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.

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

<u>Fermentation</u> - 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.

<u>Milling</u> - 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.

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.

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.

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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.

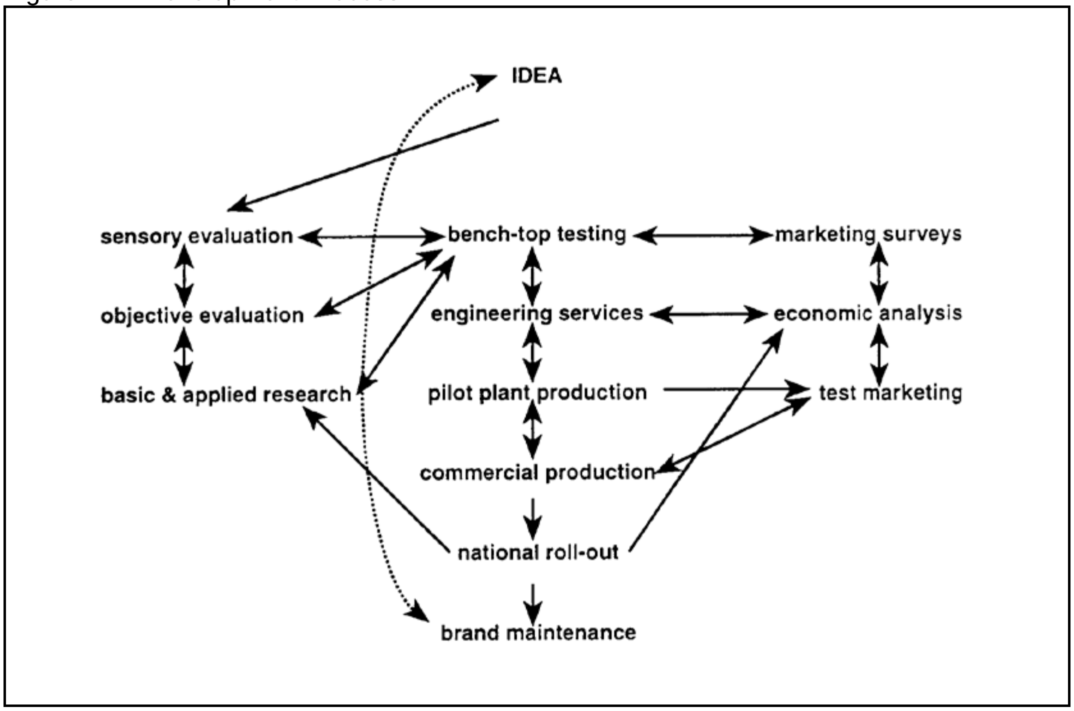
New Food Products

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.

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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.

<u>Fluid milk</u> 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).

<u>Fermented milks</u> 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 thermophilous* and *Lactobacillus bulgaricus*. These microorganisms convert lactose to

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 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 contaminates 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.

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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 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.

<u>Whole milk</u> 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.

<u>Low-fat milk</u> 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.

<u>Non-fat milk</u> (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.

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

<u>Cultured buttermilk</u> 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.

<u>Yogurt</u> is another product that can be made when appropriate microorganisms are allowed to ferment at about 110°F. *Streptococcus thermophilous*, 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_2), 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

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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.

