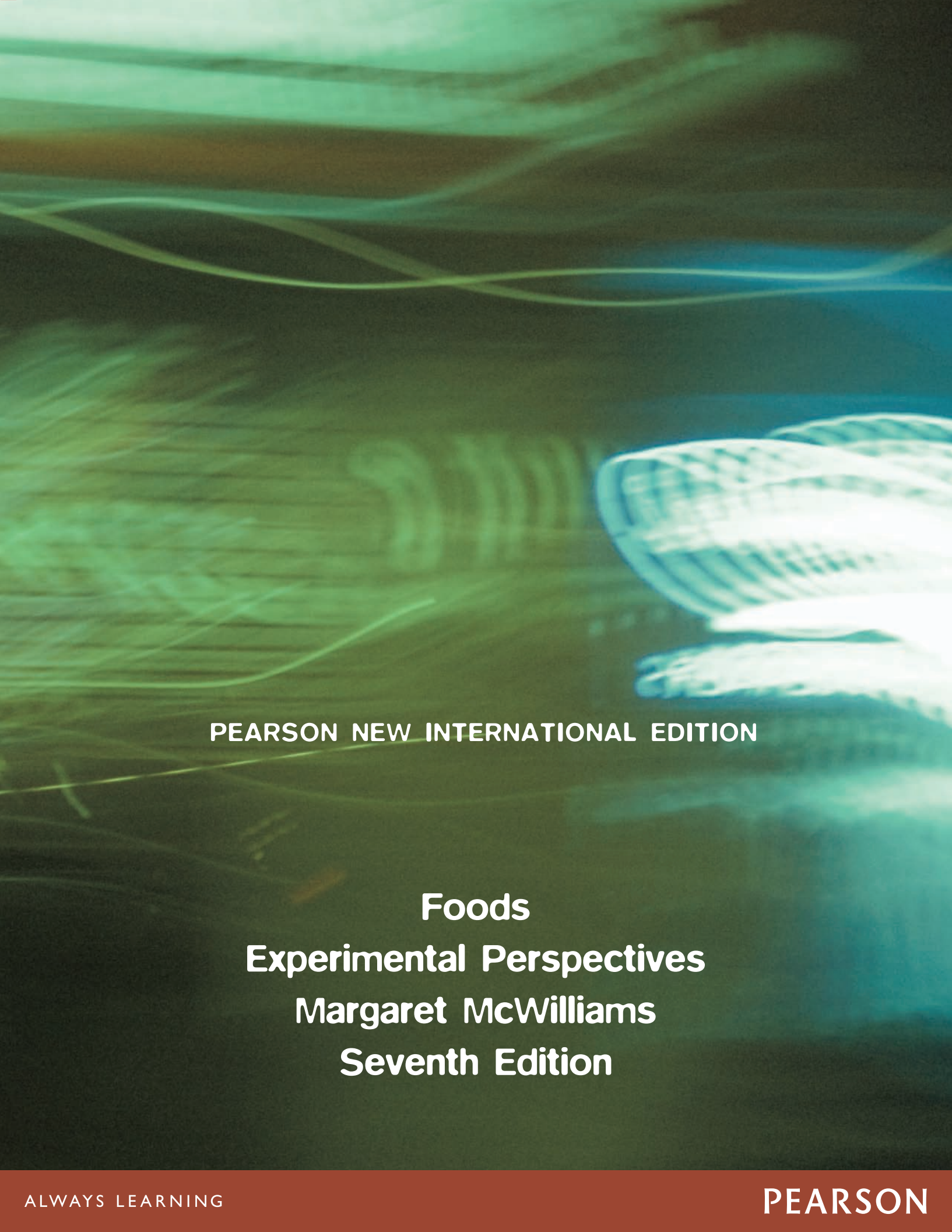

PEARSON NEW INTERNATIONAL EDITION

Foods
Experimental Perspectives

Margaret McWilliams

Seventh Edition

ALWAYS LEARNING

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Glossary

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A band Total portion of the sarcomere in which thick and thin myofilaments overlap; includes the H band.

Acesulfame-K Low-calorie sweetener derived from acetoacetic acid.

α-amylase Amylose-digesting enzyme contained in abundance in egg yolk and to a lesser extent in egg white.

α-lactose Less soluble form of lactose, the disaccharide prominent in milk; form of lactose that is largely responsible for the sandy texture of some ice creams.

Acidophilus milk Fermented milk product (usually whole milk) to which *Lactobacillus acidophilus* is added to digest the lactose.

Acrolein A highly irritating and volatile aldehyde formed when glycerol is heated to the point at which two molecules of water split from it.

Acrylamide Carcinogen formed in starchy fried foods and also in baked products.

Actin Myofibrillar protein existing primarily in two forms (F and G).

Actinidin Proteolytic enzyme in kiwi fruit.

Active dry yeast Granular form of dried *Saccharomyces cerevisiae* (8 percent moisture); storage is at room temperature and rehydration at 40–46°C (104–115°F).

Actomyosin Protein complex of actin and myosin that forms to effect contraction of the sarcomere.

Adenosine triphosphatase (ATPase) Enzyme in muscle tissue involved in glycolytic reactions leading to lactic acid formation.

Aerobic Requiring oxygen for survival and growth.

Affective testing Sensory testing to determine acceptability or preference between products.

Aflatoxicosis Condition caused by ingesting aflatoxin; begins with nausea and vomiting but ends with convulsions, coma, and death.

Aflatoxin Carcinogenic mycotoxin produced by *Aspergillus flavus* and *Aspergillus parasiticus*.

Aftertaste The aromatic message of the flavor impression that lingers after food has been swallowed.

Aging (maturing) of flour Chemical process to modify the sulfhydryl groups in flour to disulfide linkages, usually utilizing a chlorine-containing compound.

Aging (of meat) Holding of meat while it passes through rigor mortis and sometimes for a period extending several days or even two weeks, depending on the quality and type of carcass; storage of meat to enhance tenderness.

Air cell Space between the inner and outer shell membranes at the large end of an egg.

Albumen White of an egg; consists of three layers.

Albumen index Grading measurement of albumen to determine quality on the basis of the amount of thick white.

Aldose Hexose with one carbon atom external to the 6-membered ring.

Alitame Sweetener resulting from combining L-aspartic acid, D-alanine, and an amine.

Alliin Odorless precursor in garlic that ultimately is converted to diallyl disulfide.

Alliinase Enzyme in garlic responsible for catalyzing the conversion of alliin to diallyl thiosulfinate, the precursor of diallyl disulfide.

Allium Genus including onions, chives, garlic, shallots and leeks; unique for its sulfur-containing flavor compounds.

All-purpose flour Multi-use flour made from hard wheat or a mixture of hard and soft wheat; contains about 10.5 percent protein.

Alpha (α) crystals Extremely fine and unstable fat crystals.

Amebic dysentery Protozoan infection characterized by diarrhea of varying severity (sometimes containing mucus and blood) and sometimes more severe symptoms.

Amorphous Form of solid lacking an organized, crystalline structure.

Amorphous candies Candies that lack an organized crystalline structure because of their very high concentration of sugar or interfering substances.

Amphoteric Capable of functioning as either an acid or a base, depending on the pH of the medium in which the compound is found.

Amygdalin Cyanogenic glycoside in apricot and peach pits that can cause cyanide poisoning if consumed.

Amylograph Device designed to control the temperature of a starch paste and to measure its viscosity.

Amylopectin Branched fraction of starch consisting primarily of glucose units linked with 1,4-α-glucosidic linkages, but interrupted occasionally with a 1,6-α-linkage resulting in a very large polysaccharide.

Amylose Straight-chain, slightly soluble starch fraction consisting of glucose units joined by 1,4-α-glucosidic linkages.

Anaerobic Requiring an oxygen-free environment for survival and growth.

Analysis of variance (ANOVA) Statistical approach to determining differences between many sets of data.

Angel food cake Foam cake containing an egg white foam, sugar, and cake flour.

Angstrom (Å) Unit of measure; for example, 1 cm = 100,000,000 Å.

Anthocyanidin Anthocyanin-type pigment that lacks a sugar in its structure.

Anthocyanin Flavonoid pigment in which the oxygen in the central ring is positively charged.

Anthoxanthin Flavonoid pigment in which the oxygen in the central ring does not carry an electrical charge.

Arborio rice Medium-grain rice used for making paella and risotto.

Ascaris lumbricoides Type of parasitic roundworm that may be present in some seafood and may cause illness leading to possible pneumonia if food is not heated enough to kill it.

Aspartame Very sweet, low-calorie methylated dipeptide composed of phenylalanine and aspartic acid; used as a high-intensity sweetener.

Aspergillus flavus Mold capable of making aflatoxin in nuts, grains, and legumes stored under moist, warm conditions.

Aspergillus parasiticus Mold capable of making aflatoxin in stored nuts, grains, and legumes.

Astaxanthin Reddish-orange carotenoid pigment in salmon and in cooked crustaceans.

Astringency Puckery feeling in the mouth created by compounds such as tannins.

Autoxidation Oxidation reaction capable of continuing easily with little added energy.

Avidin Albumen protein that binds biotin when in the native state, but not when it is denatured.

Beta (β) crystals Extremely coarse and, therefore, undesirable fat crystals.

Bacillary dysentery Food-borne illness characterized by severe diarrhea and electrolyte loss, accompanied by intense abdominal cramps and a high fever and capable of ending in death.

Bacillus coagulans Anaerobic bacillus that digests sugar to lactic acid in canned foods to cause flat-sour spoilage.

Baked custard Sweetened milk and egg mixture that is baked without agitation until the egg protein coagulates and forms a gel.

Baking ammonia Ammonium salt of carbonic acid [$(NH_4)_2CO_3$] that dissolves to release ammonia, carbon dioxide, and water for leavening springerle and other rather dry cookie doughs, crackers, and biscotti.

Baking powder Mixture of acid and alkaline salts and a standardizing agent to produce at least 12 percent of the carbon dioxide available for leavening.

Basmati rice Long-grain, aromatic rice.

Benzoyl peroxide Food additive approved by the FDA for bleaching the xanthophylls in refined flours.

Beta prime (β′) crystals Very fine and reasonably stable fat crystals.

Beta ray Radiant energy that is very slightly longer than gamma rays and that can penetrate food, but not aluminum.

Betacyanins Group of betalains responsible for the reddish-purple color of beets; not an anthocyanin, but behaves colorwise in the same fashion.

Betalains Two groups of pigments (betacyanins and betaxanthins) that contribute the anthocyanin-like color to beets, but differ chemically from the anthocyanins.

Bicarbonate of soda Alkaline food ingredient ($NaHCO_3$) used to react with acids to form carbon dioxide.

Biotechnology Development of new products by making a genetic modification in a living organism.

Birefringence Refraction of light in two slightly different directions.

Biscuit Quick bread with a ratio of about 3:1 (flour to liquid) and also containing fat cut into small particles, baking powder, and salt; usually kneaded and rolled, but sometimes dropped.

Biscuit method Mixing method in which the dry ingredients are combined, the fat is cut into small particles in the flour mixture, all of the liquid is added at once and stirred in just to blend, and the dough is kneaded; a flaky product results.

Blast freezing Freezing in air-blast freezers with frigid (from –30 to –45°C) air circulating at a high velocity; causes rapid freezing and small ice crystals.

Bleaching Refining step in which coloring and flavoring contaminants are removed from fats, often by filtration through active charcoal or other suitable substrate.

Bloom Granular-appearing, discolored areas on the surface of chocolate, the result of melting of less stable crystals and recrystallization as β crystals.

Bloom (eggs) Natural protective coating sealing the shell pores when an egg is laid.

Bloom gelometer Modification of a penetrometer designed especially for measuring the tenderness of gels.

Boiling point Temperature at which vapor pressure of a liquid just exceeds atmospheric pressure.

Botulism Potentially fatal food poisoning results from ingesting even a minuscule amount of toxin produced by *Clostridium botulinum*.

Bound water Water that is bound to other substances and no longer exhibits the flow properties and solvent capability commonly associated with water.

Bran Outer layers (fibrous and very high in cellulose) encasing the interior endosperm and germ of cereal grains.

Bread flour Hard wheat, long-patent flour with a protein level of about 11.8 percent.

Brix scale Hydrometer scale designed to indicate the percentage concentration of sugar in sugar solutions.

Bromelain Proteolytic enzyme in pineapple.

Bt Designation that a seed has been modified by splicing a gene from *Bacillus thuringiensis* to promote resistance to insects.

Butylated hydroxyanisole (BHA) Antioxidant effective in animal fats used in baking.

Butylated hydroxytoluene (BHT) Antioxidant used to retard oxidation in animal fats.

Cage-free eggs Eggs laid by hens raised on the floor of a building rather than in cages.

Cake flour Soft wheat, short-patent flour (about 7.5 percent protein).

Calcium-activated factor (CAF) Proteolytic enzyme activated by calcium; contributes to tenderizing of aging meats.

Campylobacteriosis Food-borne illness caused by toxin from *Campylobacter jejuni* (or other toxin-producing strains).

Campylobacter jejuni Common strain of *Campylobacter* that can cause campylobacteriosis.

Canola oil Oil from rape *(Brassica napus)* seeds, a genetically modified variety of rape.

Capsaicinoids Capsaicin and related compounds responsible for the fiery quality of chili and other peppers.

Caramelization Fragmentation of monosaccharide into a variety of compounds, including organic acids, aldehydes, and ketones, as a result of extremely intense heat.

Carotenes Group of carotenoids containing only hydrogen and carbon in a polymer of isoprene.

Carotenoids Class of pigments contributing red, orange, or yellow color as a result of the resonance provided by the isoprene polymers.

Casein Collective name for milk proteins precipitated at pH 4.6.

Casein micelle Casein aggregate that is comparatively stable and remains colloidally dispersed unless a change such as a shift toward the isoelectric point or the use of rennin destabilizes and precipitates casein.

Case-ready meats Meats that are processed and packaged in retail packaging at a centralized site for distribution ultimately to retail markets.

Catechins Flavonoid pigments that are a subgroup of the flavonols.

Cathepsins Group of proteolytic enzymes that can catalyze hydrolytic reactions leading to the passing of rigor mortis.

Cellulose Complex carbohydrate composed of glucose units joined together by 1,4-β-glucosidic linkages.

Certified raw milk Milk that has a small microorganism population but has not been heat treated, and, therefore, may cause serious illness.

Cestodes Parasitic tapeworms, some of which use humans as hosts; possible food sources are various meats and fish that have been undercooked or eaten raw.

Chalazae Thick, rope-like extensions of the chalaziferous layer that aid in centering the yolk in the egg.

Chalaziferous layer Membranous layer surrounding the vitelline membrane of egg yolk.

Chiffon cake Foam cake that includes oil and egg yolk as liquid ingredients, an egg white foam, baking powder, sugar, and cake flour.

Cholera Food-borne illness especially problematic in tropical areas around the world; caused by *Vibrio cholerae.*

Chlorophyll a Blue-green, more abundant form of chlorophyll; the chlorophyll form in which the R group is a methyl group.

Chlorophyll b Yellowish-green form of chlorophyll in which the R group is an aldehyde group.

Chlorophyllase Plant enzyme that splits off the phytyl group to form chlorophyllide from chlorophyll.

Chlorophyllide Chlorophyll molecule minus the phytyl group; water-soluble derivative of chlorophyll responsible for the light-green tint of water in which green vegetables have been cooked.

Chlorophyllin Abnormal green pigment formed when the methyl and phytyl groups are removed from chlorophyll in an alkaline medium.

Chloroplast Type of plastid containing chlorophyll.

Cholesterol A sterol found in abundance in egg yolk.

Chromatography Separation of discrete chemical compounds from a complex mixture by the use of solvents or gases; separation may be accomplished by use of a GLC or a HPLC or by other somewhat less sophisticated means.

Chromoplast Type of plastid containing carotenoids.

CIE Commission Internationale de L'Eclairage; group that established a system of measuring color based on spectral color, degree of saturation, and brightness.

Ciguatera poisoning Food-borne illness caused by ciguatoxin produced in fish that have eaten the algae *Gambierdicus toxicus.*

Circumvallate papillae Large, obvious protuberances always containing taste buds and distinguished easily because they form a "V" near the back of the tongue.

***Cis* configuration** An arrangement in which the hydrogen is attached to the carbon atoms on either end of the double bond from the same direction, causing a lower melting point than its *trans* counterpart.

Climacteric Period of maximum respiratory rate just prior to the full ripening of many fleshy fruits.

Climacteric fruit Fruit that continues to ripen after it has been picked—for example, bananas and peaches.

Clostridium botulinum Anaerobic spore-forming bacteria that can produce a highly poisonous toxin capable of killing people.

Clostridium nigrificans Bacteria capable of producing hydrogen sulfide in canned foods to cause sulfide spoilage.

Clostridium perfringens Anaerobic, spore-forming bacterium that can produce a toxin capable of causing a mild food-borne illness.

Coagulation Precipitation of protein as molecules aggregate (often as a result of energy input, such as heating or beating).

Coldpack (club) cheese Cheese product made by adding an emulsifier to a mixture of natural cheeses.

Cold point Coldest area of food in a can being heat processed.

Cold pressing Mechanical pressing of olives to express oil without heat, resulting in an oil of excellent purity.

Cold shortening Severe contraction of muscles in carcasses that have been chilled too quickly and severely after slaughter.

Collagen Fibrous protein composed of three strands of tropocollagen.

Collenchyma tissue Aggregates of elongated collenchyma cells providing supportive structure to various plant foods, notably vegetables.

Colloid Material with a particle size between 0.001 and 1 millimicron.

Colloidal dispersion Two-phase system in which the particles in the dispersed phase are between 0.001 and 1 micron in diameter.

Color-difference meter Objective machine, such as the Hunter color-difference meter or Gardner color-difference meter; capable of measuring color difference between samples utilizing the CIE or Munsell color systems.

Commercially sterile Food that has been heat processed enough to kill all pathogenic microorganisms and spores.

Comminuted meats Products made by almost pulverizing meats and adding the desired fat and salts before heating the resulting mixture.

Complex carbohydrates Polysaccharides, such as starch and cellulose.

Composite ice cream Frozen dessert containing at least 8 percent milk fat and 18 percent total milk solids and no more than 0.5 percent edible stabilizer; flavoring particles are not to exceed 5 percent by volume.

Compressed yeast *Saccharomyces cerevisiae* in a cornstarch-containing cake with a moisture level of 72 percent; requires refrigerated storage; dispersion is best at 32 to 38°C (89 to 100°F).

Compressimeter Objective equipment that measures the force required to compress a food sample to a predetermined amount.

Conalbumin Protein in egg albumen capable of complexing with iron (Fe^{+3}) and copper (Cu^{+2}) ions to form red and yellow colors, respectively.

Concatenation A linking together; nonspecific description of the association of glutenin molecules by disulfide linkages.

Conduction Transfer of energy from one molecule to the adjacent molecule in a continuing and progressive fashion so that heat can pass from its source, through a pan, and ultimately throughout the food being cooked.

Cones Cone-shaped dendrites of photoreceptor neurons that enhance the sharpness of visual images and add the dimension of color to vision.

Conjugated proteins Proteins combined with some other type of compound, such as a carbohydrate or lipid.

Consistometer Device for measuring the spread or flow of semisolid foods in a specified length of time.

Consumer panel Sensory evaluation panel selected from people who happen to be available at a test site and are willing to participate.

Continuous phase Medium surrounding all parts of the dispersed phase so that it is possible to pass throughout the emulsion in the continuous phase without traversing any portion of the dispersed phase.

Convection Transfer of heat by the circulation of currents of hot air or liquid resulting from the change in density when heated.

Convection oven Oven designed with enhanced circulation of heated air to increase heating by convection, reduce baking time, and promote optimal crust browning.

Conventional method Mixing method in which fat and sugar are creamed, beaten eggs are added, and dry ingredients (a third at a time) and liquid ingredients (half at each time) are added alternately; fine texture and excellent storage qualities are advantages of this laborious method.

Conventional sponge method Method of making cakes in which part of the sugar and all of the egg are withheld to make a sugar-stabilized meringue that is folded into the cake batter as the final step in its preparation.

Cooking losses Total losses from meat by evaporation and dripping during cooking.

Corn syrup Sweet syrup of glucose and short polymers produced by the hydrolysis of cornstarch.

Correlational research Research that determines interrelationships between variables.

Creaming Separation of fat from the aqueous portion of milk that takes place when fat globules cluster into larger aggregates and rise to the surface of milk.

Cross-linked starch Starch produced under alkaline conditions, usually in combination with acetic or succinic anhydride; notable as a thickener and stabilizing agent that undergoes minimal retrogradation.

Cruciferae Family of vegetables including Brussels sprouts, cabbage, rutabagas, turnips, cauliflower, kale, and mustard; includes sulfur-containing flavor compounds that differ from those found in *Allium* vegetables.

Crustaceans Shrimp, lobsters, crabs, and other shellfish with a horny covering.

