

## **Lesson 1: Introduction to Food Preservation**

America is blessed with an abundance of food. Citizens from a developing country would see more food in one trip to an American grocery store than they would see in a lifetime at home. The United States enjoys the widest variety of healthy foods at the lowest cost relative to income that can be found in the world. Americans enjoy the combination of educated food producers/processors, abundant natural resources, a diverse climate, and advanced food science and technology.

Food scientists have identified the causes of food deterioration. Food technologists have developed techniques to preserve food. The team concept of food science and food technology allows each of us to leave the grocery store with confidence that we have purchased wholesome food.

### **Why Foods Are Preserved**

Food production is often cyclical, while food consumption is more constant. Therefore, foods must be preserved to ensure an abundant supply throughout the year. For a variety of economic, climatic, and political reasons as many as 10,000 people die each day worldwide due to starvation and malnutrition. Food is also preserved in order to prevent microbial growth. A third reason food is preserved is to maintain and enhance its taste and texture by reducing the effects of chemical changes. Also, foods are preserved to provide products in more convenient forms.

### **Importance of Food Preservation**

Ultimately, food preservation is necessary for the preservation of life. Food preservation was also important historically, is presently, and will continue to be in the future. History has shown that early civilizations developed in fertile, food producing areas. Humans learned to sun-dry certain types of foods so they might be eaten at times other than harvest.

Preservation of food was of great importance to Napoleon and his armies. His military campaigns were successful because he provided his troops with adequate food. Napoleon suffered his greatest defeat when it became difficult to feed his troops.

Later it was discovered that salt extended the storage life of foods. Spices and sugar were used as food preservatives by early Asians. American colonists and pioneers depended on salted, pickled, and smoked meat and fish in addition to dried beans. The cold winter temperatures were also useful to process and preserve meats. Lard was melted and spread over cooked sausages for protection. Fruits and vegetables were stored in root cellars, buried, or dried. The cool temperature of the spring house was valuable for storing eggs, milk, and butter.

## Food Science and Technology-Unit I

---

The 1830's ushered in the railroad, making food transportation over long distances much faster. The refrigerated rail car of the 1880's was revolutionary! The 20th century has witnessed steady progress in food science and technology, which should propel the industry into a bright future.

How will food science and technology impact the future? The world's population continues to expand as the number of food producing acres declines. Therefore, techniques to preserve food will become increasingly important. The demand for convenience will prompt development of new preservation techniques. The added energy expense of refrigeration, freezing, and irradiation could be reduced by new technology. Medical advancements may necessitate other technological developments. Already, food sterilized by irradiation is required by certain chemotherapy patients. Future trends in food science may depend on people like you!

### Food Preservation Techniques

Food may be preserved using a variety of techniques.

Heat - Heating food products is a technique used to destroy microorganisms and endogenous enzymes. Most microbial growth occurs between 61°-100°F. Heat-loving (thermophilic) microbes grow in the range of 110°-130°F. In order to destroy these microbes, food products must be heated to an internal temperature greater than 180°F. Heat-enduring (thermoduric) bacteria survive temperatures as high as boiling so food is often canned under pressure to provide a temperature above 212°F. Sterilizing food means heating the food to about 240°F and maintaining that temperature for 15 minutes or longer.

Figure 1.1 - Food Preservation Techniques

- Heat
- Cold
- Drying
- Packaging
- Additives
- Fermentation

Cold - Refrigeration, or maintaining 33°-40°F, is useful to slow microbial growth. Freezing is achieved by reducing the temperature to 0°F or lower, which virtually stops enzymatic action and microbial growth.

Drying - Dehydrating is the removal of moisture to limit microbial and chemical activity. Freeze-drying is the removal of moisture from a frozen food under reduced atmospheric pressure.

Irradiation - Irradiation is a technique that uses gamma rays or beta particles to bombard and kill microbes and inactivate enzymes.

Packaging - Vacuum packaging is the removal of most of the oxygen from food products. This prevents aerobic microbial activity and is usually applied during packaging of refrigerated solid foods. Sometimes an atmosphere rich in CO<sub>2</sub> is used to preserve food, particularly fruits and vegetables. Often the packaging material is very important in creating and maintaining the desired conditions. This type of process is called modified or controlled atmosphere packaging, commonly referred to by the acronym MAP/CAP.

Additives - The use of additives or chemicals to prevent microbial growth is another preservation technique. Sweetening, or achieving a high sugar content, produces a high osmotic pressure which causes water to be withdrawn from microbes. A 70 percent sugar level is necessary to prevent all microbial growth. Salting produces a high osmotic pressure or low water activity (Aw) and restrains microbial growth. Salt levels of 2.5-3.0 percent are common in salt cured food products. Smoking food products allows formaldehyde and phenolic compounds to settle on the food surface. The compounds inhibit microbial growth. Spicing is a technique used to slow the growth of some microbes. However, processors must use spices that are free from undesirable microbial contaminants.

Fermentation - Fermenting, also known as souring or pickling, slows bacterial growth. Acids produce a low pH, which restrict microbial growth. Sometimes, desirable microorganisms are allowed to grow in the food. They convert carbohydrates into acids or alcohol. These by-products inhibit the growth of undesirable microorganisms and provide unique flavors in foods. The use of desirable microorganisms to preserve food is called fermentation. Bacteria convert carbohydrates into acids and alcohol.

### **Causes of Food Deterioration**

Food is subject to physical, chemical, and biological deterioration. In practical terms, food starts deteriorating at the time it is harvested or slaughtered. The critical question becomes: How slow or how rapid is this process? The principle causes of food deterioration are heat, cold, light and other radiation, oxygen, moisture/dryness, natural food enzymes, microorganisms, macroorganisms, industrial contaminants, and time.

Microorganisms, like bacteria, mold, and yeast, ferment sugars and hydrolyze fats, proteins, starches and cellulose. Those that hydrolyze fats produce rancidity. Those that digest proteins make putrid odors. Others produce acid, make food sour, and discolor it. A few produce toxins that can lead to food poisoning.

## Food Science and Technology-Unit I

---

Natural enzymes can become catalysts of chemical reactions in food. Ripening and tenderizing are examples of natural enzymatic reactions. Some reactions, like the aging of beef or the ripening of tomatoes, are desirable if they are not allowed to continue too far. Tenderizing and ripening beyond an optimal point causes deterioration.

Pests include insects, parasites, birds and rodents. Insects are very destructive to cereal grains, fruits, and vegetables. While an insect may create only a small hole in a melon, this allows microorganisms to invade and cause decay. Freezing, irradiation, and O<sub>2</sub> removal are commonly used to kill insects in food. A common food-borne parasite is Trichinella spiralis. This worm can enter hogs that eat uncooked animal food wastes. If an infected pork carcass is cooked insufficiently, this parasite can enter man. Fish may also harbor parasitic worms that can enter the consumer if the fish is eaten raw.

Rodents, such as rats, not only consume large quantities of stored grain, but also contaminate it with bacteria-infested feces and urine. Flies, rats and cockroaches are all known to transmit disease causing microorganisms to food. For example, rats can transmit salmonellosis, leptospirosis, typhus fever, the plague, and other infectious diseases.

Other Factors - Heat can denature proteins, break emulsions, dry out food, and destroy vitamins. Within the temperature range of 50°-100°F, chemical reaction rates double for every 18°F rise in temperature. These chemical reactions include both enzymatic and non-enzymatic reactions.

Cold temperatures (i.e., below freezing) disrupt the texture and crack the skins of fruits and vegetables. Freezing milk breaks its emulsion and curdles its protein. Temperatures that are too cold cause off-colors, surface pitting, and decay, especially in fresh fruits and vegetables.

Light destroys some vitamins, specifically riboflavin, vitamin A, and vitamin C. It also can cause food discoloration. Ultraviolet light oxidizes milk fat and protein and changes milk's flavor. Not all wavelengths of radiation are absorbed equally. Gold colored filters for fluorescent lights in display cases and opaque packaging are preventative measures.

Moisture or dryness are factors that may contribute to food deterioration. Moisture is required for all microbial growth and for chemical reactions. Too much moisture can cause lumping, crystallization, and stickiness of dried food products. Too little moisture in baked foods can cause dehydration and staleness. Even when fruits and vegetables are placed in a moisture-proof bag, water is given off through respiration and transpiration and the produce shrivels.

Oxygen can have negative effects on vitamins A and C, food color, flavor, and other constituents. Oxygen's presence is essential for mold growth. Oxygen can be removed by deaeration (inert gas purging), vacuum packaging, or flushing containers with nitrogen (N<sub>2</sub>) or carbon dioxide (CO<sub>2</sub>).

Industrial contaminants are a minor cause of food spoilage. Chemicals may inadvertently come in contact with food and cause discoloration and off-flavors.

Most of these factors are dependent on how long the food is stored. As more time passes, the causes of food deterioration (explained above) are more likely to cause food spoilage. Food quality decreases over time. Two common sense rules of food preservation are: 1) keep food alive as long as possible, and 2) following harvest or slaughter, the product must be cleaned, and preserved as quickly as possible.

### **Storage Time and Type Affects Food Quality**

The type of storage affects food quality. Of course, food needs to be wholesome in the beginning. How the product was handled immediately following harvest also directly affects food shelf life (the time it is satisfactory to eat). Most fruits and vegetables need a refrigeration unit in the field at the time of harvest. The shorter the time required to cool food products to 33°-40°F, the longer they can be stored. For example, sweet corn will metabolize its own sugar (convert its own sugar into starch) following harvest. At 32°F only 10 percent of its sugar will be converted to starch in one day. At 68°F 25 percent of its sugar may be converted in one day. The use of portable hydrocoolers that jet spray fresh produce with cold water is highly beneficial. The water may contain a germicide to inactivate surface microbes. Nitrogen gas can also be used to induce evaporative cooling. Animal carcasses must be cooled to an internal temperature of 36°F within 24 hours of slaughter.

Another critical factor affecting long-term storage is the relative humidity (RH) during storage and handling. Most microorganisms thrive in moist environments. Therefore, relative humidity levels must be carefully controlled. Underground caves used for food storage provide a fairly static and low RH. Insufficient moisture can also cause dehydration of food. Beef stored at less than 90 percent RH dries out. If RH is between 90-98 percent, the beef will mold. If above 98 percent, the bacteria will cause spoilage. Meat tissue may be covered with a film of plastic to decrease moisture loss. Cheeses can be wrapped in impermeable films to prevent drying out. Eggs may be coated with a thin film of mineral oil to maintain desirable moisture levels.

Refrigeration refers to temperatures of 30°-61°F. Most foods may be preserved for days to weeks at these temperatures. Freezing temperatures are below 30°F. Foods can be preserved for months to years. Neither refrigeration nor freezing completely destroys all microbes. Once food is thawed, rapid microbial growth is possible. Refrigeration is

## Food Science and Technology-Unit I

---

one of the gentlest methods of food storage in terms of maintaining taste, nutritive value, and texture. Refrigeration accelerates the staling of breads. Food stored long-term must be sterilized, dehydrated, irradiated, fermented, or completely frozen.

### Summary

Food preservation is necessary to maintain human life. We preserve food for human safety, quality enhancement, convenience, and to maintain an adequate supply. Food preservation will be as important in the future as it has been in the past. Controlling microbes and enzymatic activity are the goals of a variety of preservation techniques. If these techniques are not used, physical, chemical, and biological deterioration are possible. The time and method of food storage are other major factors that influence food quality.

### Credits

*Food Technology*. Instructional Materials Service, College Station, TX: Texas A & M, 1990.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

Gaman, P.M.; K.B. Sherrington. *The Science of Food: An Introduction to Food Science, Nutrition and Microbiology*. 3rd ed. Elmsford, NY: Pergamon Press, Inc., 1990.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

## **Lesson 2: Food Perishability**

Food is a perishable commodity. The storage life, however, depends on a variety of factors as well as which food product you are considering. Egyptians stored wheat very well. Recently, some Egyptian wheat stored for more than 3,000 years was discovered. This wheat was still suitable for use as food. Other products, like fresh, uncooked meat can spoil within a few hours if left at room temperature.

### **Food Characteristics Influence Deterioration Rate**

Deterioration rate is influenced by the characteristics of the food product. The pH, or hydrogen ion concentration, affects how long food will stay fresh. In general, foods spoil fastest when pH lies between 6 and 8 (Neutral pH is 7.0).

The moisture, or water activity level, is another important food characteristic that influences deterioration rate. All microorganisms require moisture to survive. Foods with very little water content will not support microbial growth. The water activity level of foods must be reduced to 0.6 or below to prevent all microbial growth. Foods with a water activity near .99 support microbial growth best. Moisture may be removed by heating the food or by adding salt or sugar to the food, which by the process of osmosis, removes water from the microbe's cytoplasm.

Deterioration rate is also affected by the temperature of the product. Foods deteriorate fastest at temperatures between 60°F and 100°F.

The oxygen level of the food product is another important consideration. If the oxygen has been removed from the food by vacuum packaging, the growth of molds and aerobic bacteria will be stopped, but anaerobic microorganisms may flourish.

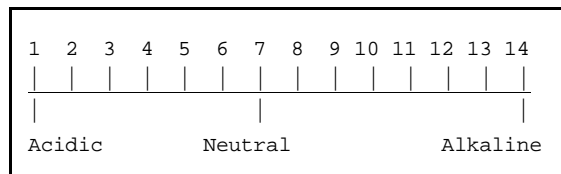
The physical characteristics of the food are also factors that influence deterioration rate. The degree of ripeness, whether immature or overmature, can have a dramatic effect on the food's perishability rate. The actual size of the product, or its surface area, is another important physical characteristic. In the case of meat, the whole carcass is less vulnerable to deterioration than steaks or ground meat because the whole carcass has less exposed surface area per unit of weight or volume. Because retail cuts such as steaks have more surface area, they provide a more readily available source of nutrients, oxygen, and water for the microbes than do whole carcasses.

### **Acidity/Alkalinity Influence on Perishability of Foods**

The pH readings of most foods vary from about 2.6 to 7.0. Some examples are: dill pickles, pH 2.9; apples, pH 3.0; tomatoes, pH 4.2; sweet potatoes, pH 5.4; and shrimp, pH 6.9. The perishability of food products is dependent upon their degree of acidity or

alkalinity. On the pH scale of 0-14, an alkali is any substance with a pH of 7.1-14.0. An acid has a pH of 0-6.9. Alkalis have a bitter taste; therefore, very few food products are alkaline. Stored eggs and soda crackers are examples of alkaline foods.

Figure 2.1 - pH Scale



An alkaline pH reading above about 8.0 slows or inhibits microbial growth. An acid modifies or denatures bacterial protein, and some acids are directly toxic to bacteria. Therefore, the more acidic a food product is, the slower its

rate of deterioration will be. Acids are natural products of citrus, apples, tomatoes, etc. Acids can also be added. In the case of pickling, acetic acid may be added. Lactic acid is the product of bacteria that is native or has been added in fermentation. Microorganisms prefer an environment with a pH range of 2.0-8.0. Bacteria favor a neutral pH, molds prefer 2.0-8.0, and yeasts prefer 4.0-4.5.

### Relationship Between Water, Salt, Sugar, and Osmotic Pressure

Water is required by all microorganisms. A reduction in the amount of water available is an effective means of food preservation. All of the moisture in a food product may not be available to the microorganisms. The amount of water that is available is called water activity ( $A_w$ ). When salt or sugar is added to food, the  $A_w$  decreases. This is the principle used for salt or sugar-curing meat and also for syrup, jelly, and jam making. The addition of salt or sugar increases the osmotic pressure of the food item. Osmotic pressure is defined as the force that a dissolved substance (e.g., salt or sugar) places on a semipermeable membrane through which it cannot penetrate when the dissolved substance is separated from pure water by that membrane. When the osmotic pressure in a food product is high enough to draw water away from a microbial cell or prevent normal diffusion of water into the microbial cell, the cytoplasm of that cell dehydrates. This is fatal to that microbe. The greater the salt or sugar concentration is, the higher the osmotic pressure will be. A 70 percent sucrose solution will stop the growth of all food microbes.

### Microbial Activity

Microbial activity affects food preservation both physically and chemically. Physical changes of food are more apparent than chemical changes. Slime formation, undesirable odors and flavors, and color changes are all physical changes caused by aerobic bacteria and yeasts. Aerobic means in the presence of  $O_2$ . Another physical change caused by aerobic molds is a sticky surface.

Chemical changes in food caused by microbial activity include the breakdown of complex organic molecules into simpler molecules. Examples include protein decomposition into peptides and amino acids under aerobic conditions. When



anaerobic (without the presence of  $O_2$ ) conditions are present, proteins are degraded into foul-smelling sulfur compounds. Non-protein nitrogen is degraded into ammonia. Microbes secrete lipases which hydrolyze, i.e., break down by adding water ( $H_2O$ ), molecules of triglycerides into glycerol and fatty acids. Similarly, phospholipases hydrolyze phospholipids. This process creates a rancid flavor in food. Carbohydrates, the preferred energy source of microorganisms, are broken into organic acids, alcohol,  $CO_2$  and  $H_2O$ , depending on the pathway the microorganism uses in metabolizing them. Lactic acid in fermented sausage is an example of an organic acid. Microorganisms, after degrading complex molecules, utilize the simpler molecules as nutrient sources for their growth and activity.

### Chemical Preservatives

Chemical preservatives are substances added to a food intentionally to improve its appearance, flavor, texture, or storage properties. They are often called additives. One example of an additive is sodium benzoate, which is used to prevent microbial growth in soft drinks and acidic foods. Calcium and sodium propionates are additives used in breads and cakes to prevent mold growth. Cheese products may have sorbic acid added to control mold. Fruits and vegetables may be washed in a germicidal chlorine compound. Ethylene oxide and ethylene formate are fumigants used to control microbes of spices, nuts, and dried fruits. Sulfur dioxide ( $SO_2$ ), is an additive which controls the browning of fruits and vegetables.

Many foods which contain fat become rancid by oxidation. Therefore, BHA (butylated hydroxyanisole), BHT (butylated hydroxytoluene), and TBQH (tertiary butylated hydroquinone) are used in products like potato chips to prevent oxidation. Nitrites are often used in cured meats to help prevent outgrowth of *Clostridium botulinum*. Salt or sugar used to lower the  $A_w$  and acid needed to lower the pH are considered additives. The addition of smoke, another additive, acts as a bacteriostat or bactericide.

### Atmosphere Affects Food Perishability

Food perishability is affected by the gaseous atmosphere. In the absence of  $O_2$ , all molds and aerobic bacteria are controlled. Nitrogen is used in immersion freezing. Nitrous oxide is a propellant used in aerosol food cans. Carbon dioxide ( $CO_2$ ) replaces the  $O_2$  in fermented products.  $CO_2$  is also used in soft drinks where it contributes to carbonic acid production.  $CO_2$  and ozone ( $O_3$ ), have been used in the holds of ships to prevent aerobic microbial growth. Ethylene gas speeds the ripening and color development in citrus and bananas. Eggs are stored in enriched  $CO_2$  storehouses to minimize micro growth. The relative humidity levels in the gaseous atmosphere also affect the rate of spoilage of foods.

### Summary

The deterioration rate of food is influenced by the type of product, pH, water activity, temperature, oxygen level, and many physical and chemical characteristics. The more acidic a food product, the slower the deterioration rate. The addition of salt or sugar to food will increase the osmotic pressure and lower the water activity, and hence the deterioration rate decreases. Microbial activity causes both physical and chemical changes in food. For this reason, food additives are often used to intentionally improve a food's storage properties. A wide variety of gaseous atmospheres can be used to help preserve food products.

### Credits

*Advanced Food Science and Nutrition*. Texas Tech University: Home Economics Curriculum Center, 1988.

*Food Technology*. Instructional Materials Service, College Station, TX: Texas A & M, 1990.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

Tortora, Gerard J.; Berdell R. Franke; Christine L. Case. *Microbiology: An Introduction*. 1st ed. Menlo Park, CA: The Benjamin/Cummings Publishing Co, 1982.

## **Lesson 1: Procedures Used in Processing Food**

The food processing industry has made an impact on people's lives. It is nearly impossible to eat a meal containing a food that has not been processed. Consumer buying habits help determine what food products will be processed and marketed. Can you name the processed food(s) that were a part of your last meal? What processing techniques helped transfer this food from the farm product to you?

### **Why Are Foods Processed?**

Food processing can be defined as any mechanical, chemical, or biological treatment to food. These processes may preserve the food or change the raw material's appearance or flavor. Food is processed for many reasons. Many processed foods can be stored for longer periods of time than raw food products. Natural deterioration along with microbial growth and activity are slowed due to food processing.

Another reason for processing food is to control a food's composition. If a food product, (e.g., oatmeal) is to have a standard protein, fat, and moisture content, it must be processed. Other reasons for food processing are for convenience, variety, flavor enhancement, and value adding. Producers grow potatoes, not potato chips. Farmers harvest wheat, not flour. Most American consumers prefer to buy frozen cut up chicken pieces, not a live bird. Without flavor enhancement, most ice cream flavors would not exist. Value adding refers to techniques used to increase the economic return or worth of food.

### **How Can Foods Be Processed?**

Foods may be processed in many different ways. The method used depends on the raw product, its destination, consumer demand, health, and safety.

Dehydration - In dehydration, the moisture is removed from a food. Dried fruit, raisins for example, and jerky are common dehydrated, processed foods.

Fermentation - Fermentation uses selected microorganisms to break down carbohydrates which releases nutrients located in plant cells. Starch in plant cells can be broken down into simple sugars. Other nutrients can be released during this process. Fermentation processes produce pickles, sauerkraut, vanilla, salami, sour cream, yogurt, cottage cheese, cocoa, beer, wine, soy sauce, and bread, just to name a few.

Milling - Milling involves the washing of grain and the removal of chaff, foreign seeds, and soil. Grains may also be separated by size using a series of sieves.

## Food Science and Technology-Unit II

---

Fractionation - Fractionation is the process of separating the hulls, germ, bran, and endosperm. Particle size and density are physical properties on which separation methods depend.

Grinding - Grinding usually follows milling and fractionation. Here the particle size of grains are reduced to that of flour or meal using rollers to crush the larger particles. Wholesale cuts of meat are ground into ground beef, ground pork, etc. The term comminution refers to grinding meat.

Emulsifying - Certain food products contain both water and oils or fats. Naturally, these two constituents repel each other and separate. Emulsifiers are materials that keep this separation from occurring. For example mayonnaise contains lecithin (a phospholipid of the egg yolk) which keeps mayonnaise from separating into layers of water and oil. Margarine, salad dressing, sausage products, and ice cream are processed with emulsifiers.

Homogenizing - Homogenizing food refers to a process of forcing the food through a small valve under high pressure to reduce the size of the globules of fat. When the large globules are reduced to a small size, the food's consistency remains constant. Milk is homogenized to keep the milk fat in suspension.

Hydrogenation - This is the process of converting vegetable oil (a liquid) to a solid shortening or spread. By chemical means, hydrogen is added to an oil and the hydrogen saturates the oil's fatty acids. The newly formed product is spreadable and resists rancidity better than the oil. Margarine is an example.

Combination - Combination is mixing constituents together. Enriching bread with vitamins is an example of a combination process. Adding chocolate to milk is another example of mixing, or combining ingredients.

Texturization - Texturization refers to processes that change the shape or color of a food. Durum wheat is processed, or texturized, into macaroni or spaghetti. Meat may be flaked, ground, or chopped and then reformed into a steak or roast-like product. These are called restructured meats.

Chemical Modification - The addition of heat, enzymes, or microbes is a process called chemical modification. Popcorn in its popped state, corn syrup, and pickles are examples.

Precipitating/Centrifuging - To precipitate means to separate a solid from a solution. Centrifuging is a quick means of separating constituents with different densities. Separating cream from milk is a common example of separation based on densities. Wet corn milling involves a procedure in which the germ floats in the settling trough

and is skimmed off. The starch, protein, and hulls are then screened to remove the hulls. The starch and protein solution is then centrifuged and the denser starch particles are thus separated.

Extrusion - Extrusion is a process where a formulated dough or mash is forced through an extruder under high pressure. High pressure causes the starch molecules to swell and then gel. The steam generated by the heat of the process causes a puffing of the product which forms a new shape. Breakfast cereals are commonly extruded.

### **Food Safety Assured**

Food safety depends on a number of factors and the activities of many people. Both the federal and state governments are responsible for food safety until the consumer purchases the food. An estimated \$1 billion is spent annually by 12 federal agencies to ensure food safety and quality inspection. Private and state agencies spend more than \$5 billion annually.

The Federal Meat Inspection Act of 1906 still provides mandatory inspection of animals, slaughtering conditions, and meat processing facilities. It regulates interstate meat sales.

In 1967, the Wholesome Meat Act was passed. It requires all state and city meat regulations to meet federal standards. The Federal Poultry Products Inspection Act of 1957 and the Wholesome Poultry Products Act of 1968 set federal standards on poultry.

The public is protected against false advertising in the food industry due to the Federal Trade Commission Act of 1938. The Food, Drug, and Cosmetic Act of 1938 set the basic principles of food safety and gave the FDA the power to enforce food safety measures. Infant formulas must contain the known essential nutrients at the appropriate levels according to the Infant Formula Act of 1980. Federal Grade Standards maintain uniform quality standards. State and Local laws are usually administered by the Health Department.

The Food and Drug Administration (FDA) assures consumers that the food they buy is safe, nutritious, and honestly represented. All additives must be approved by the FDA before use. The FDA also has a Generally Recognized As Safe (GRAS) list of over 600 ingredients (e.g., sugar, table salt, cinnamon) that are not considered additives. It is the USDA's job to monitor for safety and quality all meat and poultry. The FDA monitors all other processed foods. The Grade A Pasteurized Milk Ordinance established minimum quality standards for Grade A milk.

## Food Science and Technology-Unit II

---

America's food is arguably the world's safest and most wholesome. Yet several million people suffer from food-related illnesses each year. A large number of these illnesses (70-80 percent) can be prevented by proper food handling at home and in restaurants.

### Cleaning and Sanitization

Most equipment in food processing plants is constructed of stainless steel. Not only is stainless steel durable, but it can be easily cleaned and sanitized. Cleaning refers to removing all visible filth. Sanitizing means destroying any microbial contaminants. Food contact surfaces are usually rinsed with tap water to remove most of the food residue before cleaning starts. An alkaline cleaner in hot water is the normal cleaning solution. Its strength and temperature depend on the type of soil to be removed and whether washing is by hand or by mechanical circulation. This step is often followed by washing with an acidic solution thus dissolving residues of minerals. Following cleaning, sanitizing is performed with 180°F water or an approved chlorine or iodine rinse. Metal equipment, other than stainless steel, may need an edible mineral oil coating to prevent it from oxidizing (rusting).

