FLAVORS

1. Introduction

Flavor has been defined as a memory and an experience (1). These definitions have always included as part of the explanation at least two phenomena, ie, taste and smell (2). It is suggested that in defining flavor too much emphasis is put on the olfactory (smell) and gustatory (taste) aspects (3), and that vision, hearing, and tactile senses also contribute to the total flavor impression. Flavor is viewed as a division between physical sense, eg, appearance, texture, and consistency, and chemical sense, ie, smell, taste, and feeling (4). The Society of Flavor Chemists, Inc. defines flavor as “the sum total of those characteristics of any material taken in the mouth, perceived principally by the senses of taste and smell and also the general senses of pain and tactile receptors in the mouth, as perceived by the brain” (5).

The acceptability of food is determined by its flavor, and a large variety of industrial flavorings are used for the commercial preparation of foods. Most of the daily food intake, even in industrialized countries, contains flavor naturally or flavor formed during cooking and preparation for human consumption. Only a minor part of the daily food intake is covered by foods containing added flavorings.

2. Function

Flavors do several things in food systems. Foremost among these functions is their ability to render food more acceptable and enjoyable.

Flavors are often used to create the impression of flavor where little or none exist, and they impart food products with a recognizable character. Some food products would not exist without the addition of flavorings, eg, soft drinks, water ices, confectionery, milk desserts, etc. Many food products need a specific flavor note to characterize them among other similar products of the same food category, eg, citrus soft drinks, mint candies, gingerbread, yogurt, and cottage cheese.

Flavors can be used to alter the flavor of a product, eg, the flavor of dairy products; to modify, supplement, or enhance an existing flavor, eg, the butter flavor in margarine and the meat or chicken flavor in bouillon; and to compensate for the loss of flavor during food processing, eg, pasteurized foods, concentrated citrus fruit juices, syrups, alcoholic beverages, freezing, filtration, pasteurization, and long-term storage. Flavorings also transform nutritionally valuable materials of bland taste, eg, grasses, weeds, seeds, and roots, into well-accepted foods.

3. Food Acceptance

Four features of food are recognized to determine acceptance, ie, flavor, nutritive value, appearance, and mouthfeel. When all four aspects are in proper quantitative proportions, a food finds general acceptance. When all four are interdependent, appearance takes precedence over the others. However, a report by the Food Marketing Institute has shown that consumers placed nutrition second to flavor in importance (6).

A food must have the expected or proper appearance and color before it will be readily consumed (7). There are many prepared foods in which artificial flavors and colors are used whose flavor is sufficiently bland to make color essential for flavor identification, eg, margarine. The preservation of color in natural food during processing or the development of color by processing are aspects of primary importance in food acceptance.

Mouthfeel (8), ie, a texture or kinetic feature evaluated by the skin or muscles in the mouth, includes smoothness, roughness, stickiness, slickness, brittleness, and viscosity. Texture is not only detected during mastication, but also by the ease of cutting or dividing before consumption. A particular flavor observed without the proper mouthfeel may not only be unappreciated, but go unrecognized, ie, nutty flavor is associated with brittleness, and butter flavor with slickness and smoothness. In low fat products, when one removes or lowers the fat the mouthfeel component of the product and the perception of the flavor changes. The flavor generally has to be revised or its amount changed to accommodate this problem.

The acceptability of certain foods may be because of availability and habit, which in turn affects certain customs, eg, the sugar maple, indigenous to northern United States, provides a syrup generally enjoyed and familiar in this region but generally unacceptable in the southern states. The greater mobility of people in the late twentieth century demands variety in flavorings to produce these regional tastes.

4. Taste

Certain basic principles are involved in the physiology of flavor perception. Researchers studying taste generally agree that there are at least five tastes, ie, salty (9), sour (10), bitter (11), sweet (12), and umami (13). Umami can be defined to the Japanese as the taste of three broths, ie, Kombu, Shiitake, and Katsuobushi. In English, the narrower definition of the taste of monosodium L-glutamate [142-47-2] (MSG), or the broad but vague concept of savory, meaty, or brothy are used (13) (see FLAVOR CHARACTERIZATION). Tastes are perceived by certain sensory cells or taste buds, contained in the approximately 10,000 papillae located on the tongue. On the human tongue the taste buds are localized in three general areas. The fungiform papillae, located on the front two-thirds of the tongue, are innervated by the chorda tympani branch of the facial nerve. The foliate papillae, situated in the rear and on the sides of the tongue, are innervated by the glossopharyngeal nerve. The larger circumvallate papillae are situated principally on the back third of the tongue. Taste buds are also found on the palate, pharynx, epiglottis, larynx, and esophagus (14).

Taste-active chemicals react with receptors on the surface of sensory cells in the papillae causing electrical depolarization, ie, drop in the voltage across the sensory cell membrane. The collection of biochemical events that are involved in this process is called transduction (15,16). Not all the chemical steps involved in transduction are known; however, it is clear that different transduction mechanisms are involved in different taste qualities; different transduction mechanisms exist for the same chemical in different species (15). Thus the specificity of chemosensory processes, ie, taste and smell, to different chemicals is caused by differences in the sensory cell membrane, the transduction mechanisms, and the central nervous system (14).

Several aspects affect the extent and character of taste and smell. People differ considerably in sensitivity and appreciation of smell and taste, and there is lack of a common language to describe smell and taste experiences. A hereditary or genetic factor may cause a variation between individual reactions, eg, phenylthiourea causes a bitter taste sensation which may not be perceptible to certain people whose general ability to distinguish other tastes is not noticeably impaired (17). The variation of pH in saliva, which acts as a buffer and the charge carrier for the depolarization of the taste cell, may influence the perception of acidity differently in people (15,18). Enzymes in saliva can cause rapid chemical changes in basic food ingredients, such as proteins and carbohydrates, with variable effects on the individual.

When food contains both sweet and bitter substances, the temporal pattern of reception, ie, the order in which sweet and bitter tastes are perceived, affects the total qualitative evaluation. This temporal effect is caused by the physical location of taste buds. The buds responding to sweet are located on the surface and the tip of the tongue, the bitter in grooves toward the rear. Therefore, the two types of taste buds can be activated sequentially.