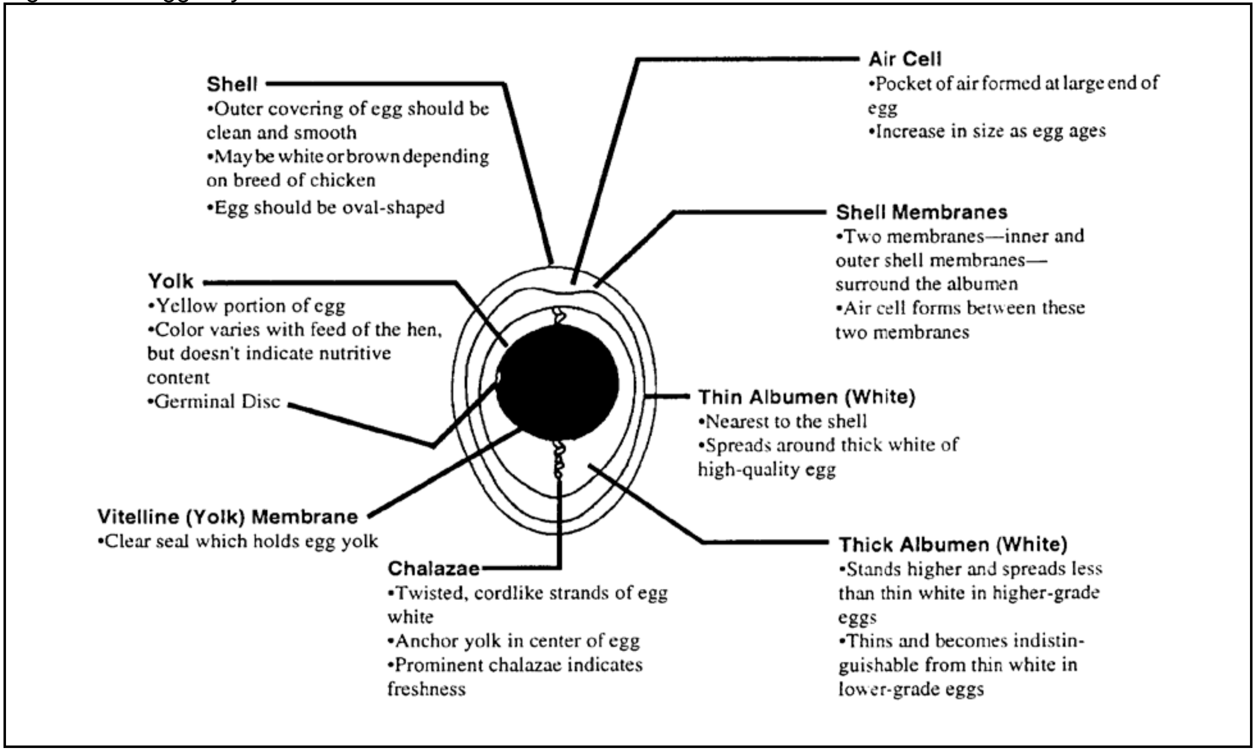
Quality Characteristics

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 cartoning. 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

Egg Size	Ounce per Dozen
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.

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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, 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'sconsumer 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