### Summary

Food processing is an important part of the food industry. Any mechanical, chemical, or enzymatic treatment to food which alters its original form is called food processing. Length of storage, slower deterioration, anti-microbial contamination, convenience, composition control, and flavor are some of the reasons for processing.

### Credits

*Food Technology*. Instructional Materials Service, College Station, TX: Texas A & M, 1990.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

Gaman, P.M.; K.B. Sherrington. *The Science of Food: An Introduction to Food Science, Nutrition and Microbiology*. 3rd ed. Elmsford, NY: Pergamon Press, Inc., 1990.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

## Lesson 2: Food Product Development

The Big Mac, tater tots, catsup in a squeezable bottle, and microwavable TV dinners were all once just ideas. Today these are common foods. People expect new food products to provide good taste and good nutrition and be easy to prepare. Many food scientists are called product developers. Their jobs are to take good ideas and turn them into reality.

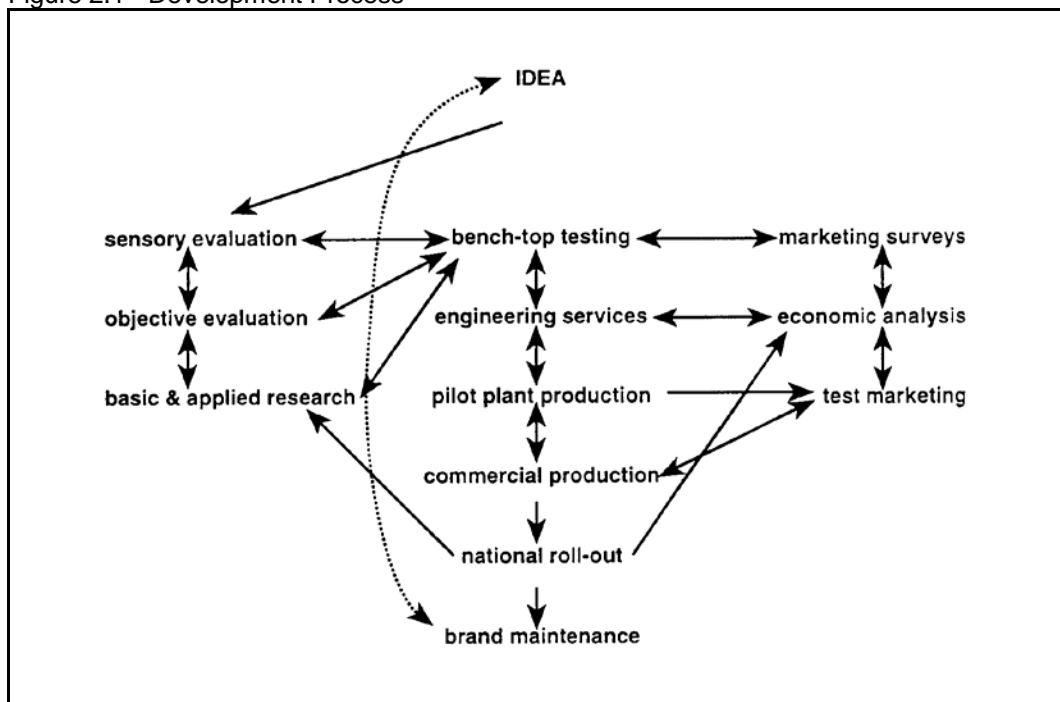
### New Food Products

Research in food science is a continual process. Reports of new ingredients, processes, and preservation techniques fill the pages of many journals every month. Product development scientists study these advances with an interest to use them to make new and different food products. Changes in nutritional information and new keys to the role of diet and health also provide impetus to scientists trying to provide foods that consumers want. It is a complex and difficult task. The success rate for new food products is less than 0.1 percent, measured as products that make it to national market for longer than three years.

Where do new food product ideas come from? Often consumer complaints about an existing product to sales staff result in significant changes in food products. Other times the sales staff themselves will see a market they could fill, if only there was a product that did what the customer wanted. Sometimes old products can be reintroduced to the market, capitalizing on nostalgia, often coupled with new ways to make the product more convenient to prepare. Even laboratory mistakes may become successful products, if the scientists are creative enough to see an application. Most new products are called "line extensions." These are products created by making small changes in existing products, like putting fruit color and flavors into a plain corn puff breakfast cereal and marketing it to children. Similarly, a successful product introduction by one food company may result in the introduction of many "me-too" products by their competitors. However they happen, every new food product begins with an idea.

Where the idea goes next is a complex series of steps that do not always follow in any particular order (Figure 2.1). Nevertheless, all these elements will be part of the process in one form or another. Bench-top development is the production of prototypes of new products on a small scale. These laboratories often look like very large kitchens, but if

Figure 2.1 - Development Process



you were to spend some time there you would find many specialized instruments not found in most home kitchens.

Objective testing involves discovering if the idea can be produced to have enough shelf-life and safety to allow successful marketing. Sensory evaluation is required to find out if consumers like the taste, color, and other characteristics of the product. Often objective testing and sensory evaluation require basic and applied research to solve specific problems uncovered in their studies. Pilot plant production evaluates the production processes using equipment that is very much like miniature equipment used in the production facility. Usually engineering services are required to modify existing processing facilities, or to design new ones to fit the specific requirements of the new product. Marketing surveys may be employed to refine the product to meet the desires of specific consumers. Economic analysis is needed to learn the costs of the product, and if the new product will make a profit for the company. Each of these pieces of the product development puzzle must be fit together in order for the product to be successful in the highly competitive food market.



Finally, a new product is born. At this point there may be as many as three years of effort by several different groups of researchers invested in the product. But the job is not over yet. Test marketing will be required to figure out if consumers will really buy the product when they see it on store shelves or on restaurant menus. National roll-outs are the ultimate test of a new food product. The national roll-out of a product occurs when a company makes a commitment to sell the product throughout their marketing system. Usually these national roll-outs are accompanied by complex, carefully orchestrated advertising campaigns. Even at this point the process is not complete. Careful brand maintenance is required to make sure the product performs the way the consumer expects. Careful evaluation of sales figures, consumer comments and complaints, and good market analysis help to prevent a product from failing. Adjusting a product to meet changing market demands may require new product development, and so the process begins again.

### **A Good Example: Margarine**

During World War I, there was a shortage of butter available to consumers living in the U.S. Most of the nation's butter was being served to the military men and women who "deserved nothing but the best." Those people left to support the war effort stateside were without this very commonly used food ingredient. There was a need for a new product.

Butter is a complex food that consists of water, oil, protein, and several other components. The oil and water mixture is stabilized into an emulsion, so that the two layers do not separate as they often do in a homemade salad dressing. Stabilization requires the presence of an emulsifier. Emulsifiers can dissolve in both oil and water, creating micelles. These micelles can be made small enough that the natural tendency of oil and water to separate can be overcome. In butter, proteins and glyceride molecules serve as the natural emulsifiers, preventing the emulsion breakdown. The goal of the product developer was to simulate this food using ingredients that were readily available, even during wartime.

The soybean provides almost all of the ingredients used in the production of margarine. Soybean oil serves as the lipid source and lecithin, a natural product extracted from the soy oil, is the principal emulsifier. The fatty acids in soybeans are very different from those found in milk, so a process known as hydrogenation was employed to change the melting point of the soybean lipids. Hydrogenation adds hydrogen atoms to the unsaturated double bonds on the fatty acids. As the fatty acids become more saturated (with hydrogen atoms) their melting point increases. By careful control of the amount of hydrogenation used, soybean oil can be made to melt very much like butter. The next step was to get the oil and water emulsion to form. By blending hydrogenated oil, water, and lecithin together in something very similar to a blender, the desired emulsion could be formed.

Unfortunately, the resulting product looked (and tasted) very much like vegetable oil shortening. By adding various colors, flavors and vitamins, margarine began to be a reasonable substitute for butter. In the early days, it was very easy to tell the difference, but as margarine development continued the product became more like butter all of the time. Since it was made from very inexpensive ingredients, and these ingredients were more consistent in composition than milk, margarine could be produced at a much lower cost than butter, contributing to its popularity. Because margarine is a completely formulated product, it is easy to make changes like "low-fat" margarine, flavored margarines and squeezable margarine, just to name a few.

### Summary

Food product development is a complex process involving many different people. However, the product always begins with an idea, which may have come from a consumer, a breakthrough in basic science, or just a mistake in the laboratory. Lots of creativity and hard work are necessary to get a food product to a national market.

Margarine is a good example of a product invented to meet a need. Margarine is a completely formulated product, replacing most of the dairy components with ingredients derived from soybeans. It is easier and cheaper to produce than butter. Many other new products have been developed from margarine because of its unique properties.

### Credits

*Food Technology*. Instructional Materials Service, College Station, TX: Texas A & M, 1990.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

Fuller, Gordon W. 1994. *New Food Product Development: From Concept to Marketplace*. CRC Press, Boca Raton, Florida.

Gaman, P.M.; K.B. Sherrington. *The Science of Food: An Introduction to Food Science, Nutrition and Microbiology*. 3rd ed. Elmsford, NY: Pergamon Press, Inc., 1990.

Graf, Ernst and Israel S. Saguy. 1991. *Food Product Development: From Concept to Marketplace*. Van Nostrand Reinhold, New York

Henry, Arba L.; Gared K. Tyson; David L. Howell. *Agricultural Products I*. Vol. 19, 5th ed. University Park, PA: Pennsylvania State University, 1978.

Hollingsworth, Pierce. 1994. The perils of product development. *Food Technology* 48(6):80-88.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

Riepma, S.F. 1970. *The Story of Margarine*. Public Affairs Press, Washington, D.C.

## Lesson 3: Milk Processing

### Quality Grades

In most states, milk is classified as Grade A raw milk, manufacturing grade, or reject. Some areas of the country classify milk as Grade A and B or C. Grade A milk must be produced in facilities that meet high standards of sanitation defined by the state health department. Grade A milk is either raw or pasteurized and is intended for fluid milk consumption or in some places for ice cream. The standard plate count of aerobic microorganisms must not exceed 100,000 or 20,000 per ml of raw or pasteurized milk, respectively. It must be pasteurized, come from a sanitary dairy, and be cooled to below 40°F. Milk producers and their milk quality are closely monitored by inspectors.

Manufacturing grade, or in some states Grade B or C, milk is produced under less stringent conditions and is used to make cheeses, butter, and dried milk.

Reject milk does not meet minimum standards for human consumption. If rejected, no grade is assigned. Milk is not easily moved from grade to grade because facilities and practices differ.

### Major Milk Products

Raw milk can be processed into fluid milk, fermented milks, cream, butter, canned milks, dried milks, cheeses, and ice cream.

Fluid milk can be whole milk, low-fat milk, nonfat milk (skim milk), and chocolate milk. Fluid milk must be made from Grade A milk only. Whole milk contains at least 3.25 percent fat. Low-fat milk can be 2 percent, 1.5 percent, 1 percent, or 0.5 percent fat. Nonfat milk contains less than 0.5 percent fat. Chocolate milk is a major product of fluid milk and may be made in any of the fat percentages listed above. Chocolate milk has liquid chocolate or cocoa and sugar added.

Any fluid milk product can be made from milk, low-fat milk, or nonfat milk and must be so labeled. For example, cultured buttermilk is made from milk (at least 3.25 percent milk fat), low-fat milk (0.5 to 2 percent milk fat), or nonfat milk (less than 0.5 percent milk fat).

Fermented milks or those that have been cultured with specific bacteria include cultured buttermilk, yogurt, and acidophilus milk. Fermented milk must be made from Grade A milk. Cultured buttermilk is skim, low-fat or whole milk that has been pasteurized, inoculated with a lactic acid-producing bacterium, and held at 72°F. Yogurt is fermented whole, low-fat or skim milk. It is fermented by *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. These microorganisms convert lactose to

## Food Science and Technology-Unit II

---

lactic acid which reduces the pH. The lowered pH reduces the solubility of casein which results in the characteristic coagulum.

Acidophilus milk is a product designed for consumers who are lactose intolerant. Much of the lactose in milk is digested by the *Lactobacillus acidophilus* bacterium; furthermore, this bacterium is able to stick to and live in the human intestine.

Creams consist of cream, half-and-half, coffee cream, whipping cream, heavy whipping cream, and sour cream. Creams must be made from Grade A milk only. Cream consists of 18 percent milk fat. Half-and-half consists of equal parts of whole milk and cream. Cream contains 18 percent and milk contains 3.25 percent milk fat, so combining them in a 1:1 ratio produces half- and-half testing  $[(18+3.25) \div 2 = 10.625$  percent fat]. This number is rounded to the nearest 0.5 percent for regulatory purposes. Whipping cream and heavy whipping cream contain at least 30 percent and 36 percent milk fat, respectively. Sour cream is pasteurized cream that has been inoculated with a lactic acid-forming and flavor-producing bacteria and incubated for a controlled length of time.

Butter is a water-in-oil emulsion made by churning cream.

Canned milks have reduced water content due to evaporation. The two types of canned milk are evaporated milk and sweetened condensed milk. Evaporated milk has had 60 percent of the water removed. The resulting product is 7.5 percent milk fat and at least 25 percent milk solids. In comparison, whole milk is 3.25 percent milk fat and 12-14 percent milk solids. The evaporated milk is homogenized before being placed in a can and is then sterilized. When evaporated milk is sterilized, the casein-whey protein complex tends to gel. The additive carrageenan is used to promote a smooth texture.

Sweetened condensed milk also has had more than half of its water removed. It differs from evaporated milk in that sucrose or glucose has been added. The added sugar serves as an antimicrobial agent, increases the viscosity of the milk, and promotes browning during heating. It also contributes toward a grainy texture. The caramel flavor is a result of heating the sweetened condensed milk during processing. Many desserts contain sweetened condensed milk.

Another major milk product is dried milk. The water content is reduced until the milk is a powder that can be stored in airtight containers at a cool temperature for long periods of time. Dried milk is usually nonfat dried milk. Nonfat dry milk is a major product made from skim milk. Much of the cream separated to make skim milk is used to make butter.

Cheese is made from pasteurized milk that has been inoculated with lactic acid-producing microorganisms (i.e. *Lactococcus lactis*). The milk sugar (lactose) is converted

to lactic acid which reduces the pH from 6.7 to 4.6. At this isoelectric point, casein clabbers (forms a soft curd). The curd is then cut, which releases the whey from the gel. To make coagulum with a higher pH the enzyme rennin is then added to the milk. Rennet splits the casein molecule into a hydrophilic glycopeptide and a hydrophobic molecule. The hydrophilic glycopeptide is removed and curd develops. The curd is cut and cooked to remove whey; then it is salted, shaped, and ripened.

A variety of textures, odors, and flavors result from ripening. Flavors result from chemical changes in the fats and proteins. Microorganisms are often added to promote these chemical changes. An example of this is in the production of Roquefort cheese. A blue mold, *Penicillium roquefortii*, is added to split certain fat molecules. Processed cheese is a combination of fresh and ripened natural cheeses with an emulsifier. The mixture is worked and cooked. Most processed cheese has a moisture level around 41 percent. Processed cheese spread has about a 45 percent moisture level.

Ice cream is a major milk product. It is a frozen mixture of cream, nonfat milk solids, sweeteners and flavorings into which air has been stirred. Ice cream must contain 10 percent milk fat, 20 percent milk solids, and no more than 0.5 percent stabilizer and 0.2 percent emulsifier. When sugar is added, the freezing and melting points decrease. Frozen custard is made by the addition of egg yolk solids to the ice cream mixture before freezing. Ice cream is labeled with descriptors when it contains less than 10 percent milk fat. These and their milk fat contents are as follows: reduced fat, 7.5 percent; light, 50 percent less fat; low fat, 3 grams of fat; fat free, less than .5 grams of fat. Sherbet contains 2-5 percent milk solids and 1-2 percent fat. In imitation ice creams part or all of the milk components are replaced with nondairy ingredients.

### **Milk By-Products**

As raw milk is processed into a variety of major products, there are some by-products that result which are quite useful. Buttermilk is the fluid removed from churning cream into butter. Most of it is dried for use in the baking industry. A by-product of cheese making, whey, is a liquid containing lactose, serum proteins, minerals, and vitamins. It is an important component in certain livestock feeds, but much of it is being used in human food today. Whey protein concentrate and isolate are two major forms of whey used in foods.

### **Taste and Composition Factors**

The taste of milk and its composition are directly related to production, handling, processing practices, and breeding. Milk may be adulterated by several different factors. Antibiotics can inhibit the growth of bacterial cultures.

Pesticides and radionuclides don't affect milk taste and only minutely change composition. Pesticides in milk can be detected by qualitative and quantitative analysis

## Food Science and Technology-Unit II

---

using chromatography. Radionuclides may contaminate milk but this usually occurs only when tests of nuclear weapons are done above ground or when an accident at a nuclear reactor releases radioactive elements. Examples of the contaminants include iodine 131, strontium 90, and barium 140.

A high somatic cell (white blood cells) count, points towards an infection in the cows udder, probably mastitis. The California Mastitis Test is used to detect high somatic cell counts in milk taken directly from the cow. A freezing point test checks for added water. Foreign material, or sediment, may contaminate the milk via the cow, equipment, or environment. A sediment test is conducted on raw milk to determine the amount of sediment.

Flavor is influenced by the age of the milk, the facilities used to process it, the temperature of the milk and rate of cooling, and certain offensive feeds in the cow's diet. The amount of milk fat also changes the milk's flavor and consistency. Facilities are unlikely to affect flavor or composition in today's milking operations.

The species and breed of animal makes a difference in milk's taste and composition. (Table 3.1). There is also a range of difference based on the animals' age, stage of lactation, season of year, feed, time of milking, physiological condition of cow (i.e. calm or excited), and length of time between milkings.

Table 3.1 - Typical Composition of the Milks of Cows

Breed	Percent in Milk				
	Water	Fat	Protein	Lactose	Ash
Guernsey	85.35	5.05	3.90	4.96	0.74
Jersey	85.47	5.05	3.78	5.00	0.70
Ayrshire	86.97	4.03	3.51	4.81	0.68
Brown Swiss	86.87	3.85	3.48	5.08	0.72
Shorthorn	87.43	3.63	3.32	4.89	0.73
Holstein	87.72	3.41	3.32	4.87	0.68

The greatest single factor governing the composition of milk is the breed of cow from which it was produced.

### Summary

Milk is quality graded based on the facilities of the producer, its bacteria and somatic cell counts, and care taken in production and processing. Milk is graded as grade A, manufacturing grade, or reject milk. The quality grade determines eligibility for use in fluid products. Milk can be processed into fluid milk, fermented milks, creams, butter, canned milks, dried milks, cheeses, and ice cream. Buttermilk and whey are important milk processing by-products. The taste and composition of milk is determined by several factors. The most important factor in composition is the breed of cow from which the milk was produced.

### Credit

Campbell and Marshall. *The Science of Providing Milk for Man*. 1st ed. New York: McGraw-Hill, 1975.

Henry, Arba L.; Jared K. Tyson; David L. Howell. *Introduction to Animal Products and Processing/Ag Products I*. Vol 19, 5th ed. University Park, PA: The Pennsylvania State University, 1978.

Milk Industry Foundation (M.I.F.). *Milk Facts*. Washington, DC: 1992.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.



## **Lesson 4: Processing Dairy Products**

Dairy products play an important role in the human diet. This lesson discusses the techniques used to process raw milk into a variety of products that can be found in the dairy case at the grocery store.

### **Processing Raw Milk**

The milk jug in your refrigerator probably contains milk from several cows. That is a result of modern processing techniques. Quality control tests are the first techniques used in processing raw milk. These tests include determination of fat and solids contents, sediment content, bacterial counts, freezing point, and milk flavor. All raw milk received at a processing plant is tested for antibiotics before the milk is pumped from the delivery truck.

The second step is separation, the process of removing fat from milk in the form of cream. Separation with a continuous centrifuge produces about 10 pounds of cream testing about 36 percent fat and 90 pounds of skim milk from each 100 pounds of milk.

The third step is standardization. Batches of milk and skim milk or cream are blended in large tanks to reach a uniform fat content. Clarification is the fourth step. Here the milk is centrifuged to remove sediment, body cells, and some bacteria.

Pasteurization is the next step aimed specifically at eliminating any disease-producing microorganism. Heating milk to 161°F for 15 seconds meets minimum pasteurization criteria. Louis Pasteur is credited with designing this technique but he did so with wine. Pasteurization effectively destroys the tuberculosis bacterium.

Modern food science helped develop step six, which is homogenization. Fat globules in fluid milk naturally clump together and rise to the top. Homogenization subdivides the fat globules so they will no longer separate and rise to the top.

In the United States, fluid milk is generally fortified with vitamin D. This is step seven. Following fortification, the milk is cooled and finally packaged.

### **Why Pasteurization and Homogenization?**

In 1871 Louis Pasteur proved that heating to a critical temperature destroyed the spoilage microbes in a liquid. Other scientists have shown what the temperature must be for different lengths of time in order to kill specific disease-producing (pathogenic) bacteria and viruses in milk and its products. The milk industry applies the concept to milk processing. Pasteurization is necessary to rid milk of any disease-producing microorganism and to reduce the total bacterial numbers for improved shelf life. Lipase and other natural enzymes are destroyed by this process which proved to be the breakthrough in preventing the spread of tuberculosis. The batch method is designed

## Food Science and Technology-Unit II

---

to heat each milk particle to 145°F for 30 minutes. The high temperature, short-time method (HTST) heats every particle to at least 161°F for 15 seconds. The HTST method has largely replaced the batch method. Pasteurized milk is not sterile, so it must be refrigerated.

Homogenization is the reason why every glass of milk from a milk jug is consistent in flavor and texture. In the homogenization process, milk is pressure pumped to subdivide its fat globules. The fat globules are divided into very small globules and this prevents them from rising to the top and forming a cream layer. Milk that has undergone homogenization, which is not necessary for health reasons, is richer in taste and whiter in appearance than unhomogenized milk.

### Processing Major Dairy Products

The milk processing industry stands as one of the largest segments in the food science area. A growing number of products result from research efforts in this field. Fifteen major products are discussed in this lesson.

Whole milk has a minimum milk fat level of 3.25 percent. It is pasteurized, homogenized, fortified with vitamin D, and packaged. Vitamin D is added because the diets of many children in the U.S. are deficient in Vitamin D.

Low-fat milk has its milk fat level standardized to 0.5 percent, 1 percent, 1.5 percent, or 2 percent, and is fortified with vitamins A & D, pasteurized, homogenized, and packaged. Vitamins A and D are fat-soluble vitamins. This means that as the milk fat is removed, so are these vitamins. Therefore, low fat milk must be fortified with them.

Non-fat milk (also called skim milk) has its milk fat level reduced to below 0.5 percent, is fortified with vitamins A & D, and is pasteurized, homogenized, and packaged.

Chocolate milk can be made from whole, low-fat, or nonfat milk that is mixed with chocolate syrup or cocoa powder and sugar.

Cultured buttermilk is skim, low-fat, or whole milk that is heated to 185°F for 30 minutes and then inoculated with lactic acid-producing bacteria and held at 72°F until the pH drops to about 4.5. Then it is cooled. This controlled environment allows the pH, flavor, and texture to be modified.

Yogurt is another product that can be made when appropriate microorganisms are allowed to ferment at about 110°F. *Streptococcus thermophilus*, and *Lactobacillus bulgaricus* are used to inoculate whole, low-fat or skim milk. The pH is lowered as lactose is converted to lactic acid, and casein (milk protein) coagulates and forms the thick texture of yogurt.

Acidophilus milk is fermented whole milk. Milk is fermented by adding *Lactobacillus acidophilus* bacteria. These bacteria digest the lactose in the milk, making it possible for lactose-intolerant people to drink this milk. Sweet acidophilus milk contains the same bacteria but is not fermented.

Cream (high in milk fat) is separated from the raw milk with a centrifuge. After it rises to the top, it is skimmed off (Quiescent method). It is then pasteurized and processed into a variety of fat-content creams, such as whipping cream, coffee cream, half-and-half, sour cream, or heavy whipping cream.

Sour cream, as previously mentioned, begins as cream that has been separated from raw milk. This cream is pasteurized and cultured with lactic acid-producing and flavor-producing bacteria. Sour cream is 18 percent fat whereas half-and-half is 10.5 percent fat.

Butter is produced by churning (agitating) sweet or sour cream. In the U.S., sweet cream is the preferred type. The cream must be churned sufficiently to break the oil-in-water emulsion of cream and form a water-in-oil emulsion. The butter is washed with cold water and then worked to reduce the water content to around 15 percent. Butter is at least 80 percent fat. Salt may be added to enhance the flavor and color may be added to reach the desired yellow color.

Canned milk has had 60 percent of the water evaporated before it is homogenized. The concentrated milk is at least 7.5 percent milk fat and 25 percent milk solids. This viscous milk is canned and sterilized at 240°F for 15 minutes. An additive, carrageenan gum, is used to give it a smooth texture. Sweetened, condensed milk is canned with sugar added.

Nonfat dried milk is skim milk that has been dehydrated so that it can be stored for long periods of time at room temperature. Growth of microbes is prevented due to the low moisture content. It may be reconstituted before use or used in the dried state. Instant nonfat dry milk has been wetted and redried to increase its ability to be dispersed and dissolved in water.

Ice cream is a frozen mixture of cream, milk solids, sugar, and flavorings into which air is stirred as the mixture is frozen. Ice cream is 10 percent milk fat which accounts for its smoothness of texture and richness of flavor. The milk is heated to 140°F and then sugar, an emulsifier, a stabilizer, and flavorings are added. This mixture is pasteurized, homogenized, and slightly aged. Then it is frozen to 20°F while air is whipped into the cream. It is now ready for packaging. Frozen custard differs in that egg yolks are added to the mixture. New labeling will replace ice milk with reduced fat, light, low-fat, and nonfat ice creams. Sherbet has 1-2 percent milk fat and only 2-5 percent total milk solids.

Natural cheese is made from pasteurized milk that has the added enzyme rennin, which helps clot the milk. Bacteria convert lactose to lactic acid and the pH drops from 6.7 to as low as 4.6. A soft curd develops. This curd is cut to release the whey, which is a watery liquid that contains lactose, serum proteins, minerals, and water-soluble B vitamins. The riboflavin in it gives it the yellow-green color. The curd is then heated, pressed down to 40 percent water, salted, shaped, and ripened. Ripening alters the texture, odor, and flavor. Two of several cheeses that are not ripened are cottage cheese and cream cheese.

Processed cheese is a mixture of different kinds of natural cheeses that have been mixed and ground together and then melted to a uniform product with the aid of emulsifiers. Processed cheeses contain about 1 percent more moisture than the natural cheese from which they are made, which forms an easier spreading product. Additional moisture is permitted in processed cheese food and even more in processed cheese spread.