Texture also influences the evaluation of taste. Sweetness in a liquid is associated with body or viscosity. An artificially sweetened beverage that lacks body, therefore, may be rated qualitatively lower than one equally sweet but containing sucrose.

The metallic taste (12,19,20) is not ascribed to any special taste buds or mouth area. Along with pungency (the hot taste of peppers), astringency (the puckering taste of alum), and cold taste (the cool effect of menthol), the metallic taste is called a common chemical sense (21).

Table 1. **Approximate Taste Thresholds**[a]

Basic taste	Test standard	CAS registry number	Wt% in water
sour	hydrochloric acid	[7647-01-0]	0.007
salty	sodium chloride	[7647-14-5]	0.25
sweet	sucrose	[57-50-1]	0.50
bitter	quinine	[130-95-0]	0.00005

[a] Ref. 22.

Although the values cannot be considered absolute, approximate magnitude of taste sensitivity has been measured (Table 1). Certain taste interrelationships should be considered in the evaluation of taste magnitude. The apparent sourness of citric acid is depressed by both sucrose and sodium chloride. Although the saltiness of sodium chloride is reduced by sucrose, it can be significantly enhanced by acid (23).

Simultaneous stimulation of the tongue with the application of different taste stimuli produces an interaction, modification, or blending of the stimuli in some instances but not in others. Warm and cold sensations are reported to act similarly on the tongue in two groups: bitter, warm, and sweet; and sour, cold, and salty (24). The theory of the specificity of the taste buds may be subject to modification (25).

4.1. Generalizations. Several generalizations can be made regarding taste (16,26). A substance must be in water solution, eg, the liquid bathing the tongue (saliva), to have taste. Water solubility is the first requirement of the taste stimulus (12). The typical stimuli are concentrated aqueous solution in contrast with the lipid-soluble substances which act as stimuli for olfaction (22). Many taste substances are hydrophilic, nonvolatile molecules (15). Taste detection thresholds for lipophilic molecules tend to be lower than those of their hydrophilic counterparts (16).

Only acids are sour. Sourness is not identical to chemical acidity or pH, which is a function of the hydrogen ion concentration, but also appears to be a function of the entire acid molecule. A combination of pH and acid concentration determines the actual degree of the sour taste. At the same pH, any organic acid, eg, citric acid, exhibits a far greater sourness than a mineral acid, eg, hydrochloric acid (27,28).

Only salts are salty; however, not all salts are salty. Some are sweet, bitter, or tasteless. The salty taste is exhibited by ionized salts, and the greatest contribution to salty taste comes from the cations (29). The salt taste is produced by monovalent cations (15).

Organic aromatic molecules are usually sweet, bitter, a combination of these, or tasteless, probably owing to lack of water solubility. Most characteristic taste substances, especially salty and sweet, are nonvolatile compounds. Many different types of molecules produce the bitter taste, eg, divalent cations, alkaloids, some amino acids, and denatonium (14,15).

4.2. Odor. The physiology of odor, which is the determining characteristic of flavor, is more complex and less understood than that of taste. It has been claimed that odor is 80% of flavor. A large number of odors are distinguishable, but it is not known how this is accomplished. Olfactory response is only observed when the substance contacts the olfactory membrane (30), called the olfactory mucosa or olfactory epithelium, which occupies an area of about 2.5 cm^2 in each nostril. Above the nasal passages, the two olfactory clefts are separated by the nasal septum. For a substance to have an odor, it must be capable of reaching the olfactory epithelium high up in the nose, and must come in contact with the olfactory cilia membrane. The actual olfactory receptors are specialized protein molecules located in the cilia. These proteins are responsible for detecting odor-producing molecules. It must have sufficient volatility and low molecular weight so that it may make contact in the nasal passages by inspiration. It also appears that solubility in lipids is essential. However, a normally nonodorous or nonvolatile substance placed in contact by a spray or mist may become odorous. Many materials now regarded as useless (30) may have practical odorant applications because of this phenomenon.

The odor of a substance is most logically attributed to its molecular structure. As in taste, its perception is preceded by the process called transduction in which a chemical reaction with a receptor cell excites a nerve center, giving a sensation. Brain functions such as emotion, attention, cognition, etc, mediate these sensations into perceptions. Other theories that have been ascribed to nonchemical reactions, such as molecular vibration or infrared absorption, seem to be without solid foundation (31,32). Although odor quality appears to be associated with chemical structure, it has not been possible to predict odor types accurately on this basis (33,34). Generally, compounds of carbon and hydrogen, ie, terpenes, are odorless or of uncharacteristic odor until such atoms as oxygen, nitrogen, or sulfur are introduced. These atoms, combining to form certain functional groups such as alcohols (RC–OH), aldehydes (RCHO), amines ($RC–NH_2$), esters (RCOOR), ketones (RCOR), etc, make up what has been called an osmophore, or odor-bearing group. The feature that affects odor is the structural form of the molecule, especially its isomeric and spatial variations which includes its enantiomeric properties. An excellent example of this is found in the difference in taste and odor between L-carvone [6485-40-10] and D-carvone [2244-16-8]. L-carvone has a spearmint character and D-carvone has a dillweed, caraway, or ryebread odor and taste.

Whatever the physiology of odor perception may be, the sense of smell is keener than that of taste (22). If flavors are classed into odors and tastes as is common practice in science, it can be calculated that there are probably more than 10^4 possible sensations of odor and only a few, perhaps five, sensations of taste (13,21,35–37). Just as a hereditary or genetic factor may cause taste variations between individuals toward phenylthiourea, a similar factor may be in operation with odor. The odor of the steroid androsterone, found in many foods and human sweat, may elicit different responses from different individuals. Some are very sensitive to it and find it unpleasant. To others, who are less sensitive to it, it has a musk or sandalwood-like smell. Approximately 50% of the adults tested cannot detect any odor even at extremely high concentrations. It is believed that this ability is genetically determined (38).