Cryogenic liquids Substances that are liquid (not solids) at extremely cold temperatures.

Cryophilic Microorganisms with optimal reproduction and survival below 15°C (59°F).

Crystalline candies Candies with organized crystalline areas and some liquid (mother liquor).

Cultured buttermilk Low fat or nonfat milk containing *S. lactis* and *L. bulgaricus* that has been incubated to produce some lactic acid.

Curd Milk precipitate that contains casein and forms readily in an acidic medium.

Cyclamate Sweetener widely used in the world but banned in the United States.

Cyclodextrins (a, b, g CD) Cyclic compounds containing 6–8 glucose units derived from starch by bacterial enzymes (cyclodextrin glucosyl transferases).

Dark-cutting beef Very dark, sticky beef from carcasses in which the pH dropped to only about 6.6.

Degradation Opening of the ring structure as the prelude to the breakdown of sugars.

Denaturation Relaxation of the tertiary structure to the secondary structure, accompanied by decreasing solubility of a protein.

Denatured globin hemichrome A gray-brown pigment formed when myoglobin is heated.

Dendritic Branching.

Deodorizing Using steam distillation or other suitable procedure to remove low molecular weight aldehydes, ketones, peroxides, hydrocarbons, and free fatty acids that would be detrimental to the aroma and flavor of fats.

Dependent variable The measured variable of an experiment.

Dermal system Outer protective covering on fruits and vegetables, as well as other parts of plants.

Descriptive flavor analysis panel (DFAP) Thoroughly trained panel that works as a team to describe precisely in words the flavor of a sample.

Descriptive scale Array of words describing a range of intensity of a single characteristic, with each step on the scale representing a subtle degree of intensity.

Descriptive statistics Probability of predicting an occurrence by use of statistical tests such as chi-square, analysis of variance (ANOVA), student's *t*-distribution, or other statistical tools.

Descriptive testing Using descriptive words in sensory evaluation to characterize food samples.

Designer food Manufactured food that has been created to meet consumer demand for a food that may be effective in promoting health and avoiding or minimizing the risk of certain physical problems.

Dextrans Complex carbohydrates in bacteria and yeasts characterized by 1,6-α-glucosidic linkages.

Dextrinization Hydrolytic breakdown of starch effected by intense, dry heat and producing dextrins.

Dextrins Polysaccharides composed entirely of glucose units linked together and distinguishable from starch by a shorter chain length.

Dextrose Synonym for glucose; so named because polarized light bends to the right in a glucose solution.

Dextrose equivalent (D.E.) Measure of the amount of free dextrose (glucose), which parallels glucose formation by hydrolysis of larger carbohydrate molecules; pure dextrose = 100 D.E.

Diallyl disulfide Key flavor aromatic compound from garlic.

Dietary Supplement Health and Education Act (DSHEA) Act from 1994 that defines dietary supplements and limits the role of the FDA in regulating them.

Dietetic balance Single-pan, spring balance suitable for portion control, but not sufficiently accurate for food experimentation.

Diet margarines Spreads made from plant oils that have been partially hydrogenated and then blended with more than twice as much water as is used in stick margarines.

Difference testing Sensory testing designed to determine whether detectable differences exist between products.

Diglyceride (diacylglyceride) Simple fat containing two fatty acids esterified to glycerol.

Dipole Molecule that is electrically asymmetrical—that is, one portion is slightly negative and another part is slightly positive.

Directed interesterification Process of interesterification in which the fat is kept below its melting temperature.

Disaccharide Carbohydrate formed by the union of two monosaccharides with the elimination of a molecule of water.

Discontinuous (dispersed) phase Phase distributed in a discontinuous fashion, making it necessary to pass through at least some of the continuous phase to reach another part of the dispersed phase.

Docosahexanoic acid (DHA) Omega-3 fatty acid containing 22 carbon atoms and 6 double bonds.

Drip losses Combination of juices and fat that drip from meat during cooking.

Duo–trio test Difference test in which two samples are judged against a control to determine which of the two samples is different from the control.

Dutch-processed cocoa and chocolate Cocoa and chocolate produced from cacao with an alkaline treatment to produce a pH of 6–7.8 and a more soluble, darker-colored product than the natural product.

Dye Water-soluble chemical coloring agent certified for use in coloring foods.

Eggs lower in saturated fat and cholesterol Eggs with at least a 25 percent reduction in saturated fat and cholesterol, the result of feeding hens a diet rich in canola oil.

Eicosapentanoic acid (EPA) Omega-3 fatty acid with 20 carbon atoms and 5 double bonds.

Elaidic acid *Trans* isomer (t9-18:1) of oleic acid produced during hydrogenation; raises LDLs.

Elastin Yellow connective tissue occurring in limited amounts intramuscularly and in somewhat greater concentrations in deposits outside the muscles.

Electronic nose Testing machine that develops diagrams of the flavor components in a headspace sample.

Emulsifying agent Compound containing both polar and nonpolar groups so that it is drawn to the interface between the two phases of an emulsion to coat the surface of the droplets.

Emulsion Colloidal dispersion of a liquid in another liquid with which it is immiscible.

Endomysium Delicate connective tissue found between fibers.

Endosperm Large inner portion of cereal grains composed largely of starch and some protein.

Endothermic reaction Reaction in which heat is absorbed without an increase in temperature of the reactants.

Endotoxin Poison in cell walls of certain bacteria.

Enolization Reversible reaction between an alkene and a ketone.

Entamoeba histolytica Type of protozoa that can cause amebic dysentery in humans.

Enterobactereaceae Bacteria that can go through the stomach and be viable in the intestines, where they can reproduce and cause illness.

Enzyme Protein capable of catalyzing a specific chemical reaction.

Epidermal cells Layer of cells providing a continuous outer covering for fruits and vegetables.

Epimysium Connective tissue surrounding an entire muscle (many bundles of bundles of fibers).

Escherichia coli Type of coliform bacterium with many different serotypes, some of which produce toxins that cause food-borne illnesses.

Ethylene gas Gas produced in vivo that accelerates ripening of fruits. $H_2C{=}CH_2$.

Evaporated milk Sterilized, canned milk that has been concentrated to about half its original volume by evaporation under a partial vacuum.

Evaporation Escape of liquid molecules into the surrounding atmosphere.

Evaporative losses Loss of weight from meat during cooking as a result of evaporation.

Exotoxin Poison formed as waste when certain bacteria thrive and multiply.

Extraction Removal of bran and shorts during milling of wheat.

Extraneous variable Variable that is not intended to be part of the experiment and needs to be eliminated from or controlled prior to conducting the experiment.

Farinograph Objective testing equipment that measures the resistance of stirring rods moving through a batter or dough and records the results graphically.

Fatty acid Organic acid containing usually between 4 and 24 carbon atoms.

Fiber Bundle of myofibrils and sarcoplasm encased in the sarcolemma.

Fibrous protein Insoluble, elongated protein molecules.

Ficin Proteolytic enzyme in figs.

Fish Broadly defined as aquatic animals, but more narrowly defined to designate those with fins, gills, a backbone, and a skull.

Flat-sour spoilage Increased acidity caused when viable *Bacillus coagulans* digest sugar without producing gas in canned foods.

Flavonoids Group of chemically related pigments usually containing two phenyl groups and an intermediate 5- or 6-membered ring connecting the two phenyl rings.

Flavor The sensory message blending taste and smell perceptions when food is in the mouth.

Flavor enhancer Additive used to improve food flavor without contributing a specific identifiable taste.

Flavor inhibitor Substance that blocks perception of a taste.

Flavor potentiator Compound that enhances the flavor of other compounds without adding its own unique flavor.

Flavor profile panel Thoroughly trained panel that works as a team to describe flavor of a sample specifically in words.

Flour The fine particles of wheat (or other grain) produced by milling.

Flukes Flatworms (parasites) that can invade the liver, small intestine, or lungs.

Foam Colloidal dispersion of a gas dispersed in a liquid.

Foam cake Cake featuring a large quantity of foam (usually egg white), which results in a light, airy batter and a baked cake with a somewhat coarse texture with moderately large cells; includes angel food, sponge, and chiffon cakes.

Food Additives Amendment of 1958 Legislation governing food additives that placed the burden of proof of safety on the food manufacturer.

Food Allergen Consumer Protection Act of 2004 (FALCPA) Legislation requiring the listing of specific food allergens and their sources.

Food Chemicals Codex International directory of food additives.

Food, Drug, and Cosmetic Act of 1938 Federal legislation establishing the U.S. Food and Drug Administration and defining its responsibilities.

Free radical Unstable compound containing an unpaired electron.

Free-range eggs Eggs laid by hens that are raised in outside enclosures during the day but in a barn at night.

Freeze-drying Preservation of food by first freezing and then dehydrating the product.

Freezing in air Freezing of food in an extremely cold environment with still air or blasts of air.

Freeze-thaw stability Ability of a starch-thickened product to be frozen and thawed without developing a gritty, crystalline texture.

Frozen custard Ice cream–like product that is a frozen egg yolk–thickened custard.

Functional food Food that may provide health-promoting qualities beyond just the nutrients it provides.

Fungiform papillae Mushroom-like protuberances often containing taste buds and located on the sides and tip of the tongue.

Fungus Lower plant that is parasitic, saprophytic, and lacking in chlorophyll (e.g., molds, mildew, and mushrooms).

Gambierdiscus toxicus Algae that sometimes are eaten by red snapper and other finfish and ultimately produce ciguatoxin in the fish.

Gamma ray Radiant energy of very short wavelength and capable of penetrating food, but not lead.

Gas–liquid chromatograph (GLC) Machine that separates individual compounds from a mixture by passing them with a carrier gas along a special column that adsorbs and releases individual compounds at different rates.

Gel Colloidal dispersion of a liquid dispersed in a solid.

Gelatinization Swelling of starch granules and migration of some amylose into the cooking water when starch is heated in water to thicken various food products.

Gelation Process of forming a gel.

Gemsweet Heat-stable peptide sweetener.

Genetically modified organisms (GMO) Plant or animal foods developed by genetic manipulation to alter nutrient levels or other characteristics; also designated as GM or GMO.

Genetic engineering Biotechnology in which a genetic modification is achieved by removing, adding, or modifying genes.

Germ (embryo) Small portion of cereal grain containing fat and a small amount of protein, as well as thiamine, riboflavin, and other B vitamins.

Germinal disk Blastoderm of the yolk, which is located at the edge of the yolk and is connected to the white yolk.

Giardia lamblia Type of protozoa that, if ingested when they are alive, causes giardiasis in humans.

Giardiasis Parasitic illness caused by *Giardia lamblia*, a type of protozoa, and characterized by severe diarrhea.

Glassy lactose Amorphous (noncrystalline) milk sugar.

Glassy state Solid, inflexible physical state formed at an extremely cold temperature and with limited moisture in an amorphous solid; capable of changing to a rubbery or somewhat elastic physical state.

Glass transition Change of state of a material from a solid glass to a supercooled rubbery or viscous liquid.

Glass transition temperature (T_g) Temperature at which an amorphous solid in the glassy state begins to transform to a less rigid state.

Gliadin Protein fraction in wheat gluten that is soluble in alcohol, compact and elliptical in shape, and sticky and fluid.

Globular proteins Native proteins with a tertiary structure that is rather spherical.

Glucosinolates Sulfur-containing irritants in mustard and horseradish.

Glutamine Amino acid prominent in gliadin protein molecules and important in intermolecular hydrogen bonding.

Glutathione Peptide in yeast cells that causes stickiness in dough if the dried yeast is hydrated below 40°C (105°F).

Gluten Complex of gliadin and glutenin that develops in wheat flour mixtures when water is added and the batter or dough is manipulated by stirring, beating, or kneading.

Gluten flour Specialty wheat flour made by adding vital wheat gluten to increase the protein level to about 41 percent.

Glutenin Alcohol-insoluble protein fraction in wheat gluten that is characterized by its fibrous, elongated shape and elastic quality.

Glycerol Polyhydric alcohol containing three carbon atoms, each of which is joined to a hydroxyl group.

Glycogen Complex carbohydrate that serves as the storage form of carbohydrate in animals.

Glycolipid Molecule with a sugar moiety and a lipid portion.

Gonyaulax catanella Algae that produce toxin to cause paralytic shellfish poisoning when infected shellfish are eaten.

GRAS list A list of additives "generally recognized as safe" for use in foods because of long use with no evidence of carcinogenicity.

Ground substance Undifferentiated matrix of plasma proteins and glycoproteins in which fibrous molecules of collagen and/or elastin are bound.

Ground system Bulk of edible portion of plant foods.

Gums Complex carbohydrates of plant origin, usually containing galactose and at least one other sugar or sugar derivative, but excluding glucose.

Gustatory cells Elongated cells in taste buds from which a cilia-like hair extends into the pore of the taste bud.

HACCP Acronym for Hazard Analysis and Critical Control Point System, food safety program.

Hard meringue Egg white foam containing about 50 grams (4 tablespoons) of sugar per egg white; baked to a dry, brittle cookie or dessert shell.

Hard water Water containing salts of calcium and magnesium.

Haugh unit Units used to denote the quality of albumen; correlates thick albumen height with egg weight.

HAV Hepatitis A virus, the cause of a food-borne illness that attacks liver cells.

Hazard Analysis and Critical Control Point System (HACCP) System for analyzing, monitoring, and controlling food safety during production.

H band Region in the center of a sarcomere where only thick myofilaments of myosin occur.

Heat of fusion Heat released when a liquid is transformed into a solid (80 calories per gram of water); also called *heat of solidification*.

Heat of vaporization Heat energy absorbed in the conversion of water into steam (540 calories per gram of water).

Hectares Area equivalent to 10,000 square meters or 2.471 acres.

Hedonic ratings Measures of the degree of pleasure provided by specific characteristics of various food samples.

Hedonic scale Pleasure scale for rating food characteristics.

Heme Compound composed of four adjoining pyrrole rings linked to an atom of iron.

Hemicelluloses Carbohydrate polymers composed of various sugars and uronic acids; structural feature of plant cell walls.

Hemoglobin Large, iron-containing compound consisting of four heme–polypeptide polymers linked together; contributes to meat color.

Hepatitis A Food-borne illness characterized by inflammation of the liver; caused by hepatitis A virus.

Hexose Saccharide with six carbon atoms, the most common size unit.

High-fructose corn syrup (HFCS) Especially sweet corn syrup made using isomerase to convert some glucose to fructose.

High-pressure liquid chromatograph (HPLC) Machine that under pressure separates a sample dissolved in liquid into its individual components as they are adsorbed along a special column and finally eluted individually from the column.

High-pressure processing (HPP) Process using high pressure and water to make food safe and give it a somewhat extended shelf life during refrigerator storage.

Hilum Innermost layer or the nucleus of a starch granule.

Hold method Pasteurization in which milk is heated to 63°C (145°F) and held there for 30 minutes before it is cooled to 7°C (45°F).

Homogenization Mechanical process in which milk is forced through tiny apertures under a pressure of 2,000–2,500 psi, breaking up the fat globules (3–10 microns in diameter) into smaller units (less then 1 micron in diameter) that do not separate from the milk.

Hot pressing Using steam or hot water to heat plant seeds to about 70°C (150°F) to facilitate extraction of lipids from the seeds, a process that also extracts some gums, off flavors, and free fatty acids.

HTST method High-temperature short-time pasteurization in which milk is heated to 72°C (161°F) and held there at least 15 seconds before it is cooled to 10°C (50°F).

Humectant Substance that helps to retain moisture.

Hydrogen swells Spoilage of food and bulging of cans caused by anaerobic, thermophilic microorganisms that produce hydrogen during storage.

Hydrogenation Addition of hydrogen to an unsaturated fatty acid in the presence of a catalyst to reduce the unsaturation of the molecule and raise the melting point.

Hydrolysis Splitting of a molecule by the uptake of a molecule of water.

Hydrolytic rancidity Lipolysis (hydrolysis) of lipids to free fatty acids and glycerol, often catalyzed by lipases.

Hydroperoxide Compound containing a –O-O-H group.

Hydrophilic Attracted to water.

Hydrophilic/lipophilic balance (HLB) Twenty-point scale indicating the affinity of an emulsifying agent for oil versus water.

Hydrophobic Repelled from water.

Hygroscopicity Ability to attract and hold water, which is a characteristic of sugars to varying degrees.

Hypodermal layer Layer of cells beneath the epidermal cells.

Hypothesis Tentative assumption to test logical or empirical consequences of applying a variable in a research project.

I band Light region on either side of the Z line in a sarcomere, consisting of non-overlapping myofilaments of actin.

Ice cream (also called plain ice cream) Frozen dessert containing at least 10 percent milk fat and 20 percent total milk solids and no more than 0.5 percent edible stabilizer; flavoring particles must not show.

Implosion Violent compression.

Independent variable Manipulated variable defined by the researcher.

Index to volume Indirect means of comparing volume by measuring the circumference of a cross section of the product.

Indirect-contact freezing Freezing accomplished by placing packages of food in contact with cold shelves or by passing liquids through a chilled tube.

Inferential statistics Another term for descriptive statistics.

Infrared spectroscopy Identification technique in which a pure compound is subjected to infrared (wavelengths from 2,500 to 16,000 nm) energy to vibrate the molecule and create a spectrum of peaks indicating its structural features (e.g., an aldehyde group or benzene ring).

In-house testing Evaluations conducted within a food company prior to field testing and test marketing.

Interesterification Treatment of a fat, usually lard, with sodium methoxide or another agent to split fatty acids from glycerol and then to reorganize them on glycerol to form different fat molecules with less tendency to form coarse crystals.

Interfacial tension The tendency for molecules at the surface of a liquid to remain with the liquid rather than intersperse with molecules of a second adjacent liquid.

Intermediate crystals Slightly coarse fat crystals that form when crystals melt and recrystallize.

International Organization of Standardization (ISO) International federation of standards boards from 91 participating countries.

Intraesterification Catalyzed reaction in which the fatty acids split from glycerol and rejoin in a different configuration, but with the same fatty acids being retained in the molecule.

Inulin Complex carbohydrate that is a polymer of fructose.

Inversion Formation of invert sugar by either boiling a sugar solution (especially with acid added) or adding an enzyme (invertase) to the cool candy.

Invert sugar Sugar formed by hydrolysis of sucrose; a mixture of equal amounts of fructose and glucose.

Invertase Enzyme that catalyzes the breakdown of sucrose to invert sugar (fructose and glucose).

Irradiation Preservation of food by exposure to beta and gamma rays.

ISO 9000 Overall document of standards for food quality, established by the ISO.

Isoelectric point The pH at which a protein molecule has lost its electrical charge and is most susceptible to denaturation and precipitation.

Isomalt Low-calorie sweetener produced from sucrose by enzyme action.

Jasmine rice Long-grain, aromatic rice; resists retrogradation in storage.

Jelmeter Pipette-like viscometer designed to measure the adequacy of the pectin content of fruit juices used to make jams and jellies.

Joint FAO/WHO Expert Committee on Food Additives (JECFA) International committee charged with overseeing issues on food additives in international trade.

Kefir Fermented milk that contains about 3 percent alcohol because of fermentation by *Lactobacillus kefir*, which also adds CO_2.

Ketose Hexose with two carbon atoms external to the 5-membered ring.

Lactase Enzyme that catalyzes the breakdown of lactose to equal amounts of glucose and galactose.

Lactobacillus sanfrancisco Bacterium used to produce lactic acid in some bread doughs.

Lake Water-insoluble chemical coloring agent certified for use in coloring foods.

Latebra Tube connecting the white yolk to the germinal disk in egg yolk.

Latent heat of crystallization Heat released during the transition from the liquid state (higher energy) to the frozen state (lower energy).

Leaking Draining liquid from a soft meringue to the surface of the filling of a cream pie.

Labneh Soft cheese made by separating the curd from yogurt.

Lecithin Phospholipid in egg yolk that is an effective emulsifying agent.

Leucoanthocyanins Flavonoid pigments that are a subgroup of the flavanols and are often termed *procyanidins.*

Leucoplast Plastid in the cytoplasm of plant cells; site of starch storage as granules.

Level of confidence Percentage expression of certainty that the results caused by a variable are statistically significant.

Level of significance The decimal value below which the results of research will be considered significant, and the null hypothesis can be rejected.

Levulose Synonym for fructose, so named because polarized light bend to the left in a fructose solution.

Lignin Structural component of some plant foods that is removed to avoid a woody quality in the prepared food.

Lipids Nonpolar, water-insoluble compounds composed of carbon, hydrogen, and a small amount of oxygen.

Linamarin Cyanogenic glycoside in cassava that is toxic to humans; can be removed by careful processing.

Line-spread test Measurement of flow of a viscous liquid or semisolid food by determining the spread of a measured amount of sample in a specified time at 90° intervals on a template of concentric rings.

Linoleic acid Essential fatty acid (18 carbons) containing two double bonds.

Linolenic acid Fatty acid (18 carbons) containing three double bonds.