### **Packaging**

Milk and dairy products should be packaged for protection and convenience. A fundamental reason for packaging is that mold and bacterial contamination are prevented with proper packaging. Shelf-life and freshness increase with a sealed package. Riboflavin (vitamin B<sub>2</sub>), thiamine, vitamin A, and vitamin C in fluid milk are light sensitive. Opaque or other appropriate packaging is useful in reducing the breakdown of these vitamins when containers are exposed to sunlight or ultraviolet light. Dried whole milk is packaged under nitrogen, so the packaging material must be impermeable to oxygen.

### **Industry Organization**

Today's dairy industry is composed largely of individual producers who belong to milk cooperatives. The cooperative pools the milk and processes it or sells it to proprietary (private) processors. Separate processing plants for cheese and ice cream production are the norm. Coops generally belong to the National Milk Producers Federation whereas processing firms belong to the International Dairy Foods Association (IDFA). These organizations conduct research and do educational, promotional, regulatory, legislative, and training activities for their members as well as the general public. California, Wisconsin, New York, Pennsylvania, and Minnesota rank as the top five milk producing states.

### Summary

Milk is nature's most complete food nutritionally. It is rich in calcium, phosphorus, water-soluble vitamins, protein, and carbohydrates. Before it arrives at the grocery store, milk is tested, standardized, clarified, pasteurized, homogenized, fortified, cooled, and packaged. Pasteurization rids milk of pathogens, and homogenization improves its drinking quality. Milk is processed into numerous products using multiple techniques. Milk products are fresher and store longer if they are properly packaged. The dairy industry is composed of individuals, cooperatives, and national organizations that work toward providing quality dairy products for American consumers.

### Credits

Campbell and Marshall. *The Science of Providing Milk for Man*. 1st ed. New York: McGraw-Hill, 1975.

McWilliams, Margaret. *Foods Experimental Perspectives*. 1st ed. New York: Macmillan Publishing Co., 1989.

Milk Industry Foundation (M.I.F.). *Milk Facts*. Washington, DC: 1992.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

## **Lesson 5: Processing Egg Products**

Eggs are one of the few foods that are popular in almost every culture. They have been a part of the human diet since the dawn of recorded history. In the United States, eggs play an important role in breakfast and baking and are responsible for employment of thousands of people. The consumption of eggs in the U.S. has declined since 1951, when the average person consumed 387 eggs a year.

### **Egg Products**

Eggs are useful in a variety of ways. About 80 percent of all eggs produced are retailed as shell eggs. Another egg product is refrigerated liquid eggs. These eggs are broken, and separated if necessary, by machines. The liquid product is usually pasteurized to kill *Salmonella* and other microorganisms prior to being packaged. They may be shipped to bakeries or to other plants for further processing. Under refrigerated conditions, 40°F or below, liquid eggs have a shelf life of 10 days. Liquid egg may be frozen for greater shelf life. Egg blends with sugar, corn syrup, or salt added are available for special uses. Another egg product is dried eggs. These may also be called egg solids. World War II created a huge demand for dried eggs. Current demand for dried eggs comes from production of convenience foods as well as the food service industry. Specialty products include pre-peeled hard-boiled eggs, frozen omelets, egg patties, and quiches.

### **Quality Characteristics**

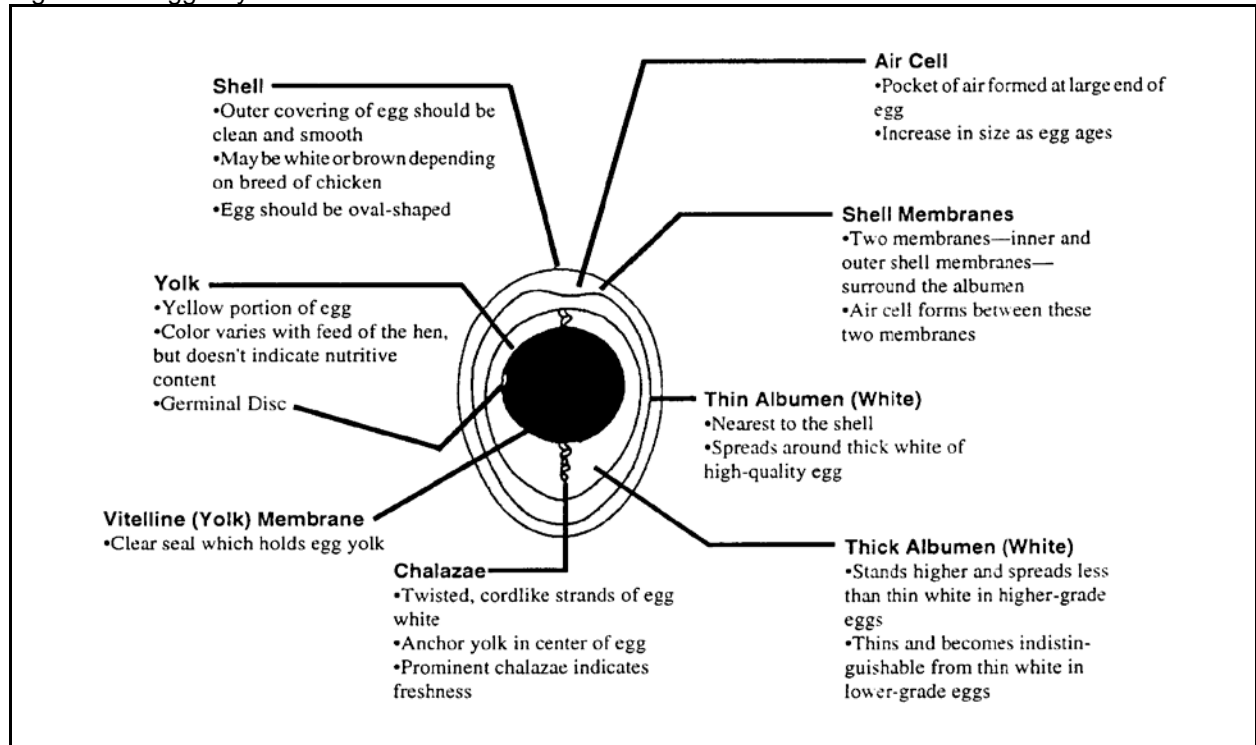
Egg quality is based on exterior and interior characteristics. The egg's exterior, or shell, should be clean and have a smooth texture. The shell is checked for soundness (i.e., the presence of any cracks). The egg should be oval-shaped with one end larger than the other. Misshapen eggs are generally used for the production of liquid egg products.

The interior quality of an egg is determined by candling. Candling allows the grader to look inside the egg without breaking it. Years ago this was done by holding the egg up to a candle, hence the name. Today, high intensity lights reveal the interior of each egg as it passes on rollers. Inspectors, sometimes called candlers, determine air cell depth, the clarity of the albumen, and the size, shape, and color of the egg yolk. New machines are being invented to automate the candling process. If the egg contains a blood spot, it is revealed during candling and the egg is discarded. Figure 5.1 details the physical structure of an egg.

Another means for determining interior egg quality is the breakout method. Sample eggs are selected at random and broken out on a level surface. The height of the albumen (egg white) is measured with a micrometer. The highest quality eggs will

stand up tall and have a firm yolk. Also, the surface area covered by the albumen is small in high quality eggs.

Figure 5.1 - Egg Physical Structure



### Quality Influences

Egg quality can be influenced by several factors. The equipment and method used to handle a freshly laid egg can affect internal and external qualities. Rough handling can result in shell breakage. Vibration of an egg can result in a thinner albumen or a free air cell. The type of animal housing often determines the method of handling as well as the frequency of egg collection. Proper temperature, humidity, and lighting in the facility affects egg quality.

The hen's diet is another factor that influences egg quality. Shell strength is determined by the presence of adequate amounts of vitamin D, calcium, and other minerals. A lack of vitamin A can result in blood spots. Maximum egg size requires an adequate amount of protein and essential fatty acids in the ration. Yolk color is influenced by the amount of xanthophylls, or yellow-orange plant pigments, in the diet. A ration of yellow corn and alfalfa meal will result in a yellow yolk while a wheat based ration will produce a lighter colored yolk. Often, producers will include dried marigold petals in the ration to increase the yellow color of the yolk. While important, yolk color is not the only factor considered when determining egg quality.

Egg shell thickness is an important characteristic in quality eggs. Research suggests that the greater number of eggs a hen lays, the thinner the shell. Because some breeds produce more eggs per year than others, the breed of hen influences quality. As a hen ages, her egg size increases which demands the same amount of shell material to be stretched to cover the larger egg. This results in thinner shells. The status of a hen's reproductive tract influences the formation of blood spots. Blood spots, also called meat spots, result from a ruptured vessel on the surface of the yolk during ovulation (the release of the yolk into the oviduct).

Egg quality is influenced by the age of the egg. Prompt gathering, washing, oiling, and cooling to 45°F or below are essential to maintain freshness and to prevent growth of salmonellae bacteria that may be deposited inside the egg by infected hens, a condition known as transovarian salmonella. Oiling the process where a film of odorless, tasteless mineral oil that is sprayed on shell eggs after washing and before cartonning. It replaces the natural cuticle, known as the bloom, that is removed during washing. Genetics also plays a role in egg quality; certain egg defects can be traced to specific genetic lines of hens.

### **Egg Grading**

The Egg Products Inspection Act of 1970 provides for USDA grading of all eggs carrying the official grade shield. Based on interior and exterior quality, eggs are graded by USDA graders and are designated AA, A, or B. All eggs must be clean and have sound shells. Grade AA and A eggs must be oval shaped. Abnormal shell shape or faulty texture are permitted under B quality. The albumen is judged on the basis of clarity and firmness. Grade AA eggs when broken out stand up tall, have a firm yolk, and have a large proportion of thick albumen. Grade A eggs are medium in height, have a firm yolk, and have an albumen that begins to spread (flatten) out. Grade B eggs have a flat yolk and a thin albumen. Air cell depth ranges from 1/8 inch in AA grade to 3/16 inch in B grade eggs.

### **Egg Processing**

Grade AA and A eggs are regularly retailed as shell eggs. Grade B eggs and surplus Grade A eggs are processed into egg products. These include refrigerated liquid, frozen, dried, and specialty products. Convenience foods such as cake and pudding mixes, pasta, mayonnaise, and bakery goods utilize egg products. The food service industry often prefers egg products to shell eggs because of convenience, uniformity, and stability. All egg products are USDA inspected and pasteurized. Pasteurized egg products are preferred because they have been treated to kill salmonellae bacteria, pathogens common in the hen and her environment.



### Egg Size

Egg size is not related to quality grades. Eggs are sized based on the number of ounces per dozen. They are shown in Figure 5.2.

Figure 5.2 - Egg Size

<u>Egg Size</u>	<u>Ounce per Dozen</u>
Jumbo	30
Extra Large	27
Large	24
Medium	21
Small	18
Peewee	15

### Egg Processing Industry

The egg production/processing industry in the United States is vertically integrated, which refers to the business structure in which the company that owns the processing plant may also own the feed company and the birds.

Producers contract with large companies to produce the eggs, while the companies supply the birds, feed, and fuel. The producer usually provides the housing and the labor. Often the contract producer receives a graduated fee that reflects bird performance and management skills.

Egg production is the greatest in the Southeast portion of the United States. Production is also concentrated near population centers such as California and Pennsylvania.

### Summary

Eggs are a wonderful source of protein and can be used to make hundreds of foods. Whether they are in the shell, liquid, frozen, salted, or sugared, eggs undergo exterior and interior inspections. Egg quality is influenced by a variety of factors ranging from the hen's diet to the facilities where the hen's lay eggs. The USDA grades eggs AA, A, and B based on interior and exterior factors. Eggs are sized according to weight per dozen. The egg production/processing industry is a vertically integrated industry.

### Credits

Cotterill, Owen J.; William J. Stadelman. *Egg Science and Technology*. 2nd ed. Westport, CT: AVI Publishing Co., Inc., 1977.

*Eggyclopedia*. 2nd ed. Park Ridge, IL: American Egg Board, 1989.

Minnesota Turkey Research and Promotion Council *The Turkey Foodservice Manual*. 1st ed. St. Paul, 1987.

Parkhurst, Carmen R.; George J. Mountney. *Poultry Meat and Egg Production*. 1st ed. New York: AVI, Van Nostrand Reinhold Co., 1988.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

## **Lesson 6: Products and By-Products From Meat Animals**

The meat processing industry is one of the largest employers in the diverse field of agriculture. This lesson examines the products and the by-products of meat processing.

### **Major Meat Animals**

Our meat supply originates from five major meat animal species. Beef and veal are products of cattle. Pork is a product of swine. Sheep produce lamb and mutton. Poultry is from chicken or turkey. Fish and shellfish are another major meat source.

### **Fresh Meat Products**

Fresh meat products are classified as either primal (wholesale) or subprimal (retail). Primal cuts are large regions of the carcass whereas subprimal cuts are cut to portion size, much like what you would find in the grocery store. Beef, pork, and lamb carcasses are divided into four primal cuts. They are: chuck/shoulder, rib, loin, round/ham/leg. Primal cuts of poultry consist of a whole fryer or turkey. Whole fish and fish fillets are primal cuts.

Subprimal cuts for beef, pork and lamb include shoulder/chuck blade, shoulder/chuck arm, breast, rib, leg/round, short loin, and sirloin. Figures 6.1, 6.2, 6.3, and 6.4 further detail the various subprimal cuts of beef, veal, pork, and lamb. Poultry subprimal cuts include half/quarter portions, breasts, and boneless strips. Fish may be retail cut into sticks, squares, or fillets.

### **Processed Meat Products**

Historical evidence suggests that the Babylonians made and ate sausage some 3,500 years ago, and that the ancient Chinese also made sausage. Sausages frequently took the name of their town of origin: bologna from Bologna, Italy; frankfurters from Frankfurt, Germany; and Vienna sausage from Vienna, Austria. Immigrants to the U.S. continued to make sausage to satisfy their ethnic tastes which has led to more than 200 different varieties in America's processed meat industry.

Processed meat products are popular today due to their long shelf life, convenience, low waste, and controlled portion size. Processed meat also provides variety in the diet. Approximately 35 percent of beef, veal, pork, and lamb produced in the U.S. is processed. Of this, 75 percent is pork. Examples of processed meat products include sausages, cured whole muscle cuts, restructured, and breaded. Sausages are classified as follows: fresh, uncooked and smoked (kielbasa), cooked (braunschweiger, liverwurst), cooked and smoked (bologna, frankfurters), dry and/or semi-dry (pepperoni), fermented (summer sausage, salami), and loaves (pickle loaf, Vienna sausage loaf). Cured whole muscles include hams, corned beef brisket, bacon, pastrami,

## **Food Science and Technology-Unit II**

---

and pork shoulder. Restructured processed meats include boneless hams and smoked/sliced beef. Restructured products are similar to sausage but are formed to look and taste like whole muscle products. Fish sticks and chicken patties are examples of breaded processed meats.

### **Meat By-products**

"We use all parts of the pig except the squeal and the curl in its tail." You may have heard this expression. The by-product industry is an integral part of meat animal processing, both historically and today.

Meat by-products (offal) are classified as either edible or non-edible. Edible by-products include liver, heart, tongue, brain, sweetbread, tripe, oxtail, chitterlings, mountain oysters, and lard.

Inedible by-products include a myriad of examples and uses. Table 6.1 details these inedible by-products.

### **Summary**

Our meat supply chiefly comes from cattle, swine, sheep, chickens, turkeys, fish, and shellfish. The meat is processed first into primal cuts, consisting of the chuck, rib, loin, and round region along with whole carcasses and fillets. Subprimal (retail) cuts are usually smaller in portion than primal cuts and are therefore more numerous.

Processed meat products are attractive to today's consumer due to their ease of preparation, controlled portions, shelf life, and low waste.

About 35 percent of our meat supply is marketed as processed meat. Processed meats range from whole muscle cuts to restructured, breaded and sausage types. Most processed meat is in the form of sausage. Meat by-products (offal) are an integral part of the processing industry. Edible and non-edible by-products are useful as food, feed, pharmaceuticals, clothing, and household supplies.

### **Credits**

*Exploring Meat and Health*. Chicago: National Live Stock and Meat Board, 1991.

Forrest, Aberle, Hedrick, Judge, Merkel. *Principles of Meat Science*. 1st ed. San Francisco, CA: W.H. Freeman and Co., 1975.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

*Inside Research*. Vol 2, 1st ed. Chicago: National Live Stock and Meat Board, 1992.

Jelen, Panel. *Introduction to Food Processing*. 1st ed. Reston, VA: Prentice-Hall, 1985.

*Lessons on Meat*. Chicago: National Live Stock and Meat Board, 1991.

Minnesota Turkey Research and Promotion Council. *The Turkey Foodservice Manual*. 1st ed. St. Paul, 1987.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

Romans, Jones, Costello, Carlson, Ziegler. *The Meat We Eat*. 12th ed. Danville, IL: Interstate Printers and Publishers, 1985.