The odor detection-threshold values of organic compounds, water, and mineral oil have been determined by different investigators (Table 2 and 3) and may vary by as much as 1000, depending on the test methods, because human senses are not invariable in their sensitivity. Human senses are subject

Table 2. **Odor Detection Threshold Levels in Water and Mineral Oil,[a] ppm**

Compound	CAS registry number	Water	Mineral oil
2-methylpyrazine	[109-08-8]	105	27
2,5-dimethylpyrazine	[123-32-0]	35	17
2,6-dimethylpyrazine	[108-50-9]	54	8
2,3,5-trimethylpyrazine	[14667-55-1]	9	27
2,3,5,6-tetramethylpyrazine	[1124-11-4]	10	38
2,5-dimethyl-3-ethylpyrazine	[13360-65-1]	43	24
2,6-dimethyl-3-ethylpyrazine	[13925-07-0]	15	24
5-isopentyl-2,3-dimethylpyrazine	[75492-01-2]	6	
6-isobutyl-2,3,-dimethylpyrazine		4.1	
5-isobutyl-2,3-dimethylpyrazine		0.77	
5-isobutyl-2-methoxy-3-methylpyrazine	[78246-20-5]	0.00018	

[a]Ref. 42.

Table 3. **Odor Detection Thresholds of Organic Compounds[a]**

		Detection threshold[b]	
Compound	CAS registry number	mg/m^3 Air	ppm/ H_2O
acetaldehyde	[75-07-0]	0.066[c]	0.000688
acetic acid	[64-19-7]	0.025–76	24.3
acetophenone	[98-86-2]	1.5	65.0
amyl acetate	[628-63-7]	0.04–31.0	0.08
benzaldehyde	[100-51-6]	0.042[c]	0.00425
butanol	[71-36-3]	0.158–1000	2.5
butyric acid	[107-92-6]	0.001	
1,8-cineole	[470-82-6]	0.055–0.19	0.012
ethanol	[64-17-5]	4000.0[c]	100.0
ethyl acetate	[141-78-6]	3.6–1.120	5.0
ethyl acrylate	[140-88-5]	0.0010	0.067
ethyl benzoate	[93-89-0]	0.62[c]	
ethyl lactate	[97-64-3]	8.0	1.4
ethyl 2-methylbutyrate	[7452-79-1]	4.6	0.0001
ethyl vanillin	[121-32-4]	0.000007	0.1
hexanol	[111-27-3]	0.04–1.5	5.2
2-hexenal	[505-57-7]	0.034	0.017
isobutyl alcohol	[78-83-1]	1–500	7.0
isobutyric acid	[79-31-2]		8.1
isovaleric acid	[503-74-2]	0.005	0.7
α-ionone	[127-41-3]	0.0001–0.008	0.5
DL-menthone	[1074-95-9]	42.0	0.17
methyl anthranilate	[134-20-3]	0.0094[c]	
methyl salicylate	[119-36-8]	0.002–112	0.10
phenol	[108-95-2]	0.001[c]	
6-isobutyl-2,3-dimethyl pyrazine[d]			4.1
pyridine	[110-86-1]	0.03[c]	
skatole	[83-34-1]	0.0000004	
vanillin	[121-33-5]	0.000001–0.005	

[a] Ref. 39.
[b] The minimum physical intensity detected by a subject (40) who is not required to identify but just detect the existence of stimuli.
[c] Value is ppm/air.
[d] Ref. 41.

to adaption, ie, reduced sensitivity after prolonged response to a stimulus, and habituation, ie, reduced attention to monotonous stimulation. The values give approximate magnitudes and are significant when the same techniques for evaluation are used. Since 1952, the chemistry of odorous materials has been the subject of intense research (43). Many new compounds have been identified in natural products (37–40,42,44–50) and find use in flavors.

5. Flavor Materials

Materials for flavoring may be divided into several groups. The most common groupings are either natural or artificial flavorings. Natural materials include spices and herbs; essential oils and their extracts, concentrates, and isolates; fruit, fruit juices, and fruit essence; animal and vegetable materials and their extracts; and aromatic chemicals isolated by physical means from natural products, eg, citral from lemongrass and linalool from bois de rose.

Artificial materials include aliphatic, aromatic, and terpene compounds that are made synthetically as opposed to those isolated from natural sources. As an example, benzaldehyde may be made synthetically or obtained from oil of bitter almond (51); and L-menthol may be made synthetically or isolated from oil of *Mentha arvensis* var. to give Brazilian mint oil or corn mint oil.

Natural and artificial flavors are defined as a combination of natural flavors and artificial flavors. It is assumed that whichever portion is in greater amount becomes the first portion of the name. For example, if the natural portion is in greater amount the flavor name is natural and artificial; if the artificial part predominates the name of the flavor is artificial and natural.

In 1992 a large number of flavor materials were allowable on the Flavor and Extract Manufacturers Association (FEMA) and FDA lists (Tables 4 and 5).

Table 4. **Chemical Classes Approved for Use in Flavors**

	Compounds		
Chemical class	1992	1965[a]	Example
sulfur	152	13	thioester, thiol, mercaptan
nitrogen	99	21	amino acids, pyrazine, ester
acids	67	42	
esters	546	372	methyl, ethyl, allyl, terpene
acetals	28	21	
aldehydes	122	21	terpene
ketones	144	64	terpene, ionone, pyrone
alcohols	143	80	terpene, phenols
ethers	52	51	dioxane, furan, oxide
hydrocarbon	8		terpene
miscellaneous	11		
Total	*1415*	*730*	

[a] Ref. 52.

Table 5. **Natural and Food Ingredients Used in Flavors**[a]

Compound	Number of items
Natural flavors[b]	
absolutes	19
botanical extracts	114
botanicals	249
concretes	3
essential oils	144
oleoresins	20
miscellaneous	9
Total	*558*
Food ingredients[c]	
emulsifiers	51
preservatives	49
anticaking agents	12
multipurpose	180
flavor	18
Total	*310*

[a] Information courtesy of Flavor Knowledge Systems, Glenview, Illinois.
[b] FEMA and FDA listings.
[c] FDA listing.