Lipase Enzyme that catalyzes the hydrolysis of fat to release free fatty acids from glycerol.

Lipolysis Reaction of a molecule of water with a fat molecule to release a free fatty acid in the presence of lipase or heat.

Lipovitellin High-density lipoprotein in granules in egg yolk, the most abundant granular protein.

Listeria monocytogenes Type of bacteria sometimes found in meats, meat products, unpasteurized milk, and other foods; toxin causes listeriosis.

Listeriosis Food-borne illness caused by *Listeria monocytogenes*.

Livetin Yolk plasma protein found in three forms (α, β, and γ).

Logarithmic order of death Percentage of bacteria and bacterial spores killed per minute at a constant temperature.

Long-patent flour Wheat flour made from 95 to 100 percent of the flour streams, yielding flour of rather high protein content (e.g., bread flour).

Low-fat ice cream Frozen dairy product containing 2 to 7 percent milk fat and 11 percent total milk solids.

Low-methoxyl pectinic acids (low-methoxyl pectins) Galacturonic acid polymers in which only between an eighth and a fourth of the acid radicals have been esterified with methanol; pectic substance found in fruit that is just beginning to ripen.

Lycopene Acyclic carotene responsible for red color in tomatoes and watermelon and overtones in apricots and other yellow-orange fruits and vegetables; antioxidant that may help prevent some cancers and coronary heart disease.

Lysozyme Albumen protein with an isoelectric point of pH 10.7; notable for its ability to hydrolyze a polysaccharide in the cell wall of some bacteria, thus protecting against contamination by these bacteria.

Mad cow disease Common name for bovine spongiform encephalopathy (BSE).

Magnetron tube Tube in a microwave oven that generates microwaves at a frequency of 915 or 2450 megahertz.

Maillard reaction Nonenzymatic browning that occurs when protein and a sugar are heated or stored together for some time.

Maltese cross A cross consisting of arms of equal length that terminate in a V-shape.

Marbling Small fatty deposits within muscles of meat.

Mass spectrometry Identification technique in which a pure compound is bombarded by a high-energy electron beam to split into various ions that then are sorted and finally recorded as a mass spectrum that reveals the actual compound.

Mass transfer Movement of a food component into or out of a food that is heating.

Masticometer Machine that measures comparative tenderness of meat and other foods by simulating chewing action.

Mealy Fine, granular.

Mean The arithmetic average of scores.

Meat Red meats, including beef, veal, pork, and lamb.

Measures of central tendency Mode, median, and mean.

Measures of dispersion Range, mean deviation, standard deviation, variance, and standard error of the mean or difference between means.

Mechanical energy Energy transferred to food through physical movements, such as beating.

Median The score at the midpoint of data arranged in a sequential array.

Medium-patent flour Wheat flour using about 90 percent of the flour streams, resulting in a somewhat higher protein content and relatively less starch (e.g., all-purpose flour).

Megahertz Measure of frequency defined as 1 million cycles per second.

Mellorine Imitation ice cream in which the milk fat has been removed and replaced by a different fat.

Melting point The temperature at which crystals of a solid fat melt.

Meniscus Curved upper surface of a liquid column that is concave when the containing walls are wetted by the liquid and convex when they are not.

Meringue Egg white foam containing sugar.

Mesophilic Microorganisms with optimal reproduction and survival between 15 and 45°C (59 and 113°F).

Metmyoglobin Brownish-red form of myoglobin formed when the ferrous iron is oxidized to the ferric form and water is complexed to the oxidized iron.

Metric system System of measurements of length, area, volume, and weight using the decimal system (the system of tens).

Micelle Casein aggregate that is comparatively stable and remains colloidally dispersed unless a change, such as a shift toward the isoelectric point or the use of rennin, destabilizes and precipitates casein.

Microwave Comparatively short (1–100 centimeters) electromagnetic wave.

Middle lamella Region between adjacent cells that cements the cells together; composed mostly of pectic substances.

Millimicron Billionth of a meter.

Milling Grinding and refining of cereal grains.

Miso Paste made by fermenting a mold culture with soybeans, salt, and often rice for up to three years.

Mitochondria Organelles in cells involved in respiration and other biochemical processes.

Mochigome Waxy (high amylopectin), sticky rice.

Mode Score or group receiving the most responses or data points.

Moisture content (Initial – dried weight/initial weight) × 100 = % moisture.

Molasses Sweetener produced as a by-product of the refining of sucrose from sugarcane.

Mollusks Shellfish with a protective shell.

Mono- and polyunsaturated fatty acids Fatty acids with one (mono) or two or more double bonds (polyunsaturated).

Monosaccharide Carbohydrate containing only one saccharide unit.

Monosodium glutamate Flavor potentiator; sodium salt of glutamic acid.

Morganella morganii Bacteria producing scombrotoxin from histidine on the surface of tuna and related fish.

Mouthfeel Textural qualities of a food perceived in the mouth.

Muffin Small, rounded quick bread baked from a batter containing a 2:1 flour-to-liquid ratio, plus egg, fat, sugar, baking powder, and salt.

Muffin method Mixing method in which the dry ingredients are sifted together in one bowl, the liquid ingredients (including fat) are mixed in another bowl and then poured into the dry ingredients, and the mixture is stirred briefly and baked; the result is a rather coarse, slightly crumbly product that stales readily.

Munsell system System of identifying colors on the basis of hue, value, and chroma, using a numerical scale.

Muscle Aggregation of bundles of bundles of fibers surrounded by the epimysium.

Mycomatta Sheet-like connective tissue in fish.

Mycotoxin Poisonous substance produced by some molds that can be lethal when consumed.

Myofibril Linear bundle of several myofilaments that contains a number of sarcomeres.

Myofilament Simplest level of organization in muscle; classified as thick or thin.

Myoglobin Purplish-red pigment consisting of heme-containing ferrous iron and a polypeptide polymer (globin).

Myosin Principal myofibrillar protein.

Myotomes Fibers in fish; these are thick and about 3 centimeters long.

Naive panel Sensory evaluation panel that has not been trained specifically regarding the product evaluation being undertaken in the study.

Nanotechnology Development, creation, and application of atomic, molecular, or macromolecular particles between 1 and 100 nanometers in size.

National Organic Program Federal legislation passed in 2002 to implement the Organic Food Production Act of 1990.

Natural A food product made without chemical or artificial additives.

Natural cheese Any cheese made by clotting milk to form a curd and then concentrating the curd by draining the whey; variations are produced by varying the curd concentration and by ripening with or without the addition of selected microorganisms or other ingredients.

Natto Fermented cooked soybean product useful as a spread or in soups.

Natural-processed cocoa and chocolate Cocoa and chocolate produced from cacao without the addition of alkali.

Nematode Roundworms that are parasitic.

Neotame Low-calorie dipeptide (aspartic acid and phenylalanine) sweetener.

Neutralization Removal of free fatty acids from fats and oils; a step in their refinement.

Newtonian Classification of materials having a flow rate that is not affected by shear rate—for example, water and sugar syrups.

Non-Newtonian Classification of materials having a flow rate that is influenced by shear rate—for example, chocolate and emulsions.

Norwalk-like virus (NLV) Virus causing sudden onset of acute gastrointestinal problems in 12 to 48 hours after eating food contaminated with feces.

Null hypothesis Statement that applying a research variable will not make a significant difference in a research project.

Number of chews Subjective test in which a judge chews similar bites of food to the same endpoint and records the actual number of chews required to reach that point for each sample.

Nutraceutical Sometimes used to describe not only functional foods but also supplements and medicinal herbs.

Objective evaluation Measurement of physical properties of a food by the use of mechanical devices.

Oil-in-water emulsion (o/w) Colloidal dispersion in which droplets of oil are dispersed in water, for example, mayonnaise.

Oleic acid Monounsaturated 18-carbon fatty acid.

Olfactory epithelium Yellow, mucus-coated area in the nose containing basal cells, supporting cells, and perikarya.

Olfactory receptors Nasal organs capable of detecting aromas.

Oligosaccharide Carbohydrate formed by the union of three to ten monosaccharides with the elimination of water.

Omega-3 eggs Eggs with increased omega-3 fatty acids (produced by feeding hens a diet high in flaxseed).

Omega-3 fatty acid Polyunsaturated fatty acid with the first double bond occurring on the third carbon from the methyl end of the molecule.

Organic Legally defined as plant or animal food produced without using growth hormones, antibiotics, or petroleum-based or sewage sludge-based fertilizers.

Organic Food Production Act of 1990 Federal legislation that regulates production and marketing of organic foods.

Oryzanols Class of sterols in rice bran oil of significance for antioxidant properties.

Ovalbumin By far the most abundant protein in egg albumin; readily denatured by heat.

Oven spring An increase in the volume (usually about 80 percent) of yeast breads during the early part of baking resulting from the expansion of carbon dioxide and the increased production of carbon dioxide stimulated by the oven heat.

Overrun Increase in volume (expressed as a percentage) that occurs when ice cream is frozen with agitation.

Ovomucin Rather fibrous protein abundant in thick egg white; contributes to the viscous texture of the thick white.

Oxidative rancidity Development of off flavors and odors in fats as a result of the uptake of oxygen and the formation of peroxides, hydroperoxides, and numerous other compounds.

Oxidized starches Thin-boiling starches produced by alkaline (sodium hypochlorite) treatment, but forming only soft gels.

Oxymyoglobin Cherry red form of myoglobin formed by the addition of two oxygen atoms.

Paired comparison Difference test in which a specific characteristic is to be evaluated in two samples, and the sample with the greater level of that characteristic is to be identified.

Papain Proteolytic enzyme from papaya.

Papillae Rough bulges or protuberances in the surface of the tongue, some of which contain taste buds.

Paralytic shellfish poisoning Often fatal, paralytic condition caused by ingesting shellfish containing high levels of toxin in their flesh, the result of red-tide feeding.

Parasite An organism living in or on a host organism.

Parenchyma cells Predominant type of cell in the fleshy part of fruits and vegetables.

Parevine Imitation ice cream in which both the milk fat and the milk solids have been replaced by nondairy ingredients.

Pasteurization Heat treatment of milk adequate to kill microorganisms that can cause illness in people.

Pasting Changes in a gelatinized starch, including considerable loss of amylase and implosion of the granule.

Pastry-blend method Method in which the flour and fat are creamed (first step); sugar, baking powder, salt, and half the liquid are added (second step); and the last half of the liquid and the egg are combined (third step).

Pastry flour Soft wheat, short- and medium-patent flour with a protein level of about 9.7 percent.

Pearl tapioca Large pellets of partially gelatinized tapioca that are dried, resulting in a product that needs a long soaking period before use but yields a translucent, nonstringy paste.

Pectic acid The smallest of the pectic substances and one lacking methyl esters; occurs in overripe fruits and vegetables; incapable of gelling.

Pectic substances Group of complex carbohydrates in fruits; polymers of galacturonic acid linked by 1,4-α-glycosidic linkages with varying degrees of methylation.

Pectinates Compound resulting from the combination of pectinic acids or pectins with calcium or other ions to form salts that usually enhance gel-forming ability.

Pectinesterases Enzymes that de-esterify protopectin and pectin, a change that reduces gel-forming ability.

Pectinic acid or pectin Methylated polymers of galacturonic acid formed from protopectin as fruit becomes barely ripe; capable of forming a gel.

Penetrometer Machine that measures tenderness by determining the distance a cone or other device penetrates a food during a defined period and using only gravitational force.

Pentosans Polymers of the pentoses xylose and arabinose.

Pentose Saccharide with five carbon atoms.

Peptization Acid hydrolysis of some of the peptide linkages in a protein to yield peptides.

Percent Portion of a hundred.

Percentile rank Relative position of a score within the total array of scores expressed on the basis of hundreths.

Percent sag (Depth in container – depth on plate)/depth in container × 100 = %.

Periderm Layer of cork-like cells protecting vegetable tissues underground.

Perikarya Bodies of olfactory cells in the olfactory epithelium from which dendrites extend to the olfactory vesicles.

Perimysium Connective tissue surrounding a bundle of several fibers.

Permanent emulsion Emulsion containing an amount of emulsifying agent sufficient to enable the emulsion to remain intact during ordinary handling and use.

Peroxide Compound with oxygen attached to oxygen.

Pheophorbide Chlorophyll derivative in which the magnesium and phytyl group have been removed; an olive-drab pigment.

Pheophytins a and b Compounds formed from chlorophyll a and b in which the magnesium ion is replaced by hydrogen, altering the color to greenish-gray for pheophytin a and olive green for pheophytin b.

Phlobaphene Derivative of a polyphenol in cacao that is formed in the presence of oxygen and is responsible for the reddish color sometimes noted in cocoa and chocolate.

Phloem Portion of the vascular system that transports aqueous solutions of substances such as nutrients.

Phospholipid Complex phosphoric ester of a lipid.

Phosphorylase Enzyme in potatoes that promotes sugar formation during cold storage.

Phosvitin Small protein in yolk granules that binds iron in yolk.

Phytochemicals Chemical compounds in plants that are important to promote healthful reactions in the body but are not classified as nutrients required for life and growth.

Phytyl Alcohol component of chlorophyll responsible for its hydrophobic nature.

Planimeter Engineering tool designed to measure distance as its pointer is traced around a pattern.

Plasmalemma Thin membrane between the cell wall and the interior of the cell.

Plastids Organelles in the cytoplasm that contain pigments or starch.

Polygalacturonase Pectic enzyme promoting degradation of pectic substances in avocados, pears, tomatoes, and pineapple.

Polyhydric alcohols (polyols) Alcohols with several hydroxyl groups, enabling them to be used as sweeteners—for example, xylitol and sorbitol.

Polymerization Formation of a variety of polymers, including simple dimers and trimers, when free fatty acids are subjected to intense heat for a long period of time during frying.

Polyphenoloxidases Group of enzymes capable of oxidizing flavonoid compounds to cause browning or other discoloration after harvest.

Polysaccharide Carbohydrate formed by the union of many saccharide units with the elimination of a molecule of water at each point of linkage.

Poultry Fowl, notably turkey, chicken, and duck.

Prebiotic Healthful bacterial culture added during manufacturing to enhance and/or modify a dairy product that does not survive in the digestive tract.

Preference testing Sensory testing designed to provide information on selected characteristics and to indicate preference or acceptability of products.

Pre-gelatinized starch Starch that has been gelatinized and then dehydrated; addition of water produces a thickened product.

Press fluids Juices forced from meat or other food under pressure.

Previously frozen Statement required on meat, poultry, fish, and shellfish if freezing occurred, but the item is thawed to at least –3.3°C (26°F) before it is purchased.

Primary structure Covalently bonded backbone chain of a protein: —C-C-N-C-C-N-C-C-N-.

Probiotic Bacterial culture added to a dairy product because of its health-promoting capability and viability in the intestines.

Prokaryotic Cellular organism without a distinct nucleus.

Process cheese Cheese product made by heating natural cheeses with an emulsifier and then cooling in a brick form.

Process cheese food Process cheese product with a moisture content of about 45 percent, which causes the cheese to be comparatively soft, yet firm.

Process cheese spread Spreadable process cheese product with a moisture content of about 50 percent.

Product Designation of Origin Legal designation that the European Union can grant to food products from specific locations.

Profiling Very detailed word description (usually of flavor) developed by a highly trained panel against which subsequent production is evaluated to maintain quality of production.

Proline Imino acid prominent in gliadin and collagen with a cyclic ring structure that restricts protein shape.

Propenylsulfenic acid Compound in onions that causes eye irritation and tears.

Propyl gallate (PG) Antioxidant somewhat effective in vegetable oils, often used in combination with BHA and BHT.

Protozoa Parasitic, single-celled complex microorganism or simple animal; some cause illnesses in humans when fecal contamination of water or food occurs and living organisms are ingested.

Protopectin Non-methylated polymers of galacturonic acid incapable of forming a gel; first pectic substance to be formed in a fruit.

Protopectinases Enzymes in fruits and vegetables capable of catalyzing the hydrolytic cleavage of protopectins to shorter chains of pectins.

PSE pork Pale, soft, and exudative pork from carcasses with a low pH, usually ranging between pH 5.1 and 5.4.

Pulsed electric field processing (PEF) Pasteurization of juice by pulsing it 1,000 times per second in an electrical field of about 35,000 V/cm.

Pyrrolidine ring Organic ring structure containing one atom of nitrogen; linkage to another amino acid through this nitrogen favors formation of a linear, fibrous protein molecule.

Pyrophosphatase Group of enzymes in muscle tissue influencing the water-holding capacity of meat.

Quantitative descriptive analysis (QDA) Development of a thorough description of characteristics of a product and a quantification of their intensity.

Quick breads Breads leavened with a leavening agent other than yeast, ordinarily either with steam or carbon dioxide generated from reaction of an acid and an alkali.

Quick-rise active dry yeast Special strain of *Saccharomyces cerevisiae* available as the active dry yeast and capable of producing carbon dioxide so rapidly in the dough that fermentation time is cut approximately in half.

Quorn™ Trade name for products based on hyphae harvested from *Fusarium venenatum* mixed with a binder and then heated and frozen.

Rad Ionizing energy equal to 10^{-5} joule per gram of absorbing material.

Radiation Direct transfer of heat energy from its source to the surface of a food.

Radiant energy Energy traveling as electromagnetic waves.

Rancidity Chemical deterioration of a fat caused by the uptake of oxygen (oxidative) or water (hydrolysis).

Randomized interesterification Interesterification accomplished using melted fat.

Range eggs Eggs laid by hens in outside enclosures during the day, but in a barn at night.

Rank-order test Preference or difference test in which all samples are ranked in order of intensity of a specific characteristic.

Recombinant bovine somatotropin (rbST) Genetically engineered hormone that stimulates milk production in cattle.

Red tide Visible evidence of unusually large populations of dinoflagellates (microalgae) capable of causing paralytic shellfish poisoning.

Reducing sugar Sugar having a free carbonyl that can combine with an amine, leading to non-enzymatic browning.

Regression Statistical methods applicable to correlational research.

Rendering Removing fat from animal tissues by either dry or moist heat.

Rennet Unpurified extract from the fourth stomach of unweaned calves, which contains rennin, an enzyme causing milk curds to form.

Rennin Enzyme from the stomach lining of calves that eliminates the protective function of κ-casein in micelles and results in the formation of a curd.

Resistant starches Starches that are not digested until entering the large intestine.

Restructured meats Meats made from meat cuts that are somewhat less expensive; made by creating small particles, adding fat and other ingredients, and shaping into uniform portions.

Reticulin A type of connective tissue protein associated with a fatty acid (myristic acid).

Retrogradation Gradual increase of crystalline aggregates in starch gels during storage that results from breaking of hydrogen bonds between amylose molecules and slow rearrangement into a more orderly configuration and establishment of new hydrogen bonds.

Reversion Development of an off flavor (beany or fishy) in soybean, rapeseed, or various fish oils as a result of a reaction involving only very minor amounts of oxygen.

Rheology Study of deformation and flow qualities of matter. Characteristics of flow and deformation of fats and other substances with flow properties.

Ripening Changes that occur in crystalline candies when they are stored.

Rods Elongated dendrites of photoreceptor neurons that transmit visual images in dim light, revealing movement and varying intensities of black and white.

Rotating dull knife tenderometer Objective testing device that measures relative tenderness of meat by determining the depth of penetration effected by a rotating dull knife.

Saccharin Non-nutritive sweetener.

Saccharomyces cerevisiae Yeast (single-celled plant) used in baking.

Saccharomyces exigus* and *Saccharomyces inusitatus Yeasts used to produce carbon dioxide in acidic bread doughs.

Salmonella Genus name for several species of gram-negative bacteria that can cause gastrointestinal illnesses, including typhoid fever.

Salmonella enteritidis Form of bacteria that can be incorporated into the yolk of an egg as the hen forms the egg;

potential source of food-borne illness if egg is not heated sufficiently during preparation.

Salmonella typhi Type of *Salmonella* causing typhoid fever.

Salmonellosis General name for illness caused by *Salmonella,* regardless of the specific species.

Sarcolemma Thin, transparent membrane surrounding the bundle of myofibrils that constitute a fiber.

Sarcomere Portion of a myofibril consisting of the area between two Z lines.

Sarcoplasm Jelly-like protein surrounding the myofibrils in muscle fibers.

SAS-phosphate baking powder Leavening containing sodium aluminum sulfate and monocalcium phosphate; double-acting baking powder.

Saturated fatty acids Fatty acids containing all of the hydrogen atoms they can possibly hold.

Saturated solution True solution containing as much solute in solution as is possible to dissolve at that temperature.

Sclereid Type of sclerenchyma cell that gives the somewhat gritty texture to pears and certain other fruits.

Sclerenchyma cells Unique supportive cells with a chewy, fibrous character.

Scombroid (histamine) poisoning Food-borne illness caused by eating spoiled fish with high levels of histamine.

Scombrotoxin poisoning Allergic-type response to ingestion of high levels of histamine, saurine, and other metabolites produced by the action of *Morganella morganii* on tuna and related fish.