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Figure 6.1 - Beef

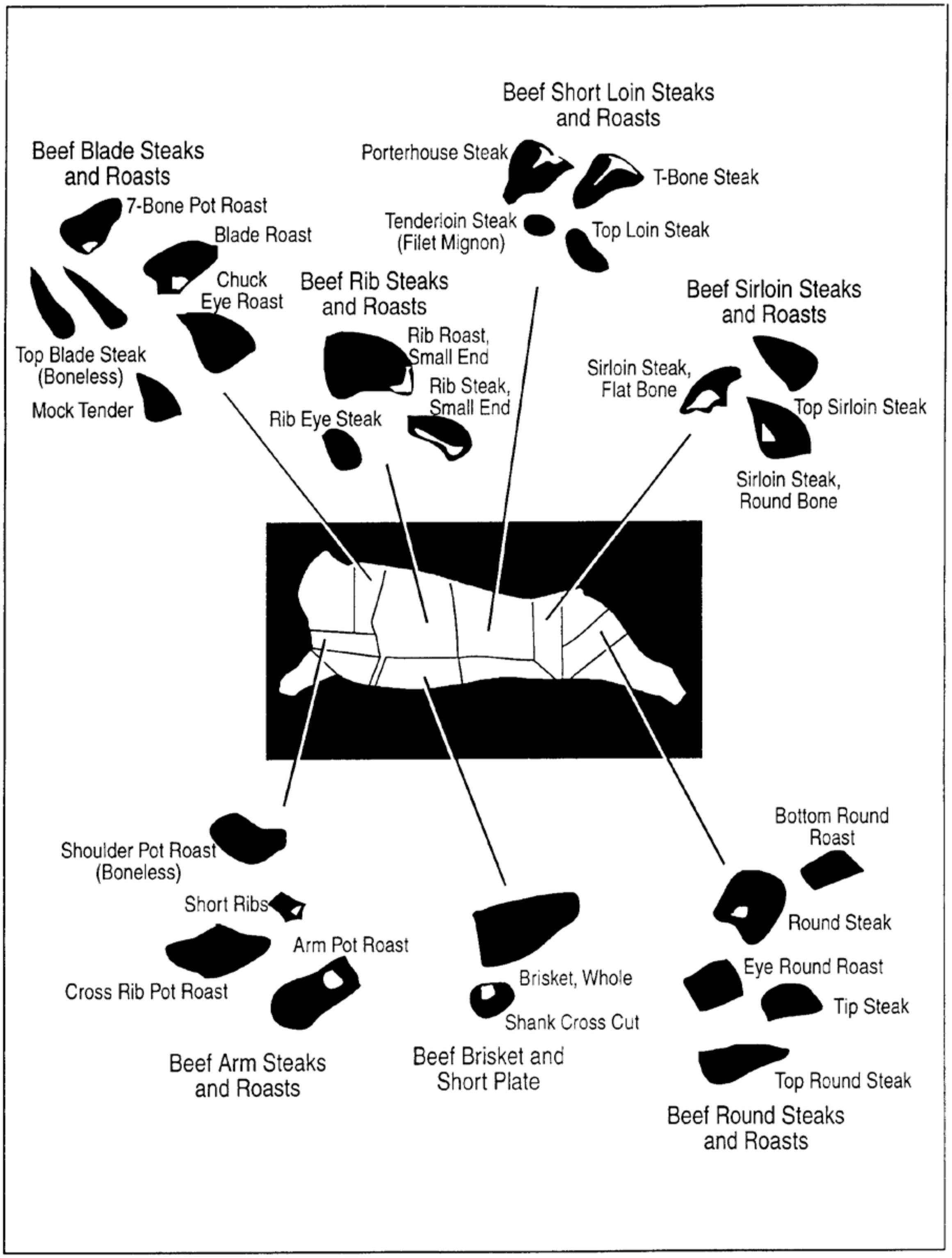

Figure 6.2 - Veal

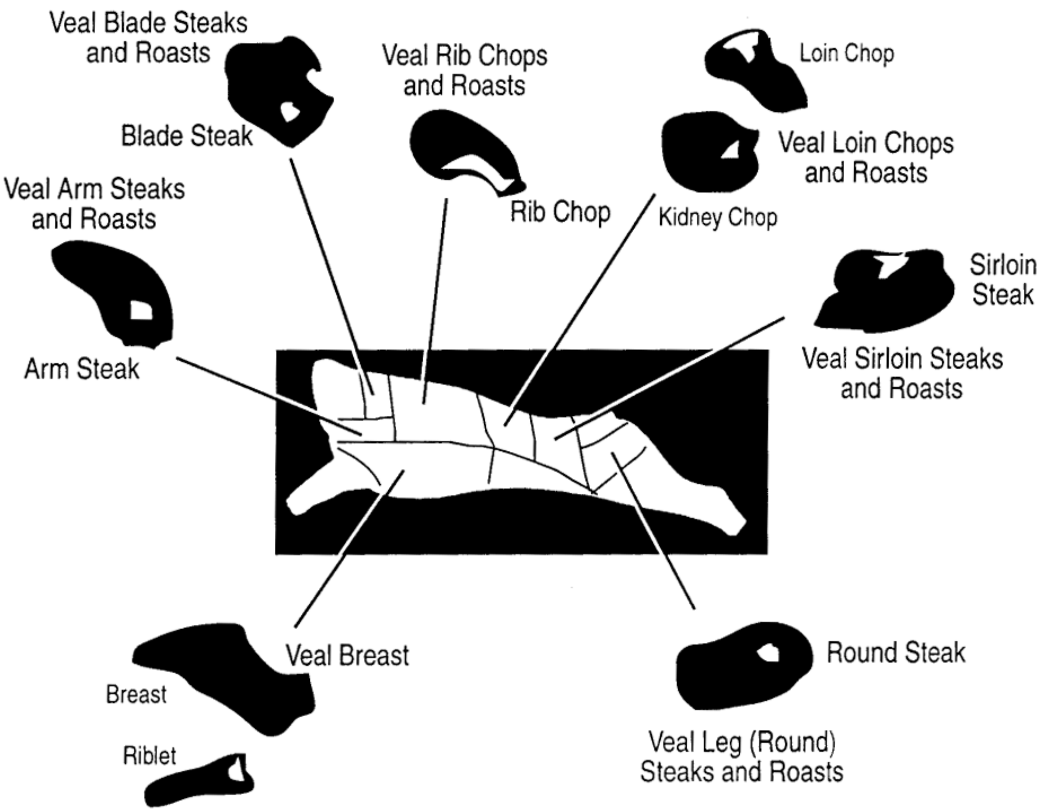

Figure 6.3 - Pork

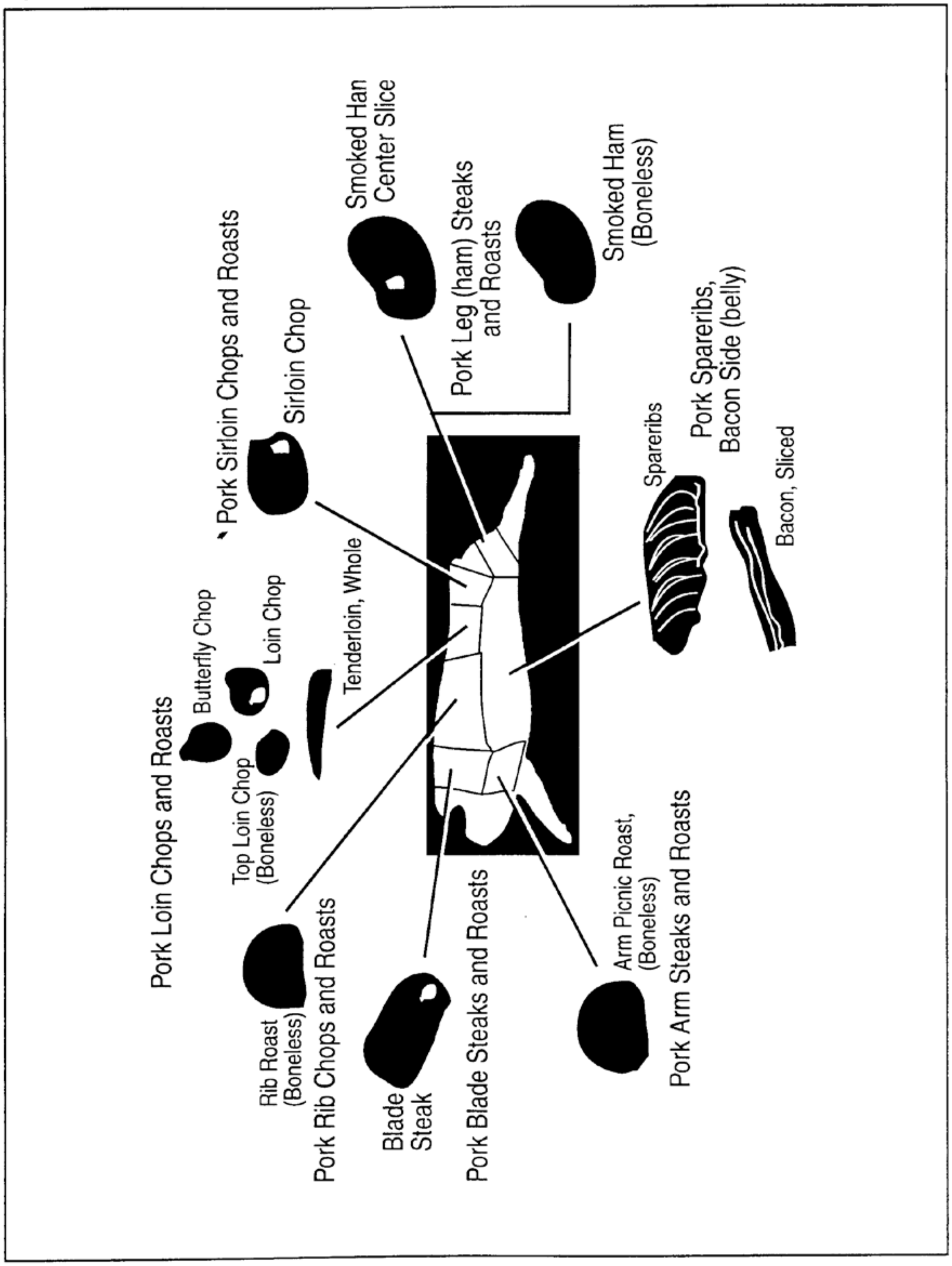

Figure 6.4 - Lamb

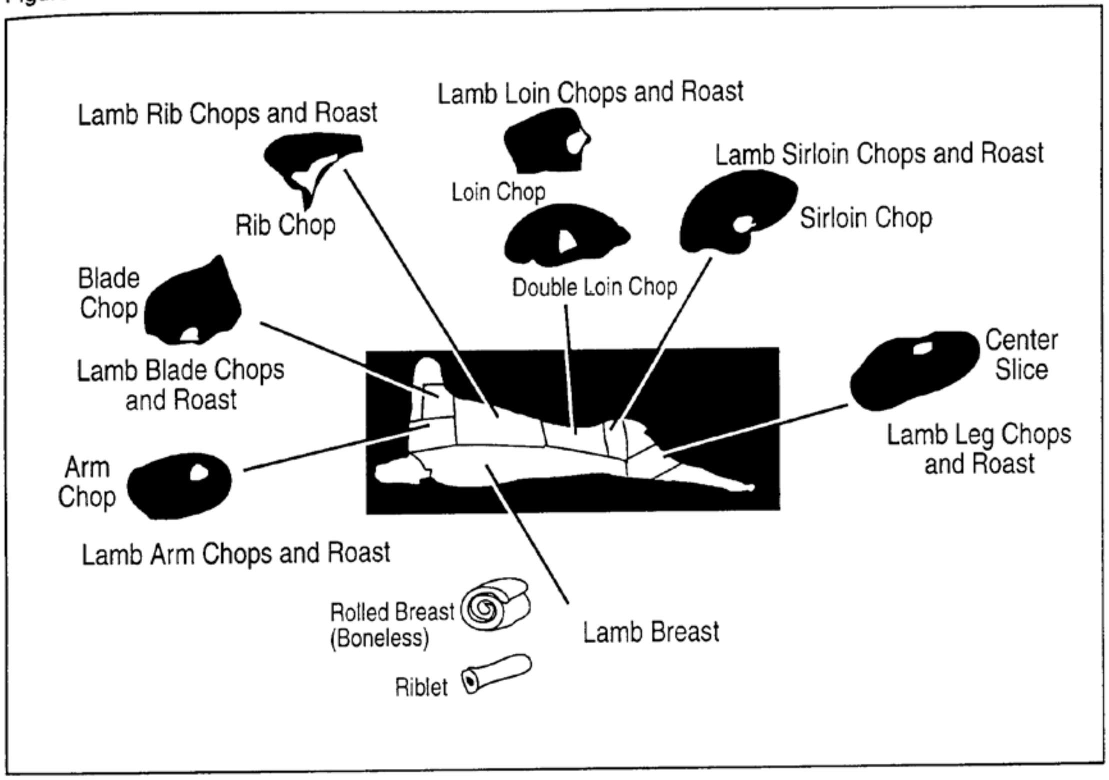

Table 6.1 - Animal By-Products

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_3*, thromboplastin*
gall bladder	cortisone*, chenodeoxycholic acid*
intestines	heparin* and casings
pancreas	insulin*
ovaries	estrogen*, progesterone*
parathyroid	hormones*, proteases*
pineal gland	melatonin*
pituitary gland	prolactin*, adrenocorticotropic 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_2 (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 <u>resolution of rigor</u>. 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

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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 andwhat do their grades mean? The answers to these questions and others are found in the following lesson.

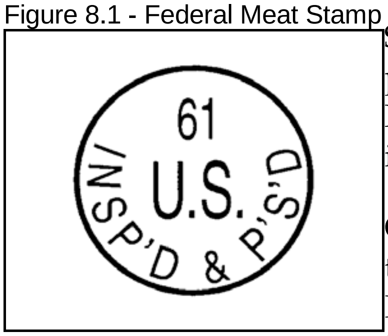
Inspection and Grading

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.