6. Natural Flavorings

U.S. regulations define natural flavorings as the essential oil, oleoresin, essence, extractive, protein hydrolysate, distillate, or product of roasting, heating, or enzymolysis, which contain the flavor constituents derived from a spice, fruit or fruit juice, vegetable or vegetable juice, edible yeast, herb, bark, bud, root, leaf or similar plant material, meat, seafood, eggs, dairy products, or fermentation products thereof, whose significant function in food is flavoring rather than nutrition. Natural flavoring agents include those items listed in the *Code of Federal Regulations* (3,53).

Many essential oils are used for flavoring and perfumery, eg, neroli, geranium, and ylang (see OILS, ESSENTIAL). The whole fruit, crushed fruit, and puree may be used directly in foods, ice cream, cakes, and confections. Fruit juices, concentrates, and essences are more commonly employed (see FRUIT JUICES).

Another group of natural flavoring ingredients comprises those obtained by extraction from certain plant products such as vanilla beans, licorice root, St. John's bread, orange and lemon peel, coffee, tea, kola nuts, catechu, cherry, elm bark, cocoa nibs, and gentian root. These products are used in the form of alcoholic infusions or tinctures, as concentrations in alcohol, or alcohol–water extractions termed fluid or solid extracts. Official methods for their preparation and specifications for all products used in pharmaceuticals are described (54,55). There are many flavor extracts for food use for which no official standards exist; the properties of these are solely based on suitability for commercial applications (56).

7. Artificial Flavorings

Artificial flavorings are defined in the *Code of Federal Regulations* (CFR) as any substance or substances, the function of which is to impart flavor, which are not derived from natural sources. These items include the list of substances found in CFR 21 parts 172.515, 182.60, and FEMA GRAS (Generally Recognized as Safe) lists. The largest group of flavoring materials is composed of hundreds of isolates from natural materials derived by chemical means and synthetic materials, eg, aldehydes, ketones, acids, esters, phenols, phenol ethers, lactones, organic derivatives of sulfur, and aliphatic, aromatic, and terpene alcohols. More than one of these chemically active or osmophoric groups may be contained in a single chemical compound, eg, vanillin (4-hydroxy-3-methoxybenzaldehyde) with phenolic, aldehydic, and ether groups; methyl anthranilate (methyl-2-aminobenzoate) with ester and amine groups; and ethyl maltol [4940-11-8] (2-ethyl-3-hydroxy-4*H*-pyran-4-one) with hydroxy and ketone groups, etc.

Several manuals devoted, at least in part, to flavor formulation have been published (52–63), eg, literature from the Fragrance Materials Association of the United States, Washington, D.C. The increasing number of materials available has resulted in the improvement of flavor characteristics and has permitted a closer rendition of natural flavors. Often such materials bear a scant sensory relationship to the true natural flavor character. When used as a component and judiciously applied, these materials serve a useful purpose in a properly compounded flavor.

Character Impact Items. The character impact item is a chemical or blend of chemicals that provide the principal portion of a flavor's sensory identity, ie, when tasted and/or smelled, the item is reminiscent of the named character, eg, vanillin is the character impact item for vanilla flavors (Table 6). A character item for one flavor can contribute to another flavor in a different way, for example, ethyl oenanthate is a character item for the grape flavor of the *Vinus vinifera* type and is a contributor to the flavor of the concord grape, ie, the labruska-type grape.

Applications for synthetic character impact items include cough drops, toothpaste, chewing gum, candies, soft drinks, baked goods, gelatin deserts, ice cream, margarine, and cheese.

Classification. In commerce, several classifications of flavoring and compounded flavorings are listed according to composition to allow the user to conform to state and federal food regulations and labeling requirements, as well as to show their proper application. Both supplier and purchaser are subject to the control of the FDA, USDA, and the Bureau of Alcohol, Tobacco, and Firearms (BATF). The latter regulates the alcoholic content of flavors and the tax drawbacks on alcohol, ie, return of a portion of the tax paid on ethyl alcohol used in flavoring.

One class of flavorings, known as true fruit, is composed of fruit juices, their concentrates, and their essences. A second group, fruit flavor with other natural flavors (WONF), contains fruit concentrates or extracts that may be fortified with natural essential oils or extractives (isolates), or other naturally occurring plants (64,65). This class of flavor is employed when the manufacturer is compelled by regulation to use only natural products, as in wines and cordials in the United States.

Table 6. **Selected Character Impact Items**

Flavor character	Materials	CAS registry number
almond	5-methylthiophen-2-carboxaldehyde	[13679-70-4]
	benzaldehyde	[100-51-6]
anise	anethole	[4180-23-8]
	methyl chavicol (estragol)	[140-67-0]
apple	isoamyl acetate	[123-92-2]
	ethyl 2-methylbutyrate	[7452-79-1]
	damaseneone	[23696-85-7]
	n-hexanal	[66-25-1]
	trans-2-hexenal	[6728-26-3]
asparagus	dimethyl sulfide	[75-18-3]
banana	isoamyl acetate	[123-92-2]
bergamot	linalyl acetate	[115-95-7]
blueberry	isobutyl 2-buteneoate	[589-66-2]
blue cheese	2-heptanone	[110-43-0]
	2-nonanone	[821-55-6]
bramble (artic)	2,5-dimethyl-4-methoxy-3(2*H*)furanone	[4077-47-8]
butter	diacetyl	[431-03-8]
caramel	2,5-dimethyl-4-hydroxy-3(2*H*)furanone	[3658-77-3]
caraway	D-carvone	[2244-16-8]
cassia	cinnamic aldehyde	[104-55-2]
	methoxycinnamic aldehyde	[1504-74-1]
celery	3-propylidene-1(3*H*)-isobenzofuranone	[17369-59-4]
	cis-3-hexenyl pyruvate	[68133-76-6]
cherry	benzaldehyde	[100-52-7]
	tolyl aldehyde	[1334-78-7]
	benzyl acetate	[140-11-4]
chocolate	5-methyl-2-phenyl-2-hexenal	[21834-92-4]
	isoamyl butyrate	[106-27-4]
	vanillin	[121-33-5]
	ethyl vanillin	[121-32-4]
	isoamyl phenylacetate	[102-19-2]
	2-methoxy-5-methylpyrazine	[2882-22-6]
cinnamon	cinnamic aldehyde	[104-55-2]
coconut	γ-nonalactone	[104-61-0]
coffee	furfuryl mercaptan	[98-02-2]
	furfuryl thiopropionate	[59020-85-8]
cognac	ethyl oenanthate	[106-30-9]
clove	eugenol	[97-53-0]
coriander	linalool	[78-70-6]
cream	*cis*-4-heptenal	[6728-31-0]
cucumber	nona-*trans*-2-*cis*-6-dienal	[557-48-2]
	2-nonenal	[2463-53-8]
fresh fruit	2-methyl-2-pentenoic acid	[3142-72-1]
fruity	ethyl butyrate	[105-54-4]
garlic	diallyl sulfide	[592-88-1]
	di-2-propenyl disulfide	[2179-57-9]
grape	methyl anthranilate	[134-20-3]
	ethyl 3-hydroxybutyrate	[5405-41-4]
grapefruit	nootkatone	[4674-50-4]
green bell pepper	2-methoxy-3-isobutylpyrazine	[24683-00-9]
green leafy	*cis*-3-hexenol	[928-96-1]
guava	cinnamyl acetate	[103-54-8]
	β-caryophyllene	[87-44-5]