Secondary bonds Attractive forces between atoms and functional groups that are less strong than the bonding that occurs when electrons are shared; examples are van der Waal's forces and hydrogen bonding.

Secondary structure Typically the α-helical configuration of the backbone chain of many proteins; held by secondary bonding forces, notably hydrogen bonds; also may be in other forms (e.g., β-pleated sheet).

Self-rising flour Flour (usually soft wheat) to which baking powder and salt have been added during production.

Semi-permanent emulsion Emulsion with rather good stability because of the viscous nature of the liquid constituting the continuous phase.

Sensory evaluation A synonym for subjective evaluation; measurements determined by using the senses of sight, smell, taste, and sometimes touch.

Serotypes Closely related organisms, such as *E. coli*, having a common set of antigens.

Sharp freezing Freezing in still air at a temperature between –23 and –30°C (–9 and –22°F); an outmoded method because of the large ice crystals that form.

Shear press Objective testing machine that measures compressibility, extrusion, and shear of food samples.

Shellfish Subclassification of fish; includes mollusks and crustaceans.

Sherbet Frozen dessert containing acid, from 2 to 5 percent milk solids and no milk fat.

Shigella boydii Type of *Shigella* most likely to cause food-borne illness designated as bacillary dysentery.

Shortening power Ability of a fat to cover a large surface area to minimize the contact between water and gluten during the mixing of batters and doughs.

Shortometer Device designed to measure the tenderness of fairly tender, crisp foods.

Short-patent flour Wheat flour comparatively high in starch and low in protein, the result of using the very fine particles of flour from the center of the endosperm (e.g., cake flour).

Simple sugars Monosaccharides and disaccharides.

Single sample Presenting one sample early in an experimental project to determine acceptability and to aid in the decision on future development of the product.

Single-stage method Mixing method in which all of the ingredients except the egg and half the liquid are added and beaten before the egg and last half of the liquid are beaten in.

Sinigrin Potassium myronate, an isothiocyanate glucoside in cabbage that is broken down to highly pungent allyl isothiocyanate.

Smiley scale Sequential pictures of very happy and continuing through to very unhappy faces used in evaluating food products when respondents are unable to use the language easily.

Smoke point Temperature at which a fat or oil begins to emit some traces of smoke.

Sodium stearoyl-2-lactylate Dough conditioner of particular merit in improving baking quality of triticale and soy flours.

Soft or tub margarines Spreads with melting points lower than those of stick margarines because of a higher content of polyunsaturated fatty acids.

Soft meringue Egg white foam containing about 25 grams (two tablespoons) of sugar per egg white; topping on cream pies.

Soft water Water treated with lime or ion exchange resins (complex sodium salts) to remove the metallic cations.

Sol Colloidal dispersion in which a solid is the dispersed phase and a liquid is the continuous phase.

Soluble fiber Plant gums and pectic substances that undergo some digestion and absorption in the large intestine.

Solute Substance dissolved in a liquid to form a true solution.

Solvent Liquid in which the solute is dissolved to form a true solution.

Sorghum syrup Syrup sweetener produced by boiling the juice of grain sorghum.

Soy flour Finely ground soy flakes.

Soy grits Coarsely ground soy flakes.

Soymilk Beverage made from whole, finely ground defatted soybeans; a beverage designed to compete with milk.

Soy protein concentrate Defatted soy product usually containing about 70 percent protein.

Soy protein isolate Defatted, highly concentrated (up to 95 percent) soy protein; used to make many textured soy products.

Specific gravity Ratio of the density of a food (or other substance) to the density of water.

Spherulite Spherical crystalline body of radiating crystal fibers.

Sponge cake Foam cake containing an egg yolk foam, an egg white foam, sugar, and cake flour.

Sponge method Method of mixing yeast breads in which the yeast, liquid, and part of the flour are mixed and fermented to make a sponge before the rest of the ingredients are added; used commercially with strong flours.

Spore Specialized structure of bacteria capable of retaining viability under extremely adverse conditions.

Standard deviation Square root of the variance.

Standing time Length of time that a food is allowed to stand in a microwave oven without operation of the magnetron tube so the residual heat in the food can be transferred by conduction.

Staphylococcus aureus Bacteria capable of producing an enterotoxin as it grows, which can lead to food-borne illness.

Starch Complex carbohydrate consisting of two fractions—amylose and amylopectin—both of which are polymers of glucose joined together by the elimination of water.

Starch granule Concentric layers of amylose and amylopectin molecules formed in the leucoplasts and held together by hydrogen bonding.

Starch phosphates Starch derivative made by reaction with sodium tripolyphosphate or other phosphate to achieve a thickener with excellent stability and clarity.

Stearic acid Saturated 18-carbon fatty acid.

Stevioside Sweetener extracted from a South American plant; suitable for tabletop sweetener.

Stick margarines Spreads made by hydrogenating plant oils and adding water, milk solids, flavoring, and coloring to achieve a product similar to butter.

Stilton cheese Blue-veined cheese made by an approved process in any of six creameries in Leicestershire, Nottinghamshire, and Derbyshire, England.

Stirred custard Sweetened milk and egg mixture that is heated to form a sol; agitation during heating prevents formation of sufficient intermolecular linkages to form a gel.

Straight-dough method Method of mixing yeast breads in which all of the ingredients are added, mixed, and kneaded prior to fermentation and proofing.

Strategic Partnership Program—Agroterrorism (SPPA) Partnership of federal agencies (USDA, FDA, DHS, and FBI) with states and private industry charged with safeguarding food supplies and commodities.

Student's *t*-test Statistical test to determine the significance of the mean of the experimental group versus the mean of the control group.

Subjective evaluation Evaluation by a panel of individuals using a scoring system based on various characteristics that can be judged by using the senses.

Sublimation Transition from the frozen state directly to the gaseous state without liquefaction.

Substrate A general term for the compound that an enzyme alters.

Subthreshold level Concentration of a taste compound at a level that is not detectable but can influence other taste perceptions.

Sucralose Sweetener made from sucrose and containing three chlorine atoms.

Sucroglycerides Sucrose esters (sucrose and glycerides or free fatty acids) used as a dough conditioner with soy flour.

Sulfide spoilage Canned food contaminated with hydrogen sulfide produced by viable *Clostridium nigrificans*.

Sulfuring Exposure of cut fruits to the smoke fumes created by burning sulfur flowers to retain a bright color during drying.

Supercooling Reduction of the temperature of water below freezing until crystallization begins, after which the temperature rises to 0°C (32°F) because of the latent heat of crystallization.

Supersaturated solution True solution containing more solute than theoretically can be dissolved at that temperature, a situation created by cooling a heated saturated solution carefully.

Surface tension Attraction between molecules at the surface of a liquid.

Surimi Purified and frozen minced fish containing a preservative; intermediate seafood product used in making structured seafood products.

Suspensoid Colloidal dispersion of a gas dispersed in a solid.

Sweet acidophilus milk Unfermented milk to which *L. acidophilus* has been added.

Sweetened condensed milk Canned milk to which sugar is added (contains more than 54 percent carbohydrate because of milk sugar and added sugar); evaporation of about half the water and heat treatment to kill harmful microorganisms precede the canning process.

Sweet glutinous rice General name for waxy, sticky rice varieties; mochigome and calmochi are examples.

SWOSTHEE (Single-pan Wood Stoves of High Efficiency) Acronym for wood-burning stove designed for families to cook food efficiently using wood as the fuel.

Syneresis Weeping or drainage of liquid from a gel.

Tagatose Sweetener derived from dairy products and approved as GRAS.

Tannins Term sometimes used to designate plant phenolic compounds.

Tapioca Root starch derived from cassava, a tropical plant.

Taste buds Tight clusters of gustatory and supportive cells encircling a pore, usually in the upper surface of the tongue; organs capable of detecting sweet, sour, salt, and/or bitter.

Tempeh Fermented cooked soybean product resembling cake.

Tempering Removing heat resulting from crystallization of fats and maintaining a selected temperature to promote the formation of stable, desirable crystals.

Template Pattern guide to ensure accurate cutting of samples from a large sample, such as a cake.

Temporary emulsion Emulsion that has little emulsifying agent and is too fluid to restrict movement of droplets; such instability requires that the ingredients be shaken to form a temporary emulsion immediately before use.

Tertiary-butylhydroxyquinone (TBHQ) Antioxidant often added to animal fats used in baking and frying.

Tertiary structure Distorted convolutions of the helical configuration of a protein; the form in which many proteins occur in nature and which is held by secondary bonding forces.

Tetrapyrrole Complex compound with four unsaturated, 5-membered rings (containing one nitrogen and four carbon atoms) linked by methyne bridges, resulting in a very large molecule with a high degree of resonance because of the excessive number of alternating double bonds.

Tetrose Saccharide with four carbon atoms.

Textured soy protein (TSP) or textured vegetable protein (TVP) Product of a series of steps producing fibers from soybeans.

Texturometer Simulation device that measures physical textural properties such as hardness, cohesiveness, and crushability of foods.

Thaumatin Natural sweetener from a West African plant—licorice flavor.

Thearubigens Dark orange-yellow compounds formed when polyphenoloxidases oxidize epigallocatechin gallate and epigallocatechin to theaflavin gallate and theaflavin for ultimate oxidation to thearubigens in oolong and black teas.

Thermal death time curve Comparison of the rate of death of pathogenic microorganisms over a range of processing temperatures.

Thermophilic Microorganisms with optimal reproduction and survival between 45 and 95°C (113 and 203°F), but capable of withstanding high processing temperatures.

Thick albumen Viscous white forming the middle layer of albumen in an egg.

Thick myofilament Thicker, longer type of myofilament; composed of myosin molecules joined together to form a screw-like, thick, and elongated filament.

Thin albumen Rather fluid egg white adjacent to the yolk and also to the inner membrane.

Thin myofilament Thin filament formed by the helical twisting of two strands of polymerized actin.

Thin-boiling starch An acid-hydrolyzed starch containing many debranched amylopectin molecules; useful for making gum drops and other products in which the hot mixture must flow and then cool to form a firm gel.

Thixotropic Ability of a gel to become more fluid with increasing shear and then to regain previous viscosity after shearing stops.

Threshold level Concentration of a taste compound at a barely detectable level.

Tocotrienols Class of sterols related to vitamin E valued for antioxidant properties; found in rice bran and palm oils.

Tofu Soybean curd.

Tofutti Frozen dessert of sweetened, flavored tofu, the soybean counterpart of ice cream.

Tonoplast Membrane separating the protoplasm from the vacuole in a parenchyma cell.

Top-loading electronic balance Very accurate, electrically operated balance.

Torsion balance Very sensitive (within 0.02 gram) laboratory balance particularly useful for weighing very small quantities or quantities greater than 2 kilograms.

Trained panel Sensory evaluation panel that has been thoroughly trained regarding the use of the scorecard and the evaluation of various characteristics.

***Trans* configuration** An arrangement in which the hydrogen is attached to the carbon atoms on either end of the double bond from opposite directions, causing a higher melting point than its *cis* counterpart.

Trehalose Moderately sweet ingredient used in some foods to improve flavor and/or texture.

Triangle test Difference test in which three samples (two of which are the same) are presented, and the odd sample is to be identified.

Trichinella spiralis Parasite sometimes found in pork or wild game.

Trichinosis Illness caused by eating meat containing viable *Trichinella spiralis*.

Trigeminal cavity Olfactory receptors, taste buds, and oral cavity, the three parts of the body required for perceiving flavor.

Triglyceride (triacylglyceride) Simple fat containing three fatty acids esterified to glycerol; the most common form of simple fat.

Triose Saccharide with three carbon atoms.

Trip balance Balance with two pans; the one on the left is used to hold the food being weighed, and the one on the right is used to hold the weights needed to counterbalance the left pan. Riders are also available for counterbalancing.

Triticale Hybrid grain produced by crossing wheat and rye.

Tropocollagen Fibrous protein consisting of three strands twisted together and containing large amounts of glycine, proline, and hydroxyproline.

Tropomyosin Least abundant of the three principal myofibrillar proteins.

True solution Dispersion in which ions or molecules no larger than one millimicron are dissolved in a liquid (usually water).

TVP (or TSP) Textured vegetable (soy) protein made of fibers of soy protein.

UHT pasteurization Extreme pasteurization [138°C (280°F) for at least 2 seconds] that kills all microorganisms and makes possible the storage of milk in a closed, sterile container at room temperature.

Umami Taste sensation that enhances savory qualities of flavor but does not have a distinctive flavor itself.

Universal testing machine Multipurpose, complex machine capable of measuring various textural properties of food samples.

Unsaturated solution True solution capable of dissolving additional solute at the temperature of the solution.

Unsaturation Lack of hydrogen relative to the amount that can be held, a situation characterized by a double bond between two carbon atoms in a fatty acid chain.

Untrained panel Sensory evaluation panel that has not been trained regarding the use of the scorecard and the evaluation of the various product characteristics.

Vaccenic acid *Trans* isomer (t11-18:1) of oleic acid occurring naturally in butterfat; does not raise LDLs.

Vacuole Portion of the cell containing most of the water, flavoring components, nutrients, and flavonoid pigments.

Vapor pressure Pressure exerted as molecules of a liquid attempt to be in the gaseous rather than the liquid state.

Variable Quantity or symbol that has no fixed value.

Variance Measure of the dispersion of data; the sum of the squares of the deviation of each value from the mean.

Vascular system System in plants that transports water and other essential compounds; composed of xylem and phloem.

Vibrio cholerae Bacteria carried by fecal contamination of food and causing cholera when ingested.

Virus Chemical macromolecule capable of being engulfed by a body cell and eventually altering or killing the host cell.

Viscometer Objective testing device for measuring viscosity of liquids that flow on the basis of rotational resistance or capillary action.

Vital wheat gluten Dried crude gluten.

Vitelline membrane Sac enclosing the yolk.

Volumeter Device for measuring volume of baked products; consists of a reservoir for storing the seeds, a transparent column for measuring volume, and a lower compartment in which the sample is placed.

Warner–Bratzler shear Objective testing device for measuring the force required to shear a sample of meat or other food with measurable tensile strength.

Water activity (a_w) Ratio of the vapor pressure of a food sample to the vapor pressure of pure water.

Water bath canning Heat processing of food in containers immersed in water at atmospheric pressure.

Water-binding capacity Amount of water held by muscle protein as bound water; heating reduces capacity.

Water-in-oil emulsion (w/o) Colloidal dispersion in which droplets of water are dispersed in oil, for example, butter.

Waxy starch Starch containing only amylopectin, the result of genetic research and breeding for this composition.

Wettability Ability of a cake or other food to absorb moisture during a controlled period of time; high moisture retention means a cake is sufficiently moist.

Whey Liquid that drains from the curd of clotted milk; contains lactose, proteins, water-soluble vitamins, and some minerals.

Whipped margarines Stick margarines that have been whipped mechanically into a fat foam; increased volume results in fewer calories per given volume.

White yolk Small sphere of light-colored yolk at the center of the yolk.

Whole wheat flour Wheat flour containing most of the bran and shorts.

Winterizing Refining step in which oils are chilled carefully to precipitate and remove fractions with high melting points that would interfere with the flow properties of salad dressings or other products containing the oils.

Xanthophylls Group of carotenoids containing some oxygen, as well as hydrogen and carbon, in a polymer of isoprene.

Xylan A hemicellulose composed of xylose and some glucuronic acid that contributes structure to plant cell walls.

Xylem The water transport system in plants; the tubular cells that move water.

Yeasts Single-celled fungi that reproduce by budding, are active at room temperature, and die at moisture levels below 20 percent.

Yersinia enterocolitica Bacteria sometimes found in raw and undercooked pork and raw milk, which cause yersiniosis.

Yersiniosis Food-borne illness focusing on the intestines caused by consuming infected raw milk or undercooked pork.

Yogurt Clabbered milk product resulting from controlled fermentation by *Streptococcus thermophilus, Placamo bacterium yoghourti,* and *Lactobacillus bulgaricus* or other lactose-fermenting microorganisms to reach a pH ~5.5.

Yolk index Measure of egg quality based on the ratio of yolk height to yolk width.

Z lines Region in a myofibril where the thin myofilaments of actin adjoin, creating a dark line that defines the end of a sarcomere.

Dimensions of Food Studies

This dinner featuring a slice of rib roast, baked potato, steamed broccoli, and a glass of milk provides a variety of flavors, textures, and color for dining pleasure.

Dimensions of Food Studies

Chapter Outline

OBJECTIVES

After studying this chapter, you will be able to:

1. Appreciate the interrelationships between consumers and their food, including scientific and safety factors influencing agriculture, production, and marketing.
2. Describe various career opportunities that are centered on food.
3. Outline how to conduct basic classroom laboratory experiments.

INTRODUCTION

Food is a vital part of life for everybody, and for many people it is the central focus of their careers. All of us eat, but what we choose varies widely, depending on availability, affordability, and preferences. Consumers play a major role in defining the marketplace and its inventory. Farmers and fishermen produce the basic commodities of our food supply, often with the assistance of research scientists who focus on studies to improve yield and safety. On the way to market, these basic ingredients may be transformed into convenient, varied, and tempting products with extended shelf life.

Food transportation systems are so effective today that fresh produce of high quality is available in most markets throughout the year, and the variety includes seasonal items grown locally, as well as imports from around the world. Vast arrays of packaged and convenience items are also displayed in abundance on grocery shelves and in the freezer section. Food manufacturers have been highly creative in developing items that meet the needs of busy consumers with little time to prepare meals at home from basic ingredients.

Unfortunately, the plentiful and tempting food supply, in combination with lifestyle choices, has created a nation with an increasing number of overweight and obese people

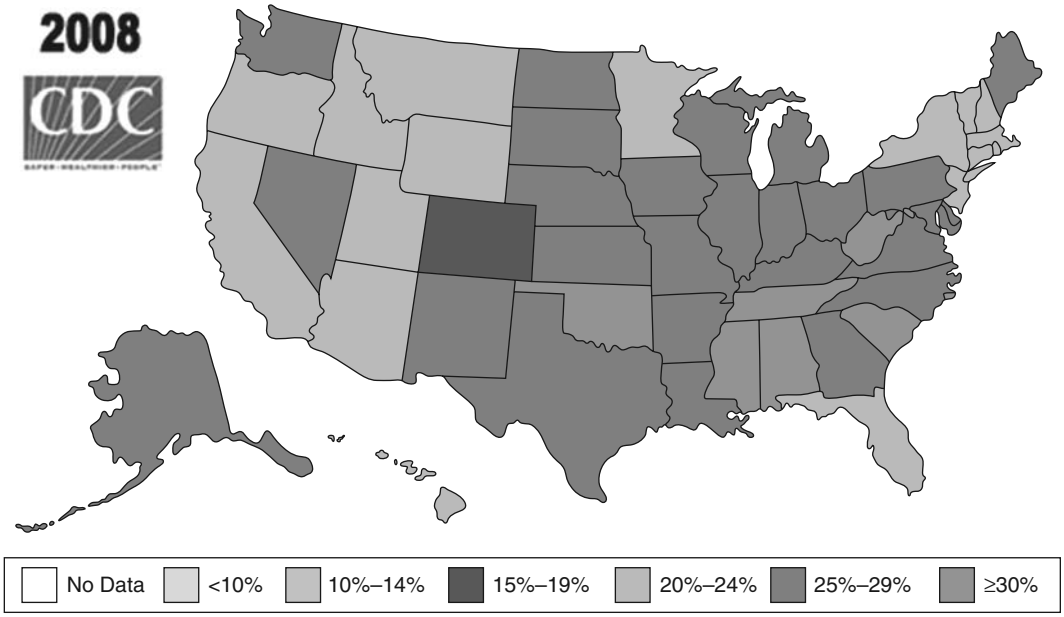

Figure 1 Incidence of obesity in the United States, 2008.

(Figure 1). Now, the food industry is challenged with helping consumers alter their practices and choices to bring about weight loss and to improve health.

Among key issues confronting the food industry today are safety, biotechnology, and health promotion (functional foods):

- Safety has always been a concern for food manufacturers and handlers, but the specter of possible terrorist actions has accentuated the need for constant vigilance in safeguarding products.
- Agricultural researchers have been developing genetically modified organisms that will have increased resistance to insects, a better amino acid profile, or other useful qualities.
- Nutrition researchers are constantly expanding scientific understanding of the body's requirements. Consequently, many food products are being modified by increasing the levels of some key nutrients and other substances that help protect the body. Food companies develop and market new products, conduct basic research on food-related topics, and monitor and shape consumer trends in food preferences and dietary concerns. Clearly, the combined expertise of dietitians, food scientists, and chefs is being used today to meet the challenge of bringing a healthy diet and dining pleasure to consumers.

All of these aspects converge in the marketplace and afford a wide variety of career opportunities centered on food. Academic preparation for these positions combines a strong foundation in science with the pleasures of eating. Knowledge of the principles of physics and chemistry that govern the changes occurring during food preparation is essential for professionals involved in the food industry. However, these aspects of food science need to be blended with an understanding of the qualities in food that create consumer satisfaction and promote good health. Consumers rely on the food industry to provide a bounty of products that are convenient and pleasant to eat, while also providing the nutrients their bodies require.