Figure 6.1 - Beef

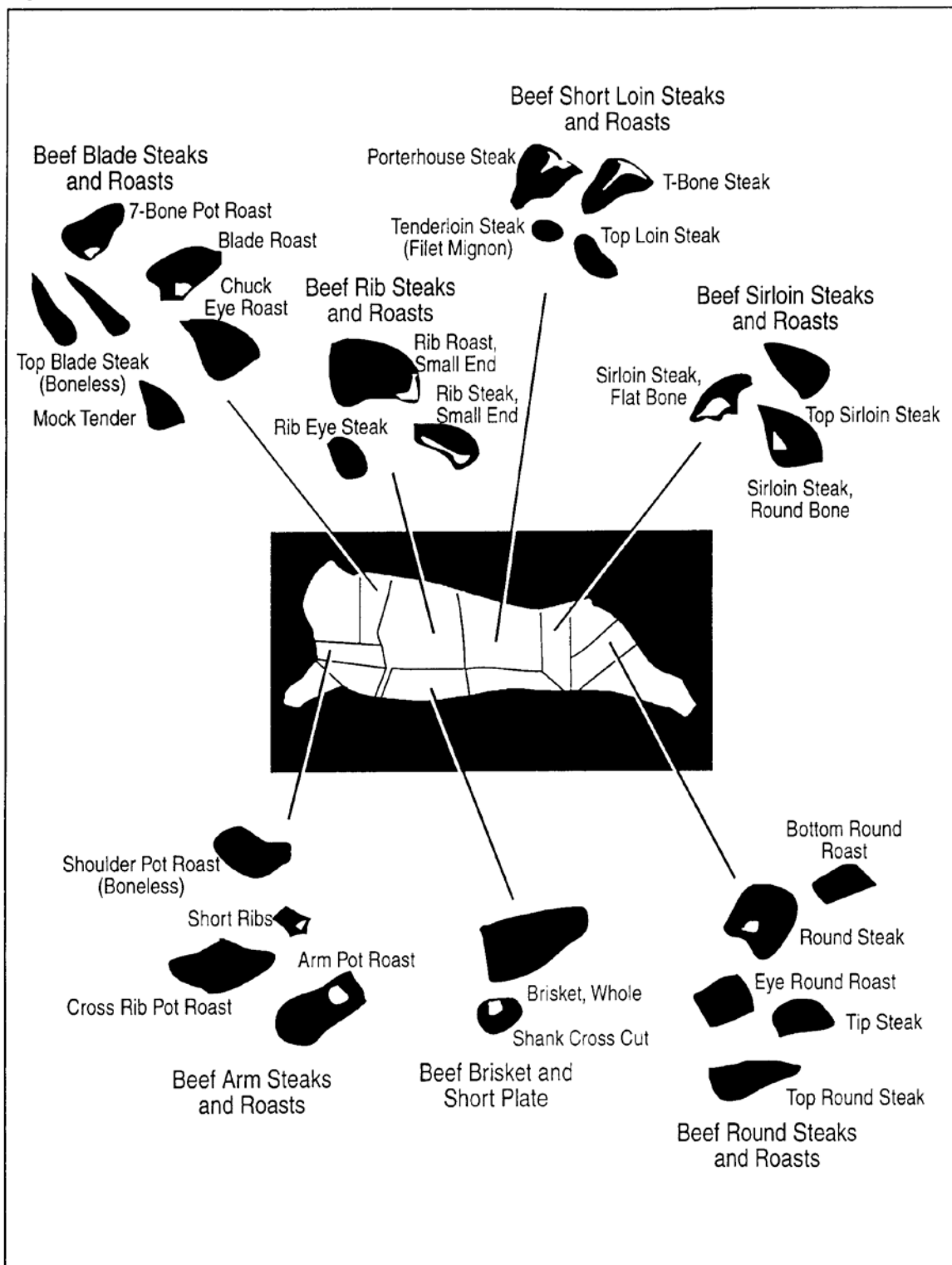


Figure 6.2 - Veal

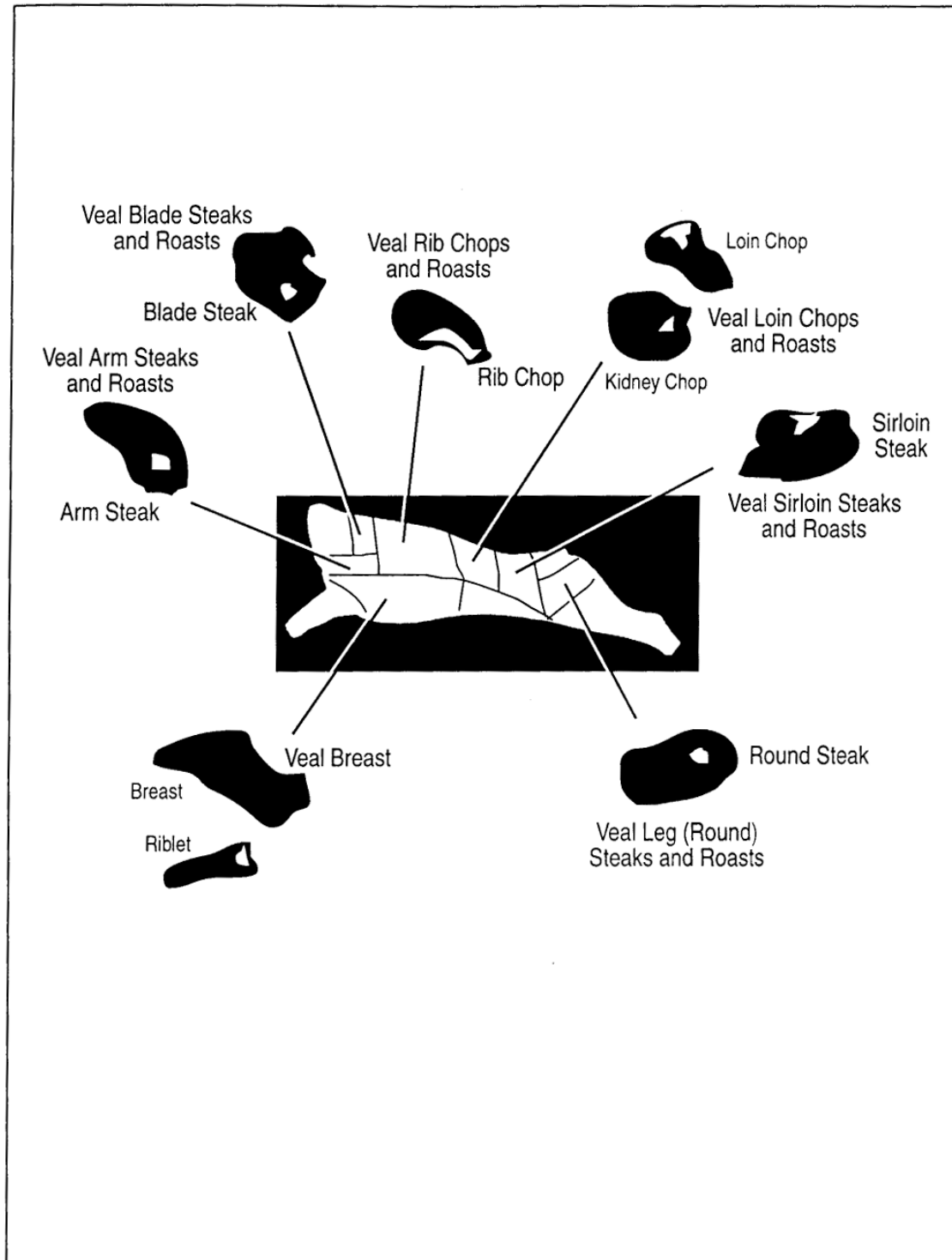


Figure 6.3 - Pork

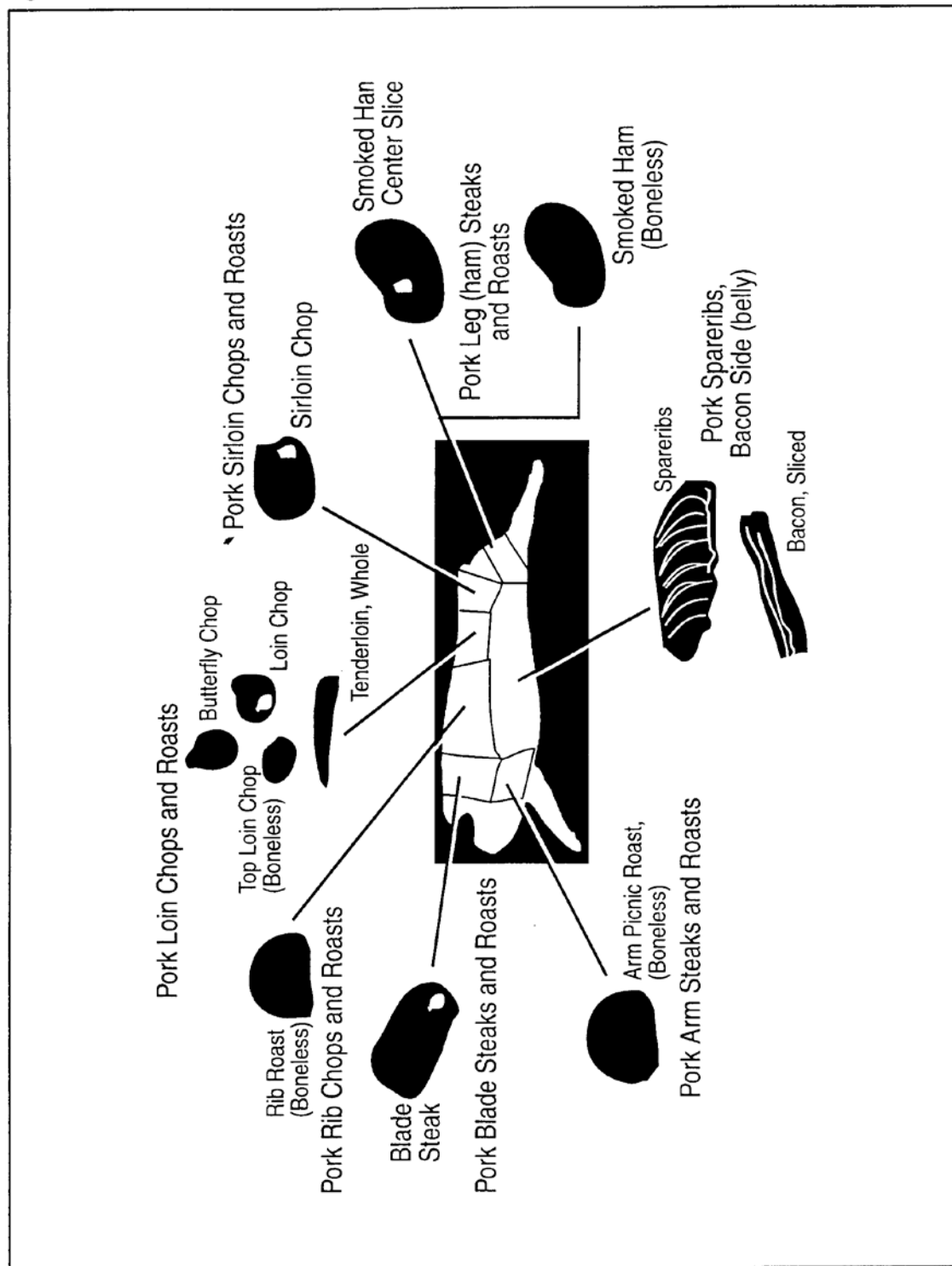




Figure 6.4 - Lamb

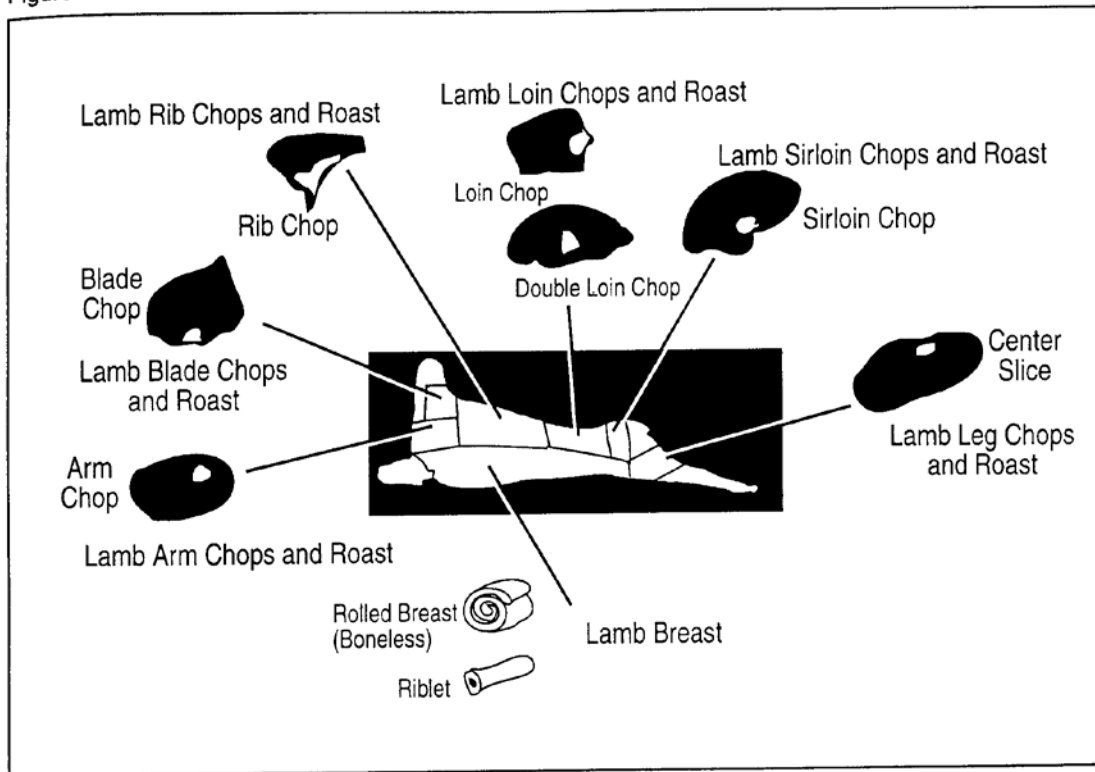


Table 6.1 - Animal By-Products

By-product	Used for
fats	soap, animal feeds, oils, fatty acids
tankage	soft tissue processed in a wet-rendering system used for protein, Ca, P source in feed
bone meal	used for protein, Ca, P source in feed
feather meal	used for protein, Ca, P source in feed
blood meal	used for protein, Ca, P source in feed
fish meal	protein source
hides and pelts	clothing, leather
adrenals	epinephrine*, corticosteroids*
blood	plasmin*, thrombin*, fertilizer, hair conditioner
brain	vitamin D <sub>3</sub> *, thromboplastin*
gall bladder	cortisone*, chenodeoxycholic acid*
intestines	heparin* and casings
pancreas	insulin*
ovaries	estrogen*, progesterone*
parathyroid	hormones*, proteases*
pineal gland	melatonin*
pituitary gland	prolactin*, adrenocorticotrophic hormone*, growth hormones*
skin	gelatin, glue
spleen	splenin fluid* (affects capillary permeability)
stomach	antacids
thyroid	thyroxin*
feathers	pillows
hair	brushes, upholstering
bones	dice, crochet needles, buttons

\*pharmaceuticals

## Lesson 7: Processing Meat Animals

By the beginning of the 20th century, meat packing was the nation's largest industry. Its one billion dollar annual sales exceeded the total yearly budget of the U.S. government! The refrigerated railroad car had quickly changed the focus of livestock producers from producing animals excelling in stamina to animals bred for carcass quality. By 1880, the U.S. was exporting beef to England, which had long claimed to have the world's best beef. Gustavus Swift, a meat packer from Chicago, established the first refrigerated railroad car service. Soon to follow was Philip Armour, another Chicago meat packer. These men helped convert meat processing into a mechanized industry. Chicago had the reputation as the hog butchering capital of the world.

### Steps in Processing Meat Animals

Modern processing techniques are quite different than those used in the early 1900s, yet the multi-step agenda remains. Depending on the meat species being processed, the steps may vary.

Immobilization is the first step in processing a meat animal. Usually the animal is stunned with either a rod (mechanical), CO<sub>2</sub> (chemical), or an electrode (electrical). Once the animal is stunned, it is stuck with a sharp knife, severing its carotid arteries and jugular vein. A good stick can remove up to 50 percent of the animal's total blood. The process is called exsanguination. It is important to bleed all meat animals thoroughly and quickly. Immediately following death, the heart continues to pump and will do a thorough job of removing the blood.

The Kosher method of exsanguination is performed by a rabbi or shohet. The animal is restrained without stunning it and cut across the throat in a single stroke. This process requires much skill. It is considered by some religious groups to be more humane than the more commonly used stunning procedures.

Rigor mortis (stiff death in Latin) is an essential process in the conversion of live muscle to meat. After death, the biochemistry of muscle tissue changes. The muscle will use up energy (from glycogen - a complex carbohydrate found in animal tissue). However, since the blood is no longer flowing to remove the by-products of metabolism, lactic acid builds up in the muscle. This reduces the pH, causing a complex series of reactions that results in the contraction of the muscle fibers. This contraction makes the muscle feel hard or stiff, thus the name rigor mortis.

After more time, the muscle fibers will begin to relax. The relaxation of muscle post-rigor is sometimes called the resolution of rigor. This process is greatly influenced by temperature, being faster at higher temperatures. If you read murder mysteries, you may have noticed the coroner using body temperature and the state of rigor to help fix

the victim's time of death. In processing meats, the time and temperature during rigor are carefully controlled to maximize tenderness. This part of the process is sometimes called aging. In France, the aging process is manipulated to achieve maximum tenderness. The meat becomes almost spoiled by U.S. standards. This process is known as mortification and produces highly prized (and very expensive) meat products.

Beef cattle are immobilized. Immobilization may be by an electrical jolt, which speeds the rigor mortis process and tenderizes the meat. Rodding the weasand is the next step. This procedure separates the esophagus from the trachea and allows the abdominal cavity organs to be pulled out separately from the thoracic cavity organs. Removing the head and neck hide, or heading, is the next step. This precedes shanking, or removal of the foreshanks and rear shanks. Siding, or skinning, follows shanking. Finally, evisceration, or removal of the abdominal and thoracic viscera, precedes splitting the carcass into halves. The carcass is now ready for refrigeration, inspection, and grading.

Hogs are immobilized, stunned and stuck, and then scaled or skinned. Scalding in 141°F-145°F water permits removal of the hair. Heating at this temperature causes the protein in the hair follicles to denature, thus loosening the hair. Removal of hair and scurf (the pigmented epidermal layer) follows. "Polishers" are mechanical devices used to remove the hair in a scraping fashion. The toenails are removed along with the skin and hair on all four feet. If the hog's head is to be used for human consumption, its inner ears must be removed. This eliminates dirt and wax. The head is removed, followed by evisceration, splitting, inspection, refrigeration, and grading.

Following immobilization, stunning, and exsanguination, lambs are pelted (skinned). It is during pelting that lamb carcasses are differentiated from mutton. The front foot is removed at the "break joint", or at the swelling at the lower part of the lamb's cannon bone. In sheep older than about 15 months, this joint is ossified, and the foot is removed at a slightly lower point called the spool joint. After pelting, the head is removed. The esophagus and trachea are separated just before evisceration. The carcass is then ready for refrigeration, inspection, and grading.

Chickens and turkeys are immobilized and stuck to remove the blood. Following bleeding, birds are defeathered. If they are scalded, the carcass is dipped into 150°F-160°F water for only a short period to avoid cooking the skin. The hot water denatures proteins of the feather follicles; this loosens the feathers. If the bird is to be dry-picked, a knife blade must be inserted into the cleft in the roof of the mouth and forced through to the rear lobe of the brain. This process relaxes the feather muscles. This relaxed condition only lasts for 2-3 minutes before rigor mortis begins so feathers must be removed quickly in this process. Following defeathering, the carcass is chilled to 32°F-36°F. The final steps are evisceration and grading.

Most fresh water fish have their heads removed behind their gills. Then, the scales and the tail fin are removed. The entrails are removed by cutting from the anus to the headless area. The body cavity should be thoroughly rinsed and the product chilled.

### Processing Fresh Meat Products

Following the slaughtering process, most carcasses undergo further processing before they reach the consumer. The first technique used is carcass size reduction. Beef carcasses are split in half then quartered between the 12th and 13th ribs.

Approximately 52 percent of a beef carcass, by weight, is in the forequarters with the balance in the rear quarters. Veal is processed into fore and rear saddles or halves. Almost all of today's beef is sold as boxed. Pork carcasses generally undergo processing to subprimal cuts prior to leaving the slaughtering facility. Lambs, in contrast, are usually shipped whole. Poultry carcasses are shipped either whole or pre-cut. Shellfish are usually shipped whole while fish may be shipped whole or portioned (fillets).

Following carcass size reduction, fabrication of the primal cuts takes place. Examples would be the removal of the relatively low value vertebrae from the whole rib or possibly deboning the entire rib primal cut. Subprimal fabrication is the third step. Here primal cuts are transformed into roasts, steaks/chops, and ground meat. Steaks are generally portions of muscle cut 3/4"-1" thick. Roasts are cut with a thickness of at least 2". Ground meat is free of bones, cartilage, and other heavy connective tissue. Ground meat must be 70 percent lean. Some primal and subprimal cuts undergo deboning, for example, a boneless chuck roast or a fish fillet. Patty production is conversion of boneless meat into uniform, ready to cook patties. Another processing technique involves shelf-life extension. Methods include freezing, heat pasteurization, heat sterilization, curing and smoking, dehydration, irradiation, and, the most popular method, refrigeration.

Tenderization, or improving the meat's tenderness, can be accomplished with either mechanical or enzymatic methods. Mechanical tenderizers pass a bank of needles through the muscle to sever connective tissue and muscle fibers. Enzymatic tenderization uses tropical plant (e.g., papaya, pineapple, fig) enzymes to degrade connective tissue.

Control of composition by restructuring is another processing technique used in the food industry. Restructured meats are those that have been ground, flaked, or chopped and formed into steak/chop or roast-like products. Through restructuring, the percent lean, water content, etc., can be carefully controlled.

Finally, portion control or product sizing is a processing technique used for fresh meat products.

### Meat Quality Factors

Various factors affect meat quality. Factors can be production-related, be inherited, or occur during processing.

Production-related factors include: age of animal, health and nutrition of the live animal, and how it is sorted and hauled. As animals get older, their muscles have walked many miles and carried heavy loads, thus reducing their tenderness when consumed. Young animals are, therefore, more desirable in terms of meat tenderness.

Obviously, it takes a healthy animal to produce a healthy carcass. When animals are sick, their bodies draw energy, chiefly fat, from their muscles. The influence of diet on the physical properties of muscle is of minor importance, so long as there are no serious nutritional deficiencies.

Sorting and hauling can have substantial effects on a meat animal. If improperly done, bruising and/or stress may result. Stress on an animal just prior to slaughter can have a dramatic effect on carcass quality. Stressed animals have higher temperatures, lower muscle pH levels due to lactic acid build-up, and early onset of rigor mortis. This can cause muscle tissue to be pale in color, soft in texture, and excessively wet. This condition is called pale, soft, and exudative (PSE). Animals that have survived a stressful period but have not had sufficient time to recover may have dark meat. This is because of a glycogen deficiency in the muscle tissue. As stress increases, lactic acid increases and pH values decrease.

Research indicates that the physical properties of muscle are at least moderately heritable. In beef cattle, heredity is likely to influence tenderness by 60 percent color and firmness by only 30 percent. Heredity influences tenderness by 30 percent, marbling by 25 percent and color and firmness by 30 percent in swine.

Processing-related factors include: sanitation of the processing plant, efficient immobilization and exsanguination, postmortem temperature, postmortem handling, processing sanitation, water holding capacity, and color control.

Certainly, to avoid contamination, consumers expect processing plants to have sufficient sanitation practices. These include proper cleaning/disinfecting of equipment or personnel, absence of cross contamination between offal and carcass, absence of rodents, etc.

Efficient immobilization and exsanguination are important to avoid unnecessary stress. Immobilization should be followed immediately by rapid bleeding to prevent the animal from regaining consciousness and to allow the heart to aid in the bleeding process.

Low postmortem temperatures inhibit microbial growth. Postmortem handling, specifically carcass suspension and prerigor processing, can affect carcass quality. If a carcass is suspended by the achilles tendon, the psoas (tenderloin muscle) is placed under a maximum amount of tension. Consequently, it is extremely tender when compared to muscles allowed to shorten freely during rigor mortis. When a carcass is suspended from the pelvis, the tension is increased in round and loin muscles making them more tender.

The interval of time between slaughter and meat grinding can affect physical properties of the finished product. To maximize the juiciness and water binding properties of sausage, the meat should be ground before onset of rigor mortis. To ensure a moist cut of meat and a higher water holding capacity, surface area must be properly covered and/or packaged. Processors desire to retain the brightest meat color to meet consumer expectations. Whenever meat tissue lacks oxygen contact, like the portion permitted to remain in contact with the surface of a pan, it discolors to a dark red. Meat cutters must ensure proper oxygen contact with meat. They must also be careful to ensure that improper lighting or over-exposure to oxygen does not occur because these, too, can discolor the meat.

### **Meat Industry**

The meat industry represents producers, packers, processors, retailers, and food service operators. In a vertically integrated industry, the packers not only process the meat animals but they also raise the animals and often mill the feed they eat. Whereas with an independent structure, the packer purchases the meat animals from the producer.

The poultry industry in the United States is almost totally vertically integrated. The company that owns the processing plant owns the birds and may also own the feed company. Producers contract with large companies to produce the chickens, while the companies supply the chicks and feed. The producer usually provides the housing, utilities, and the labor. Often the contract producer receives a graduated fee plus a bonus that reflects bird performance and management skills.

Only about five percent of the pork industry is vertically integrated. Usually, lamb and beef processors are independent from producers.

The National Live Stock and Meat Board represents beef, pork, and lamb producers, packers, processors, and retailers. The National Broiler Council and the National Turkey Federation represent the poultry industry in terms of research, education, and promotion.

### Summary

The United States has a rich history in meat packing, dating back to the late 19th century. Meat processing, then and now, is a multi-step process beginning with immobilization and exsanguination. Skinning, evisceration, and cutting are processing techniques used on meat animals. Most of today's beef and pork are processed into primal cuts and placed in a box for transport. Further carcass processing/ fabrication is done to prepare the meat for the consumer. Meat may be tenderized or restructured to improve its retail quality. The quality of meat depends on several production-related factors as well as heritability and processing factors. Today's meat industry is very diverse ranging from complete integration to independent producers and processors.

### Credits

*Exploring Meat and Health*. Chicago: National Live Stock and Meat Board, 1991.

Forrest, Aberle, Hedrick, Judge, Merkel. *Principles of Meat Science*. 1st ed. San Francisco, CA: W.H. Freeman and Co., 1975.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

*Inside Research*. Vol 2, 1st ed. Chicago: National Live Stock and Meat Board, 1992.

Jelen, Panel. *Introduction to Food Processing*. 1st ed. Reston, VA: Prentice-Hall, 1985.

*Lessons on Meat*. Chicago: National Live Stock and Meat Board, 1991.

Minnesota Turkey Research and Promotion Council *The Turkey Foodservice Manual*. 1st ed. St. Paul, 1987.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

Romans, Jones, Costello, Carlson, Ziegler. *The Meat We Eat*. 12th ed. Danville, IL: Interstate Printers and Publishers, 1985.



## Lesson 8: Quality Grades, Inspections, and Brand Names in the Meat Industry

What do the words prime, choice, and select, mean to you? How are carcasses graded and what do their grades mean? The answers to these questions and others are found in the following lesson.

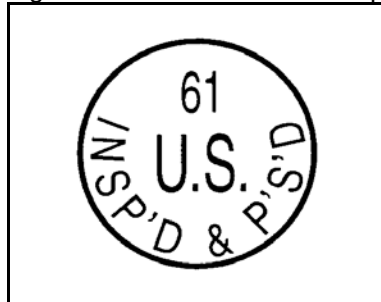
### Inspection and Grading

The Federal Meat Inspection Act of 1906 made inspection mandatory for all meat that crossed state lines. The Wholesome Meat Act of 1967 required that meat sold within a state must meet inspection requirements at least as stringent as the federal system. Federal meat inspection is the responsibility of a division of the United States Department of Agriculture (USDA) called the Food Safety and Inspection Service (FSIS). State meat inspection is the responsibility of each state government. The federal government subsidizes each state's inspection efforts.

These inspection programs assure that only healthy animals are used for meat and that the processing facilities and equipment meet certain standards. The FSIS monitors the temperature of meat being processed, examines the labels and packaging, controls the use of additives, and controls imported meat.

A round stamp of approval is placed on each primal cut when it passes inspection. This purple ink stamp contains the abbreviation for "United States Inspected and Passed" and the official establishment number assigned to that packing/processing plant. See Figure 8.1.

Figure 8.1 - Federal Meat Stamp



standards do the work. See Figure 8.3 for Kosher stamp.

Some states have state inspection stamps, which also use purple ink and are usually the shape of the state itself. See Figure 8.2 for example. Missouri does not have a state inspection stamp.

Qualified USDA inspectors do the inspecting. In the case of a Kosher plant, Kosher inspectors who meet USDA

Figure 8.2 - State Meat Stamp



Figure 8.3 - Kosher Stamp



Meat grading was established in 1927 when the USDA set standards for quality and cutability. Participation is voluntary on a fee-for-service basis, and is administered by the USDA. The USDA quality grade is indicated by a shield-shaped stamp which also uses purple ink. See Figure 8.4.

Grading costs are paid for by the consumer with other processing costs.

### **Not All Inspected**

Not all meat in the U.S. is inspected. Currently there is no law requiring fresh fish to be inspected. Meat that is processed "Not for Sale" is also exempt from inspection. Also, squabs (pigeon), gamebirds, rabbits, and most wild game are exempt.

Figure 8.4 - Quality Grade Stamp



### **Quality Grades**

Carcasses are quality graded so that packers can sort carcasses and primal cuts into groups of similar grade, and retailers can buy the appropriate grades for their markets. Quality grading assures consumers that the product conforms to an established set of standards which predict palatability and/or cutability (amount of lean).

Beef quality grading is based on marbling and maturity. Marbling is intramuscular fat viewed in the ribeye muscle. Intramuscular fat contributes to meat juiciness, tenderness, and flavor. The higher the degree of marbling the higher the quality grade assigned. Younger cattle qualify for prime, choice, select, and standard. Older cattle qualify only for commercial, utility, cutter, or canner grades. The USDA inspector determines the animal's age based on skeletal characteristics, and the color and texture of the ribeye muscle. Younger animals have red-colored bones and bright red lean (muscling). Older cattle show white bones and dark red lean.

Veal carcasses are graded on color, shape, and the amount of feathering (i.e., fat intermingled with the rib lean). The quality grades are: prime, choice, good, standard, utility, and cull.

Pork carcasses are graded on their leanness and meat quality (color, texture, etc.). Pork quality grades are acceptable and utility.

Sheep are graded on their maturity, color, and fat streaking. Lamb, yearling mutton, and mutton are three maturity classes based on differences that occur in the development of the muscular and skeletal systems. Fat streaking in the flank area and flank firmness are evaluated when grading. Prime, choice, good, and utility are the quality grades in lamb. The quality grades of yearling mutton are prime, choice, good, and utility. Mutton quality grades are choice, good, utility, and cull.

Poultry grading is based on several factors: conformation, fleshing, fat covering, presence of pin feathers, and exposed flesh. Disjointing, broken bones, and missing parts are also considered during grading. Poultry are graded into Grade A, Grade B, and Grade C poultry.

### **Inspection Detail**

Inspectors must consider a variety of factors before they pass or condemn a carcass or primal cut. They inspect for unwholesome or adulterated carcasses, a sanitary processing plant, honest labeling, correct temperatures, correct use of additives, and a lab analysis that meets their microorganism specifications.

### **Quality Grade Versus Brand Name**

Quality grade is independent from the brand name used. Many companies may use specific brand names to designate different grades of meat. The terms "star," "gold," or "lean" can be found on particular quality packages. These terms are the company's label not a quality grade determined by the USDA grader. Remember that the quality grade will be stamped with purple ink. The brand name may vary from company to company and from one location to another.

### **Summary**

The citizens of the United States enjoy a safe and abundant meat supply. The safety of the meat is the responsibility of the USDA Food Safety and Inspection Service. Inspection is performed by qualified inspectors. Fresh fish, "not for sale" meat, certain game birds, and rabbits are not inspected. Quality grading is based on carcass cutability, color, and marbling/feathering. Quality grades and brand names are independent of one another. Many processing companies market their meat products under a variety of brand names, some of which designate a particular grade.

### **Credits**

*Exploring Meat and Health.* Chicago: National Live Stock and Meat Board, 1991.

## Food Science and Technology-Unit II

---

Forrest, Aberle, Hedrick, Judge, Merkel. *Principles of Meat Science*. 1st ed. San Francisco, CA: W.H. Freeman and Co., 1975.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

*Inside Research*. Vol 2, 1st ed. Chicago: National Live Stock and Meat Board, 1992.

Jelen, Panel. *Introduction to Food Processing*. 1st ed. Reston, VA: Prentice-Hall, 1985.

*Lessons on Meat*. Chicago: National Live Stock and Meat Board, 1991.

Minnesota Turkey Research and Promotion Council *The Turkey Foodservice Manual*. 1st ed. St. Paul, 1987.

Parkhurst, Carmen R.; George J. Mountney. *Poultry Meat and Egg Production*. 1st ed. New York: AVI, Van Nostrand Reinhold Co., 1988.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

Romans, Jones, Costello, Carlson, Ziegler. *The Meat We Eat*. 12th ed. Danville, IL: Interstate Printers and Publishers, 1985.

## Lesson 9: Products from Grain Crops

Grains have been an important aspect of the human diet since recorded history. Grains provide the world with most of its food calories and about half of its protein. Grains may be consumed directly or fed to livestock, which converts the grain to meat, milk, and eggs.

### Primary Food Grains

Cereal grains include: wheat, corn, oats, barley, rice, rye, grain sorghum, and buckwheat.

Oil-bearing grains include: soybeans, sunflower, peanut, cottonseed, and canola (rapeseed).

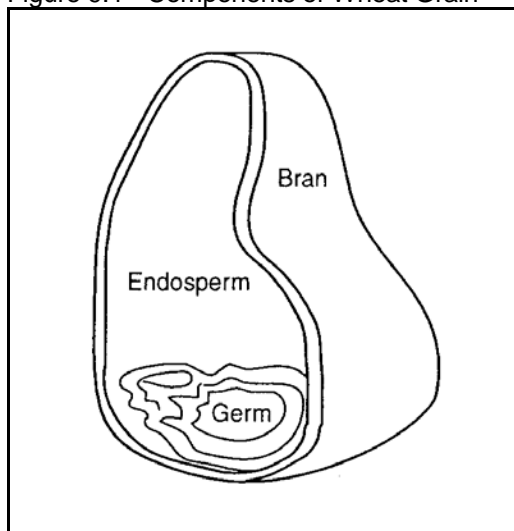
While not strictly grains, dry legumes such as dry peas, lentils, and various beans (navy, pinto, black, etc.) are often processed in similar ways.

### Primary Food Products

The major use of cereal grains is milling them into flour. Flour is processed into bread, pasta, bakery products, and other flour-based foods. Cereal grains are also used as raw material for a variety of breakfast foods and for direct consumption in the case of rice and corn (corn meal, corn flakes).

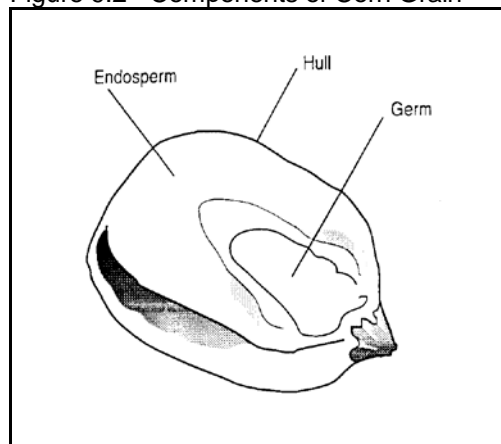
Wheat varieties are grouped into two major categories: hard wheat and soft wheat. Hard wheat is higher in protein, and yields a stronger, more elastic dough which is better for breadmaking. Durum wheat, a hard wheat, is the primary flour source for pasta products. Soft wheat is primarily used in cake and cookie making. Wheat is milled to separate the hull, germ, and endosperm. See Figure 9.1.