Table 6 (*Continued*)

Flavor character	Materials	CAS registry number
hazelnut (filbert)	methyl(methylthio) pyrazine	[21948-70-9]
	5-methyl-2-hepten-4-one	[81925-81-7]
honey (clover)	methyl anthranilate	[134-20-3]
horseradish	1-penten-3-one	[1629-58-9]
jasmine	benzyl acetate	[140-11-4]
	indole	[120-72-9]
lamb	4-methylnonanoic acid	[45019-28-1]
lemon	citral	[5392-40-5]
lime (distilled)	α-terpineol	[98-55-5]
	citral	[5392-40-5]
mandarin	β-sinensal	[8028-48-6]
	dimethyl anthranilate	[85-91-6]
	thymol	[89-83-8]
maple	2-hydroxy-3-methyl-2-cyclopenten-1-one	[80-71-7]
meat	methyl-5-(β-hydroxyethyl) thiazole	[137-00-8]
melon	2-methyl-3-*p*-tolylpropionaldehyde	[16251-78-8]
	hydroxycitronellal dimethylacetal	[141-92-4]
	2,6-dimethyl-5-heptenal	[106-72-9]
	2-phenylpropionaldehyde	[93-53-8]
	2-methyl-3-(4-isopropylphenyl) propionaldehyde	[103-95-7]
mint	menthol	[89-78-1]
mushroom	1-octen-3-ol	[3391-86-4]
	2-octanol	[123-96-6]
	1-octen-3-one	[4312-99-6]
	2-octene-1-ol	[10849-17-1]
	1-octanol	[111-87-5]
	3-octanol	[589-98-0]
	3-octanone	[106-68-3]
mustard	allyl isothiocyanate	[57-06-7]
okra	2-methoxy-4-vinylphenol	[7786-61-0]
onion	dipropyl disulfide	[629-19-6]
orange	β-sinensal	[8028-48-6]
	octyl aldehyde	[124-13-0]
	decyl aldehyde	[112-31-2]
paprika	2-isobutyl-3-methoxypyrazine	[24683-00-9]
	2-nonene-4-one (cooked)	[14309-57-0]
passion fruit	3-methythio-1-hexanol	[5155-66-9]
peach	γ-undecalactone	[104-67-6]
	6-amyl-α-pyrone	[27593-23-3]
peanut	2,5-dimethylpyrazine	[123-32-0]
	2-methoxy-5-methylpyrazine	[68358-13-5]
pear (bartlett)	ethyl decane-*cis*-4-*trans*-2-dienoate	[3025-30-7]
peppermint	menthol	[89-78-1]
pineapple	allyl caproate	[123-68-2]
	methyl β-methylthiopropionate	[13532-18-8]
	ethyl butyrate	[105-54-4]
	allyl cyclohexanpropionate	[2705-87-5]
popcorn	methyl-2-pyridyl ketone	[5910-89-4]
potato	methional	[3268-49-3]
	2-ethyl-3-methoxypyrazine	[25680-58-4]
	2,3-dimethylpyrazine	[5910-89-4]
prune	benzyl-4-heptanone	[7497-37-7]
	dimethylbenzylcarbinyl isobutyrate	[59354-71-1]

Table 6 (*Continued*)

Flavor character	Materials	CAS registry number
quince	ethyl tiglate	[5837-78-5]
raspberry	6-methyl-α-ionone	[79-69-6]
	trans-α-ionone	[127-41-3]
	p-hydroxypheny-1-2-butanone	[5471-51-2]
	damasceneone	[23696-85-7]
red currant	*trans*-2-hexenol	[928-95-0]
seafood	pyridine	[110-86-1]
	piperidine	[110-89-4]
	trimethylamine	[75-50-3]
scallop	dimethyl sulfide	[75-18-3]
soursop	methyl caproate	[106-70-7]
	methyl 2-hexenoate	[32585-08-3]
soy sauce	4-ethylguaicol	[2785-89-9]
	maltol	[118-71-8]
	phenylethyl alcohol	[60-12-8]
	methionol	[505-10-20]
	2-acetylpyrrole	[1072-83-9]
smoke	guaicol	[90-05-1]
	2,6-dimethoxyphenol	[91-10-1]
	p-vinylguaicol	[7786-61-0]
spearmint	L-carvone	[6485-40-10]
strawberry	ethylmethylphenylglycidate	[77-83-8]
	ethyl maltol	[4940-11-8]
	methyl cinnamate	[103-26-4]
	4-hydroxy-2,5-dimethyl-3(2*H*)-furanone	[3658-77-3]
sugar	4,5-dimethyl-3-hydroxy-2,5-dihydrofuran-2-one	[28664-35-9]
tangerine	dimethyl anthranilate	[85-91-6]
	thymol	[89-83-8]
	β-sinensal	[8028-48-6]
tomato	2-isobutylthiazole	[18640-74-9]
	cis-4-heptenal	[6728-31-0]
tomato (cooked)	dimethyl sulfide	[75-18-3]
	β-damaseneone	[23696-85-7]
	isovaleraldehyde	[590-86-3]
	2-methylbutyric acid	[116-53-0]
vanilla	vanillin	[121-33-5]
	ethyl vanillin	[121-32-4]
	propenyl quaethol	[94-86-0]
vinegar	ethyl acetate	[141-78-6]
	acetic acid	[64-19-7]
watercress	2-phenylethyl isothiocyanate	[2257-09-2]
wintergreen	methyl salicylate	[119-36-8]