This chapter examines the roles of consumers, producers, and industry in shaping the food marketplace; it describes career opportunities and the academic path toward professional positions that focus on providing food for people.

CONSUMERS: WHO ARE THEY?

Demographics

Defining consumers is a daunting task, one that is constantly shifting because of multiple factors and the time frame being considered. In 2000, the U.S. Census Bureau determined that the nation's population was 281,421,906, but the estimated population in 2008 increased dramatically to 304,059,724, a rise of 8 percent. The percentage changes were distributed quite unevenly: Northeast (2.5), Midwest (3.4), South (11.5), and West (12.1).

The median age in 2008 was 36.8 years. Infants and children to age 19 comprised a little over a quarter (27 percent) of the population; just over a third (34.3 percent) of the people were between ages 19 and 34; about a quarter (25.7 percent) were between ages 35 and 64; and 12.8 percent were 65 or older.

The group below the age of 35 is expected to comprise only about 45 percent of the population by 2030 (Sloan, 1998) compared with more than 61 percent in 2008, but an increase in the percentage of the population ages 65 and older is predicted by 2030. Such age shifts can be expected to alter consumer demands for foods during the upcoming decades.

The ratio of women and girls to men and boys is another demographic of interest to the food industry because of its influence on food patterns. In 2008, there were 154,135,120 females and 149,924,604 males (50.6 and 49.3 percent respectively). However, the ratio of women to men increased with the age-group. The percentage of females and males age 18 and older was 51.3 and 48.7 respectively, and rose to 57.6 and 42.4 in the group 65 and older. Boys outnumbered girls below age 18, but there were somewhat more adult women than men; among people in their nineties, there were only 37 men per 100 women.

Even greater changes in food expectations will occur as cultural diversity continues to change in the United States as a consequence of both immigration and differences in birthrates between the various groups comprising the American population in the upcoming decades. According to the U.S. Census Bureau, the Hispanic population is increasing five times faster than the total population. Projections of racial distribution of the U.S. population (Table 1) anticipate a reduction in the percentage of whites alone (not Hispanic), a slow increase in blacks, and a slightly larger increase in Asians. In contrast, the percentage of Hispanics of any race is predicted to almost double between 2000 and 2050.

Lifestyles

In addition to the cultural heritage of consumers, their preferred lifestyles definitely influence the food marketplace. Frequency of meals or even the definition of a meal can evoke very different expectations and behaviors among consumers. Some people, particularly the elderly, still expect to eat three times a day, but for many, eating seems to be appropriate any time of day and any number of times. Perhaps the most noticeable behavior is the lack of agreement on when and how often to eat during the day. Ready availability of prepared foods and snacks for consumption at work, school, home, or anyplace in between has prompted people to eat frequently, if not always wisely.

Table 1 Projected Percentage of U.S. Population by Race and Hispanic Origin

Race	2000	2010	2020	2030	2040	2050
White alone, not Hispanic	69.4%	65.1%	61.3%	57.5%	53.7%	50.1%
Hispanic (of any race)	12.6	15.5	17.8	20.1	22.3	24.4
Black alone	12.7	13.1	13.5	13.9	14.3	14.6
Asian alone	3.8	4.6	5.4	6.2	7.1	8.0
All other races[a]	2.5	3.0	3.5	4.1	4.7	5.3

[a]Includes American Indian and Alaska Native alone, Native Hawaiian and other Pacific Islander alone, and two or more races.
Adapted from U.S. Census Bureau, 2004, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin."

Take-out food eaten in a car or at home is a popular solution to meals in today's society. Prepared items from the deli counters at grocery stores are frequently purchased on the way home for the evening meal (Sloan, 2006). These options are significant reasons why only about a third of the evening meals in the United States is prepared at home, and convenience foods from the shelf or the freezer often play a significant role in these meals. Busy people are selecting time-savers such as fruit, vegetable, and salad packages that are already washed, sliced, cut up, and ready. Increasingly, preparation responsibilities are being relegated to the food industry, and consumers are becoming managers rather than cooks in many homes.

Health

Health and the impact that food has on it are among the top interests of Americans. In response, the food industry has developed many products with added nutrients and others with higher fiber, lower salt, or other formulations to provide healthier food choices. The relationship between weight and health has been the subject of much research striving to understand and manage weight.

The nationwide emphasis on the "epidemic of obesity" is focusing attention on helping consumers make wiser food choices for reducing weight and achieving better health. The Center for Disease Control (CDC) found that 11 percent of children ages 2–5, 15 percent ages 6–11, 18 percent ages 12–19, and 67 percent of adults over 20 were overweight in 2005–2006. Blame for this national health crisis frequently has been aimed at the food industry. Now, food manufacturers and commercial food establishments are directing considerable effort to create products that contain fewer calories; smaller portions are also being promoted.

PRODUCERS

Fishermen

Fish of many types are important sources of nutrients in diets today. These may be caught in the sea by independent fishermen or by commercial fishermen who often operate from large vessels sailing on extended missions far from shore. The increased demand for seafood has resulted in seriously depleted quantities of some of the more popular types, such as abalone, some types of tuna, and orange roughy. Quotas have been implemented in some regions in an attempt to re-establish the quantities that used to be found in the commercial fishing grounds.

Fish farming is a growing industry in freshwater, as well as in the ocean. Catfish, shrimp, abalone, mussels, and salmon are some of the types that have been farmed successfully (Figure 2). As this industry has grown and matured, problems of safety have emerged, and research is being conducted to study ways of preventing contamination to sustain viable production from ponds and enclosures over an extended period. Despite some concerns, fish farming appears to be a source of food that will play an increasingly important role in feeding consumers.

Farmers

Crops for consumers and food companies are grown by farmers across the nation and also in other countries. Whether they are grown on farms operated as a commercial enterprise or as a family business, the food that is produced is an essential, but sometimes precarious source of income. Although irrigation is utilized in many areas when needed, even this source of water is being reduced in California and other drought-affected states as rain and snow levels have declined (possibly an effect of global warming). In 2009, many farmers in California suffered serious losses because their water rations were inadequate to support their crops. In some cases, the impact was so serious that some lost their farms.

Figure 2 Researchers and fish farmers sample catfish to check the efficiency of a floating platform grader near Belzoni, Mississippi. (Courtesy of Agricultural Research Service.)

The recent erratic weather patterns have resulted in flooding in some regions and drought in others. Either condition can have a very significant impact on crop yields (Figure 3). Added to this picture may be abnormal temperatures that alter the usual growth patterns: For example, an unusually late spring delays planting; an early killing frost may end the growing season before the crop is mature and ready for harvest. In 2009, planting of corn was late in the Midwest due to bad spring weather, and harvesting was delayed because rain continued so long in the summer that the field corn was slow in drying to the 15-percent moisture level required to prevent mold growth during storage. Some farmers had to pay to have their harvested corn dried, a factor that further reduced income. By Halloween, 20 percent of the Midwestern corn crop had been harvested in 2009 compared to an average of 58 percent by that date in the preceding five years; comparable figures for the Midwestern soybean harvest were 44 and 88 percent. These are some of the factors that influence price and availability of foods in the marketplace.

Consumers influence what crops farmers decide to raise and what technologies to consider. The pressure for organic produce has resulted in considerably more crops that meet the standard for this designation. A related issue is biotechnology, also referred to as genetically modified organisms (GMO or GM).

In Sweden, the pressure to eat a diet that minimizes the carbon footprint from producing various foods became a national issue in 2009. This concern involves not only raising crops, but also using livestock practices that reduce carbon dioxide emissions and minimize the amount of energy required to produce each food. By publicizing this information on labels, Sweden hopes that people there will alter their diets to select foods that have a relatively low impact on the environment and that this example will encourage other nations to follow.

Organic Concerns

As environmental concerns have moved to the forefront on the social agenda, there has been a strong trend toward buying "natural" foods. Despite the evidence of improved yields

Figure 3 Weather plays a significant role in determining crop yields from farms. (Courtesy of Agricultural Research Service.)

and blemish-free fruits and vegetables when farmers apply chemical fertilizers and pesticides to their crops, many consumers insist upon organically grown food. Their assumption that the food grown using only manure is higher in nutrients than that with chemical fertilizers often is not true.

FOOD FOR THOUGHT: World Farming Challenges and Nonprofits

Concerns about the environment and the many people who are involved in agriculture have prompted a variety of efforts directed at improving the situation. Approaches toward helping vary, but two nonprofit organizations that are working to help meet these challenges are Rainforest Alliance and World Cocoa Foundation.

Rainforest Alliance, formed in 1987, is an organization that is trying to improve soil and water conservation, integrated pest management and integrated management of waste on farms, ecosystem conservation, wildlife conservation, and fair treatment and good conditions for workers (including access to healthcare, education, and equitable wages) in rainforest regions around the world. Its program includes a certification seal on crops from fields that have been certified as meeting the standards specified by the Rainforest Alliance.

World Cocoa Foundation was founded in 2009 and is funded by the Bill and Melinda Gates Foundation and 12 chocolate companies. Its programs are designed to help cocoa farmers in 15 countries around the world to implement farming practices that will improve productivity and quality of their crops, learn business skills, promote diversification of income, and enhance access to support services.

Figure 4 Produce that meets the legal requirements can be marketed with the organic label.

Natural and **organic** foods are not necessarily synonymous. When used in reference to foods, *natural* means that original food ingredients have been used and that artificial or chemical additives have not been included. Using beet pigments rather than a red chemical dye to color a food product is one example of using a natural coloring agent. The legal definition to label a food *organic* is that the plant or animal food has been produced without using growth hormones, antibiotics, or petroleum-based or sewage sludge-based fertilizers. Designation as organic does not mean that the food is higher in nutrients than the same type of food that has not been produced according to organic requirements. Nevertheless, many consumers often are willing to pay more for organic produce because they think they are buying more nourishing food.

Natural
A food product made without chemical or artificial additives.

Organic
Legally defined as plant or animal food produced without using growth hormones, antibiotics, or petroleum-based or sewage sludge-based fertilizers.

The first federal legislation regarding producing and marketing organic foods was the **Organic Food Production Act of 1990.** However, the impact of this act was not evident until passage of legislation in 2002 that implemented the earlier act. The **National Organic Program**, administered by the Agricultural Marketing Service of the U.S. Department of Agriculture (USDA), went into effect in late 2002 (Figure 4).

Organic Food Production Act of 1990
Federal legislation that regulates production and marketing of organic foods.

National Organic Program
Federal legislation passed in 2002 to implement the Organic Food Production Act of 1990.

Plant and animal foods marketed as organic may carry the USDA Organic seal if they meet the following requirements:

- To be eligible for the designation of organic or 95 percent organic, at least 95 percent of produce (by weight) must not have been treated with sewage sludge-based or petroleum-based fertilizers, conventional pesticides, ionizing radiation, or bioengineering.
- Food mixtures in packages may be labeled "made with organic ingredients" if 70 percent of the ingredients (by weight) meet the requirements for being designated organic.

Biotechnology

Demand for natural foods and more and improved food to feed the world is spurring the efforts of **biotechnology** to develop plants and even animals that have specific desired characteristics or traits (Figure 5). Researchers using bioengineering techniques in animals

Biotechnology
Development of new products by making a genetic modification in a living organism.

FOOD FOR THOUGHT: Ultragrain®

The conflict that some people face when choosing bread that is good for them (whole grains) and the one they prefer (soft, white) has been addressed by ConAgra. This food company spent more than eight years developing a new strain of wheat and a modified milling process to produce a flour for people who want whole grain nutrition benefits and soft white bread. The new strain of wheat is grown in the Mid-west, the part of the country where the hard wheat traditionally used for bread making is grown. New milling equipment was developed to mill this new wheat into flour with a uniform texture and small specks of bran. These efforts on the farm and in the mill resulted in a flour that is being marketed as Ultragrain®. Compared with other hard wheat flours, Ultragrain® is sweeter and milder in flavor and has a lighter color. Commercial bread bakers and other food manufacturers are seeing whether this new flour will win acceptance among those seeking the characteristics of white bread and the nutrients of whole grains.

Figure 5 Biotechnology is the avenue for developing crops with such advantages as increased resistance to disease. (Courtesy of Agricultural Research Service.)

have met with limited success, but this is an active field of scientific studies. They are working toward such objectives as animals with faster growth rates, more lean muscle mass, strengthened resistance to disease, or improved use of dietary phosphorus to lessen the environmental impacts of animal manure. In the plant world, research is aimed at developing healthier plants (resistant to insects and diseases and capable of producing a high yield) that can be raised with less fertilizer or insecticide than the traditional crop would require. Other research may have the objective of increasing the nutritive value of the food.

Genetic engineering is another term for biotechnology. A gene is a segment of DNA that encodes enough information to synthesize a protein. By identifying specific genes that provide the codes for making proteins that impart desirable traits, researchers have then been able to transfer the desired genes to other organisms to develop plants or animals that continue to replicate the desired gene(s) in succeeding generations.

Genetic engineering
Biotechnology in which a genetic modification is achieved by removing, adding, or modifying genes.

Research in biotechnology to improve specific qualities of a plant results in food crops that are designated as **genetically modified organisms (GMO)**, sometimes simply referred to as GM. Corn and soybeans are major crops that have been the object of efforts to create plants that effectively can resist infections from insects, viruses, and/or fungi. Roundup-Ready® is one brand of genetically modified crops (e.g., soybeans) already being grown in the United States. Biotechnology also has led to the development of sunflower, peanut, and other oilseed plants with reduced levels of *trans* fatty acids and higher smoke points.

Genetically modified organism (GMO)
Plant or animal foods developed by genetic manipulation to alter nutrient levels or other characteristics; also designated as GM.

Continuing research projects to develop a range of crops with modified nutrient value and health benefits include:

- altering oil composition of oilseed rape and soybeans
- soybean protein for use as meat substitutes
- potatoes to reduce discoloration from bruising for commercial storage and also to lower moisture content (to reduce oil absorption during cooking)
- vitamin A levels (increased) in rice (Golden Rice™) to aid in preventing blindness in Southeast Asia
- increasing the antioxidant content in some vegetables

Other research in biotechnology is aimed toward improving flavor, color, and/or texture of tomatoes (e.g., FlavrSavr® tomato), corn, and squash (Figure 6). Additional research is being directed toward creating plants that are drought resistant, heat resistant, and/or able to survive increased salinity.

In many countries in various parts of the world, particularly in Europe, concerns initially were raised regarding the growing and marketing of food resulting from biotechnology. Nevertheless, farmers in many parts of Asia, South America, and the United States have been raising GMO crops for more than a decade. In 2005, one billion acres around the world were planted in GMO crops, and these crops were raised by 8.5 million farmers in 21 countries. European nations were slower to accept the new strains of crops. However, farmers in the European Union (EU) planted 107,719 **hectares** of GMO crops in 2008, which was an increase of more than 20 percent over 2007. Spain is the leading producer of these crops among the EU. In 2009, more than 200 different GMO crops were grown or being developed in 46 countries around the world.

Hectares
Area equivalent to 10,000 square meters or 2.471 acres.

Resistance to insect attack on corn and a few other crops is being incorporated by inserting a gene from *Bacillus thuringiensis* (a soil bacterium), resulting ultimately in the formation of a toxin that serves as an insecticide in the plant. Crops that incorporate this gene are designated as **Bt**. Bt maize is being grown in Europe despite the fact that France has banned it. Ongoing research and monitoring are being done to detect possible negative consequences of Bt crops. On the positive side is a significant decrease in worldwide fertilizer use (estimated to be almost 30 percent during the decade from 1996 to 2006) because of Bt maize and cotton.

Bt
Designation that a seed has been modified by splicing a gene from *Bacillus thuringiensis* to promote resistance to insects.

Governmental regulatory agencies are involved in approving and regulating the products of biotechnology. In the United States, the FDA is responsible for food products of plant

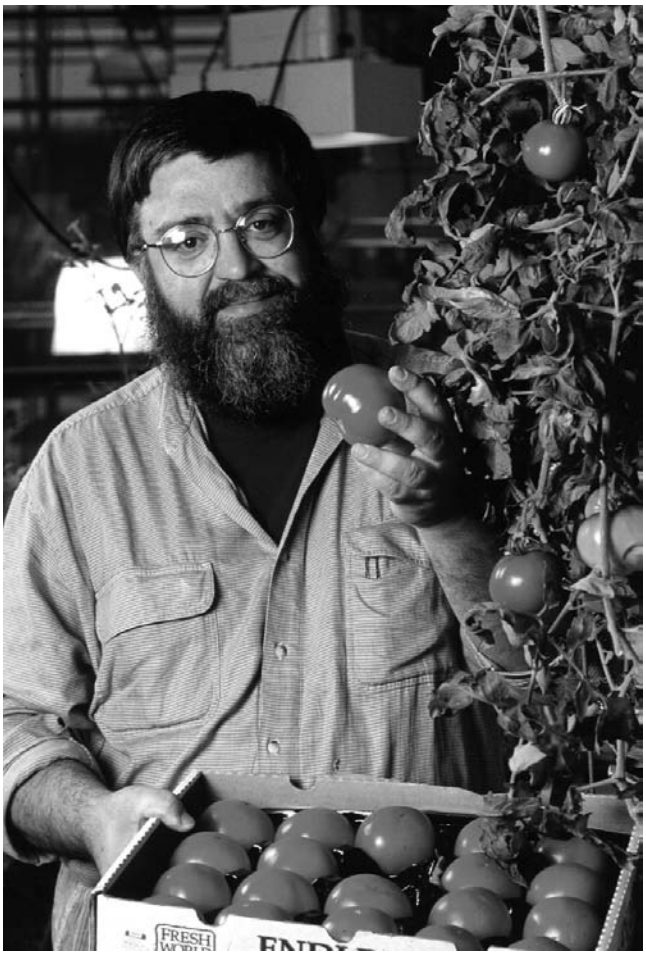

Figure 6 Endless Summer tomatoes are an example of bioengineering to create produce for today's markets. (Courtesy of Agricultural Research Service.)

biotechnology. Agricultural products are under the purview of the USDA, primarily its Animal and Plant Health Inspection Service (APHIS). Herbicides and pesticides are under the aegis of the U.S. Environmental Protection Agency (EPA). These agencies are all involved in the regulation and oversight of some products of biotechnology.

The possibilities for improved food products as the result of biotechnology (specifically by techniques of genetic engineering) are diverse and multiplying. Examples include increased essential amino acid content in corn and soybeans, naturally decaffeinated coffee, plant oils with modified fatty acid content, potatoes and tomatoes with higher solids content (to decrease energy needed to remove water during processing), and controlled ripening of fruits and vegetables that are difficult to ship to markets in satisfactory condition.

Other plant crops have also been genetically modified and are now being farmed successfully. For example, rape (*Brassica napus*) has been genetically modified to increase its tolerance of herbicides and improve health benefits by achieving high levels of lauric and oleic acids and little erucic acid in the **canola oil** produced from it. Canola oil was named to indicate that it is an oil developed in Canada and also to distinguish this desirable oil from unpleasant images that the name rape seed might imply. Golden Rice™ was developed to help increase the levels of vitamin A in diets in Asia, where this vitamin is often deficient. This new rice variety was created by inserting a gene from *Erwinia uredovora* (a bacterium) and two genes from daffodils, which causes a yellowish color due to production of

Canola oil
Oil from rape (*Brassica napus*) seeds, a genetically modified variety of rape.

β-carotene in the endosperm. Summer squash modifications have been directed toward improving crop yields by increasing resistance to viruses, such as zucchini yellow mosaic virus, that attack the plants.

INDUSTRY

The food industry provides consumers with a wide range of products that incorporate ingredients produced by fishermen and farmers. In some cases minimal processing is done, while in others, numerous ingredients and processing steps may be required. The challenge for these companies is to create and market products that meet consumer expectations and concerns. To do this, they are constantly monitoring consumer issues, conducting internal research and development, and checking quality and safety. Consumer concerns about the relationships between diet and health have fostered considerable research and product development in the areas of functional foods, nutraceuticals, and nanotechnology. The National Center for Food Safety and Technology (NCFST) is a unique food research consortium of the U.S. Food and Drug Administration's (FDA) Center for Food Safety and Applied Nutrition (CFSAN), Illinois Institute of Technology (IIT), and the food industry. It was established to bridge the gap between the food industry, government agencies with responsibilities for food safety, and academics in this field.

Functional Foods

Functional food refers to food and food products that provide possible health benefits beyond just the nutrients they contain. **Nutraceutical** is sometimes used to describe a functional food, but it also may be used more broadly to cover supplements and medicinal herbs. Some of the pigments and certain other compounds naturally occurring in plants, animals, and fish may contribute to human health when they are included in the diet.

Functional food
Food that may provide health-promoting qualities beyond just the nutrients it provides.