Figure 9.1 - Components of Wheat Grain



Corn is consumed in a variety of ways. Popcorn, for example, is a special variety that puffs or explodes when sufficient heat is applied causing the internal moisture to convert to steam. Corn is also milled to separate the hull, germ, and endosperm. See Figure 9.2. The majority of food corn undergoes milling. The endosperm or starchy component, is the most useful food component. Corn may be milled to produce corn meal, corn flour, corn starch, corn oil, and corn syrups (a variety of sweeteners).

Figure 9.2 - Components of Corn Grain



Oats are processed into flour or rolled into the familiar rolled oats breakfast cereals. Oatbran is a good fiber source.

Barley is milled primarily to produce malt. Malt is produced after the barley germ has sprouted. Sprouted barley is high in enzymatic activity, especially a starch digesting enzyme called amylase. It is an essential element in the production of beer and many liquors. Dried, sprouted barley (malt) is used as a flavor agent in some breakfast cereals and malted-milk concentrates. Barley may also be milled into flour

or eaten whole.

Rice is the most important human food crop because of the billions of people who rely on rice as their staple food. Rice is primarily consumed as the intact grain, minus the hull, bran, and germ. Rice is ground into flour and can also be consumed as whole grain rice, which maintains a higher vitamin and mineral content than milled and polished rice.

Rye flour is mixed with wheat flour in the production of rye bread.

Oil-bearing grains are a source of edible oil as well as a substantial protein source.

Soybeans are the most important oil seed. Soybeans are 20 percent oil. Soybean oil meal is 44-48 percent protein that contains amino acids necessary for a human diet. Soybean protein is often used to fortify other foods. Soybeans may also be roasted, converted to soy milk, soy flour, tofu or soy cheese, lecithin, and soy sauce.

Sunflowers are consumed whole or converted to oil. A sunflower is 50 percent oil.

Peanuts may be roasted and salted, or they may be processed into peanut butter or peanut oil.

Canola is an important oil seed in countries with cool climates. Canada produces many times more canola (rapeseed) than soybeans. Canola is processed into cooking oil.

Lastly, dry legumes are an important part of the human diet. Beans and dried peas are high in protein and low in oil content. Legumes are converted to flour and used in baking in many parts of the world.

### By-Products

By-products, or non-principal use products, from food grain processing are important ingredients in livestock feeds and pet food. Wheat bran, corn gluten, rice hulls, germ,

distiller's grain (wet remains of grain following malting), peanut hulls, and midlings (the oily germ) are some examples.

### Non-Food Products

Food/feed grains are the subject of research to determine new uses. There are hundreds of uses for grains. Corn starch can be used to make a biodegradable substitute for plastic. It is used in diapers, packing nuts, ethanol, paper production, encapsulated herbicides, etc. Corn is also used in the production of ethanol, lecithins, paints, antibiotics, dyes, paper, linoleum, etc. Soybeans can be converted to soy diesel, soy ink, soaps, pesticides, cosmetics, animal feeds, paints, etc. Peanut hulls are used as "cinders" on slick roads.

### Summary

Grains have always played a major role in the human diet. Cereal grains include wheat, corn, oats, barley, rice, rye, grain sorghum, and buckwheat. Cereal grains are normally ground into flour before further processing. Oil-bearing grains include soybeans, sunflowers, peanuts, cotton-seed, and canola. Oil-bearing crops produce an edible, high protein oil when cooked. Dry legumes are represented by dry peas, lentils, and various beans. Dry beans are an important low oil, high protein food.

Food grains produce several by-products when they are processed. Animal feeds are the primary beneficiary. Non-food products derived from food grains are a rapidly expanding field. Corn and soybeans are the two major grains used for numerous industrial products.

### Credits

Jelen, Panel. *Introduction to Food Processing*. 1st ed. Reston, VA: Prentice-Hall, 1985.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

Schoeff, Robert W.; Tim Herrman. *U.S. Grain Grading Handbook*. Manhattan: Kansas State University, 1993.

## Lesson 10: Processing of Grain Crops

Since the beginning of time, people have enjoyed eating grain crops. Crops like corn, rice, wheat, oats, and barley have been a steady supplier of complex carbohydrates. Leguminous crops supply protein to the diet. This lesson will focus on the processing of these grain crops.

### Steps in Processing Grain

Before becoming human food, most grains are processed. They are processed to improve their digestibility, flavor, texture, and storage qualities.

Grain must be harvested and transported to the appropriate processing plants. Transporting grain is accomplished by rail, barge, or truck. Once at the processing plant, the procedures vary depending on the type of grain.

Cereal grains undergo milling. There are two types of milling: dry and wet. Dry milling includes the removal of any foreign seeds and soil; conditioning the grain to the proper moisture level (17% for wheat, 21% for corn); and loosening and separating the germ, bran (hull), and endosperm. The germ, bran, and endosperm are separated after they have been passed through a roller. The flakes of bran and the flattened, semi-plastic germ are separated from the small, brittle particles of endosperm by the sieves under the rollers. The pulverized endosperm is now in the form of grits or meal and may be further processed into flour.

Wet milling is a process used mostly by corn processors. It involves steeping the corn in large tanks of warm water that contain acid and sulfur dioxide (SO<sub>2</sub>). The soft kernels are passed through a grinder to break up the kernels. The result is a paste that is pumped into water-filled settling troughs. The germ, which has the lowest density, can be skimmed off the top. It is then pressed for oil. The slurry passes through screens to separate the bran from the endosperm. High speed centrifuges separate the remaining starch and protein fragments found in the endosperm. The starch is dried to yield corn starch and corn sugars. The dried protein becomes corn gluten.

Malting is primarily a process used for barley. The barley seed is germinated to activate dormant enzymes. The swollen grain is gently kilned to dry the seed without destroying the enzymes. The dry malt is then storage-stable.

Oil seeds must be roasted to remove the oil. The seed is steamed and crushed to rupture the cellular structure and expose the free oil. The oil is extracted by high pressures, or dissolving the oil in solvents such as hexane or liquified carbon dioxide. The remaining meal or flakes are high in protein and may be further processed into flour.



Enrichment and fortification are used to improve the nutritional characteristics of some processed grains to meet U.S. nutrient standards. Wheat and rice often undergo processing procedures that unintentionally remove nutrients. These nutrients are often added back into the food product. These products are enriched. Some nutrients are added to products to help ensure good nutrition in an entire population. These products are fortified.

Extrusion is a process that combines several operations, including mixing, kneading, shearing, heating, cooling, shaping, and forming. Extrusion compresses the food into a semisolid mass and forces it through a restricted opening. The moisture in the food turns instantly to steam, causing the product to expand or puff. Many breakfast cereals and snack foods, macaroni, textured food products, and confections have been extruded.

### **Preserving Grain Products**

Nature, in the form of sun rays, will dry grain to about 14 percent moisture. At this moisture level, spoilage is usually not a problem. Grain processors eliminate spoilage problems by drying meal, flour, pasta, and grain to below 14 percent moisture, (3-5 percent). Very few grain products contain an added preservative. Insects pose the greatest spoilage threat. Thus, packaging in insect-proof containers is vital. Insects along with molds and bacteria can be destroyed by irradiation treatments of flour, cornmeal, etc.

A second method to preserve grain products can be accomplished by regulating osmotic pressure. Corn syrup contains sufficient nutrients to promote bacterial growth. Growth of microbes is prevented, however, because of the high osmotic pressure found in syrup due to its sugar concentration.

A third technique used to preserve grain in Europe and Russia is irradiation. High energy atomic particles are used to bombard the grain and destroy insects, molds, and bacteria. The irradiated grain must be protected from future contamination by proper packaging.

### **Grain Inspection**

The quality of a food product can only be as good as the raw materials. The laws that govern grain inspection today were initiated by the Grain Standards Act of 1916. Grain is inspected to determine its quality, thus influencing its price.

### **Grading Grain**

There are several factors to consider when grading grain. These include test weight, moisture, damaged or split grains, heat damaged grains, foreign material, and diseased or treated kernels. These variables carry the potential to alter a grain's food value. Variances in test weight can affect density, moisture levels affect storage life, damaged grain may hinder the germ-endosperm-hull ratio, and excess heat can reduce enzyme activity and protein content.

Some grains have different classes or subclasses. Each class is also graded. Corn is divided into three color classes: yellow, white, and mixed. Soybeans are also classified by color, however, in only two classes: yellow and mixed. Wheat is extensively classified into eight areas: hard red spring, hard red winter, soft red winter, Duram, hard white, soft white, unclassified wheat, and mixed wheat.

Corn and wheat are graded into U.S. Grade 1, U.S. Grade 2, U.S. Grade 3, U.S. Grade 4, U.S. Grade 5 and U.S. Sample grade. U.S. Grade 1 is the highest quality grade.

Oats and soybeans may be graded as: U.S. Grade 1, U.S. Grade 2, U.S. Grade 3, U.S. Grade 4 or U.S. sample grade. The higher the sample quality, the closer to U.S. Grade 1.

Barley and oats do not have any classes or subclasses.

### **How Grades of Grain are Used**

Grading grain is essential for fair trade. It provides information in an understandable language for buyers and sellers. It facilitates selling/buying grain without personal inspection.

U.S. Grades 1 and 2 grain are primarily used for food production. U.S. Grades 3, 4, 5, and U.S. sample grade grains are normally processed or exported for animal feed. This is not to say, however, that it cannot be upgraded by mixing U.S. Grade 1 or 2 grain with it. If the grain contains too many cobs or cockleburs, these can be cleaned out and the grain upgraded. On the other hand, if a mold (aflatoxin) is present, no amount of mixing would be permissible.

### **Food Grain Industry**

The food grain industry is diverse in size, ranging from small locally owned processors to multi-million dollar corporations. This industry also includes contract growers (raise specific varieties for contracted mill), independent growers, and corporate production sites. The Kansas City Board of Trade plays a significant role in the world's wheat trade while the Chicago Board of Trade deals with the buying and selling of many different grains.

### Summary

Most grains are processed to improve their flavor, texture, storage quality, and digestibility. Following harvest, grains are transported to processing mills. Dry milling separates the bran, germ, and endosperm with a series of rollers and sieves. Wet milling is useful for corn processors. This involves swelling the grain with moisture, rolling it into a paste, and then separating the constituents by density. Malting, roasting, fortification and enrichment are other means used to process grain. Oil-seed grains must be roasted to remove and process the oil. Extrusion is a process that compresses a semi-solid mass and reforms it as it passes through a restricted opening.

Grain products rely on a low moisture content or a high sugar concentration to prohibit microbial invasion. Grain inspection and standards identify grain quality, and thereby, are essential for fair trade. Grades for corn and wheat are similar. Grades for oats and soybeans are very much alike. Test weight, moisture, damaged kernels, heat damage, foreign material, color, variety, and evidence of diseased or treated kernels all contribute to grain grades. The US grain industry is very diverse in structure and organization.

### Credits

Hui, Y.H. *Encyclopedia of Food Science and Technology*. 1st ed. New York: Wiley-Interscience, 1991.

Jelen, Panel. *Introduction to Food Processing*. 1st ed. Reston, VA: Prentice-Hall, 1985.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

Schoeff, Robert W.; Tim Herrman. *U.S. Grain Grading Handbook*. Manhattan: Kansas State University, 1993.

## **Lesson 11: Fruit, Vegetable, and Nut Products**

Fruits, vegetables, and nuts are important sources of vitamins A and C. They also supply necessary minerals in the human diet. Nuts provide a protein source in snacks, cookies, and confectionery items.

### **Major Classes of Fruits, Vegetables, and Nuts**

Fruits can be divided into six major classes. These categories include melons (cantaloupe, honeydew, watermelon), drupes or single pit fruits (apricots, cherries, peaches, plums), berries (grapes, blackberries, cranberries), pomes or multiple pit fruit (apples, pears), citrus (oranges, grapefruit), and tropical (bananas, dates, figs, pineapples, mango, papaya).

Vegetables are classified relative to the anatomical portion that is eaten. These include earth vegetables (potatoes, onions, sweet potatoes), herbage vegetables (cabbage, spinach, lettuce, celery, rhubarb), and fruit vegetables (peas, green beans, sweet corn, squash, tomato).

Nuts have two classifications: cultivated tree nuts (almonds, Brazil nuts, cashews, pecans, black walnuts), and wild nuts (apricot nuts, beechnuts, chestnuts, chinquapins, heartnuts, hickory nuts, pecans, and black walnuts). Certain nuts may be included in either classification depending on whether they have actually been cultivated or grown in the wild.

While peanuts are classified as legumes, they are processed very similarly to tree nuts.

### **Products**

The products from fruits, vegetables, and nuts are numerous. Fresh fruits and vegetables are in the largest demand. Frozen fruits and vegetables (e.g., corn, lima beans, strawberries) are a product, along with canned fruits and vegetables. Juices obtained from tomatoes, prunes, oranges, apples, and grapes are an important part of the diet, while purees, like baby food and tomato sauce, are also useful products. Processed products like apple sauce and cranberry sauce are other products, as well as, jellies, jams, dried fruits, and vegetables. Nuts are processed into products which include nut meats, shell nuts, cracked nuts, and roasted nuts.

### **Quality Grade Factors**

Fruits and vegetables are graded, based on their quality. The quality grade standards include maturity, instrumental evaluation (used to measure compression/texture and size), color, size, shape, firmness/texture, aroma, variety of fruit or vegetable,

## **Food Science and Technology-Unit II**

---

harvesting method, acid concentration, sugar to acid ratio, and evidence of any disease or physical damage. Canned fruits and vegetables are evaluated on their canned weight. Grades include U.S. Grade A or U.S. Fancy, U.S. Grade B or U.S. Choice, U.S. Grade C or U.S. Standard, and U.S. Grade D or U.S. Substandard.

### **By-Products**

The processing of fruits, vegetables, and nuts produces a variety of by-products used for jelly-making, animal feed, and confections. These include rinds, peels and shells, pits, and non-juice solids.

### **Crop Characteristics**

The variety of fruit, vegetable, or nut determines how it is processed. Processing plants are located in specific regions of the country to efficiently process specific varieties.

Characteristics that determine how a fruit, vegetable, or nut is to be used include: time of maturity and yield, response to weather, pest and disease resistance, shape, size, resistance to physical damage during harvesting and processing, storage stability, suitability to certain processing methods, color of flesh, firmness when cooked and when raw, amount of juice, acidity level, and solids content.

These characteristics are directly related to the molecular composition and, therefore, variety of fruit, vegetable, or nut. There are more than 1,000 cultivars of apples and 3,000 cultivars of pears, for example.

### **Summary**

Fruits, vegetables, and nuts are important components in the human diet. Necessary vitamins and minerals are found in these food sources. Classification of fruits includes melons, drupes, berries, pomes, citrus, and tropical. Vegetables are classified as earth, herbage, or fruit. Cultivated tree nuts and wild nuts are the two types of nuts.

Products are available in a variety of forms: fresh, frozen, juices, purees, canned, jellies/jams, dried, nut meats, in-shell nuts, cracked nuts, and roasted nuts. Quality grades are based on physical and chemical properties and determine how the fruit, vegetable, or nut will be processed. By-products result from the processing of fruits, vegetables, and nuts. The method of processing depends on the variety of the crop.

### **Credits**

Bence, Deborah L.; Claudia A. Lazok. *Guide to Good Food*. 4th ed. South Holland, IL: Goodheart-Willcox Co., 1992.

Henry, Arba L.; Jared K. Tyson; David L. Howell. *Introduction to Animal Products and Processing/Ag Products I*. Vol 19, 5th ed. University Park, PA: The Pennsylvania State University, 1978.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

Woodroof, Jasper Guy; Bor Shiun Luh. *Commercial Fruit Processing*. 2nd ed. Westport, CT: AVI Publishing, 1986.

Woodroof, Jasper. *Tree Nuts*. 2nd ed. Westport, CT: AVI Publishing, 1979.

## **Lesson 12: Processing Fruits, Vegetables, and Nuts**

### **Fruit, Vegetable, and Nut Processing**

Fruits and Vegetables - Fruits and vegetables are high water content foods. This promotes bacterial, yeast, and mold growth. If fruits and vegetables become partially dehydrated or wilted because of bruising or rough handling, their economic value sharply decreases. Processors, therefore, must practice superb techniques in handling and transporting these commodities. Processing techniques must also minimize natural enzymatic deterioration.

Much of today's harvesting is accomplished by mechanical pickers or harvesters. Because fruits and vegetables are delicate items, harvesting is usually conducted before maturity is reached. Ripening chambers containing ethylene gas are an important part of the processing of certain fresh fruits and vegetables. Other controlled atmospheric conditions, like temperature, humidity, O<sub>2</sub> levels, and light, are used to regulate shelf-life. Potatoes need large amounts of O<sub>2</sub>, 5-7 days post-harvest, to develop their hard skin. Then they can be successfully stored under normal conditions.

Processors realize the need for immediate cooling of freshly picked produce. This has led to the development of mobile processing units that super cool produce immediately after harvest. Jet streams wash the product and begin to remove internal heat, and super coolers remove the remaining heat.

Freezing and canning are frequently used in the processing industry. Many fruits and vegetables are pitted, stemmed, cut, or cored before being frozen to a temperature of 20°F or less. Some fruits and vegetables may also be blanched. Canning operations include: blanching, peeling and/or coring, can filling, removal of air, sealing, retorting, cooling, and labeling.

The peels of fruits and vegetables may be removed by rotating drums; quick exposure to steam to expand the skins, immediately followed by water jets to remove peel; exposure to hot lye, followed by washing; or exposure to a burning flame, as in the case of onions.

Blanching, or inactivation of enzymes, is a critical step in fruit and vegetable processing. Blanching is heating the produce to 200° F for 2-5 minutes to deactivate the enzymes. For example, blanching prevents orange juice concentrate from becoming bitter, lipid or fat oxidation in frozen peas, and browning in cut potatoes.

## Food Science and Technology-Unit II

---

An alternative to blanching would be to use an additive such as sodium bisulfite to prevent peeled potatoes from enzymatic browning. Excessive browning when sun-drying apricots and peaches is prevented with sulfur dioxide (SO<sub>2</sub>).

Nuts - Commercial nut producers harvest their trees with mechanical tree shakers. Nuts are hulled as soon as possible by mechanical nut hullers. Sorting machines separate nuts by size and/or color. Pecans are dried to a 4.5 percent moisture level to prevent molding, discoloration, and breakdown of their oil.

When processing for nut meats, pecans are re-moistened to around 8 percent to reduce breaking of the meats. Then they are shelled. The meats are then packaged.

Processing in-shell pecans involves bleaching by washing in wet sand to remove black streaks, polishing, and waxing.

Roasted nuts are heated at 300°F in vegetable oil. After cooling, an oil coating is applied along with salt. The nuts are cooled a second time and then receive a "shine" oil treatment which seals on the salt. Dry roasted nuts are heated without oil.

If a nut butter such as peanut butter is to be produced, the nuts would undergo shelling, roasting, removal of skins, grinding, salting, and sugaring (optional) before becoming butter. Then the butter is packaged.

### **Nutritional Quality**

Generally, fresh fruits and vegetables are highest in nutritional value. Frozen fruits and vegetables would rank second in nutritional quality. Canning fruits and vegetables requires a long processing period causing the destruction of many of the water-soluble vitamins. Dried fruits contain only trace levels of vitamin C.

The composition of nuts is not generally affected by processing treatments.

### **Treatments and Packaging**

Fresh fruits and fresh vegetables are regular items at the grocery store. Many of these items have been transported hundreds of miles. Without certain treatments and proper packaging, these commodities would only be available on a regional or seasonal basis.

Fruits and vegetables may be treated with: ethylene gas to promote maturation; sodium bisulfite or sulfur dioxide (SO<sub>2</sub>) to retard browning; waxes to prevent dehydration in apples and nuts; irradiation to inhibit sprouting in potatoes; and cool temperatures to slow enzymatic reactions.



Modern packaging places nuts in opaque containers to avoid the red spectrum of light which can cause rancidity. Fruits and vegetables are packaged in plastic with ventilation holes. This allows for a normal respiration process without moisture build-up. Certain produce is treated to improve the color or shine of the skin to increase eye appeal.

### Organization of Industry

The fruit, vegetable, and nut processing industry is very complex. Processing plants are scattered over the nation. A growing number of producers are contracted by processors to supply a known quality and quantity of products. Cooperatives play a major role in pooling, processing, and marketing member production. Very large parent companies play a major role in fruit, vegetable, and nut processing. They often supply the necessary financial support and the name recognition of national brands. This is an industry known for its use of immigrant and migrant labor, and its reliance on national organizations to promote its products.

### Summary

Fruits and vegetables are delicate and highly perishable items; therefore, careful attention to handling and transporting is essential. Because of the high moisture levels in fruits and vegetables, microbial and enzymatic deterioration must be carefully controlled.

Shelf-life and appearance enhancement are promoted with a variety of agents. These include additives, controlled atmosphere, coatings, irradiation, and packaging.

Independent producers, cooperatives, contract producers, large processing companies, promotional organizations, and migrant labor all play a part in fruit, vegetable, and nut production.

### Credits

*Experiments in Food Science*. Chicago: The Institute of Food Technologists.

Frick, Marty. *Food Science, Safety and Nutrition*. The National Council for Agricultural Education, 1993.

Gaman, P.M.; K.B. Sherrington. *The Science of Food: An Introduction to Food Science, Nutrition and Microbiology*. 3rd ed. Elmsford, NY: Pergamon Press, Inc., 1990.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

## Food Science and Technology-Unit II

---

Woodroof, Jasper Guy; Bor Shiun Luh. *Commercial Fruit Processing*. 2nd ed. Westport, CT: AVI Publishing, 1986.

## **Lesson 1: Factors That Affect Food Safety and Quality**

Food safety is closely related to food spoilage, but they are not always the same thing. Food becomes unsafe when pathogens, pesticides, toxins or other potentially harmful chemicals are present. Foods that appear safe may contain toxins (poisonous plants), while other foods may look and smell very bad - yet still be quite edible (Limburger cheese). Food quality is a combination of safety and aesthetic factors.

### **Food Spoilage**

Feeding a growing population is a large task. The effort is compounded due to food spoilage. Even if an adequate food supply is produced, it must be stored and prevented from deteriorating. Several factors cause deterioration: microorganisms in the form of bacteria, yeasts, and molds; activities of natural food enzymes; insects, parasites, and rodents; temperature (both cold and hot); moisture or dryness; air; light; and time. In essence, food undergoes progressive deterioration beginning at harvest. It is critical to know how much time the deterioration process takes.

### **Contaminants Influence Food Safety and Quality**

When microorganisms attack food, they cause many deteriorative effects. They can ferment sugars; hydrolyze starches and fats; digest proteins; and form acids, pigments and discoloration. These can lead to rancid flavors, putrid odors, gas and foam production, and poisonous toxin production.

Enzyme activity is necessary in living plants and animals; however, it continues after harvest or slaughter. Unless these enzymes are inactivated by heat, chemicals, or radiation, they continue to catalyze reactions. Some of these reactions are desirable, like continued ripening of a tomato. Unfortunately, ripening or tenderizing beyond a critical point becomes food deterioration. The weakened tissue is subject to microbial invasion and rotting, development of rancid flavors, or browning and other discoloration.

In addition, insects cause damage, which permits microbial invasion. Parasites, like worms in raw fish and the Trichina worm in uncooked pork, can infect the person who consumes them and cause nerve and muscle damage. (The Trichina worm is no longer a problem in the U.S. pork industry.) Parasites can also cause dysentery. Rodents not only consume large quantities of food, but their excrement and urine can harbor several diseases such as typhus fever, the plague, salmonellosis, and leptospirosis.

Natural dehydrating may cause skin breakage which allows bacterial invasion. Freezing causes cell swelling which causes the cell membrane to rupture.

## Food Science and Technology-Unit III

---

The remaining factors, temperature, moisture, air, light, and time, can contribute to physical and chemical deterioration. These can also lead to microbial invasion.

### Production Practices

If a food product is to be consumed safely, it must be safe when it arrives at the processing plant, at the grocery store, and at the place and time of consumption. Food producers are responsible for growing safe products. Many producers are following Quality Assurance programs to document their practices.

Producers of animals must follow withdrawal guidelines for antibiotics and vaccines, follow recommended injection site procedures so as not to damage muscle tissue; and must sort, load, and transport animals as gently as possible to avoid bruising (bruised tissue deteriorates more quickly). Plant food producers document proper use and timing of pesticides.

Grain grade standards regulate grain quality. Producers use honesty as their policy in grain sales. To place rodent damaged grain on the bottom or treated wheat on the sides of the truck to avoid the grain sampler is dishonest and may be unsafe.

### Food Additives

Food additives are one very useful tool to maintain the safety and quality of food during processing, storage, and distribution. A food additive is any substance added intentionally or incidentally to food to improve its appearance, flavor, texture, nutritional value, or storage properties. The Food and Drug Administration (FDA) tests all potential additives over a two-year period on at least two different species of animals. The FDA has compiled a Generally Recognized As Safe (GRAS) list which can be added to or subtracted from as needed. Additives may not be used to deceive the customer or lower the nutritional quality of the food. They cannot be used to conceal spoilage, damage, or low quality. There are over 2,000 additives which perform a variety of functions. The Food Additives Amendment of 1958 provides legal standards for both intentional and incidental additives.

Antioxidants prevent the breakdown of vitamins and lipids in foods exposed to oxygen. Common antioxidants are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), Vitamin E, ascorbic acid (Vitamin C), and lecithin.

Bleaching and maturing agents change the yellowish color of freshly milled flour to white. Hydrogen peroxide whitens milk for certain cheese manufacturing processes.

Buffers, acids, and alkalies modify the pH.

Flavoring agents include spices, herbs, plant extracts, and artificial flavors.

Food colors are used extensively. Extract of annatto, caramel, carotene, and saffron are used in carbonated beverages, candies, and gelatin. In 1976, FD & C Red No.2 and FD & C Red No.4 were banned. Reliance on natural reds from grapes, beets, and cranberries has subsequently increased.

Nitrates and nitrites contribute to the flavor and pink color in cured pork. They also are antimicrobial agents.

Non-nutritive and special dietary sweeteners are used in low-calorie soft drinks, in dietetic foods, and by diabetics.

Nutrient supplements such as Vitamin D in milk, iodine in salt, and iron in cereal products are useful supplements to diets that may otherwise be deficient in those nutrients.

Preservatives extend shelf life and prevent deterioration. Common preservatives include sodium nitrite in processed meats, sodium benzoate in soft drinks, sodium and calcium propionates in breads and cakes, sorbic acid in cheese, and chlorine as a germicidal wash on fruits and vegetables. Sulfur dioxide is used to control browning of fruits and ethylene oxide is used to fumigate spices.