A third class, artificial fruit flavors, includes fruit concentrates fortified with synthetic materials. These may be subdivided into two or more groups according to price, use of the proportionate strengths of the natural fruit, and synthetic fortification. Flavors other than fruit flavor can also be fortified with synthetic materials, ie, the making of an artificial maple flavor as well as an artificial meat flavor.

7.1. Specifications. Specifications for many of the essential oils and artificial flavorings are available (66). Physical specifications encourage standardization and uniformity in basic flavor and perfume materials. Although compliance with specifications does not guarantee that flavor quality standards will be acceptable, the specifications fill a need and provide a valuable reference for the flavor industry.

The *Food Chemicals Codex* defines food-grade quality for the identity and purity of chemicals used in food products. In the United States, the FDA adopts many of the *Food Chemicals Codex* specifications as the legal basis for food-grade quality of flavor and food chemicals.

Specifications also appear in other publications, including publications of the Fragrance Materials Association (FMA) of the United States (53,57) (see also FINE CHEMICALS). The FMA specifications include essential oils, natural flavor and fragrance materials, aromatic chemicals, isolates, general tests, spectra, suggested apparatus, and revisions adopted by the FMA.

In 1993, the FDA lists 199 flavorings and food adjuncts accepted, proposed, and under investigation (64). Day-to-day status of materials can be found in the *Federal Register*. The Flavor Extract Manufacturers' Association (FEMA) lists approximately 1774 GRAS chemicals for food and flavor use, including nonflavoring agents (58,67). The *Food Chemical Codex* lists approximately 845 flavoring materials (66); 116 additional specifications will be added in the fourth edition scheduled to be published in 1994.

The flavor chemist is responsible for the basic knowledge of sensory and application properties of each of this large number of raw materials; the large number of possible combinations of these items to produce specifically flavored finished compounds is readily apparent. It is not uncommon to develop a flavor that combines essential oils, plant extractive, fruit juices, and synthetics. The choice of materials depends on type of product, conditions of manufacture, labeling, and intended use.

The terms synthetic, artificial, and chemical have aroused the doubts and suspicions of consumers in some instances (68,69). However, many such chemical components also occur in nature, ie, nature identical (37,68) (see FOOD ADDITIVES). It has been noted by the FDA that an artificial flavor is no less safe, nutritious, or desirable than a natural flavor, and that the purpose for distinguishing between a natural and artificial flavor is for economic reasons, ie, the natural flavor is often more expensive than the artificial flavor (70). Since it is generally economically impractical to isolate many of the components now used in flavorings from natural product, synthesis creates effective replacements.

8. Compounding

In the compounding technique, constituents are selected or rejected because of their odor, taste, and physical chemical properties, eg, boiling point, solubility, and chemical reactivity, as well as the results of flavor tests in water, syrup, milk, or an appropriate medium. A compound considered to be characteristic is then combined with other ingredients into a flavor and tested as a finished flavor in the final product by an applications laboratory.

A flavor is tried at several different levels and in different mediums until the most characteristic one is selected. This is important because the character of a material is known to change quality with concentration and environment. For example, anethole, benzaldehyde, and citral taste different with and without acid. Gamma-decalactone has different characters at different levels of use. *p-tert*-Butyl phenylacetate with acid is strawberry or fruity; without acid it is creamy milk chocolate. 2,5-Dimethyl-4-hydroxy-3-(2*H*)-furanone with acid is strawberry; without acid it is caramel or meat.

Once the characteristic level is determined, the flavor is put into panel tests. After it passes these panel tests it is then subjected to storage stability.

Flavoring proportions, often referred to as dosage, used in high fat foods must be greater than in low fat foods because flavors are absorbed or suppressed by the fat, thereby lowering flavor impact (71). The distribution coefficient between the fat (oil) and water also changes, causing different flavor perception. Often the flavor must be revised to accommodate this phenomenon. A hard candy with a high glucose content compared to the cane sugar content requires either more flavoring or an increase in the more potent ingredients of the flavoring than a hard candy with a low glucose content.

8.1. Flavor and Diluent Portions. *Flavor Portion.* A flavor compound consists of a flavor portion, ie, flavor character impact item(s), as well as flavor contributory and flavor differential items, and a diluent portion.

A flavor contributory item is an additive that when smelled and/or tasted helps to create, enhance, or potentiate the named flavor. It is not characteristic of the flavor, but essential in that it acts with other substances to produce a definite character.

A flavor differential item is an additive or combination of additives that when smelled or tasted has little, if any, character reminiscent of the named flavor. It gives roundness and fixation to the flavor. It may be added by the flavor chemist to confuse simulation of the flavor, and it is neither characteristic of, nor essential to, the intended flavor. The greatest examples of creativity are found in this area.

The flavor portion of a flavor compound gives it its name, acceptability, and palatability, and provides character fixation of the flavor, ie, relatively high boiling point solids, usually in combination, are used at concentrations above their threshold values at use level so that upon dilution the levels remain above threshold value and the perception of the flavor does not change.