Nutraceutical
Sometimes used to describe not only functional foods, but also supplements and medicinal herbs.

Considerable publicity has been given to the importance of such foods (e.g., the "5-a-day" campaign by the USDA to increase consumption of fruits and vegetables). Soy in various forms is an ingredient in many different types of products from beverages to energy bars because of the potential health benefits associated with its isoflavone content. Some eggs with enhanced omega-3 polyunsaturated fatty acid levels now are available for people striving to lower their cholesterol levels.

Phytochemicals. **Phytochemicals** are compounds in foods that have biological activity that may promote health benefits beyond the effects of such nutrients as vitamins and minerals. Some examples of phytochemicals are catechins in tea, lycopene in tomatoes and red peppers, and beta glucan in oats (Table 2).

Phytochemicals
Chemical compounds in plants that are important to promote healthful reactions in the body but are not classified as nutrients required for life and growth.

Considerable research is underway to explore the relationship between diet and health problems, particularly cancer and heart disease. These two diseases concern many consumers

Table 2 Sources and Potential Benefits of Some Phytochemicals

Phytochemical	Source	Potential Health Benefit
Indoles	Brussels sprouts, cabbage, cauliflower, broccoli	Help block cancer growth
Lignan	Flax seed	May interfere with estrogen and help block cancer growth
Beta glucan	Oats	Reduce risk of cardiovascular disease
Carotenoids	Orange, dark green, and red fruits and vegetables	Antioxidant action promotes health of eyes, other tissues
Lutein	Spinach, kale, collard greens	May help protect against eye diseases in the elderly
Lycopene	Tomatoes	Reduce risk of prostate and cervical cancers, degeneration
Flavonoids	Tea, wine, celery, cauliflower, apples	Raise HDL cholesterol; antioxidant action protects cells
Catechins	Green tea	Inhibit carcinogenic processes
Genistein, daidzein	Soybeans, dried legumes	May reduce cancer risk; block estradiol at receptor sites
Resveratrol	Skin of red grapes, red wine	Lower cholesterol; may reduce cancer risk

Figure 7 Fruits and vegetables are essential in the diet for their phytochemicals, vitamins, and minerals.

because of the toll they take each year. Researchers are trying to determine whether various phytochemicals may aid in fighting or protecting against some diseases. Results sometimes have been contradictory; early findings of effectiveness have been countered by subsequent studies that failed to find similar results. Nevertheless, studies have not shown any harmful effects from eating foods high in various phytochemicals.

The fact that some researchers have found positive ties between diet and the incidence of these problems has added impetus to the importance of eating plenty of fruits, vegetables, and cereal products, all of which are rich in various minerals, vitamins, and phytochemicals. In fact, phytochemicals (Figure 7) such as lycopene, genistein, catechins, and tocotrienols, are becoming buzz words.

Prebiotic
Healthful bacterial culture added during manufacturing to enhance and/or modify a dairy product that does not survive in the digestive tract; or a carbohydrate readily digestible by bacteria in the intestine, but not by humans.

Probiotic
Bacterial culture added to a dairy product because of its health-promoting capability and viability in the intestines.

Prebiotics and probiotics. **Prebiotics** and **probiotics** are other illustrations of functional food components. Various bacterial cultures such as *Streptococcus thermophilus* and *L. delbrueckii ssp. bulgaricus* are added as prebiotics to create yogurt and other milk products resulting from the action of the culture during manufacturing. Prebiotic cultures may be killed by the acidity encountered in the digestive tract after the food is ingested.

Other prebiotics are incorporated into some designer foods (see next section) to ultimately feed bacteria in the intestinal tract and promote the desired bacterial flora there. Fructooligosaccharide, inulin, and even honey are examples of ingredients that may serve as prebiotics to enhance the growth of desirable intestinal microflora and possibly to reduce diarrhea, urogenital infections, and colon cancer.

Probiotics (cultures of useful health-promoting bacteria that are viable in the intestines) now are being added to some dairy products to create functional foods. The cultures used as probiotics are selected for their ability to survive the very low pH levels (1.5–2) of the stomach and bile acids; they also may be microencapsulated in alginate gels to protect their viability as they travel through the gastrointestinal tract into the intestines. Among the probiotics used are certain strains of such bacteria as *Lactobacillus acidophilus, L. bulgaricus, L. helveticus, Bifidobacterium adolescentis, B. lactis,* and *B. subtilis*.

Table 3 Some Food and Drug Administration-Approved Heart-Health Claims

Nutrient/ Health Relationship	Section in Title 21 CFR[a]
Sodium/ hypertension	101.74
Dietary saturated fat and cholesterol/ risk of coronary heart disease	101.75
Fruits, vegetables, and grain products that contain fiber, particularly soluble fiber/ risk of coronary heart disease	101.77
Soluble fiber from certain foods (oat and psyllium products)/ risk of coronary heart disease	101.81
Soy protein/ risk of coronary heart disease	101.82
Plant sterol or stanol esters/ risk of coronary heart disease	101.83
Whole-grain foods/ risk of heart disease	Docket No. 99P–2209
Potassium/ risk of high blood pressure and stroke	Docket No. 00Q–1582

[a]Code of Federal Regulations.

Health concerns have motivated many consumers to seek food products containing ingredients that help in avoiding or improving outcomes of cancer, strokes, heart attacks, and other physical threats. As an aid to consumers, the FDA identified some apparent relationships between diet and health and approved some heart-health claims (Table 3).

Designer Foods

The increasing recognition of the relationship between diet and health has prompted food companies to develop a wide variety of products with added nutrients and/or ingredients to enhance the health benefits of these items to meet consumer demand. Foods that are developed specifically to meet the demand for products that promote improved health often are referred to as **designer foods**. These are also considered to be functional foods.

Designer food
Manufactured food that has been created to meet consumer demand for a food that may be effective in promoting health and avoiding or minimizing the risk of certain physical problems.

The FDA established definitions for some of the wording that can be used on food labels (Table 4). The intent is to aid consumers in understanding the nutritive content of the various products they are buying so they can make healthful choices. Food manufacturers can only use these defined words on their packages if the product conforms to the definition.

Table 4 FDA Food-Labeling Definitions

Label Wording	Definition
Calorie free	<5 calories/g
Low calorie	40 calories or less/serving
Low sodium	140 mg or less/serving
Very low sodium	35 mg or less/serving
Low cholesterol	20 mg or less and 2 g or less saturated fat/serving
Lean (meat, poultry, seafood)	10 or less g fat, $4\frac{1}{2}$ g saturated fat, <95 mg cholesterol/$3\frac{1}{2}$ -oz serving
Fat free or sugar free	<1/2 g fat or sugar/serving
Low fat	3 g or less/serving
Low saturated fat	1 g or less/serving
High fiber	5 or more g fiber/serving
Reduced	25% less of specified nutrient or calories than the usual product
Light	$\frac{1}{3}$ fewer calories or $\frac{1}{2}$ the fat of the usual food
Good source of	At least 10% of Daily Value of specified vitamin or mineral/serving
High in	20% or more of Daily Value of specified nutrient/serving
Healthy	Decreased fat, saturated fat, sodium, cholesterol, and at least 10% of the Daily Value of vitamins A and C, iron, calcium, protein, and fiber
Fresh	Raw or unprocessed (not even frozen or heated), no preservatives added

Another option that food manufacturers may consider in package labeling and marketing is to make a health claim. The FDA has developed precise rules for making claims about each of the following:

- Calcium/osteoporosis
- Fat/cancer
- Saturated fat and cholesterol/coronary heart disease (CHD)
- Fiber-containing grain products, fruits, and vegetables/cancer
- Sodium/hypertension (high blood pressure)
- Fruits and vegetables/cancer
- Folic acid/neural tube defects
- Dietary sugar and alcohols/dental caries (cavities)
- Soluble fiber from certain foods, such as whole oats and psyllium seed husk/heart disease.

Nanotechnology

Nanotechnology
Development, creation, and application of atomic, molecular, or macromolecular particles between 1 and 100 nanometers in size.

Nanotechnology is a rather new area of research and development, but the potential applications in the food chain from the field to consumers are numerous and likely will play significant roles in improving safety, quality, and nutrient content of our food. This technology develops, creates, and uses particles at the atomic, molecular, or macromolecular range of approximately 1–100 nanometers (1 nanometer equals 1 billionth of a meter); these nanostructures have unique properties.

Nanotechnology may be of significance in various ways on farms in the future. Nanosensors may be of use in monitoring moisture levels and water flow, which may lead to reduced pollution from runoff in areas where livestock are being raised. Other nanoparticles might be created that can neutralize pathogens in crops and animals. These are some of the avenues being explored in this emerging field. A cloth that is embedded with nanoparticles of insecticide releases the chemical very slowly, which reduces the need for fresh applications.

Applications of nanotechnology in food technology and science are being explored in a variety of directions. A particularly active area is food packaging materials. Edible films that include oil (from cinnamon or oregano) or nanoparticles of such elements as silver, zinc, or calcium are being developed as a type of antimicrobial packaging. The problem of gas permeability of plastic containers is being addressed by integrating nanoclays to impede entry of oxygen and the resulting oxidation that occurs over time when plastic containers are used. Another food packaging material being developed uses chitin, a polysaccharide that contributes rigidity to the shell-like coverings of crabs, lobsters, and other crustaceans. The fiber that can be spun from a solution of chitin by electrospinning is of nano dimensions and can be incorporated in packaging materials to impart antimicrobial properties.

By creating nano-size lipids, it is possible to form multiple emulsions that provide improved spreadability and stability of such foods as a low-calorie mayonnaise without adding extra thickening agents. Flavors can also benefit from nanotechnology. Nanoscale assays of how taste buds interpret various flavors create opportunities for modifying a flavor by introducing bitter blockers or enhancers of sweet or salt. The sweet and salt enhancers could be of particular value in developing foods with reduced levels of sugar or salt.

Nanotechnology may also be of help in detecting *E. coli* and other harmful microorganisms. A silicon chip with a protein from the microorganism can scatter light when a laser encounters cell mitochondria in a contaminated sample of food, and a digital camera records the scattering. This method will provide immediate detection so that the food can be removed from the system immediately, thus providing an accelerated response to such risks. Rapid *Salmonella* detection is becoming possible by coating antibody particles with nano-sized particles that fluoresce.

Security in the Food Supply

Food safety is not a new issue triggered as a result of terrorism. Food-borne illnesses were recognized many, many years ago, and numerous governmental regulations and considerable personnel have been committed to protecting people from such risks.

A recent example of legislation to protect the health of consumers with severe food allergies is the **Food Allergen Consumer Protection Act of 2004 (FALCPA)**. This act requires that milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, and soybeans be named as ingredients, followed by the source of the allergen so that sensitive people can avoid the specific allergens that might even be fatal to them.

Food Allergen Consumer Protection Act of 2004 (FALCPA)
Legislation requiring the listing of specific food allergens and their sources.

The gradual growth of agencies responsible for food safety has resulted in widely scattered governmental agencies, leaving gaps in some oversight areas and overlaps in others. The potential threat of terrorism has added to the challenge. Homeland security efforts encompass virtually all aspects of life in the United States today, including safeguarding the food supply from possible terrorist efforts. Tamper-proof packaging has been a fact of life for many years, but security plans triggered by the events of September 11, 2001, now go far beyond that protection.

In 2005, the federal government announced the **Strategic Partnership Program—Agroterrorism (SPPA)**. This program is a partnership of USDA, FDA (from HHS), DHS, and the FBI, all of which will collaborate with states and private industry to protect U.S. food and commodities from terrorism. These government agencies are developing and implementing the strategies deemed necessary to safeguard the nation's food and water supplies.

Strategic Partnership Program—Agroterrorism (SPPA)
Partnership of federal agencies (USDA, FDA, DHS, and FBI) with states and private industry charged with safeguarding food supplies and commodities.

Among some of the key units now involved with increasing protection of the food supply are the USDA and the Centers for Disease Control and Prevention (CDC). The FDA is providing guidance on such diverse challenges as (1) improved inspection of facilities and sampling products, (2) more careful examination of imported foods, (3) strengthened communication and collaboration with appropriate federal and state agencies, and (4) improved security at food plants and along the marketing and distribution chain. Cooperation and communication between and within agencies are essential to safeguarding the nation's food and water.

FOOD FOR THOUGHT: Safety with Pressure

Concerns about food safety and consumer desire for the convenience of shelf-stable foods have led to the establishment of a research program to develop sterilized foods using high pressures and moderate heat. The special equipment needed for this innovative approach was made by Flow International, Inc., and installed at the National Center for Food Safety and Technology in Chicago. This center provides an opportunity for academic researchers (including those from the Illinois Institute of Technology and the University of Illinois) to work cooperatively with specialists from both industry (Procter & Gamble, ConAgra Grocery Products, and Kraft Foods) and government (FDA and the U.S. Army). Experiments are still being conducted on low-acid products that need to be shelf-stable. Safety of low-acid foods that will be marketed as needing no refrigeration requires sterilizing the food itself and also destroying any spores that may be present. Research to determine processing parameters that are needed to assure sterilization of shelf-stable foods is being conducted at the National Center for Food Safety and Technology.

High-pressure processing begins with preheating prepackaged food in a water bath before subjecting the packages to pulses of pressure for a controlled period of time. Rapid cooling occurs before packages are removed from the processing cylinder. Some low-acid foods such as guacamole already are in markets, but require refrigeration.

CAREER OPPORTUNITIES

Because food is absolutely essential to survival, careers centered on any aspect of food will always exist even though the focus and products may undergo considerable evolution over time. Advances in science and technology, food preferences, lifestyles, economics, and environmental factors combine to alter the food scene and to create the dynamic opportunities for careers based on food. Some careers are oriented toward interrelationships between food and health, some are based on feeding people in settings away from their homes, and still others are centered on basic food science and the development of marketable products for consumers (and the innumerable steps in bringing food from farms to consumers).

Careers in the food industry exist in such specialties as quality management, marketing, research and development, packaging, labeling, and compliance. The settings might include particular areas such as ingredients, food products, or food service. Work in governmental agencies and laboratories that administer and monitor various aspects of the food industry is yet another dimension for careers with food.

The great emphasis on food and health has spurred the building of bridges between the domains of professionals in the food industry, dietetics, nutrition, governmental agencies with responsibilities involving food and consumers, and food service (including restaurants and institutions). Chefs are among the food professionals who have played a significant role in shaping the public's food expectations and preferences, sometimes locally in restaurants and even nationally through television shows.

National attention on the growing problem of obesity in the United States and the health problems that often are compounded by excess weight are generating considerable interest among food professionals and consumers. Awareness of the need for healthful dietary habits has created public demand for products that are consistent with good nutrition, but also are appealing to eat. The dialogue that is developing in the various food-related professions is beginning to blur the divisions between the different segments. This change is opening opportunities for individuals to create unique positions that utilize the particular strengths they bring to the food industries.

Sound academic preparation is essential for persons planning to become food professionals, and that curriculum must include strong courses in the basic sciences that underlie food-chemistry, microbiology, biology, and physics. This science foundation needs to be incorporated into the study of food and its preparation and evaluation. Appreciation of the role that food plays in influencing the quality of life, because of its wonderful sensory and nutritional contributions, should be developed so that food professionals will always remember the needs of consumers as real people. Oral and written communication skills are essential for all professionals. Knowledge of research techniques and computer literacy are part of the tools of the food professional. Basic understanding of business is another requisite for most careers in this field.

Students wishing to focus on a health-related food career will pursue a degree in nutrition and/or dietetics. For many of these positions, applicants are required to be Registered Dietitians (R.D.). Positions are quite varied in this field and include clinical dietetics, food service administration, community nutrition, sports nutrition, consulting, and nutrition counseling, and are found in industries based on nutrition-related products.

The rapidly expanding realm of hospitality, hotels, and restaurants is the source of many positions requiring extensive food knowledge and culinary skills. Preparation for careers in this arena may be obtained through a dietetics curriculum or from programs tailored specifically toward this field. Emphasis is placed on the applied aspects of food and its service to groups of people. Entrepreneurial-minded students may use this curriculum to prepare for eventually owning and operating their own restaurants. Others may focus on managerial positions in one of the large corporations that dominate this arena. Still others may wish to enter the field of catering, either on their own or as employees.

Food businesses provide career opportunities that are quite diverse. Product development, quality assurance, food analysis, processing, packaging, microbiology and food safety, sensory evaluation, physical testing, labeling and governmental regulation, and marketing are some of the niches available in the food industry. Depending on the particular career objective, a

student might prepare to enter the food business by obtaining a degree in nutrition and dietetics, food science, food technology, food service, hotel and restaurant (hospitality or culinary) management, or business.

EXPERIMENTING WITH FOOD

A scientific attitude and research orientation are needed to enter the world of the food professional. Basic chemical and physical principles are the foundation of the food science that undergirds the nation's food supply. A thorough understanding of these principles allows the food professional to apply them to achieve the best possible results with the resources available.

The experimental approach to food study integrates theory and professional research studies with laboratory work. Valuable knowledge of the influence of ingredients and preparation procedures can be gained by performing experiments designed to illustrate key scientific principles involved in food preparation. The characteristics of foods can be identified and measured using subjective evaluation (vision, olfaction, taste, and feel) and objective (mechanical) tests. Frequently, experiments in a class in experimental food science are presented to the class as a group, and individuals conduct a portion of the work so that a suitably broad array of samples will be available to illustrate selected principles. Additional insights into food research are gained when an experiment is planned, conducted, evaluated, and reported individually.

Students of experimental food science quickly find that the emphasis is primarily on the theoretical "why" more than on the "how" approach to food and its preparation. The combination of scientific theory with the laboratory-based illustrations presented in food science courses provides deep understanding of foods: their structure, composition, and behavior. This knowledge provides the cornerstone on which professionals in food science, dietetics, and food service management function.

In an experimental foods class, attention can focus on the effects of modifying ratios and types of ingredients in food items and of altering methods. One product prepared correctly can serve as the control, and several variations made at the same time can illustrate the effects of varying ingredients and/or methods. Careful examination and testing of these samples are of great value in developing a clear understanding of the scientific principles undergirding the field of food science.

At the conclusion of this study of experimental food science, students will be able to evaluate a broad range of foods accurately, to identify possible errors in their preparation or formulation, and to plan appropriate corrective measures for subsequent preparation of the items. This knowledge is essential for anyone involved in food production, whether it be in supervising production in an institutional food service setting, developing new products, handling production or quality control in a food plant, or working with food in an educational or home context.

The dynamic nature of food and its susceptibility to changes during handling, storage, and preparation provide constant challenges to the professional working in the field of food. Solutions for controlling quality can be effected appropriately when the underlying principles are understood and their practical illustrations have been experienced.

Science Adventures in a Seattle Kitchen

Dr. Nathan Myhrvold is not the usual cook in a Seattle kitchen; in fact, he is so unique that the *New York Times* featured him in an article on November 17, 2009. This former Microsoft technologist has left the world of computers and Bill Gates and now explores his interests in food and other branches of science at Intellectual Ventures, his company that pursues such diverse challenges as creating the perfect Peking duck (using dry ice and a dog brush with stiff bristles to create pinholes in the crust to drain the fat) and freeze-dried lobster tail. Eventually, some of his food experiments will be featured in a cookbook that he and his staff are developing. Chefs, a photographer, writers, and editors are part of the team to augment this scientist in his bustling kitchen research laboratory.

Metrics

Metric system
System of measurements of length, area, volume, and weight using the decimal system (the system of tens).

Laboratory work in food science is done using the **metric system**. Classroom experiments as well as research laboratories use metric units. However, consumer information is presented in household measures (teaspoons, tablespoons, cups for recipes, and inches to describe the sizes of baking dishes). Professionals working in a developmental laboratory with the possibility of applying the research to the consumer market need to be able not only to work in the metric system but also to convert between the language of the consumer kitchen and the research laboratory.

The metric system is a method of expressing length (distance), area, volume, and weight in an orderly fashion in basic units that are quantified by expressing values in decimals, the system of tens. Hence, length is expressed in meters, area in square meters, volume in cubic meters or liters, and weight in grams. Food experimentation utilizes primarily volume and weight.

To achieve reasonable numbers when working in the metric system, prefixes are appended to the unit of measure. A large array of prefixes can be used within this system, as shown in Table 5, but food experimentation usually is based on the following: kilo (k), centi (c), and milli (m). By use of a prefix, 1,000 g can be expressed simply as 1 kilogram (Kg); similarly, a hundredth of a meter is 1 centimeter, and a thousandth of a liter is 1 milliliter (ml).

Because household recipes frequently express the quantities of solids in volumetric measures, conversion to weight or volume (if a liquid) in the metric system is necessary if these recipes are to serve as the basis for experimental work. Conversely, metric experimental amounts must be converted to common household measures if recipes are to be made available to the public. These conversions can be done by determining the weight of the required household measure for the various ingredients. Liquids conversions are based on a household measuring cup equaling 236.6 ml or cubic centimeters (cc). Table 6 presents some of the equivalent measures and conversion factors that may be useful when converting recipes.