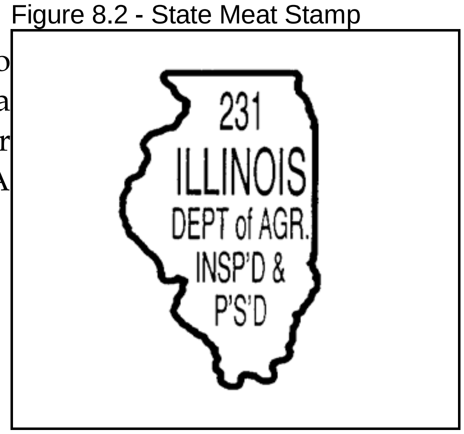
A round stamp of approval is placed on each primal cut when it passes inspection. This purple ink stamp contains the abbreviation for "United States Inspected and Passed" and the official establishment number assigned to that packing/processing plant. See Figure 8.1.

Figure 8.1 - Federal Meat Stamp



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.

Figure 8.2 - State Meat Stamp

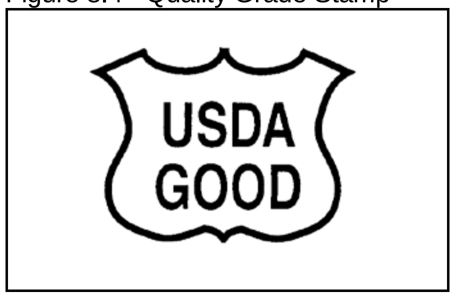


Qualified USDA inspectors do the inspecting. In the case of a Kosher plant, Kosher inspectors who meet USDA standards do the work. See Figure 8.3 for Kosher stamp.

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.

Figure 8.4 - Quality Grade Stamp



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.

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.

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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).

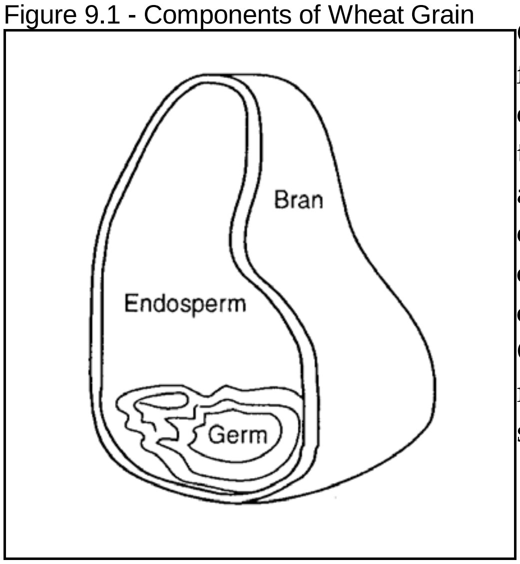
While not strictly grains, dry legumes such as dry peas, lentils, and various beans (navy, pinto, black, etc.) are often processed in similar ways.

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).

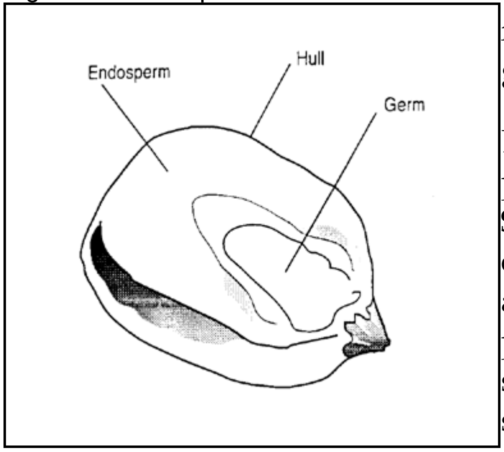
Wheat varieties are grouped into two major categories: hard wheat and soft wheat. Hard wheat is higher in protein, and yields a stronger, more elastic dough which is better for breadmaking. Duram wheat, a hard wheat, is the primary flour source for pasta products. Soft wheat is primarily used in cake 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

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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 <u>harvested</u> and <u>transported</u> 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 <u>milling</u>. 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_2). 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.

<u>Malting</u> 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 <u>roasted</u> 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, unclassed 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.

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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, 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

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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_2 levels, and light, are used to regulate shelf-life. Potatoes need large amounts of O_2, 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.

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_2).

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_2) 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.

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