Diluent Portion. The diluent portion of a flavor compound is the carrier for the color and the flavor, ie, the solvent for the flavor portion. It keeps the flavor homogenous, ie, keeps solids in solution; retards chemical reactions from occurring; and regulates flavor strength, ie, the greater the amount of solvent, the weaker the flavor.

The diluent gives the flavor a physical fixation. Relatively high boiling point materials are used in the diluent to make the flavor less heat labile. They are included when a flavor is to be used at temperatures above the boiling point of water; examples include vegetable oils and isopropyl myristate.

The diluent portion also determines the form, or physical appearance, of the flavor, ie, liquid, powder, or paste. Liquid flavor forms include water-soluble, oil-soluble, and emulsion forms; powder flavor forms include plated (including dry

Table 7. **Modern Flavor Formulas, % by Weight**

Ingredient	A	B	C
fruit juice, 72 brix[a]	80.0	40.0	60.0[b]
fruit essence[c]	5.0	20.0	
fortifier			
natural[d]		1.0	
artificial[e]			1.0
ethyl alcohol, 95%	15.0	15.0	15.0
water		24.0	24.0

[a] Brix = g of sugar per 100 g liquid.
[b] 60 brix.[a]
[c] 150-fold, ie, one gallon (3.785 L) of concentrated distillate is obtained from 150 gallons of single-fold juice.
[d] A blend of botanical extracts; natural chemicals, ie, isolates and those derived via natural processes, eg, ethyl acetate, absolute tagette; and oil petitigrain mandarin.
[e] Composed of some, if not all, artificial chemicals, botanical extractive, essential oil, etc.

solubles), extended, occluded, inclusion complexes, and other encapsulated forms; and paste flavor forms include fat, protein, and carbohydrate-based paste.

8.2. Flavor Formulas. Tables 7 and 8 give examples of modern flavor formulas. In Table 7 formula A is composed of fruit juice concentrate and essence distilled or extracted from the fruit juice. It is all natural and all from the named fruit, and is therefore termed a "natural flavor." It has a characterizing natural flavor. In Formula B the flavor is all natural, but is not all from the named fruit, ie, the fortifier is all natural but is not totally derived from the named fruit. Since

Table 8. **Pineapple Flavor, Artificial**

Ingredient	Wt%
Characterizing flavor items	
allyl cyclohexane propionate	1.4
allyl caproate	13.0
methyl β-methylthiolpropionate	0.2
Contributory flavor items	
geranyl propionate	0.5
ethyl isovalerate	1.0
ethyl butyrate	1.0
γ-nonalactone	0.1
Differential flavor items	
maltol	1.0
vanillin	0.5
2,5-dimethyl-3(OH)-4-(2*H*)-furanone	0.2
oil orange	1.0
Diluent portion	
ethyl alcohol, 95%	46.0
propylene glycol	34.1

the fortifier simulates, resembles, or reinforces the named flavor, eg, apple or pineapple, the flavor must be called "flavor with other natural flavors." It has a natural flavor with characterizing naturals added. Formula C is composed of both natural and artificial components with the natural usage outweighing the artificial. Therefore, it is a "flavor natural and artificial." It has a characterizing natural and artificial flavor.

The formula of an artificial pineapple flavor is given in Table 8. The flavor contains no natural pineapple components, ie, juice and essence, and the artificial portion far outweighs the natural portion of the flavor; this flavor is a "flavor artificial." It has a characterizing artificial flavor.

The characterizing, contributory, and differential flavor items are listed. The diluent portion of the flavor makes the flavor applicable and is generally the largest part of every flavor formula.

Essential Oil Equivalents. Essential oil equivalents (Table 9) are now commonly used to replace, in whole or in part, the dry spices from which they are derived. The latter serve primarily to enhance the attractiveness or appearance of the products, which are usually packed in glass containers. For example, a blend of 12.7 grams of the essential oils of black pepper, ginger, allspice, cinnamon, nutmeg, and clove is equivalent to the flavoring strength of one kilogram of the dry seasoning blend.

Enzyme Flavor Precursors. The characteristic flavors of foods, such as in fruits and vegetables, are considered to result from enzymatic action upon certain more complex components during the normal developmental or ripening process (72). The formation of volatile flavor components has been studied *in vitro* (73–75). Fruits and vegetables were deflavored by heat, usually by boiling, and their flavor was partially restored by the addition of an enzyme. Although many different enzymes develop from a precursor only certain ones produce the characteristic flavor (73,74). Thus a true raspberry flavor is produced in a deflavored raspberry puree only by enzymes obtained from raspberry fruit (76). A vegetable product contains several different enzymes in varying proportions that cause the formation of volatile components in ratios that may be different from the actual ratio of precursors present in that particular product.

It has been found that the flavor of fruit can be increased by a process called precursor atmosphere (PA) (77). When apples were stored in a controlled atmosphere containing butyl alcohol [71-36-3], the butyl alcohol levels increase by a factor of two, and the polar products, butyl ester, and some sesquiterpene products increase significantly. The process offers the possibility of compensating for loss of flavor in fruit handling and processing due to improper transportation conditions or excessive heat.

Another process employed to increase the formation of volatile compounds in fruit is that of bioregulators. When a bioregulator is applied to lemon trees an increase in both the aldehyde and alcohol fractions of the lemon oil extracted from the fruit of the treated lemon trees was observed (78).

Enzymes not only produce characteristic and desirable flavor (79) but also cause flavor deterioration (80,81) (see ENZYME APPLICATIONS, INDUSTRIAL). The latter enzyme types must be inactivated in order to stabilize and preserve a food. Freezing depresses enzymatic action. A more complete elimination of enzymatic action is accomplished by pasteurization.