Sequestrants chelate or sequester trace metals and prevent them from causing oxidation or off-coloring. Citric acid and ethylenediamine tetra acetic acid (EDTA) are examples.

Stabilizers prevent food products from changing chemically. They are also called thickeners. Pectin, casein, gelatin, carrageenan, and gum arabic are common stabilizers use to thicken gravies, pie fillings, chocolate milk drinks, jellies, puddings, and salad dressings.

Surface active ingredients include emulsifiers to stabilize oil-in-water, water-in-oil, gas-in-liquid and gas-in-solid mixtures. Lecithin, monoglycerides and diglycerides are commonly used.

Miscellaneous additives include yeast in breads, calcium chloride used to firm fruits and vegetables, anticaking agents in salt, and gibberellic acid to stimulate growth in barley for malting.

### **Monitoring Food Safety**

The USDA's Food Safety and Inspection Service is responsible for inspecting and checking the quality of food products as they enter and leave processing plants. The FDA must approve processing plants and processing procedures. These include the use

of additives. Food products must be correctly labelled to show their ingredients and nutritional information.

The state, county, or local health departments have jurisdiction over food establishments and regularly inspect them for cleanliness and approved practices.

All meat must pass state or federal inspection for wholesomeness to guarantee the consumer that meat being purchased is from healthy animals, which were slaughtered and processed under sanitary conditions.

Federal inspection of meats and poultry is supervised by the USDA. Meat that passes federal inspection is stamped with a round, purple mark. State-inspected meat will have a different shaped inspection mark depending on the state. The inspection mark is placed only once on the wholesale cut, so it will not appear on every cut that is purchased.

### **Risk Assessment**

Life is a risk. Eating is a risk. There is some level of risk associated with everything we do. You personally must assess the risk of whatever activity you wish to do, and then make a decision on whether to do the activity. Food safety is very important and is also a very popular topic. If you want to survive, you must eat. You must be rational in assessing the risk versus the cost.

Undesirable residues in the food supply is an area of popular concern. Residues may be heavy metals, pesticides, aflatoxins, hormones, etc. The food supply is randomly sampled and tested to meet safety standards. Today's testing equipment can measure in parts per trillion and beyond. In 1958, when the Delaney Clause was adopted, measurement was done in parts per million. What was once considered safe, may very well be removed from the market today. The Delaney Clause prohibited known carcinogens from being added to the food supply.

Consumers assess risk in a variety of ways. First, they use rational thinking and common sense. They consume food that has not expired; looks, smells, and tastes wholesome; is produced, processed, and retailed by reputable businesses; and meets U.S. safety standards. However, consumers are not always rational when assessing risk. Sometimes fear of a product may be more important than any assurances of safety the processor can provide. On the other hand, some people choose to ignore the risk because of the pleasure associated with the product (Consider cigarettes and raw oysters). Consumers are the final 'line of defense' in keeping foods safe for consumption. Some consumers have allowed the media to be very influential in their decision making.

### Summary

Food spoilage may be caused by a wide variety of factors including microorganisms, natural enzymes, insects, parasites, rodents, temperature, air, moisture, light and time. In reality, progressive deterioration in food occurs. The critical question is how slow or fast is the process. Microbial contamination causes sugar fermentation, hydrolyzation of fats and starches, and many other negative effects. Enzymatic activity is a natural metabolic process and can be a positive or negative agent in food preservation. Insects cause spoilage which permits microbial invasion. Several other factors can influence food spoilage. One of them includes production practices used.

Our food safety is monitored by the USDA, the FDA, and health departments. Food additives are substances added intentionally or incidentally to foods to improve appearance, flavor, texture, nutritional value, or storage properties. All consumers must assess the risk associated with eating food and rely on common sense to determine their decisions.

### Credits

Finley, J.W., et al. *Food Safety Assessment*. ACS Symposium Series 484, American Chemical Society, Washington, DC, 1992.

Gaman, P.M.; K.B. Sherrington. *The Science of Food: An Introduction to Food Science, Nutrition and Microbiology*. 3rd ed. Elmsford, NY: Pergamon Press, Inc., 1990.

Hamilton, Whitney,Sizer. *Nutrition*. 4th ed. St. Paul: West Publishers, 1988.

Jelen, Panel. *Introduction to Food Processing*. 1st ed. Reston, VA: Prentice-Hall, 1985.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

## Lesson 2: Problems with Food Deterioration

Food is subject to physical, chemical, and biological deterioration. The most obvious to the human eye, physical deterioration, will be discussed first.

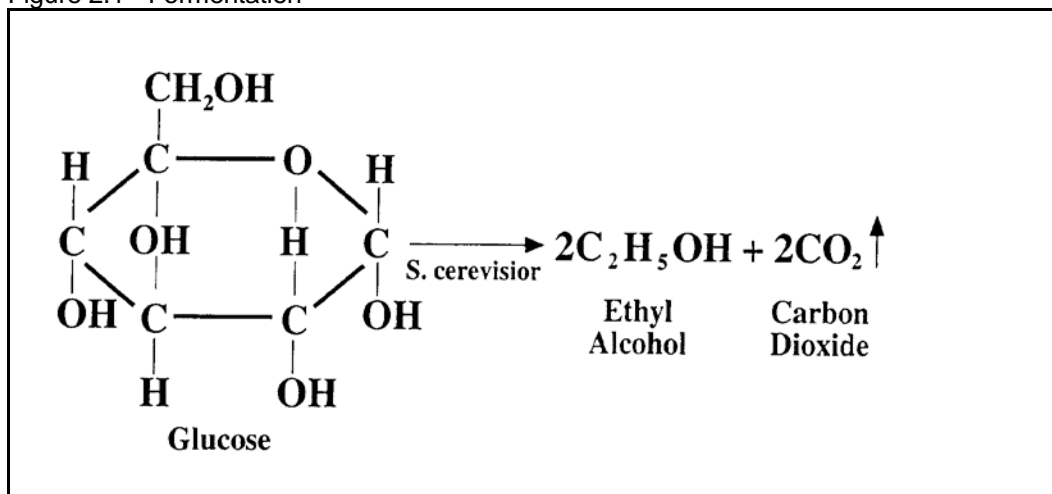
### Physical Changes from Food Deterioration

When food is exposed to excessive amounts of heat, cold, or circulating air, it may become dehydrated. Cracked skin found on fruits that have been frozen and thawed is another type of physical change. A broken or separated emulsion (example, salad dressing) in liquid foods that have been frozen and allowed to thaw is a third type of physical change. A fourth is texture degradation. This can be found in fluid milk that has been frozen, which causes curdles to develop.

Lumping, caking, or crystallization may result from an excess of moisture. Surface pitting on fruit is the result of storage temperatures that were too cold.

External off-color development may be the most obvious physical change caused by food deterioration. Meat exposed to fluorescent or incandescent light too long develops a brownish-red color. Meat color is determined by its predominant pigment, myoglobin. Myoglobin is a purple red pigment due to its iron constituents. When exposed to air, myoglobin adds two oxygen atoms and becomes oxymyoglobin. Oxymyoglobin is responsible for an intense red color. Oxygen permeable wrapping is preferred on meat cuts to promote this appealing color. If insufficient amounts of oxygen are available, however, oxymyoglobin oxidizes to metmyoglobin, a brownish-red pigment. Mold growth on the surface comes in a rainbow of colors. Some fruits, when stored at low temperatures may develop internal browning.

Figure 2.1 - Fermentation





### Chemical Changes

Chemical deterioration is due to a change in the chemical, or molecular structure, of food. Fermentation of sugars is a chemical change that, under controlled conditions, is a beneficial process in the production of bread, buttermilk, and yogurt. Fermentation can cause deterioration in uncontrolled environments. Fermentation splits a glucose molecule into two ethyl alcohol and two carbon dioxide atoms. (Figure 2.1)

Carbohydrates (starches) and proteins may undergo hydrolysis. Hydrolysis is defined as the splitting of a molecule by the uptake of a molecule of water. Corn syrup is produced by the hydrolysis of cornstarch with hydrochloric acid. The end product is called corn sugar. Hydrolysis of proteins is usually undesirable in foods.

A third type of chemical reaction that can cause deterioration is called lipolysis, or the reaction of a water and fat molecule that releases a fatty acid in the presence of heat or the lipase enzyme. This process alters the flavor and aroma of fats or oils and creates a rancid odor.

Proteins also can denature, losing their unique structure. If the protein is an enzyme, it loses its ability to be a catalyst. Often a denatured protein is less soluble. Denatured proteins often coagulate. Think about what happens when you fry an egg. The proteins in the egg white denature when heating. The once clear liquid becomes an opaque rubber solid. Denatured proteins may be more easily digested by microorganisms resulting in development of undesirable flavors, odors, or textures.

Toxin production is the sixth chemical change resulting from food deterioration. A food intoxication results from a toxic substance being produced in a food item before consumption. Certain molds can produce mycotoxins, which are poisonous. One well known mycotoxin is aflatoxin. Aflatoxins may be found on moldy grains and peanuts. Ergot is a mold toxin that can cause hallucinations. It may have been responsible for the Salem witch trials.

Enzymatic reactions are the advanced stage of normal enzymatic reactions. While the plant or animal is alive, enzymes are busy catalyzing chemical reactions. These reactions are kept in control by the living system. However, when the tissue is dead, these enzymes continue to work and ultimately cause degradation. These chemical changes may be inactivated by heat, chemicals, and/or radiation.

Pigment conversion is an eighth example of deteriorative chemical changes. For example, as the green pigmented chlorophyll molecule in plants is transformed into the pheophytin molecule, the bright green is converted to greenish-gray and olive green. A magnesium ion is replaced by hydrogen. Similarly, the oxymyoglobin molecule in red meat is chemically changed to metmyoglobin.

### Environmental Conditions for Bacterial Growth

Bacteria, along with yeasts and molds, prefer warm, moist growing conditions. Most bacteria are mesophilic. Mesophilic bacteria survive in temperatures ranging from 60°-100°F. There are also cold-loving (psychrophilic) bacteria, which survive at temperatures down to 32°F. Conversely, thermophilic bacteria can grow in temperatures up to 180°F. Because moisture is required for bacterial growth, a zero or very low water activity level is the reason why salted and/or dehydrated foods are not overcome by bacteria. Because there are aerobic and anaerobic bacteria, the need for oxygen depends on the type of bacteria.

### Microorganisms that Contribute to Food Deterioration

An important point to remember is that microorganisms are generally not found within the living tissue of a healthy plant or animal. Milk, for instance, is sterile when secreted. Fruits, vegetables, grains, and nuts become contaminated when their protective skin or shell is broken or weakened.

Bacteria - Not all bacteria cause food spoilage. Many types of bacteria are used to preserve food, like the lactic-acid producing organisms of cheese, sauerkraut, and certain types of sausage. Others are used for flavor production.

Bacteria are found everywhere from the hides and feathers of animals, to shells of nuts, in the soil, water, and air, and on processing equipment that has not been sanitized.

Bacteria are unicellular organisms; they are cells without a nucleus, known as procaryotes. They are classified based on their shape: spherical shapes are cocci; rod shapes are bacilli; and spiral forms are spirilla and vibrios. Many bacteria move by means of a flagella, a whip-like tail. Others produce spores, which are seedlike and incredibly resistant to heat, chemicals, and other adverse conditions. Bacterial spores are more resistant than yeast or mold spores. They resist most processing conditions to a greater extent than natural food enzymes. Needless to say, sterilization processes are aimed at these bacterial spores.

Bacteria are small, one to a few micrometers (um) in length, and can penetrate the smallest openings. Most bacteria multiply at 60°-100° F, the temperature range of mesophilic bacteria. Recall, however, that psychrophilic bacteria multiply at very low temperatures while thermophilic bacteria can withstand very high temperatures. Some bacteria are aerobic, while others are anaerobic.

Bacteria multiply in an exponential fashion. Under favorable conditions, their numbers can double every 30 minutes.

Bacteria are also classified based on their staining characteristics. Gram-positive bacteria retain a dark violet or purple color after a purple dye/iodine mixture is applied followed by an alcohol treatment in an attempt to decolorize. Gram-negative bacteria lose the dark violet color after the alcohol is applied. The Gram method of bacterial identification is one of the most important methods used. While this method is not absolute, it does provide valuable information in determining which bacteria are present. Thus, a corresponding method of treatment or sanitation can be established.

Fungi - Fungi, or yeasts and molds, are also helpful/harmful agents in food science, depending on which specific ones are present. Yeasts are necessary in making bread, wine, and beer because of their fermentation qualities. Molds are used to ripen Danish blue, Roquefort, and Camembert cheeses. They are also used to manufacture soy sauce and citric acid. The mold penicillium produces the antibiotic penicillin.

Yeasts and molds are found everywhere and can cause food spoilage. Yeasts and molds like warm, moist growing conditions. Yeasts are larger than bacteria, around 20 micrometers in length. Most yeasts are spherical or ellipsoidal in shape. Yeasts reproduce asexually in the form of spores. Most yeast colonies are creamy white in color and slimy in appearance.

Molds are larger than yeasts and grow by hairlike fibers call mycelia. Mold spores create the blackness of bread mold and the blue-colored veins in blue cheese. All molds are aerobic.

### Organisms That Can Cause Diseases

Camphylobacter - The camphylobacter bacteria are responsible for causing camphylobacteriosis, which is the leading cause of acute gastroenteritis (inflammation of the stomach and intestines) in humans. Only a few bacteria are required to cause illness. This bacterium has been found primarily in raw milk and poultry, but it has also been found in cake icing, eggs, beef, and contaminated drinking water.

Clostridium botulinum - Botulism is caused by these bacteria, which are present throughout the environment. The bacteria can be found in damaged canned foods and home-processed foods that were not properly processed. Also, other foods such as potato salad, sauteed onions, chopped garlic, raw cabbage, and hazelnut yogurt have been found to contain the botulism bacteria. Infant botulism can be caused by honey, which often contains botulinum bacteria. That is why it is recommended that infants not be given honey. The most common symptoms of botulism are fatigue and blurred vision. Few people have the usual gastrointestinal symptoms of food poisoning. Death is common for people getting botulism.

Escherichia coli - These bacteria, commonly called E. coli, live naturally in the human intestinal tract. They are responsible for causing diarrhea in infants and travelers. One uncommon strain causes two life-threatening conditions: hemorrhagic colitis and hemolytic uremic syndrome. Bacteria found in raw and undercooked ground beef and raw milk have been linked to these illnesses. The bacteria can be controlled by cooking meat thoroughly and keeping cooked meat away from uncooked meat.

Hepatitis A virus - The hepatitis A virus can be contracted from food not properly prepared by a person infected with hepatitis or from eating contaminated raw shellfish or contaminated mollusks. Cooking does not always kill the virus. Hepatitis symptoms at onset of illness include: malaise, appetite loss, nausea, vomiting, and fever. As the illness progresses, the patient develops jaundice with darkened urine, and may have liver damage.

Listeria - Listeriosis disease is caused by the listeria bacteria. While the bacteria infect shellfish, birds, spiders, and mammals all over the world, it is uncommon in humans. Although there are not nearly as many cases of listeriosis as there are salmonellosis, it is a very deadly disease especially for fetuses, newborns, and people with weakened immune systems. People can get listeriosis by eating foods contaminated with the bacteria such as soft cheese, unpasteurized milk, seafood products, cooked shrimp, and cooked surimi (fish, sausage, artificial crab). The disease is also transmitted by direct contact with mud, sewage, or soils contaminated with the organism and by inhalation of contaminated dust particles. This tough bacteria can grow at refrigeration temperatures and can survive mild heat.

Salmonella - This bacteria causes salmonellosis. Very low levels of bacteria can cause this disease. More than 40,000 illnesses are reported each year, but experts believe there are many more cases that are not reported. Nearly half the reported cases of salmonellosis require hospitalization, and one to two percent result in death. The salmonella bacteria have been found on many foods, particularly on raw meats, poultry, dairy products, pasta, and chocolate. Symptoms range from none to very severe but most often include nausea and diarrhea.

Staphylococcus - Staphylococcal infections are caused by the staphylococcal bacteria. Staphylococcal bacteria are found in the nose and mouth and on the skin of healthy people. The bacteria multiply at warm temperature, which produces the toxin that causes illness. Infected people who prepare or handle food can spread the illness to others if proper hand washing and utensil cleaning are not followed. Also, the bacteria can multiply quickly if leftover food is not promptly refrigerated.

Toxoplasma - Cats frequently are infected with this parasite, which can be transferred to humans by contacting contaminated cat feces or by eating improperly cooked meat or poultry. The animals received the infection from infected cats. Infants can acquire the

parasite from their mothers before birth. Severe mental retardation may result. Meat, particularly lamb and pork, should be cooked thoroughly to kill the parasite. Individuals with a weak immune system are particularly susceptible to toxoplasmosis.

Trichinella - This parasite causes trichinosis. It is commonly found in animals that eat human garbage. It is mostly transmitted to humans by eating undercooked pork or bear. Symptoms include abdominal pain, nausea, fever, diarrhea, muscle pain, and fatigue. There are few cases of trichinosis in the United States.

Vibrio parahaemolyticus - *Vibrio parahaemolyticus* bacteria cause vibrio gastroenteritis, which can cause water diarrhea, abdominal cramps, vomiting, headache, chills, and fever. This organism can be ingested in contaminated uncooked or undercooked shellfish. The bacteria can also enter the human body when an individual with open wounds comes in contact with infected coastal waters. A very closely related microorganism, *vibrio cholera* also can be transmitted by seafood, salt water, but it is most commonly found in areas with poor water treatment facilities.

Yersinia - *Yersinia* bacteria cause the plague. The rat is the primary carrier. If an infected rat leaves droppings in grain, for example, those contaminated droppings could get into the food supply for humans, thus spreading the disease. Improperly cooked pork or raw milk may have the *Yersinia* bacteria present. *Yersinia* can grow at refrigeration temperature, but heating kills the bacteria.

Using a thermometer when cooking meat can reduce the incidences of these food-borne diseases.

### Summary

Foods are a perishable commodity. Foods are subject to both physical and chemical deterioration. Dehydration, a cracked skin, a broken emulsion, off-colors, and a change in the texture are all physical deterioration examples. Chemical reactions that lead to deterioration include fermentation hydrolysis, toxin production, enzymatic reactions, and pigment conversions. Moisture and warm temperatures are necessary for growth of bacteria, yeasts, and mold. Bacteria, yeasts, and molds are the organisms responsible for the majority of food deterioration. A variety of human diseases result from microbial invasion. Examples include botulism, salmonella, trichinosis, campylobacteriosis, etc.

### Credits

Forrest, Aberle, Hedrick, Judge, Merkel. *Principles of Meat Science*. 1st ed. San Francisco, CA: W.H. Freeman and Co., 1975.

Hamilton, Whitney,Sizer. *Nutrition*. 4th ed. St. Paul: West Publishers, 1988.

Jacobson, Michael F.; Lisa Y. LeForts; Anne Witle Garland. *Safe Food*. Los Angeles, CA: Living Planet Press, 1991.

Kowtaluk, Helen; Alice O. Kopan. *Food for Today*. 4th ed. Misson Hills, CA: Glencoe, 1990.

McWilliams, Margaret. *Foods Experimental Perspectives*. 1st ed. New York: Macmillan Publishing Co., 1989.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

Tortora, Gerard J.; Berdell R. Franke; Christine L. Case. *Microbiology: An Introduction*. 1st ed. Menlo Park, CA: The Benjamin/Cummings Publishing Co, 1982.

## Lesson 3: Nutritional Properties of Foods

### Major Food Groups

A complete meal has five parts. Meats, breads and cereals (also called grains), fruits, vegetables, and dairy products are the five major food groups. Fats, oils, and sweets should be used sparingly.

### Six Classes of Nutrients

The five food groups can be divided into six classes of nutrients. These essential nutrients consist of: carbohydrates, proteins, fats, vitamins, minerals, and water.

Figure 3.1 - Nutrient Classes

<ul style="list-style-type: none"><li>• Carbohydrates</li><li>• Protein</li><li>• Fats</li><li>• Vitamins</li><li>• Minerals</li><li>• Water</li></ul>	<p><u>Carbohydrates</u> are energy-rich compounds that supply the majority of the body's energy, or caloric needs. Carbohydrates consist of carbon, hydrogen, and oxygen atoms in a <math>C_1H_2O_1</math> ratio. Sugars, starches, and plant fibers provide carbohydrates with glucose, a monosaccharide, being the simplest form of carbohydrate.</p>
--	---

Protein supplies the body with molecules that contain nitrogen. Eight essential amino acids are the building blocks of protein and consist of: leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine, along with histidine for childhood growth.

Fats (also called lipids), are the most energy-rich compounds. They provide necessary fatty acids for normal metabolism. They are also needed for transporting fat-soluble vitamins.

Vitamins are organic molecules that are needed in small amounts but can make big differences in one's health. Vitamin D can be synthesized by a healthy body, while the remaining vitamins must be supplied in the diet. At times, Vitamin D may also need to be a part of the diet to meet necessary levels. Vitamins are broken into two groups: fat-soluble and water-soluble. Vitamins A, D, E, and K are fat-soluble, while vitamins C and B complex are water-soluble.

Minerals are inorganic molecules needed in small amounts. The major minerals include Calcium (Ca), Phosphorus (P), Magnesium (Mg), Cobalt (Co), Sodium (Na), Chloride (Cl), Potassium (K), and Sulfur (S). The trace minerals consist of Selenium (Se), Fluorine (F), Iodine (I), Iron (Fe), Zinc (Zn), Copper (Cu), Manganese (Mn), Chromium (Cr), and Molybdenum (Mo).

Water is also a necessary nutrient. A person may survive several days, possibly weeks without food. However, without water, you can live only a few days.

### **Nutritional Characteristics**

Meats are a primary source of protein. They also contribute carbohydrates, fats, vitamins, and minerals.

Breads and cereals are a primary source of carbohydrates. They also contribute protein, fat, vitamins, and minerals.

Fruits are a primary source of vitamins and minerals.

Vegetables are a good source of minerals and vitamins. Carbohydrates and protein are also supplied by fruits and vegetables.

Dairy products are excellent sources for all nutrient categories.

Fats and Sweets - Foods containing high amounts of fats and sweets tend to have very limited amounts of essential nutrients (vitamins, minerals, and protein). They are sometimes called empty calories.

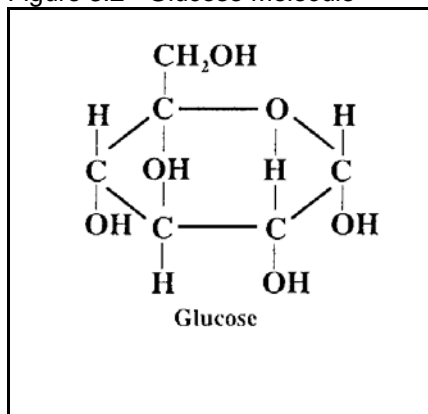
### **Functions of Each Nutrient Class**

Scientists use the terms "Kilo-calories" and "calories" in their discussions about nutrition. A Kilo-calorie (Kcal) is 1000 calories. One calorie (with the lowercase "c") is the amount of heat (i.e., energy) needed to raise the temperature of one gram of water one degree Celsius. Frequently, "Calories" with an uppercase "C" is used to indicate the number Kilo-calories in foods. Technically, these Calories are actually Kilo-calories. Throughout the discussion of nutrition in this manual, the number of Kilo-calories in a food will be identified as Calories.

Carbohydrates supply 4 Calories per gram of energy. Ninety-eight percent of sugars and starches are digested and fully oxidized into cellular energy. Carbohydrates are needed for body heat, tissue synthesis, and energy for work and play. Carbohydrates also supply carbon, which helps the body use fat efficiently, spare proteins from being converted to a major energy source, provide fiber, and promote vitamin B synthesis. Complex carbohydrates are long-chain molecules of glucose.



Figure 3.2 - Glucose Molecule



Proteins provide 4 Calories per gram of energy, but are only 70 percent digested and oxidized, on the average. Their primary roles are to supply nitrogen-based molecules necessary for tissue synthesis and to provide the essential amino acids needed for enzyme production. A complete protein contains all eight amino acids: leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, plus histidine for childhood growth.

Animal proteins are complete. Plant proteins are incomplete, meaning they are missing at least one of the essential amino acids. Most wheat, rice, and corn grains lack lysine. Legumes lack methionine. A lack of protein in early childhood can lead to retardation. A critical point is not how much protein is consumed, but rather a combination of the amount and the quality. Not all protein is digestible or palatable. A raw soybean is not digestible, but a processed soybean is digestible.

Fats provide 9 Calories per gram of energy. Approximately 95 percent of this is digested and oxidized. Fats provide essential fatty acids to the human diet. Linoleic acid is one essential fatty acid that promotes normal growth and prevents skin disorders. Research also suggests that linoleic acid, when present in high proportions compared to other dietary fats, may lower blood cholesterol. Dietary fat allows vitamins A, D, E, and K to be transported and absorbed. Fats contribute to phospholipid production and function. They help insulate and protect the body and store excess energy.

Vitamins serve a required function in enzyme systems which metabolize proteins, carbohydrates, and fats.

Vitamin A, or retinol, occurs only in foods from animal sources. Plants do contain beta-carotene, which is a precursor to vitamin A. Beta-carotene can be converted to vitamin A and is found in orange, yellow, and green leafy vegetables. A deficiency in vitamin A can lead to night blindness, abnormal bone and tooth development, or diseases of the epithelial cells.

Vitamin D can be formed in an animal's skin by ultraviolet sunlight activating cholesterol or ergosterol. Eggs, dairy products, liver, and fish oils are good food sources of vitamin D. This vitamin increases the absorption of calcium and phosphorus from the intestinal tract. A lack of vitamin D can lead to a bone defect condition.

Vitamin E favors iron absorption and serves as an antioxidant, which spares vitamin A and carotene from oxidation. Vegetable oils are good sources.

Vitamin K is essential for normal blood clotting and is prevalent in cabbage and spinach.

Vitamin C, or ascorbic acid, prevents scurvy, bone joint diseases, teeth loosening, and fragile capillary walls. It is needed for normal protein collagen formation. It favors iron absorption. Good sources are citrus fruits, tomatoes, cabbage, and green peppers.

Nine specific B vitamins make up the B complex group. All are abundant in liver, yeast, and cereal grain bran. Thiamine, or B<sub>1</sub>, is needed to oxidize glucose. Riboflavin, or B<sub>2</sub>, is needed for cellular growth and tissue maintenance. Niacin is used for tissue respiration and oxidation of glucose. B<sub>6</sub> is needed for enzyme systems. Pantothenic acid is needed for mental health. B<sub>12</sub> helps prevent anemia and is required for nucleic acid formation. Folic acid also helps prevent anemia and is required for nucleic acid formation. Biotin helps metabolize fatty acids and amino acids.

