioline.osu.edu/hyg-fact/1000/1189.html).

5. Buy local food—make at least 10 percent of your food purchases local and share what you know about local food with friends and family.
6. Pool your resources with family and friends to purchase locally.
7. Drink tap water instead of bottled water.
8. When purchasing foods, choose the ones with less packaging.
9. Support state initiatives that support local farmers and build infrastructure to sell more healthy food.
10. When dining out, ask what nutrients are in the food and where the food labels are on the menu (to encourage the restaurants to label). Also, visit the restaurant's website as the information may be posted there with a space for comments.

These are some great steps to build a more sustainable food system for you and your family, friends, neighborhood, community, city, state, nation, and the world. For more solutions, watch Video 1.7.1. Throughout this book, we will highlight multiple steps you can take toward building a sustainable food system in the Tools for Change sections, so stay tuned.



Figure 16.5.3: You can do your part in building a sustainable environment by literally starting in your own backyard. © Shutterstock

Video 16.5.1: Sustainable Food Systems

This link brings you to an educational video on sustainable food systems.

Key Takeaways

- Sustainability promotes the ditions under which people and nature can interact harmoniously. It is based upon the principle that everything needed for huma upon the natural environment. A sustainable food system includes not only the food and those who consume the food, but also t ood (such as farmers and fishermen), and process, package, distribute, and regulate food.
- The challenges to building a stem are many, from providing affordable and accessible food, to supplying nutritious, high-quality, low-cost food regardless of socioeconomic status, to changing the ways foods are produced, processed, and distributed.
- There are many solutions to the challenges of building a sustainable food system. Some of the solutions are to: expand the infrastructure for locally grown food, improve access to healthy and local food for low-income Americans, provide education on food origin and production, build up the livelihoods of local farmers, and use sustainable farming methods.
- You can take action individually and locally to help build a sustainable food system.

Discussion Starters

1. Share with each other in the classroom some of the things you might have already done to help build a sustainable food system in your community.
2. Form debate teams in the classroom and have a formal debate on the topic of the regulation of food. One side must present the reasons it is beneficial for the government to regulate food. The other side will argue the reasons it is better for people to grow their food locally.

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CHAPTER OVERVIEW

Chapter 17: Review of Chapters 10-16

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