A cup of flour does not weigh the same as a cup of butter or a cup of chopped nuts. The difference in mass of various ingredients that would be measured volumetrically in household recipes requires that the weight of this volume be known if a household recipe is to be used as the basis of an experimental formula. It sometimes is necessary to determine this weight by weighing the desired volume of the ingredient. Fortunately, tables have been developed by experiments that provide uniform weights for a cup of many of the ingredients commonly used in food preparation. Table 7 includes the weights of a few selected ingredients to illustrate the need for determining the weight of various ingredients when recipes are converted for experimental use or back to household measures.

Just as metrics is the language of quantities in the realm of scientific research, so is the Celsius scale used for measuring temperature in the laboratory of the food scientist. This choice is not surprising in view of the fact that the Celsius scale is related to the decimal

Table 5 Prefixes in the Metric System

Prefix	Symbol	Numerical Definition
Tera	T	$1{,}000{,}000{,}000{,}000 = 10^{12}$
Giga	G	$1{,}000{,}000{,}000 = 10^{9}$
Mega	M	$1{,}000{,}000 = 10^{6}$
Kilo	k	$1{,}000 = 10^{3}$
Hecto	h	$100 = 10^{2}$
Deka	da	$10 = 10^{1}$
Deci	d	$0.1 = 10^{-1}$
Centi	c	$0.01 = 10^{-2}$
Milli	m	$0.001 = 10^{-3}$
Micro	μ	$0.000{,}001 = 10^{-6}$
Nano	n	$0.000{,}000{,}001 = 10^{-9}$
Pico	p	$0.000{,}000{,}000{,}001 = 10^{-12}$

Table 6 Equivalent Measures and Conversion Factors Commonly Used to Convert Between Household and Metric Measures

Equivalent
Weights[a]
1 kg = 2.2 lb
454 g = 1 lb
28.35 g = 1 oz (avdp)
1 g = 0.035 oz (avdp)
Measures[b]
1 l = 1.06 qt
1 gal = 3.79 l
1 qt = 946.4 ml
1 c = 236.6 ml
1 fl oz = 29.6 ml
1 tbsp = 14.8 ml
Length[c]
1 in = 2.54 cm
1 m = 39.37 in

[a]kg = kilograms, lb = pounds, g = grams, oz = ounces, avdp = avoirdupois (weight).
[b]l = liters; qt = quarts; gal = gallons; ml = milliliters; c = cups; fl oz = fluid ounces (volume); m^3 = cubic meters; tbsp = tablespoons
[c]in = inches, cm = centimeters, m = meters.

Table 7 Average Weight of a Measured Cup of Selected Foods

Food	Form	Weight of 1 Cup (g)
Almonds	Blanched	
	Whole	157
	Chopped	117
Baking powder	Double-acting	207
Cheese, Cheddar	Shredded	98
Cornmeal		
White	Uncooked	140
Yellow	Uncooked	151
Eggs	Whites	255
	Whole	251
	Yolks	240
Flour	Rice, white unsifted	149
	Rye, dark stirred	127
	Soy, full-fat, unsifted	96
	Wheat, all purpose, unsifted	
	Spooned	126
	Dipped	143
	Wheat, all purpose, sifted, spooned	116
	Wheat, cake, sifted, spooned	99
	Gluten, sifted, spooned	136
	Self-rising, sifted, spooned	106
Gelatin	Flavored	187
Margarine	Regular	225
	Soft	208
Rice	White, raw	
	Long grain	192
	Short grain	200
	Parboiled	181
Sugar	Brown, packed	211
	Confectioner's sifted	95
	Granulated	196
Yeast	Active dry	142

Adapted from Fulton, L., Matthews, E., and Davis, C. Average Weight of a Measured Cup of Various Foods, *Home Economics Research Report No. 41,* Agricultural Research Service, U.S. Department of Agriculture: Washington, DC, 1977.

system, with the freezing point of water being designated as 0 and the boiling point at sea level as 100. To relate Celsius temperatures to the Fahrenheit temperatures commonly used on oven indicators and household thermometers, food professionals need to be able to convert from one of these common temperature scales to the other. By simply knowing that the boiling point of water is 212°F or 100°C and remembering that the number 32 (the temperature of freezing in Fahrenheit) and either 5/9 or 9/5 must be used, you can derive the formulas for conversions quickly (Figure 8). For example, to convert from Celsius to Fahrenheit, derive the formula by converting from 100°C to 212°F:

$$100\,°C \times 9/5 = 20 \times 9 = 180$$
$$180 + 32 = 212\,°F$$

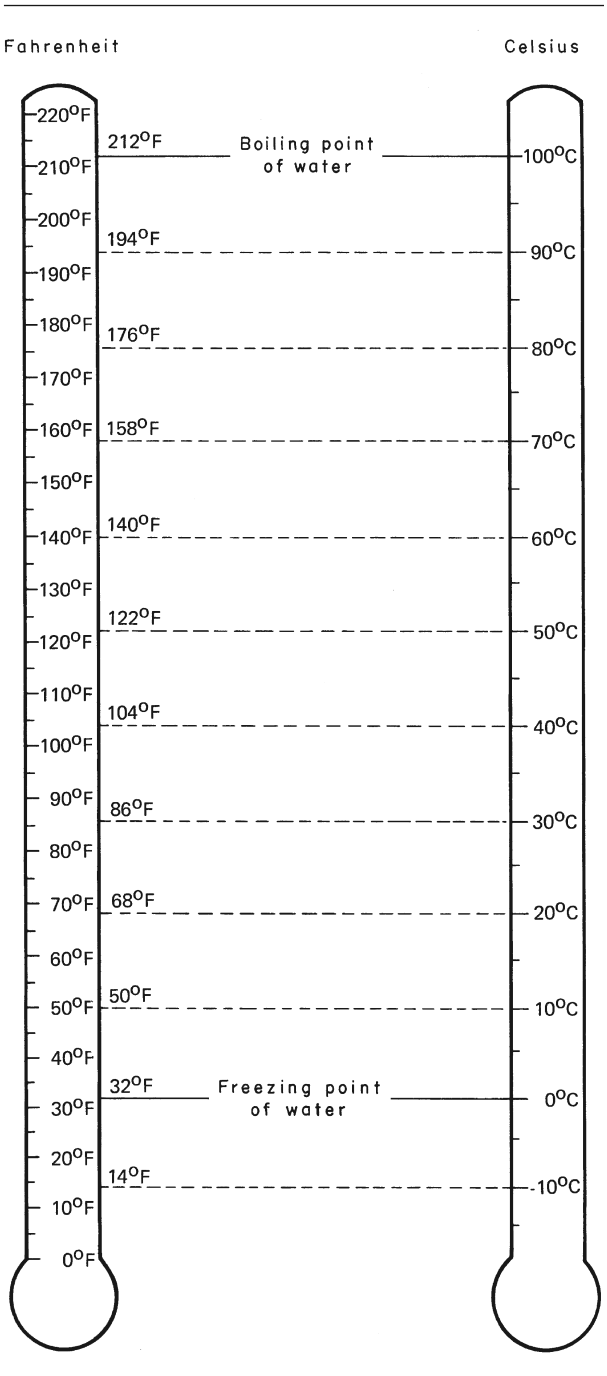

Figure 8 Comparison of the Fahrenheit and Celsius temperature scales.

Thus, the formula is

$$\left(\_\_\_\_°C \times \frac{9}{5}\right) + 32 = \_\_\_\_°F$$

The formula for converting from 212°F to 100°C is

$$212°F - 32 = 180$$
$$180 \times 5/9 = 20 \times 5 = 100°C$$

This formula then is

$$(\_\_\_\_°F - 32) \times \frac{5}{9} = \_\_\_\_°C$$

Table 8 provides some corresponding temperatures in Fahrenheit and Celsius.

Taking Control

Experiments provide meaningful information only when controls are established and maintained to eliminate (as much as possible) unintentional variables. All aspects of the experiments, from the ingredients and their preparation to the evaluation process, need to be considered carefully to identify potential experimental errors that can lead to invalid results.

Researchers conducting experiments intended ultimately for publication spend considerable time developing their methods to eliminate uncontrolled variables and then replicating their experiments numerous times to ensure accurate results. Carefully documented techniques are repeated each time by the same laboratory personnel to eliminate the variability that would occur if others were to do the same task. Such measures enable researchers to obtain results that can be replicated again and again.

Unfortunately, it is not practical for individual students to prepare in class all of the variations needed to illustrate the impact of altering ingredients and/or methods used in food preparation. However, a class laboratory situation can provide considerable information if various class members prepare some of the samples required to demonstrate the scientific principles underlying the day's experiment. This broad involvement of class members in sample preparation obviously introduces the possibility of considerable experimental error. To keep this error to an absolute minimum, individual members of the class need to become personally responsible for thoughtfully and carefully preparing the variations assigned to them.

Control of the quantity of ingredients used in preparing samples is essential if results from objective and subjective testing are to be meaningful. In the laboratory, solids are weighed carefully, and liquids are measured volumetrically in graduated cylinders, pipettes, or burettes. Far greater accuracy is possible with these procedures than with standard household techniques. The diameter of household measuring cups is so great that precise measurements cannot be obtained, whereas the very narrow diameter of a graduated cylinder or other laboratory volumetric equipment reduces the potential for imprecise measurements of liquids. Other errors in household measurements occur as the result of packing

Table 8 Selected Examples of Comparable Temperatures in the Fahrenheit and Celsius Scales

Celsius (°)	Fahrenheit (°)	Celsius (°)	Fahrenheit (°)
− 10	14	150	300
0	32	163	325
10	50	176	350
20	68	191	375
30	86	204	400
40	104	218	425
80	176		

of ingredients when they are transferred into the measuring cup. By weighing solid ingredients, the researcher can eliminate this source of potential errors.

Liquid ingredients should be measured in the smallest volumetric device capable of holding the entire measurement at one time. This practice minimizes the use of devices with a larger diameter than is absolutely necessary. For example, 80 ml of oil can be measured more accurately in a graduated cylinder with a capacity of 100 ml than in one that holds 500 ml. On the other hand, if this same 80-ml measurement were made by filling a 10-ml graduated cylinder eight times, error would be introduced because some oil would cling to the graduated cylinder each time it was emptied. Each liquid measurement should be made at eye level by reading the bottom of the **meniscus**, the usually concave surface of the liquid. Pipettes and burettes provide greater accuracy than do graduated cylinders.

Meniscus
Curved upper surface of a liquid column that is concave when the containing walls are wetted by the liquid and convex when they are not.

Dry ingredients and solids such as fats are weighed on balances, using careful and accurate laboratory techniques. **Trip balances** are available in some instructional laboratories. Ingredients can be weighed to an accuracy of 0.1 percent if 100 g of food is being weighed. This degree of accuracy requires that the container holding the food on the left pan be counterbalanced precisely with a similar, lighter container on the right pan to which shot or water has been added to zero the balance. The trip balance is an inexpensive, suitable choice because of its durability and satisfactory sensitivity for most laboratory experiments conducted by a class. It is preferred over the spring-type **dietetic balance** because of its greater sensitivity. The error of a dietetic balance is approximately 0.5 g when 100 g of food is weighed, whereas the trip balance error for this quantity is about 0.1 g.

Trip balance
Balance with two pans; the one on the left is used to hold the food being weighed, and the one on the right is used to hold the weights needed to counterbalance the left pan. Riders also are available for counterbalancing.

Dietetic balance
Single-pan, spring balance suitable for portion control, but not sufficiently accurate for food experimentation.

Some **torsion balances** are used for weighing quantities greater than 2 kg, for this quantity cannot be weighed satisfactorily on a trip balance. They also are needed for weighing very small amounts, as might be the case for spices. The sensitivity of torsion balances makes them the preferred balance for all weighing, but cost and possible need for repairs limit their availability in instructional laboratories.

Torsion balance
Very sensitive (within 0.02 g) laboratory balance particularly useful for weighing very small quantities or quantities greater than 2 kg.

Direct-reading, **top-loading electronic balances** with a sensitivity of 0.01 g are yet another, but definitely costly, alternative for weighing spices or other foods needed in very small quantities. Top-loading electronic balances are desirable because of their convenience and accuracy. Unfortunately, their cost limits their availability in student laboratories. These balances save time by making it possible to weigh the container for the food and then use the tare mechanism to offset that weight so that only the weight of the actual food is indicated. Top-loading electronic balances are of particular merit when small amounts of ingredients need to be weighed because they are extremely sensitive and accurate, even when tiny quantities are required.

Top-loading electronic balance
Very accurate, electrically operated balance.

Conducting and Evaluating Classroom Experiments

When the entire class conducts experiments, more samples can be prepared to demonstrate the effects of selected variables than can be produced by an individual researcher. This advantage is countered by the fact that individual techniques of the class members introduce uncontrolled variables into the experiment. Using electric mixers operating at a specified speed for a defined period of time can obtain some control of mixing techniques. In preparations requiring other mixing techniques, the class members should be sure to use the same design of beater, spoon, or other mixing tool; the total amount of mixing and the rate also need to be defined and heeded.

In some experiments, it is possible to set up an assembly line to prepare the samples for the class. When this is done, the same part of the preparation of each sample is done by the same person. The mixture passes in sequence along the assembly line. The obvious advantage of preparing samples for the class in this manner is that variations in preparation are kept to a minimum.

The completed products should be evaluated carefully according to the standards of quality appropriate for the type of food being tested. To distinguish the unique qualities of each of the variations available, each sample needs to be examined very carefully under good light

and in a quiet place. To avoid biases from other class members, all should refrain from any comments while evaluation is being done.

Comments should be recorded clearly as each sample is evaluated. A chart listing the variations and the characteristics to be evaluated will make the process smooth and accurate. If the samples are arranged on the display table in the same order as the chart and each sample is clearly labeled, the possibility of confusing the samples when recording results will be kept to a minimum.

SUMMARY

Consumers, farmers and fishermen, and the food industry are constantly reshaping the food marketplace in response to increasing cultural diversity, environmental, economic, and lifestyles concerns. Among current key issues are food safety (including terrorism and environmental and microbiological risks) and health. Functional foods, designer foods, organic foods, phytochemicals, prebiotics, probiotics, genetically modified organisms (Bt), biotechnology, and nanotechnology are now in the vocabularies of consumers.

Careers related to food may involve the role of food and health or the feeding of people away from home or may be in the broad food industry (from basic food research to all aspects of bringing food products to the consumer, including governmental roles).

Food research, which had its origins primarily in the search for answers to problems observed in the home, is now shifting its emphasis increasingly toward the technological challenges presented as a considerable portion of the food consumed is prepared in factories and processing plants. Whether the food under study is intended for preparation in the home or on a vast commercial basis, the scientific principles underlying the properties and behavior of the various components are the same. A course in experimental foods considers the chemical and physical principles underlying the preparation of the diverse foods commonly served in the United States. Laboratory experiments can be conducted to learn evaluation techniques and to correlate cause and effect in food preparation. The language of experimental foods, like that of other sciences, is metrics. Food professionals need to be able to use the metric system and also to convert between the conventional system and metrics when necessary. Conversions between the Celsius and Fahrenheit scales frequently are required in research.

Accuracy of measurements is a key aspect of control in food experimentation. Volumetric devices (pipettes, burettes, and graduated cylinders) are used for measuring liquids, with the bottom of the meniscus being the location for determining the exact volume. Trip balances usually are the main type of balance used to weigh solid ingredients in classroom laboratories. Direct-reading, top-loading electronic balances are desirable for weighing very small quantities, but less expensive and slightly less precise torsion balances may be used satisfactorily for weighing ingredients needed in very small amounts or in quantities exceeding 2 kg.

For best results in classroom experiments, all aspects of sample preparation should be controlled as much as possible. Electric mixers are recommended whenever feasible to regulate the speed and duration of mixing. Evaluating class samples needs to be done in an accurate and organized manner.

STUDY QUESTIONS

1. Identify and describe four characteristics of consumers where you live. How has each of these influenced the food markets in your town? Would the markets in a city in another state be the same as your market? If not, explain how they might differ.
2. Define “organic” and “natural” (in the context of food) and clarify any distinction between the two terms. Is there a difference in price and quality of organic produce versus the same type of regular produce in your market?

3. Define (a) phytochemical, (b) functional food, (c) prebiotic, (d) probiotic, (e) biotechnology, (f) GMO, (g) Bt, (h) genetic engineering, (i) nanotechnology.
4. What are two reasons why some people are opposed to GMO foods? What are two reasons GMO foods are appropriate to grow?
5. Identify the career that you wish to enter and describe the academic preparation you will need.
6. Why is it important for food researchers to weigh all ingredients carefully or measure them in a calibrated volumetric pipette, burette, or graduated cylinder?
7. Explain how to weigh 225 g of flour on your laboratory balance.
8. Convert the following measures:
   a. 40 °F = ____°C
   b. 150 °C = ____°F
   c. 375 °F = ____°C
   d. 55 °C = ____°F
   e. 14 tbsp = ____ml
   f. 472 ml = ____c
   g. $1\frac{1}{3}$ c = ____ml
   h. 7 fl oz = ____ml
   i. 1236 g = ____kg
   j. 236 ml = ____l
   k. 1 tsp = ____ml
   l. 4 tsp margarine = ____g
   m. 3 in. = ____cm

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INTO THE WEB

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http://www.rainforest-alliance.org/—Web site for Rainforest Alliance.

http://www.worldcocoafoundation.org/—Web site for World Cocoa Foundation.

http://irps.ucsd.edu/assets/021/8422.pdf—A critique of Rainforest Alliance certification.

http://www.ams.usda.gov/AMSv1.0/NOP—Web site for the National Organic Program.

http://www.ams.usda.gov/—Site for the U.S. Department of Agriculture.

http://www.nifa.usda.gov/nea/biotech/in_focus/biotechnology_if_animal.htm—Overview of some animal biotechnology research possibilities and potential benefits.

http://www.csrees.usda.gov/plantbreedinggeneticsgenomics.cfm—Overview of some plant biotechnology research.

http://www.monsanto.com/biotech-gmo/asp/default.asp—Overview of plant biotechnology and some references.

http://www.soyconnection.com/pdf/usbs_position/English/8007_USB_BioTechBro_v1.pdf—Discussion of importance of biotechnology.

http://www.agbios.com/dbase.php?action=Synopsis—Database on global status of approved genetically modified plants.

http://www.isaaa.org/—International Service for Acquisition of Agri-biotech Applications; information on biotech programs around the world.

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http://www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=235716. Impact of Bt crops on nontarget organisms and insecticide use patterns.

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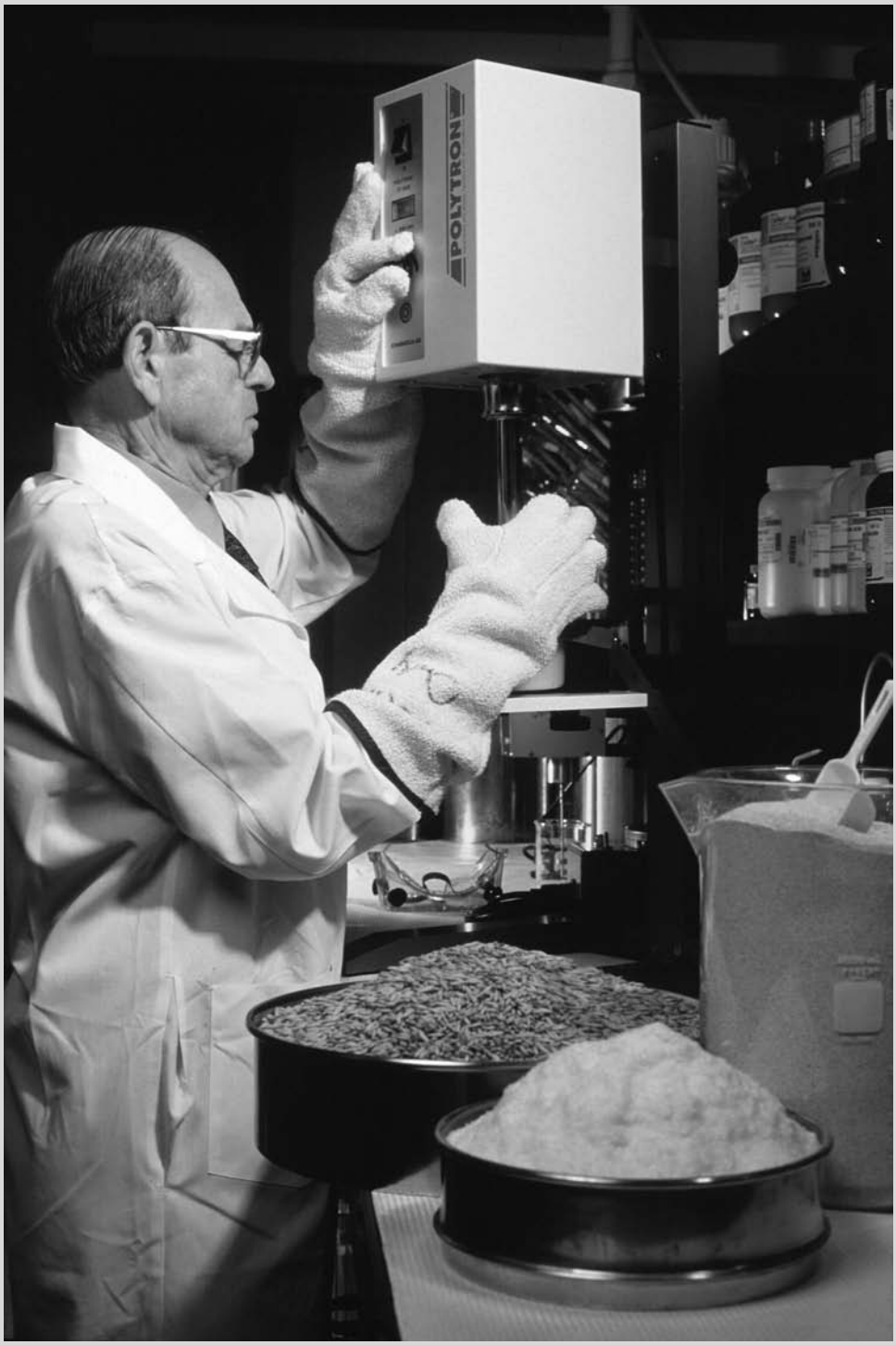
http://pubs.acs.org/doi/abs/10.1021/jf903170b—Article in Agriculture and Food Chemistry on phytoglycogen octenyl succinate, a carbohydrate nanoparticle to improve lipid oxidative stability of emulsions.

http://www.senomyx.com/flavor_programs/receptorTech.htm—Flavor receptor technology.