Several minerals are necessary for growth and metabolism. Calcium (Ca) is needed for blood clotting, bone and tooth development, enzyme function, and to control fluid movement through membranes. Phosphorus (P) is required for normal metabolism, acid alkaline blood reactions, and phospholipid production. Milk and dairy products are excellent Ca and P sources. Magnesium (Mg) is required to help metabolize Ca and P for muscle contractions, electrical potential in nerves, and enzyme systems.

Iron (Fe) is needed for blood hemoglobin, the O<sub>2</sub> carrier, and muscle myoglobin, the O<sub>2</sub> storehouse. Iron is abundant and readily available in red meat. Copper (Cu) helps manufacture hemoglobin and aids in iron utilization.

Cobalt (Co) is a part of vitamin B<sub>12</sub>. Zinc (Zn) is needed for enzyme production. Sodium (Na) is needed for osmotic equilibrium and body fluid volume regulation. Chlorine (Cl) exists as the chloride ion and is used to produce hydrochloric acid.

Potassium (K) is used to regulate osmotic pressure, equilibrium, and pH. Cellular enzymes need potassium.

Iodine (I) is needed for thyroid hormone production. Fluorine (F) prevents tooth decay. Manganese (Mn) is needed for bone structure, central nervous system function, and reproduction. Chromium (Cr) is used for glucose metabolism. Molybdenum (Mo) is required for protein metabolism.

Water is a vital nutrient although its functions are often overlooked. Besides comprising about 60 percent of a human's body weight, it serves as a chemical solvent for reactions in the body, it transports media to cells, removes body waste, regulates body temperature, and is essential for a controlled metabolic rate.

### Nutrient Sources

To list every source of the six nutrients would require a listing of every food source known to man. Rather, an abbreviated list of foods that are particularly rich in a specific nutrient follows.

Carbohydrates come from potatoes, rice, flour, and dairy products.

Protein is found in meat, poultry, fish, eggs, legumes, and dairy products.

Fats are found in meat, poultry, grain oils, nuts, and dairy foods.

Vitamins come in fruits, vegetables, and dairy products.

Minerals are obtained from meat, fruits, vegetables, and dairy foods.

Water comes in beverages and high water-content foods.

### Summary

Meats, breads and cereals, fruits, vegetables, and dairy products are the five main food groups. The body digests these foods into six major nutrient categories: carbohydrates, proteins, fats, vitamins, minerals, and water. Each nutrient serves an essential role in the body's health. These nutrients are found in a variety of food sources and are essential for a healthy diet.

### Credits

Bence, Deborah L.; Claudia A. Lazok. *Guide to Good Food*. 4th ed. South Holland, IL: Goodheart-Willcox Co., 1992.

Hamilton, Whitney,Sizer. *Nutrition*. 4th ed. St. Paul: West Publishers, 1988.

Kowtaluk, Helen; Alice O. Kopan. *Food for Today*. 4th ed. Mission Hills, CA: Glencoe, 1990.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 2nd ed. New York: Glencoe, 1994.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.



## **Lesson 4: Processing Influences Nutritional Value**

This lesson will examine four variables that can cause food to lose part of its nutrients during processing. The enhancement of food nutrients will likewise be examined.

### **Temperature Affects Nutrient Availability**

Consumers who are nutrition conscious realize that purchasing nutritious food is only the first step in a healthy diet. The manner in which this food is stored and prepared determines the nutrients that will be available when the food is eaten. Temperature is one such variable. The organic nutrients: carbohydrates, fats, proteins, and vitamins, contain enzymes that are constantly being produced and then degraded. When, for example, a peach is harvested its natural enzymatic activity begins to degrade tissue. At room temperature, a significant vitamin loss could occur. Therefore, chilling is necessary to slow the enzymatic processes. Another control for fruit and vegetable enzyme activity is blanching. Blanching or boiling briefly stops enzymatic activity.

High temperatures can likewise be detrimental to proteins. Proteins tend to toughen when exposed to high temperatures. But they are usually more easily digested after heating. High temperatures and long cooking times tend to destroy vitamins.

### **Light Affects Nutrient Availability**

Fluorescent light and the ultraviolet rays of the sun can destroy riboflavin in foods. It is for this reason that milk is no longer retailed in transparent glass containers, but rather it is sold in opaque plastic or cardboard. Vitamins, in general, are susceptible to light breakdown.

### **Water Content Affects Nutrient Availability**

Foods that have a high water content need to be prepared in a different manner in order to preserve their nutrients. Vegetables that are cooked in water can lose nearly one-half of their water-soluble vitamins to the water. It is for this reason that steaming vegetables is often suggested. If food is to be prepared in water, think of ways to use the "pot juice," like in soup or to cook rice.

### **Oxidation Affects Nutrient Availability**

Oxidation is the chemical reaction that takes place in the presence of oxygen. When it is controlled in the body cells, oxidation results in the breakdown of nutrients and the release of energy. However, when foods are overcooked, burned, or charred, nutrients are oxidized to carbon and oxygen gas and are not available for digestion. Protein molecules release nitrogen as  $N_2$  or Nitrous oxide. Similarly, fruits that have been exposed to air and are dried out have lost some of their nutrients. For example, vitamin

## Food Science and Technology-Unit III

C is lost from oranges. Transition BHA and BHT are commercial antioxidants. Vitamins C and E are natural antioxidants.

**Table 4.1 - Nutrients in 2 oz Serving of Dry Spaghetti Pasta - % Daily Values\***

Type of Spaghetti Pasta	Iron	Calcium	Thiamin	Riboflavin	Niacin	Vitamin B	Folacin	Fiber	Fat
Whole Wheat	10%	2%	20%	6%	15%	6%	8%	25%	1%
Enriched	15%	2%	40%	15%	25%	4%	2%	10%	1%
Unenriched	4%	2%	4%	2%	6%	4%	2%	6%	1%

\*Based on 1994 USDA Percent Daily Values

### Processes Used to Enhance Nutritional Value

The twentieth century has seen a nutritional revolution. Modern processes were invented to convert wheat into white bread rather than the standard whole wheat bread. This process, and similar ones, produce foods that are more pleasing to the taste buds; however, some nutrients may be reduced or even eliminated. The Enrichment Act of 1942 standardized the return of necessary nutrients to commercial flour. Enriched bread was supplemented with iron, niacin, thiamin, and riboflavin. Scores of food products today are enriched. Table 4.1 compares whole wheat spaghetti pasta, spaghetti pasta-enriched, and spaghetti pasta-unenriched.

Another means of nutrition enhancement is called fortification. This is very similar to enriched foods except that fortified foods have added nutrients that may or may not have originally been there. Examples of fortified foods include milk fortified with vitamins A & D, salt with iodine, and soft drinks with added vitamin C or calcium.

Nutritional supplements are slightly different from fortified foods. Supplements contain nutrients, usually vitamins and minerals, in amounts greater than 50 percent of the RDA. The most common form of supplements are vitamin pills, but many sport drinks are now on the market that could be considered to be supplements.

Sometimes foods have been fortified or supplemented with vitamins and minerals because the addition of these vitamins and minerals may be needed to help the body utilize vitamins and minerals naturally occurring in the foods. For example, vitamin D increases the absorption rate of calcium and phosphorous.

Many processing techniques are useful in maintaining nutrients. These range from quick cooling fresh fruits and vegetables to proper cooking temperatures and cooking length. Some types of produce are waxed or packaged to prevent dehydration.

### Summary

Temperature is an important environmental variable that determines the nutrient availability of food. Organic molecules break down faster at high temperatures than at low temperatures. Fluorescent lights and ultraviolet rays break down riboflavin. High water content foods are likely to lose many of their nutrients when boiled or cooked in a liquid. Oxidation decreases levels of many vitamins. Careful control of storage and processing conditions is necessary to assure the maximum nutritional value of food products.

Enrichment and fortification may be used to enhance the nutritional status of food. Occasionally foods are formulated to contain relatively high levels of individual nutrients. These foods are called supplements.

### Credits

Bence, Deborah L.; Claudia A. Lazok. *Guide to Good Food*. 4th ed. South Holland, IL: Goodheart-Willcox Co., 1992.

Hamilton, Whitney,Sizer. *Nutrition*. 4th ed. St. Paul: West Publishers, 1988.

Henry, Arba L.; Jared K. Tyson; David L. Howell. *Introduction to Animal Products and Processing/Ag Products I*. Vol 19, 5th ed. University Park, PA: The Pennsylvania State University, 1978.

Kowtaluk, Helen; Alice O. Kopan. *Food for Today*. 4th ed. Mission Hills, CA: Glencoe, 1990.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 2nd ed. New York: Glencoe, 1994.

## **Lesson 5: Biotechnology in the Food Industry**

In the food industry, biotechnology has likely made an impact on food you have consumed. This lesson will define biotechnology, examine its effect on food production, discuss examples of bioengineered foods, and look at biotechnology's future.

### **What is Biotechnology?**

Biotechnology can be defined in many ways. The use of microorganisms, animal cells, plant cells, or components of cells such as enzymes to produce products or carry out processes for human benefit is the detailed definition. A more concise way of defining biotechnology may be the use of living organisms or their enzymes to make commercial products.

### **Biotechnology's Effects on Food Production**

People using principles of biotechnology have made dramatic impacts on global food production. A greater variety of foods is the first result. A tangelo is a bioengineered hybrid between tangerine and grapefruit trees. Potatoes prefer cool climates, but may soon be produced in hot, humid climates. Soybeans are one of the brightest stars of current food biotechnology research.

A second result of biotechnology's effect on food production is the increased shelf life/safety of food. Food preservatives and fermentation are some of the areas in which food scientists have applied biotechnology toward food safety and shelf life enhancement. This area holds great promise in reducing the need for synthetic pesticides and food additives.

Another area of biotechnological advances has been harvested to benefit greater efficiency in food production. Crop production benefits from biotechnology produced fertilizers, pesticides, genetic-engineering, and hydroponics. Animal agriculture benefits from new vaccines, nutritional advances, embryo transplant programs, feed additives, and growth hormone research.

### **Bioengineered Foods**

One only has to browse through a grocery store to find hundreds of food products that are a result, to some degree, of bioengineering. Enzymes, low-calorie foods, waste management, biological monitoring, casings, and insulin will be evaluated in this section.



## Food Science and Technology-Unit III

---

Rennet and lactase are enzymes used in the dairy fermentation industry. Naturally, the enzyme rennet is used to coagulate casein during cheese-making, and is consumed in each batch. Bioengineered, immobilized rennet improves its stability and allows easy separation from the cheese, thus it can be recycled and reused. Lactase cleaves lactose to glucose and galactose. It too can be immobilized and recycled.

Low-calorie foods may contain non-nutritive sweeteners like aspartame, thaumatin, or monellin. These compounds are taste active proteins. The genes that code for these compounds may be isolated and transferred to non-harmful bacteria. Since bacteria reproduce so quickly, bacteria with these sweetener genes can be added to food products in a fermentation process and transfer the taste. Low-calorie foods are also one of the goals of soybean and rapeseed research. By reducing the oil content of the seed, more protein would be produced per seed. Genetic engineering may soon produce extra-lean pork and beef carcasses, resulting in red meat that fits better into a healthy diet.

In waste management, the waste from food processing, particularly the whey from cheese making, can be consumed by a bioengineered yeast. This particular yeast produces a grape aroma and could be used as a flavor component in the wine and food industries.

Biological monitoring is another prospect for bioengineered foods. DNA fragments from disease-causing microbes can be coded, isolated, and hybridized to detect the presence of the same microbe in food.

Bioengineering is responsible for manufactured casings used as a substitute for natural casings. Cellulose casings are produced from cotton lint and paper pulp. Collagen casings are made from the inedible portions of the beef carcass.

### Businesses Involved in Biotechnology Research

Anyone who has been involved in selective breeding programs has been involved in biotechnology. However, the new technologies that allow scientists to work at the cellular or chromosomal level require expensive equipment. Major advances in biotechnology have been the result of the cooperative efforts of many business enterprises.

The United States Department of Agriculture (USDA), universities, food processing companies, commodity organizations, the National Live Stock and Meat Board, and other food related companies are active in biotech research.

### Future Influence

The Green Revolution, which is the widespread adoption of high-yielding grain varieties along with an expanded use of fertilizers and irrigation, started in the late 1960's. Will the Green Revolution continue? As long as there are hungry people to feed, science and agriculture will continue to strive to feed them. The need for better weed control, less insect damage, enhanced nutritional quality and safety, greater disease resistance, and improved genetics will fuel the machine to continue the biotechnology revolution. Look for a longer shelf life, new vaccines, less dependence on petroleum-based oil, further advances with soybean- and corn-based products, a greater dependence on biological control of insects, and new resistant varieties of fruits and vegetables. Herbicide-resistant corn, greater reliance on hydroponics, possibly grasses that fix their own nitrogen, soy-based coatings to keep food from dehydrating or oxidizing, and natural antifreeze sprays to prevent citrus trees from freezing are just a few samples of what the future may hold. Herbicide-Resistant Corn is a genetically engineered corn variety that is tolerant to previously lethal herbicides.

### **Factors Influencing New Developments**

To name every factor that may influence new developments in food biotechnology would be similar to forecasting next year's weather. Some factors are known while several remain unknown.

Generally, the greatest need receives the most attention and effort. "Where there is a will, there is a way" is the old saying. If there is semi-drought growing conditions in the Midwest for five consecutive years, drought-resistant crops will be developed and planted. If a new strain of grasshopper invades the South, a new insecticide will likely be developed.

Finances always play a role. Research takes money, whether it is federal, state, or private funds. The need for talented, committed, educated researchers will need to be met. Biotechnology takes some specific facilities and equipment. The weather will play a part in research of plants, insects, animals, etc. Time is also a factor. New releases must be thoroughly tested before release. The Food and Drug Administration and Environmental Protection Agency require extensive testing.

### **Summary**

The biotechnology revolution will continue to make major impacts on human lives. The use of microorganisms, animal cells, plant cells, or components of cells such as enzymes to produce products or carry out processes for human benefit will increase in the future. Whether it is protein derivatives; resistant varieties, or low-calorie foods, biotechnology will continue to impact a growing population.

## Food Science and Technology-Unit III

---

### Credits

Avery, Dennis. *US Agriculture in a Global Economy*. 1st ed. Washington, DC: US Government, 1985.

*Food Technology*. Instructional Materials Service, College Station, TX: Texas A & M, 1990.

Harlander, Susan K.; Richard G. Garner. *Research for Tomorrow*. 1st ed. Washington, DC: USDA, 1986.

*Inside Research*. Vol 2, 1st ed. Chicago: National Live Stock and Meat Board, 1992.

Romans, Jones, Costello, Carlson, Ziegler. *The Meat We Eat*. 12th ed. Danville, IL: Interstate Printers and Publishers, 1985.

## Lesson 1: Factors that Affect Consumer Choice

What do food producers and grocers have in common? They work together to provide the consumer a wholesome product that is a good value. Because the consumer has the right to accept or reject any food item, producers and grocers must work together to influence consumer choice. This lesson focuses on the factors that affect consumer choice.

### Factors Affecting Consumer Choice

There are several factors that play a part in helping the consumer decide what food selections to make. The location in which you live may determine your food supply. Small rural grocers are less likely to carry exotic food items, whereas a large supermarket may carry almost everything. The cost of food obviously is a factor. The time of day in which the consumer is shopping helps make some food choice decisions. A ready-to-eat meal is a priority when the shopper is hungry. The shopper who is planning ahead may select the raw ingredients to make the meal.

The consumer's knowledge and skill help determine what is purchased. A more knowledgeable consumer purchases more balanced and nutritious foods. Energy is the fifth consideration. Not only is the energy to prepare the food a concern but also the amount of energy the shopper has while grocery shopping.

Other people play a big part in the quantity of food purchased. A person's emotions will influence what is purchased. When a certain athlete's picture is on a box, admirers are more likely to purchase it. The first items that are encountered in a grocery store also appeal to the emotions. The tools or equipment the consumer has at home also determine what foods will be purchased. Without a microwave oven, why buy microwavable popcorn?

A person's culture also plays a role in his/her diet. Many consumers buy food that fits their culture. Religion determines some people's diets. No red meat on Fridays during lent, no meat at all, and no pork are all dietary restrictions based on different religious views. Advertising influences consumers to purchase foods. The products found in newspaper advertisements are commonly high volume items. A person's lifestyle greatly affects their selection. High energy diets are necessary for active people. Less active people require fewer calories. Finally, a person's values influence selection. The growing segment of the population who avoid alcohol and the shopper who compares different package sizes of the same products are all basing their decisions on their value systems.

### Sensory Attributes

Why is parsley used to decorate a steak meal? Because people are drawn to attractive food. The color of a food and/or its packaging helps sell that product. Eyes are also drawn to what they perceive to be ideal sizes and shapes of food, or whose picture is on the package. Processors take advantage of the sense of eyesight.

The second sensory attribute that is used to make sales is the smell or odor of a product. Can you imagine walking past a bakery that is emitting the delicious aroma of fresh baked bread? How would the popular hickory smoke BBQ influence a customer's buying habits?

The third sensory attribute of food is the sense of taste. Different tastes satisfy different taste buds. Foods are made sweet, sour, salty, or bitter to satisfy the specific taste desired.

The texture or feel of a product may also influence purchase decisions. Soft bread, crisp celery, and firm apples are considered desirable texture characteristics by most consumers.

### Convenience Affects Selection

Most people do not enjoy washing dishes. This seems to be one of the reasons why people buy convenience foods. Time, energy, clean-up, variety, and equipment all influence consumers to purchase convenience foods. Today, many people are rushed for time. Convenience foods are easy to prepare. It takes energy to plan a meal, shop for it, and prepare it. Convenience foods save most of the energy required to make a meal from scratch. There is little clean-up with convenience food. Variety may induce a consumer to choose convenience. Food leftovers, especially for single-person households, may be the main course too often. Fast food businesses and other restaurants can provide a person with variety. Also, it may take special equipment to prepare foods such as deep-fry or grilled foods. Many convenience-food businesses already have these tools. These five reasons help explain why convenience food is steadily growing.

Not every shopper is a convenience food fan, however. Consumers who believe that slower food preparation or only using fresh or home-grown produce is more nutritious, may be negatively influenced by convenience food advertisements. Another reason why fast foods are not purchased may be because of their high cost relative to a home-cooked meal. If the home-cooked meal is entirely consumed, without spoilage, it is normally cheaper to prepare the meal in the home. Also convenience foods may have more packaging which results in increased disposal costs.

### **Price's Influence**

Price has always been a deciding factor for consumer food selection. Many grocers stock two or more brands of each food type to offer shoppers a variety of brands at a variety of prices. Smart shoppers are careful to examine not only the cost of a food product, but also its nutritional content. Impulse buyers are less likely to be influenced by price.

### **Packaging's Influence**

Food processors have studied consumers' buying habits and realize that packaging definitely affects consumer choice. Labeling claims, "environmentally-friendly," size, and the cost of packaging are four factors that need to be examined.

Current trends reveal that foods low in fat or calories are usually packaged with a label proclaiming in bold letters "fat free" or "just 1 calorie." The Nutrition Facts Panel list is another catchy design, not to mention a star athlete's picture or "free offer inside" approaches. Environmentally-friendly packaging frequently influences consumers. If recyclable paper or biodegradable plastics are used, stewardship-minded consumers will respond positively.

Thirdly, the size of the package can exert an influence. Those family-size packages are great for families, while single-person households shop for smaller packages. Lastly, the cost of packaging plays a part. Current statistics indicate that up to one-third of a food product's cost comes from its packaging. For example, fruits and vegetables sold in bulk with the shopper doing the packaging are cost-savers. On the other hand, resealable lunch meat packages cost more but help maintain freshness. Different packages are beneficial in different situations.

### **Shelf Life**

In general, the longer the shelf life of a product, the more flexibility the grocer and consumer has. Dairy products that spoil within a week are a high risk item to carry. In general, consumers desire fresh foods. Shelf life is extended with frozen, canned, cured, and dried foods.

### **Safety Concerns**

To describe the average consumer's approach to food safety would be a difficult task, for there is a wide spectrum of concern. Most shoppers, when asked, would voice concern over the safety of the food supply. However, when observing consumer's habits, a slightly different picture is painted. More and more people rely on other people to prepare their meals with little knowledge of the cleanliness of the restaurant's kitchen. Safety-conscious shoppers are a growing rank. They can be found carefully

examining produce for blemishes, canned goods for dents, and packaged foods for broken seals.

### Nutritional Concerns

"You are what you eat" is a popular saying. Nutritious, wholesome food is the goal of most consumers and producers. Today's smart consumers are probably more nutrition-minded than ever before. Fat content, calories, additives, minerals, vitamins, fiber, and cholesterol are factors related to food quality. Skilled consumers select foods that combine the necessary elements in the right balance to provide for healthy living.

### Summary

Choosing wholesome food that will provide a balanced diet is an important task. Consumers are influenced by a variety of factors in their attempt to reach this goal. Factors such as location, time, energy, cost, skill level, advertising, values, and emotions are just a few of the influences on consumer choice. The sense of sight, smell, and touch play a role in selection also. Convenience foods offer an alternative that, depending on your perspective, is a positive or negative influence. Most consumers are price conscious as well as skilled in package selection. Shelf life is directly proportional to value. Safety concerns are slowly growing and are usually voiced when questioned. Likewise, nutritional concerns are in the forefront and heavily influence the labeling of food items.

### Credits

Bence, Deborah L.; Claudia A. Lazok. *Guide to Good Food*. 4th ed. South Holland, IL: Goodheart-Willcox Co., 1992.

*Focus on Food Labeling*. An FDA Consumer Special Report. Rockville, MD: Food and Drug Administration, May, 1993.

Kowtaluk, Helen; Alice O. Kopan. *Food for Today*. 4th ed. Missoula, MT: Glencoe, 1990.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 2nd ed. New York: Glencoe, 1994.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

## Lesson 2: Interpreting the Food Label

You may be familiar with the old saying: You can't judge a book by its cover. However, for a food product, the cover says a lot. By careful analysis of the food label, you can get information about what is inside, how much is there, what ingredients were used to make the product, and finally how nutritious the product will be to eat.

Many people believe that information on the food label is false and misleading. If the information is false or misleading, then officials from the Food and Drug Administration and the Federal Trade Commission would put the food scientists in jail for mislabeling the product. The food labeling law requires that everything on the label be the truth. However, a discerning consumer can spot efforts at misdirection and confusion on some food labels.

In 1990, Congress passed the most comprehensive food labeling law in the world. This law is known as the Nutritional Labeling and Education Act of 1990. Included in this law were changes in many elements of a food label. These changes were designed to assure that the consumer would have access to accurate, easily understood information. Hopefully consumers will use this information to improve their eating habits. This in turn should improve health, reducing costs paid to physicians and hospitals to take care of people who did not eat correctly.

### Parts of the Food Label

A food label is divided into two parts. The largest part, at least 40% of the total package area is known as the principal display panel (PDP). This is the part of the label that the consumer is most likely to see when the package is placed on the grocery store shelf. Thus, it may be the top of an ice-cream carton, or the large side panel of a box of cereal. The PDP must contain information to identify the food, either by a real name (*e.g.*, green beans) or a made-up name (*e.g.*, Cherrios). If a picture appears, it must look like the food in the box. Sometimes, if the food will require cooking before eating, the picture may say "serving suggestion." This says that it requires some additional work to get the product to look like it does on the package. The PDP must also state how much of the product is in the container, usually reported as net weight. The net weight is the weight of the food in the container, minus any liquid or other component that would not normally be consumed. The net weight must be reported in avoirdupois (ounces, pounds, and gallons) and metric (grams and milliliters) units.

The second part of the food label is the information panel (IP). The IP is the part of the label that is immediately to the right of the PDP. There are three elements that must appear on the IP. These include the name and address of the manufacturer, a list of ingredients, and a nutrition facts panel. The address must be present so that a consumer could get additional information about the product, or complain if they wanted to. The



list of ingredients must be in order by descending weight. That is, the ingredient present in the greatest amount appears first, then the next greatest amount and so on until all ingredients are listed. There have been many changes in the ingredient listing so that consumers can know what they are eating. The original source of ingredients is sometimes listed, such as "animal fat" or "protein from soybeans." This allows consumers to avoid animal products for religious reasons or soybeans because of allergic reactions for example. They can carefully read the ingredient statement and discover what raw products were used in the food. Artificial ingredients are identified as such in the ingredient listing.

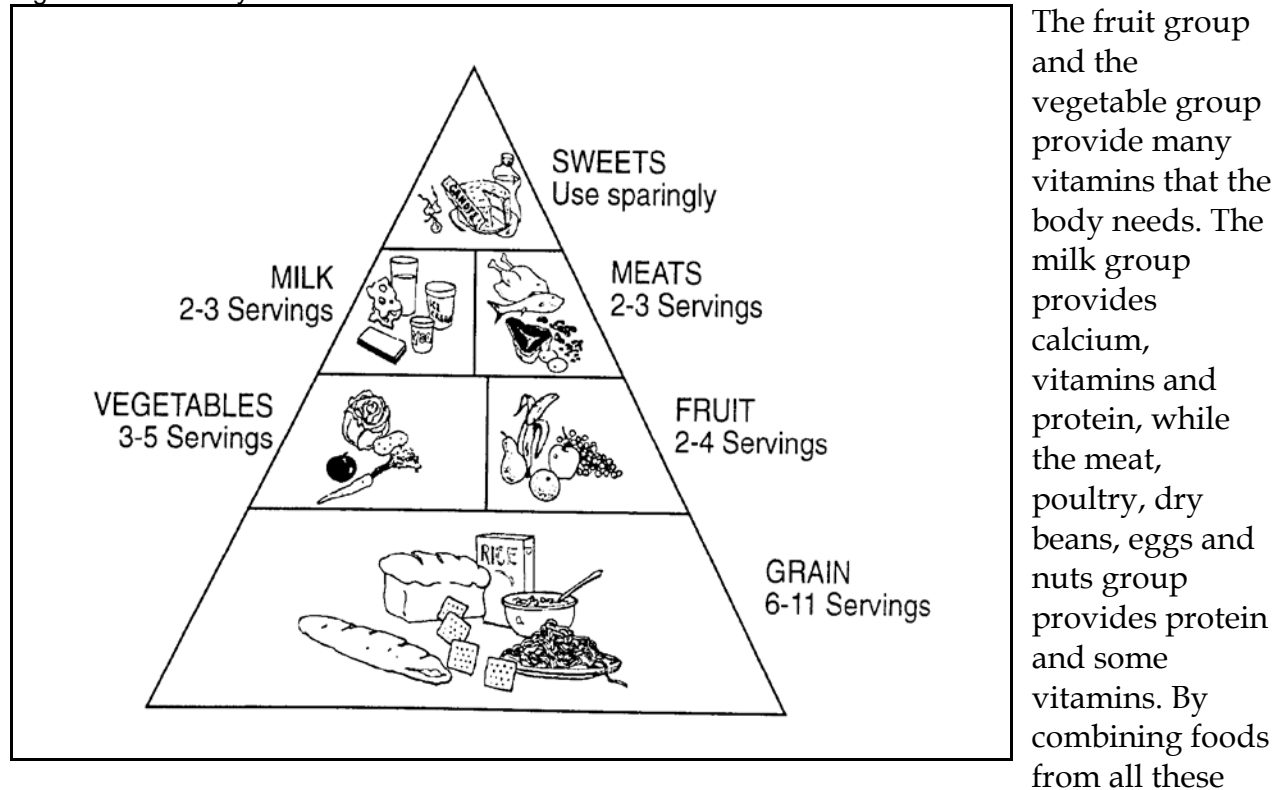
Finally there is the nutritional facts panel. In a very few instances, the nutrition facts panel may be omitted, but all of the other elements must appear on every food product offered for sale to the public. To understand the nutritional facts panel, we must understand something about the way nutrition information is being made available to the average consumer.

### **Daily Dietary Requirements**

While some people may say they live to eat, in reality all people eat to live. Our body cells need a constant supply of many different elements to use as building blocks. Sometimes, these cells need entire molecules to do their functions. These elements and molecules are supplied by the food eaten. Since most people do not want to do a complete chemical analysis before every meal, nutritionists usually talk about food groups and serving sizes. These are easily estimated by most people. Correctly understanding the food groups will be helpful in planning a healthy diet. Nutritionists and other scientists working for the USDA have classified foods into six groups. Five of the groups are: 1) bread, cereal, rice and pasta; 2) fruits; 3) vegetables; 4) meat, poultry, fish, dry beans, eggs and nuts; 5) milk, yogurt and cheese. The sixth group is called the fats, oils, and sweets. This group of food products provides few of the building blocks necessary for proper function of the body, so it is not generally considered a food group. To maintain optimal health, it is necessary to eat some of all of the five food groups each day. But how much?

To help organize these groups in your mind, the USDA has developed a food pyramid (Figure 2.1). The size of each food group block in the pyramid represents how much of each group you should eat each day. For example, the bread group is the largest block, and is located on the bottom of the pyramid. The bread, cereal, rice, and pasta group of foods should serve as the foundation of your diet. Depending on several factors, including your age, sex, and weight, you should eat between 6 and 11 servings of these foods each day. While there are some exceptions, a serving of a food is generally about one-half cup. The foods in the bread group provide the carbohydrates needed for energy, many water-soluble vitamins, and trace minerals needed for proper cell function.

Figure 2.1 - Food Pyramid



groups every day, you will be more assured of eating a healthy diet.

### Nutrition Facts Panel

Many people eat foods in which the food groups are combined. Consider a pizza. It contains food from the bread, vegetable, milk, and meat groups (sometimes even the fruit group!) How many servings of each are in a slice? This is why the food label contains specific information on individual nutrients important in the American diet. To make things simpler, the nutrient content of foods is reported in both grams and Percent Daily Value. The Nutrition Facts panel includes total calories, calories from fat, total fat, saturated fat, cholesterol, sodium, total carbohydrate, dietary fiber, sugars, protein, vitamin A, vitamin C, calcium, and iron. (Figure 2.2)

The Percent Daily Value assumes a 2000 calorie per day diet. This is the average calorie needs for most American women. (Men usually need about 500 calories more per day to maintain their weight.) Not all nutrients have to appear on a nutritional label. To keep the label simple, only nutrients known to be a problem for Americans are required to appear on the food label. In the American diet there are some nutrients that people should be sure to eat, such as carbohydrates, dietary fiber, and some vitamins and minerals. There are other nutrients that are important, but it is so easy to get enough of these that they are not included on the label. Unfortunately, there are some nutrients that Americans eat too much of, such as fat, cholesterol, and sodium. The amount of each nutrient in a specific food is calculated as a percentage of the total amount of that nutrient that should be consumed each day. By keeping track of the percentage of each nutrient consumed, when 100 percent is reached, you will know that you have gotten enough (of things like carbohydrates, dietary fiber, and vitamin C) or that you should not eat any more (fat, cholesterol, or sodium).

You may wonder why the daily value for protein does not appear on some labels. The first reason is that proteins have different quality. Foods like meat, eggs, and milk have very high quality protein, while other products like gelatin are very low quality. Other foods like grains, need to be combined with legumes (dry beans) in order for the protein to be of high quality. This would be very difficult to express on the food label. Since protein amount and quality is not a problem for most Americans, the daily value is not required. When you see a daily value for protein on a label, the value is adjusted for the protein quality.

The serving size on a food label is determined by comparison to a standard serving size. Serving sizes were found in a US government survey by interviewing thousands of people all over the United States. This is not necessarily the same serving size that is

Figure 2.2 - Nutrition Facts Panel for Thick Crust Pizza

<b>Nutrition Facts</b>			
Serving Size 1/2 of 10" pie (208 g)			
Servings Per Container 2			
Amount Per Serving			
<b>Calories</b> 480		Calories from Fat 90	
		% Daily Value*	
<b>Total Fat</b> 10g			<b>15%</b>
Saturated Fat 4.5g			<b>22%</b>
<b>Cholesterol</b> 25mg			<b>9%</b>
<b>Sodium</b> 1100mg			<b>46%</b>
<b>Total Carbohydrate</b> 76g			<b>25%</b>
Dietary Fiber 4g			<b>15%</b>
Sugars 10g			
<b>Protein</b> 24g			
Vitamin A 20%	•	Vitamin C 6%	
Calcium 35%	•	Iron 15%	
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower based on your calorie needs:			
	Calories:	2,000	2,500
Total Fat	Less than	65 g	80 g
Sat Fat	Less than	20 g	25 g
Cholesterol	Less than	300 mg	300 mg
Sodium	Less than	2,400 mg	2,400 mg
Total Carbohydrate		300 g	375 g
Dietary Fiber		25 g	30 g
Calories per gram:			
Fat 9	•	Carbohydrate 4	• Protein 4

used on the Food Pyramid, but it is based on real amounts of food consumed at one meal by many Americans. The actual serving size on a label must compare to the standard serving size, the size of the package, and the weight of the food itself. It is a complicated process, but it is designed to make it easier to compare similar foods while shopping.

Unless you have an identical twin, there is no one else in the world exactly like you. Just as people look different, their nutritional requirements are different. It would be impossible to put all of the information necessary to figure out one's exact nutritional needs on every food label, so the information there is only an average for all Americans.

If a person wants to be more specific, he/she can use the information about the grams of each nutrient to calculate specific nutritional requirements. The information necessary to do this is included in the bottom portion of the food label, called the footnote section (see Figure 2.2). Additional information on the changing nutritional requirements for different ages can be found in almost any textbook on nutrition.

Most people are better nutritionists than they might think. As long as people eat a broad variety of foods, in moderation, the body does a good job of selecting what it needs, and disposing of the rest. Nutritional health is decided in the average over a long time, not just what you eat each day. For example, if you "pig out" on a high fat pizza today and get 200 percent of Daily Value for saturated fat you may think your diet is ruined. By limiting your intake of saturated fat from other foods over the next few weeks, there will be no harm done. However, if you consume 200 percent of the Daily Value every day for several months, you probably will find that you have gained a few unwanted pounds and may be at greater risk for heart disease and cancer in the future.

Nutrition, like most sciences, changes almost daily. At universities and research institutes all over the world, scientists are struggling to understand the role of food in health and disease. This means that nutritional recommendations may change as new evidence is uncovered. The food pyramid and the food label reflect the knowledge gained over the past 100 years, and are unlikely to change dramatically in your lifetime. But you never know.

### **Nutrient Level and Health Claims**

Until 1990, words like "lite," "high," "low," and "good source" on a food label were hard to understand. There were no standards so food companies could use anything they wanted. Now these words, known as nutrient content claims, are defined by comparison to the Percent Daily Value. Foods that are "good sources" of a nutrient must contain at least 10% of the Daily Value for a nutrient per serving. Foods that are "high" must contain at least 20% per serving. There are similar rules for other descriptors such as lite, low, and free.

Usually foods that contain high levels of fat, sodium, or cholesterol may not claim to be a good source of some other nutrient. It is very complicated for a food company to be sure they can make a nutrition level claim. However, specific rules for using nutrient content claims assures the consumer the claim is meaningful in a real diet.

Some food labels will have health claims. These are sentences that remind the consumer that certain nutrients affect the development of specific diseases. The claims are monitored by government scientists. They must be true and they must be related to some disease that is important to Americans. There are currently (1994) seven different types of health claims allowed:

- high calcium levels may prevent osteoporosis (a loss of calcium from bones)
- low sodium levels may reduce high blood pressure
- low fat levels may decrease problems with cardiovascular disease
- low fat levels may reduce the risks of some types of cancer
- high levels of dietary fiber may reduce the risks of some types of cancer
- high levels of dietary fiber may decrease problems with cardiovascular disease
- high levels of folic acid may reduce risks of some types of birth defects (neural tube defects)

Foods that make health claims must be "high" (calcium, fiber or folic acid) or "low" (fat, sodium) in the specific nutrient. In addition, the levels of other nutrients in the food are considered. For example, whole milk is high in calcium, but it is also a significant source of fat and cholesterol, so it cannot make a health claim. Skim milk on the other hand, may make calcium and fat claims. Again, the rules are complicated, but they assure the consumer that the food making a health claim really is part of a healthy diet.

### Summary

The food label is designed to communicate to the consumer. There are four required parts of the food label: 1) the name of the food; 2) the amount of the food in the container; 3) the name of the manufacturer; 4) the ingredient list. Almost all foods also require a Nutrition Facts Panel. Some foods may also have nutrient content or health claims. These parts of the food label are carefully controlled.

Nutritional requirements are illustrated by the Food Pyramid. This graphic representation of the five food groups is very helpful in choosing an adequate diet. However, more complex foods that contain many food groups are difficult to place on the Pyramid. The food label reports a Percent Daily Value that is very helpful.

Proper nutrition depends on the individual. Specific recommendations can be found by combining information from several sources including the food label. Fortunately, by using variety and moderation in food choices, most people do not have to become professional nutritionists to eat a balanced diet.

### **Credits**

*Focus on Food Labeling.* An FDA Consumer Special Report. Rockville, MD: Food and Drug Administration, May, 1993.

Hamilton, Whitney,Sizer. *Nutrition.* 4th ed. St. Paul: West Publishers, 1988.

## **Lesson 3: Nutritional Value of Beverages**

Have you ever heard of "empty calories." These are foods or drinks that provide calories in your diet but supply very few or no nutrients. Yet many beverages do supply nutrients, as this lesson will explain.

### **Nutritional Benefits of Beverages**

Beverages are an important part of the human diet. The most important function of a beverage is to supply necessary fluids for the body. Depending on the specific beverage, some supply carbohydrates, protein, fat, vitamins, and or minerals. Also, beverages supply the fluid necessary for normal metabolism.

### **How the Body Utilizes Beverages**

Since the human body is 60 percent water, water is very important in the diet and to a person's health. Dehydration symptoms appear when a 5-10 percent reduction in the water balance occurs, accompanied by thirst, weakness, and mental confusion. Water has four major functions in the body: a medium for carrying nutrients within body fluids; a solvent for organic and inorganic chemicals necessary for life, and a medium for which the chemical reactions can be dispersed in; a carrier for the nitrogenous wastes generated by cellular metabolism; and as a control and maintainer of body temperature.

Of course the body will utilize the other nutrients that may be found in the beverage similarly to how it utilizes nutrients found in food. Generally, nutrients are absorbed through the intestinal wall into the bloodstream, with the exception of molecules of aspirin and alcohol which are absorbed through the stomach wall.

Alcohol is metabolized differently than most nutrients. It is absorbed in the stomach where it goes directly to the liver. Alcohol is broken down to its components and used like other nutrients. However, too much alcohol can overwork the liver, causing it to incompletely break down other nutrients. An overworked liver will convert other components to fat. This fat deposits in the liver, causing many other problems. Ultimately, the liver can stop functioning properly. This disease, called cirrhosis, is one of the top ten causes of death in the U.S.

### **Nutritional Qualities of Common Beverages**

Milk is very nutritious as it supplies protein, carbohydrates, fat, vitamins, minerals, and water.

Carbonated soft drinks, the leading beverage in terms of consumption, provide water and carbohydrates. Some provide minerals, like sodium. Others contain fruit juice, which supplies some vitamins. In general, carbonated beverages contribute very few nutrients and should be consumed in moderation. Excessive consumption of these beverages may interfere with the body's ability to absorb calcium.

Coffee and tea, unless they include cream or sugar, supply no nutrients except water.

Fruit juices provide water, carbohydrates, vitamins, and minerals. Some may provide small amounts of protein.

### **Nature's Almost Perfect Food**

Why is milk called nature's most nearly perfect food? It is nature's most perfect food because it is naturally in a liquid state and is easily consumed by young and old alike. Milk protein is of premium quality, including all essential amino acids. The nutritive value of vegetable proteins are substantially increased when milk is consumed with them. The two primary proteins in milk are casein and lactalbumin.

Lactose is the principal carbohydrate found in milk. Milk is the only significant source of lactose in nature. Lactose may have a special role in the growth and development of the central nervous system. Lactose stimulates the growth of microorganisms in the intestine, which produce organic acids and synthesize many B-complex vitamins. Lactose enhances absorption of calcium, phosphorus, and magnesium in the intestine.

Milk fat contains a relatively high amount of short-chain fatty acids, which are easily digested by humans. Some nutritionists believe these short chain fatty acids do not contribute to heart disease like the longer chain saturated fatty acids found in other animal fats. Milk also contains unsaturated, essential fatty acids.

The major minerals found in milk include calcium, phosphorus, potassium, chlorine, sodium, sulfur, and magnesium. Milk is not a very good source of iron or copper in the diet.

Milk contains all known vitamins and is an especially good source of riboflavin and other B vitamins. Vitamins A and D are usually added to milk as a supplement. Vitamin C, ascorbic acid, is the only vitamin needed for good health that milk cannot completely satisfy.

Milk is not a particularly good source of vitamin C, principally because it is pasteurized to prevent the spread of disease causing microorganisms.



### Summary

Beverages play a vital role in the diet. Water balance is maintained in the body by consuming water and other beverages.

Body fluid is a medium for carrying nutrients, a solvent for organic and inorganic chemicals, a carrier of waste products, and a control for body temperature. Common beverages provide carbohydrates, protein, fat, minerals, and vitamins depending on the particular beverage. Milk is considered nature's most nearly perfect food. It contains most of the necessary nutrients in high quality form.

### Credits

Campbell and Marshall. *The Science of Providing Milk for Man*. 1st ed. New York: McGraw-Hill, 1975.

Curtis, Helena. *Biology*. 4th ed. New York: Worth Publishers, 1983.

*Focus on Food Labeling*. An FDA Consumer Special Report. Rockville, MD: Food and Drug Administration, May, 1993.

Hamilton, Whitney,Sizer. *Nutrition*. 4th ed. St. Paul: West Publishers, 1988.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 1st ed. Mission Hills, CA: Glencoe Publishing, 1989.

Mehas, Kay; Sharon Rodgers. *Food Science and You*. 2nd ed. New York: Glencoe, 1994.

Potter, Norman N. *Food Science*. 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.

## **Lesson 4: Relationship Between Diet and Health**

Food labels are highlighted with eye-catching slogans such as: "contains no cholesterol" or "high fiber" or "fat-free." Do these influence you? Are you conscious about your diet? Whether you are or are not, you can be sure that your diet does influence your health. This lesson highlights a few of today's issues.

### **Cholesterol**

Cholesterol is a popular topic of conversation. Do you know what it really is? How does it work? Is it true that the body actually makes cholesterol? What are HDL and LDL?

Cholesterol is a waxy, fat-like substance necessary for building membranes, particularly in the brain and nervous system. Cholesterol plays a vital role in bile synthesis and in the production of adrenal and sex hormones. A derivative of cholesterol found in the skin is converted by sunlight to vitamin D. If insufficient amounts of cholesterol are in a person's diet, the liver will produce cholesterol.

Cholesterol found in the blood is called serum cholesterol, or blood cholesterol. Dietary cholesterol is present in foods. Cholesterol is only found in foods of animal origin, like eggs, meat, fish, poultry and cheese. Dietary cholesterol is spread throughout the food, it is not isolated in the skin or fat portions.

Blood cholesterol levels are affected by many factors including diet, heredity, age, and gender. Blood cholesterol levels are measured in milligrams per deciliter. Standards are set as: less than 200 mg/dl - desirable; 200-239 mg/dl - borderline; greater than 240 mg/dl - high. A high blood cholesterol level is a major risk factor for a person developing coronary heart disease. Cholesterol is carried in the blood by molecules called lipoproteins. Low-Density Lipoprotein (LDL) is referred to as "bad" cholesterol because it carries cholesterol to the tissues. High-Density Lipoprotein (HDL) is referred to as "good" cholesterol because it is transported from the tissues to the liver for elimination.

Cholesterol is often discussed in connection with dietary fat, even though they are two different substances. A diet that is high in total fats and saturated fats will tend to increase blood cholesterol levels. The connection between dietary cholesterol and blood cholesterol levels is less certain. This area of nutrition is changing rapidly as we learn more about the role of diet in health.

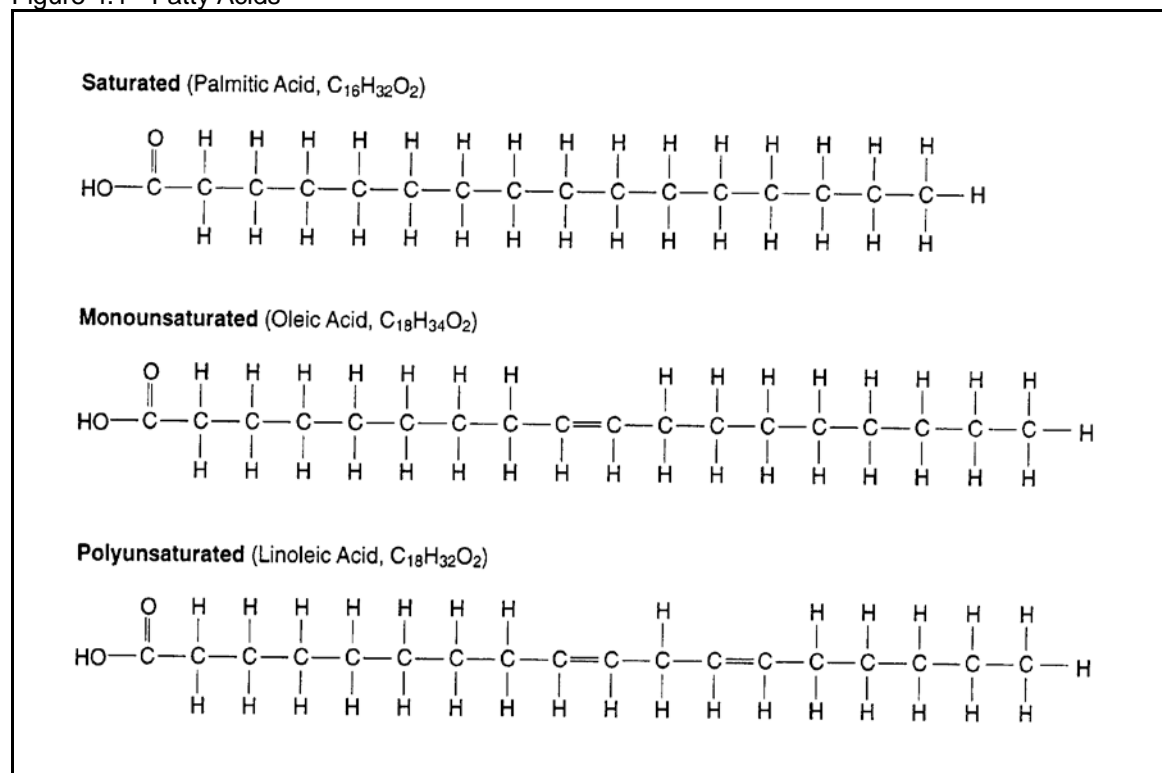
### Fats

Fats in food are responsible for many of the flavors, textures, and aromas we find desirable. Fat also influences the degree of fullness and satisfaction (satiety) of a meal. Fats are the most concentrated source of food energy, supplying nine Calories per gram. They are needed to transport and absorb the fat-soluble vitamins: A, D, E, and K.

Fats are composed of fatty acids, which can be classified as saturated, monounsaturated, or polyunsaturated. Three fatty acids attached to a glycerol molecule constitute a triglyceride. Most triglycerides have a chemical structure composed of a long, straight chain of carbon atoms (Figure 4.1). If the carbon atoms are linked together by single bonds, the molecule is a saturated fatty acid. If one double bond connecting carbon atoms is present, it is a monounsaturated fatty acid. If two or more double bonds are present, the fatty acid is polyunsaturated. Their chemical structure determines their behavior in your digestive system and in your body cells.

Saturated fatty acids predominantly come from animal sources and coconut, palm, palm kernel, and vegetable oils. Bear in mind that fats and oils contain many types of fatty acids. They are classified according to their predominant acid type. Because

Figure 4.1 - Fatty Acids



saturated fatty acids can raise blood cholesterol levels, it is recommended that they compose 1/3 or less of total fat intake.

Monounsaturated fatty acids are found in animal and plant fats, especially in olive, canola, and peanut oils. These may help lower blood cholesterol levels. Recommendations call for 1/3 or less of total fat intake to be supplied by monounsaturated fatty acids.

Polyunsaturated fatty acids come from sunflower, safflower, corn, sesame, and soybean oils. These can help lower blood cholesterol. Linoleic acid, which is one example of a polyunsaturated fatty acid, is an essential fatty acid needed for normal growth.

The proportion of saturated to unsaturated fatty acids give fats and oils their individual physical properties. Fats containing more saturated than unsaturated fatty acids are typically solid at room temperature. Fats which are more unsaturated than saturated are typically liquid at room temperature. The exceptions are the mostly saturated palm and coconut oils which are liquids at room temperature.

It is recommended that fats should contribute no more than 30 percent of total calories in your diet.

### **Fiber and Health**

It has long been recognized that fiber contributes to a healthy intestine. Cellulose, pectins, lignin, and other plant substances that are not readily digested, constitute fiber. Fiber holds water, loosens the stool, and decreases the stool transit time through the large intestine.

Research also has shown that adequate dietary fiber may lower serum cholesterol, decrease the incidence of colon cancer, and lower the insulin requirements of diabetics. Fiber from different sources varies in its proportion of the different indigestible components and is not equal in its physiological effect. Grinding and other processes also influence fiber's effectiveness. Excessive fiber may bind minerals and make them unavailable for absorption.

### **Health Issues and Nutrition**

One of the privileges of living in America is the vast supply of high quality, low-cost foods. Americans have a longer life expectancy than many other countries. One of the reasons for this is the availability of good nutritious foods. However, the availability of low fiber, high fat foods contributes to poor health among Americans. Most nutritional diseases in the United States are diseases of excess, but nutritional deficiencies do occur. Many health issues are tied to nutrition.

## Food Science and Technology-Unit IV

---

Anorexia is a disease where the individual refuses to eat, even though they are starving.

Bulimia is a disease characterized by a person vomiting food before it provides nourishment. Bulimia results in starvation and other physiological complications.

Diverticulitis is the condition of an inflamed colon, which can be initiated by certain foods as well as being treated with fibrous foods.

Heart disease is characterized by problems associated with blood circulation. Consumption of high levels of fat seem to increase the risk of developing this problem.

Malnourishment is defined as the lack of, or an insufficient amount of an essential nutrient. There are several diseases caused from malnourishment. Most vitamins and minerals are associated with some nutritional deficiency.

Obesity is almost the opposite of starvation. Obesity occurs when more calories are ingested than spent. An accumulation of calories leads to fat deposits and extra weight. Obesity is a contributing factor to many other diseases including heart disease, arthritis, and diabetes.

Starvation is a condition of being without food for an extended period of time. The body's energy stores are also depleted and the body begins to break down in an attempt to supply energy to the brain, heart, and lungs.

Ulcers are lesions in the stomach lining. Ulcers can be caused by specific foods and treated by specific foods.

Beri-beri is a thiamin deficiency. Osteoporosis is a softening of the bone tissue linked to a calcium deficiency. Night blindness is a vitamin A (carotene) deficiency. Neuritis is a thiamin deficiency. Photophobia is caused by a riboflavin shortage. Anemia is caused by a lack of iron or vitamin B<sub>12</sub>. Pellagra is caused by a lack of niacin. Scurvy is caused by a shortage of vitamin C. Rickets is a defective bone formation caused by a vitamin D deficiency. And hemophilia is caused by a vitamin K shortage.

A final health-related issue affected by nutrition is a person's recovery time following an illness or surgery. People in good health, who have a balanced diet and lifestyle, require less recovery time.

### Health Problems Can be Minimized by Nutrition

The human body is an intricate creation. Its physiological functions depend on hundreds of factors. One of the most important factors is proper nutrition. A balanced diet accompanied by sufficient regular exercise is a great start. Eating habits that follow

the Recommended Dietary Allowance (RDA's) and are appropriate in caloric intake in order to remain in weight range for age and height are highly encouraged. And finally, if diet modification is recommended to correct or prevent a health problem, following a doctor's or dietician's suggestions is recommended.

### Summary

There is a direct relationship between diet and health. Issues about cholesterol, fat composition, grams of fat, and others are popular topics. Cholesterol is a necessary part of normal health. The type and amount consumed can be controlled by what a person eats. Fats are either saturated, monounsaturated, or polyunsaturated depending on the number of double bonds between carbon atoms. A balance of all three types in the diet is recommended. Fiber influences intestinal health and is therefore very important. There are many diseases related to dietary deficiencies, imbalances, and over indulgence. Many of these health problems can be minimized by a balanced diet that includes an appropriate caloric intake.

### Credits

*Exploring Meat and Health.* Chicago: National Live Stock and Meat Board, 1991.

*Focus on Food Labeling.* An FDA Consumer Special Report. Rockville, MD: Food and Drug Administration, May, 1993.

Guyton, Arthur C. *Human Physiology and Mechanisms of Disease.* 4th ed. Philadelphia: W.B. Saunders Co., 1987.

*Lessons on Meat.* Chicago: National Livestock and Meat Board, 1991.

Mehas, Kay; Sharon Rodgers. *Food Science and You.* 2nd ed. New York: Glencoe, 1994.

Potter, Norman N. *Food Science.* 4th Ed. Westport, CT: AVI Publishing Co. Inc., 1986.