The Research Process



Already noted for developing Oatrim and Z-trim, ARS chemist George Inglett has come up with another healthful food ingredient-Nutrin (bowl in foreground).

The Research Process

Chapter Outline

OBJECTIVES

After studying this chapter, you will be able to:

1. Develop a clear statement of the purpose of a prospective research project.
2. Identify bibliographic references pertinent to the project.
3. Propose the research design, including method, evaluation, and data recording.
4. Describe how the research is to be conducted.
5. Explain how to interpret and report results of an experiment, including use of some statistics.
6. Outline how to write the report of a research project.

INTRODUCTION

Classroom laboratory experiments often are planned to demonstrate pertinent scientific principles by having samples prepared and evaluated by members of the class. This approach is valuable to help illustrate the significance of the principles and the effects of variations on food products. There also is much that can be learned about research by planning, conducting, and reporting an individual experiment in which you define the purpose and justification. By identifying the problem and actually proceeding through the several steps involved in conducting your research project, you can begin to appreciate the realm of food research and the many factors involved in conducting, evaluating, and reporting such research. The following sections provide an overview of the process and serve as a guide for doing independent food research.

DEFINING THE PURPOSE

Drafting a clearly stated purpose is the first step in designing a research study. Initially, it may be helpful to write down the general subject to be studied. This could be as vaguely defined as "roasting meat with aluminum foil." From this beginning, a specific statement

can be developed. The following statement of purpose for an individual project is an example:

> The purpose of this experiment is to determine the effect on muffins of substituting fructose for sucrose at two levels.

This statement indicates that two levels of substitution will be used, that the control will be sucrose and the substitute will be fructose, and that the product being tested is muffins. The specific characteristics to be evaluated are not indicated in this particular statement. Instead, the general term *effect* is used, which leaves the evaluation methods to be identified when the experimental method is developed. If it is appropriate to define *effect* more specifically, the statement of purpose might read as follows:

> The purpose of this experiment is to determine the effect on volume, texture, flavor, tenderness, and moisture when fructose is substituted for sucrose at two levels in muffins.

Although somewhat cumbersome, this type of statement clearly stipulates the scope of the experiment and aids in the development of the methods needed, particularly the method of evaluation.

Statements of the problem are appropriate for descriptive research studies. However, researchers wishing to apply statistical analysis to their results need to develop a *hypothesis* and a *null hypothesis*. This permits statistical testing to determine the probability that the variable being tested caused the results obtained in the study.

Hypothesis
Positive assumption to test logical or empirical consequences of applying a variable in a research project.

Null hypothesis
Statement that applying a research variable will not make a significant difference in a research project.

A **hypothesis** is a stated assumption of a consequence that is the outcome of the application of a variable in a research project. Researchers also state a **null hypothesis**, which is a statement that there will be no significant difference resulting from the application of the variable in the experiment.

An example of a hypothesis is:

- There will be a significant difference in the volume of a shortened cake made with sucrose and one made with fructose.

An example of a null hypothesis is:

- There will be no significant difference in the volume of a shortened cake made with sucrose and one made with fructose.

Since research is often costly in both time and money, experimentalists should consider the justification for conducting the intended experiment. This justification should be developed concomitantly with the statement of purpose. In the case of the research topic just suggested, the justification may be based on the fact that fructose in solution is known to be sweeter than sucrose and that its use in cakes might be useful in reducing the caloric content. If this experiment demonstrated that fructose could replace sucrose satisfactorily at lower levels in cakes, reduced-calorie cakes could be developed and marketed to meet consumer demand for desserts with fewer calories.

Justification frequently is based on consumer needs. In some instances, special diet requirements for physical conditions such as a high serum cholesterol level may provide the justification for an experiment using egg substitutes or various other special ingredients related to the condition. Sometimes the cost of similar ingredients may be the basis of a study determining the feasibility of substituting the less costly ingredient for the more costly one, or even of reducing the amount of the costly item. Other experiments may be based on the need for a longer shelf life for products to maintain their acceptability during the marketing process. These are only a few of the factors that may provide justification for conducting food research.

REVIEWING THE LITERATURE

Research projects are most meaningful when they are planned after a thorough search of the literature on the topic being studied. Previous work published on the research topic can provide insight into anticipated problems, appropriate methods, theories and facts related to

the topic, and evaluation techniques. Considerable time can be saved and the quality of the research can be enhanced.

A computer search of the literature can be done using certain key words that are pertinent to the topic. For the preceding example, appropriate key words for the preliminary computer search would include *fructose, cakes, shortened cakes, sucrose,* and *sugar.* References regarding test methods can also be searched via computer.

Many journals have appropriate articles relating to specific research topics. Table 1 presents a list of some of the pertinent journals that may be helpful.

The table of contents in the most recent issues of the journals that may be most appropriate for your research topic may be useful in locating a pertinent article that has just been published. The bibliography in the article also will prove helpful. Many of the journals provide an annual index of articles. A quick examination of the index provides a review of articles in that publication that may be useful.

If a computer search is not a possibility, or the results of the search are delayed, alternative approaches to finding appropriate research articles may prove helpful. *Biological and Agricultural Index,* an index issued monthly, has a quarterly cumulative issue. Another index is the *Applied Science and Technology Index*. As the name suggests, indexed articles focus on applications and technology, rather than food science. Consequently, this index does not include articles from the *Journal of Food Science,* which is an especially important technical journal in the field. *Current Contents: Agriculture, Biology, and Environmental Sciences,* which publishes weekly the tables of contents from journals pertinent to food research, affords yet another entry to the literature in food research. All of these publications provide the bibliographic information needed to locate articles to help gather the research information available related to the research topic. You will need to obtain the articles themselves to gain the information needed in your literature review.

Abstracts also can be of help in gathering background information for your research topic. Whenever possible, read the actual article, rather than relying solely on the abstract. However, articles written in foreign languages or appearing in foreign journals may be available only in the form of the abstract. Several sources of abstracts may be available in the library and on the Internet. These include *Food Science and Technology Abstracts, Chemical Abstracts (Section 17),* and *Biological Abstracts*. A survey of their subheadings will help to identify the sections of the abstracts that might contain appropriate entries for a given topic.

Table 1 Some Research Journals Pertinent to Food Research Problems

Journal	Types of Topics Covered
Agricultural and Biological Chemistry	Chemistry of basic products
American Journal of Potato Research	All aspects of potatoes
Cereal Chemistry	Applied research in the baking industry
	Some food science applications and scientific research on topics such as starch
Cereal Foods World	Various cereals
Food Technology	Food industry and problems related to product evaluation, control, and development
International Journal of Poultry Science	Many aspects of poultry
Journal of Agricultural and Food Chemistry	Chemical research on food
Journal of the American Dietetic Association	A few articles on nutrient content and food ingredients
Journal of Dairy Science	Milk and dairy products
Journal of Food Protection	Food microbiology
Journal of Food Quality	Some review articles on quality
Journal of Food Science	Very wide range of applied and basic food research articles
Journal of Texture Studies	Textural properties and characteristics theory and applications

FOOD FOR THOUGHT: AGRICOLA

AGRICOLA, although a word from Latin, is very much a product of the computer age. It is an acronym for AGRICultural OnLine Access. The U.S. Department of Agriculture established this online database in 1970 and continues to maintain extensive bibliographic information on a very broad base of agriculture-related disciplines, including food and human nutrition, animal and plant sciences, aquaculture and fisheries, farming, agricultural economics, extension, and education (Figure 1).

Users of AGRICOLA may search two data sets—Online Public Access Catalog (for books and other related types of publications) and Journal Article Citation Index (for journal articles). Bibliographic information is available using each of these search approaches. In some cases, the actual original text can be accessed via available links. Library materials can be obtained from the National Agricultural Library via http://agricola.nal.usda.gov/.

Computers can provide access to still other sources of information regarding pertinent articles. Two databases available by computer, but not in print, are AGRICOLA and Foods Adlibra™. The World Wide Web is a useful computer index.

After gathering the articles, careful reading and thought are necessary to relate the findings to the current project. Ideas for the statement of hypotheses and for the development of method often can be gleaned from the literature. Previous research can help validate the results obtained in the new experiment. Accepted analytical methods can be learned from the literature, thus enhancing comparison of the new results with previous research.

Be sure to record the complete citation for each article studied in an accepted bibliographic style. This style should be the one required either at the university or in the specific class; usually the style selected is based on the format used in an appropriate professional journal. In all forms, the basic information needed will include the authors' names (usually with initials), the title of the article, the volume (and issue, if necessary), the page number (either initial page or inclusive pages), and the year. Methodical notation of these pertinent data for each article will avoid the need to relocate the article later to complete the citation. Bibliographic styles differ from journal to journal, as can be seen from the following citations (*Food Technology* and *Journal of the American Dietetic Association,* respectively):

Pillai, S.D. and Jesudhasan, P.R. 2006. Quorum sensing: How bacteria communicate. *Food Technol. 60* (4): 42–49.

Stein, K. Contemporary comfort foods. *J. Am. Diet. Assoc.* 2008; 108:412.

DESIGNING THE EXPERIMENT

When the purpose of the experiment has been stated clearly, a design can be developed to achieve the desired goal. Individual student experiments in an experimental foods course can be conducted meaningfully if only one variable is tested. In the example used in the preceding section, the variable is the substitution of fructose for sucrose; the levels of substitution need to be determined. The design of this experiment might be based on preparation of three cakes for each run: a control containing 100 percent sucrose and 0 percent fructose, an experimental cake containing 50 percent sucrose and 50 percent fructose, and a second experimental cake containing 0 percent sucrose and 100 percent fructose.

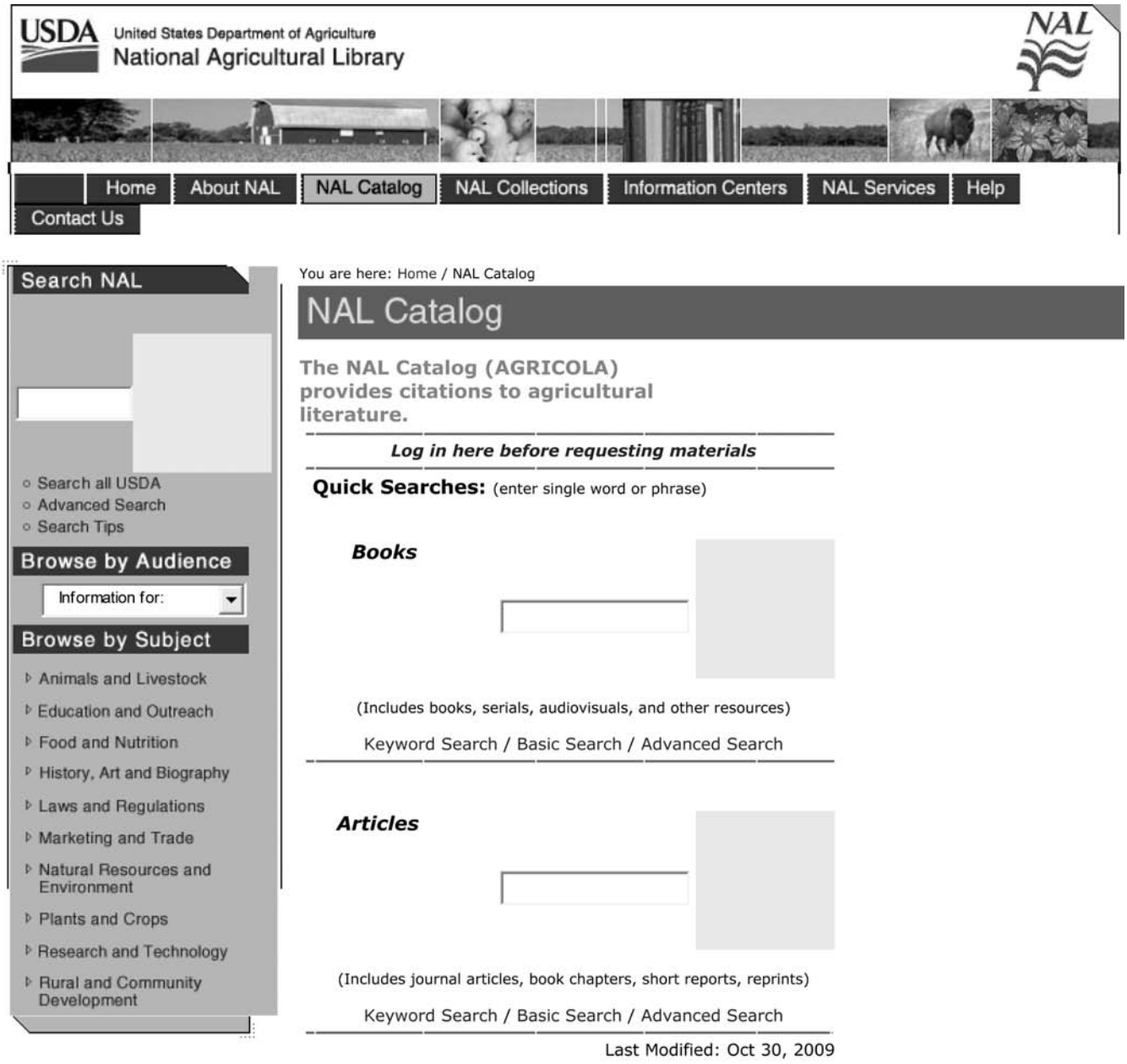


Figure 1 Home page of the AGRICOLA Web site.

A **variable** is any quantity or symbol that has no fixed value. In designing a research project, it is important to identify all aspects of the research that might vary. **Extraneous variables** are those that might add variations that are not truly a part of the experiment and that are not useful—for example, using two different brands of baking powder when that is not the focus of the experiment. Recognition of these undesirable extraneous variables is important so that they can be eliminated prior to conducting the experiment.

Two types of variables, independent and dependent, are of particular interest in designing an experiment. An **independent variable** (sometimes referred to as the *manipulated variable*) is defined by the researcher and is not measured. The **dependent variable** will have measured results or data as outcomes of the experiment. In the research comparing cakes made with sucrose and fructose, the independent variable is the type of sugar and the dependent variable is the volume of the cakes.

Variable
Quantity or symbol that has no fixed value.

Extraneous variable
Variable that is not intended to be part of the experiment and needs to be eliminated from or controlled prior to conducting the experiment.

Independent variable
Manipulated variable defined by the researcher.

Dependent variable
The measured variable of an experiment.

Ordinarily, the appropriateness of the planned variations might be tested in some preliminary runs to obtain insight into possible results and to develop the controls necessary for preparing and evaluating the samples. However, the time restrictions of an experimental foods course may dictate that this mini research project be designed with only two runs, with no preliminary runs to develop the optimal formulas and method.

Publishable research requires extensive testing during the planning stage to establish the controls needed to eliminate errors resulting from variations in sample preparation. Actual data collection should begin only after repeatable results are obtained and the problems involved in the evaluation process have been solved. Once data collection begins, it is necessary to include sufficient repetition to ensure that the results are due to the variables and not due to chance (Figure 2).

Method

Plans for sample preparation require careful consideration of the entire process. The first step is to identify a formula for the ideal control product so that the experimental samples can be measured in relation to an excellent standard. Then, every action involved in preparing that product must be identified and included in the written statement of the method.

All mixing techniques need to be described so clearly that anyone would be able to prepare the same product and obtain the same results following the stated method. Specifically, the type of mixing utensil to be used, the number of strokes (revolutions, or other appropriate control), and the rate (strokes per minute) are examples of the details necessary in writing the statement of the method. The usual statements in recipes (e.g., stir until blended) are too vague to ensure the controls necessary for precise laboratory investigations. Similarly, temperatures and times for heating must be specific.

Even potential variations resulting from the ingredients themselves need to be eliminated as much as possible. For example, all of the eggs to be used in the control and variations for one run can be broken out of the shell and blended together gently for a designated amount of mixing, and then the amount needed for each sample can be weighed from this common source. The flour and other staple ingredients needed for the whole

Figure 2 Dr. Pamela White, Dean of the College of Human Sciences at Iowa State University, is loading vials into the automatic injector of a gas chromatograph as she conducts an experiment on oils.

experiment should come from the same packages. If more than one package of an ingredient is needed for the entire experiment, the total amount should be mixed together thoroughly before starting and then stored appropriately for use throughout all of the runs. Of course, perishable ingredients will need to be procured throughout the experiment. Even though there will be some variation in ingredients of this type from one run to another, variation between the samples within a single run should be eliminated.

Evaluation

Evaluation devices are a key part of the planning process. Careful thought should be given to ensure that all pertinent characteristics are tested appropriately. This means that the necessary objective measurements—for example, volume, tenderness, viscosity, pH, and chemical and physical attributes—are identified, and that plans for conducting each measurement are specified.

Sensory evaluation requires that a taste panel be designated and that a suitable scorecard be developed. If the panel is to be trained in the use of the scorecard, the training process also needs to be planned. Evaluations by objective and subjective methods are discussed in the next two chapters.

Plans for both objective and subjective evaluations need to be formulated to determine the quantities of sample required. Preparation of the samples for the evaluation also requires a thoughtfully developed written plan. For such objective testing as tenderness, the thickness of the samples must be controlled, a control usually achieved for a dough by rolling it on a board specially equipped with parallel guides that dictate the thickness of the dough prior to baking (Figure 3). In other cases, it may be necessary to develop a **template** to guide the cutting of specific samples for judges and for certain objective tests (Figure 4).

Template
Pattern guide to ensure accurate cutting of samples from a large sample, such as a cake.

Not only must the sample size be determined, but also the timing and temperature of samples for testing must be considered. Significant changes in textural characteristics occur in many foods as they cool after being heated. The notable increase in viscosity of a white sauce as it cools illustrates the need to plan testing circumstances. Baked products become firmer as they cool, making it necessary to specify the time for determining tenderness after removal from the oven. The gel structure of a starch-thickened pudding gradually tightens and becomes less fragile as it is allowed to cool without any agitation. These are but a few examples of the changes that necessitate careful planning of the conditions for evaluation.

Data Recording

All information regarding a research project should be maintained safely and accurately. This record should include the statement of purpose, justification for the project, and the design. The formula and its variations, along with specific directions for preparing the samples, instructions for each phase of the evaluation, and samples of any forms to be used in the evaluation should all be recorded.

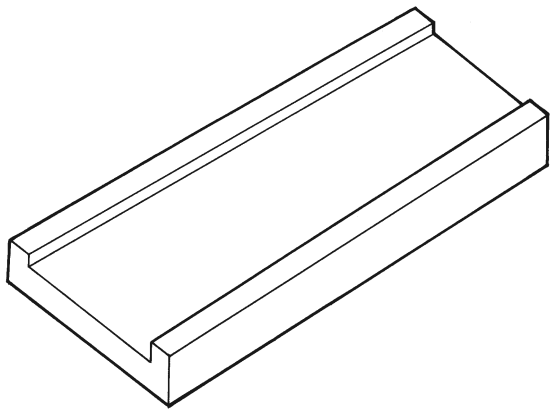


Figure 3 Board for controlling thickness of pastry dough when preparing samples for testing in the shortometer. The rolling pin is rolled over the dough placed in the center until the dough is pressed down so that the rolling pin rolls evenly along the raised edges of the board.