Table 9. **Essential Oil, Herb, and Spice Equivalents**

Herb or spice	Essential oil equivalent,[a] kg
allspice (pimento berries)	2.5
almond, bitter	0.5
angelica root	0.75
angelica seed	1.0
anise seed	2.5
basil, sweet reunion	0.15
caraway seed	2.5
cardamon seed	3.0
cassia cinnamon	1.5
celery seed	2.0
cinnamon Sri Lanka	0.5
clove	15.0
coriander seed	0.75
cumin seed	3.0
dill seed	4.0
dill weed	1.0
tarragon	0.13
fennel seed	5.0
garlic	0.5
ginger	0.25
horseradish	1.0
laurel leaves (bay)	1.0
lovage root	0.5
mace	5.0
marjoram, sweet	0.5
mustard seed	0.25
nutmeg	5.0
onion	0.05
origanum	0.75
parsley seed	3.0
pepper, black	1.0
rosemary	0.5
sage	1.25
savory	0.25
thyme	2.0
valerian root	1.0

[a] To 100 kg of corresponding best quality dry herb or spice.

The creation of flavor by enzymes is used in the fermentation process to prepare products such as alcoholic beverages, cheese, pickles, vinegar, bread, and sauerkraut. In some vegetables, such as Cruciferae (mustard) and Alliacae (onion and garlic), the flavor components are released enzymatically when the tissue is crushed or broken. In the case of Cruciferae, the enzyme myrosinase [9025-38-1] degrades the naturally occurring glucosinates to isothiocyanates. In the Alliacae, the enzyme alliinase [9031-77-0] acts on the substrate, ie, alkyl cysteine-*S*-oxide, to release the flavor and lachrymator found in the onion. Several essential oils are also created enzymatically. In the case of oil sweet birch, the oil is released from the bark enzymatically; in the case of oil bitter almond, the enzyme emulsin [9001-22-3] attacks the glucoside (amygdalin) and releases the oil of bitter almond (82,83) (see FERMENTATION).

Table 10. **Amino Acid Sugar Reactions**[a]

Amino acid	Sugar	Temperature, °C	Aroma
cysteine	glucose	100	meat
	ribose	180	sulfur, spicy meat
	arabinose	100	beef
cystine	glucose	100	meat, burnt turkey skin
	ribose	180	meat with H_2S note
glutamic acid	ribose	180	roasted meat
methionine	ribose	180	crust of roasted meat

[a] Ref. 103.

A more complex flavor development occurs in the production of chocolate. The chocolate beans are first fermented to develop fewer complex flavor precursors; upon roasting, these give the chocolate aroma. The beans from unfermented cocoa do not develop the chocolate notes (84–88) (see CHOCOLATE AND COCOA). The flavor development process with vanilla beans also allows for the formation of flavor precursors. The green vanilla beans, which have little aroma or flavor, are scalded, removed, and allowed to perspire, which lowers the moisture content and retards the enzymatic activity. This process results in the formation of the vanilla aroma and flavor, and the dark-colored beans that after drying are the product of commerce.

The use of dry heat, as in roasting (89,90), baking, and frying, develops flavor characteristics not found in the unheated product (91). The roasting of meats (47,92), coffee, (93), peanuts (94), and sesame seeds (95); the baking of bread (96,97); and the baking (98) or frying of potatoes (99) are methods by which desirable flavor is created. The distinctive flavor development in breakfast foods, ie, the crust of baked bread, the aroma of roasted coffee, etc, can be directly attributed to the chemical combinations brought about during the heat-treatment operation. These types of flavor are generally characterized by the presence of pyrazines in the product. The reactions of sugars and amino acids (or proteins), ie, the Maillard reaction (100), is accomplished by a loss of free amino groups, increased acidity (101), the evolution of carbon dioxide, and the development of flavors and a brown color. Glucose combines with α-aminobutyric acid [16750-42-8] to give a product with a maple flavor, and glucose and/or fructose reacts with proline [609-36-9] to produce a bread-like flavor (102) (Table 10). A honey-flavored syrup can be obtained by heating glucose, β-phenylalanine [63-91-2], invert sugar, and glutamic acid [56-86-0]. Many amino acids generate a typical aldehyde odor when heated with glucose, probably due to the Strecker degradation portion of the Maillard reaction; ie, the decarboxylation and deamination of an α-amino acid to an aldehyde or ketone of one carbon less than the starting amino acid (eq. 1 and 2) (104,105).

$$(CH_3)_2{-}CH_2{-}CH_2{-}CH(NH_2){-}COOH \xrightarrow{H_2O} (CH_3)_2{-}CH_2{-}CH_2{-}CHO + CO_2 + NH_3 \quad (1)$$

$$2\,HSCH_2{-}\underset{NH_2}{\underset{|}{C}H}{-}COOH + 2\,H_2O \longrightarrow HSCH_2{-}\underset{O}{\underset{\|}{C}}{-}H + 2\,NH_3 + H_2S + H_3C{-}\underset{O}{\underset{\|}{C}}{-}H + 2\,CO_2 \quad (2)$$

Table 11. **Estimated Employment of Flavoring Extract and Syrups Industry**

Year	Companies	Companies with >20 employees, (%)
1972	400	115 (28.8)
1977	368	132 (35.9)
1982	343	131 (38.2)
1987	280	99 (35.4)

Other examples are glycine ⟶ formaldehyde, alanine ⟶ acetaldehyde, valine ⟶ isobutyraldehyde, phenylalanine ⟶ phenylacetaldehyde, and methionine ⟶ methional (106). Products such as dried skim milk, dried eggs, and dehydrated vegetables and fruits are particularly susceptible to deteriorative flavor changes ascribed to this reaction (Table 10).

9. Economic Aspects

The flavoring extract and syrups industry employs approximately 8200 employees (107) in approximately 280 companies; 99 companies employ more then 20 workers (Table 11). The total number of flavor companies has diminished since 1972, but the percentage of larger flavor companies has remained fairly constant (108).

10. Flavor Regulations

The Pure Food and Drug Act of 1906 introduced federal regulations to combat food and drug alteration and fraud (109). The law was superseded by the Food, Drug, and Cosmetic Act of 1938 and the Amendments of 1954, 1958, 1960, and 1962 (110) (see Food Additives). Flavor regulations differ from country to country but progress is being made to harmonize regulations in the interest of international trade (111). There are at least five different ways countries can control and administer flavor regulations: countries may have a positive list of flavor materials, a negative list of flavor materials, a mixed-system having both a positive and negative list, no flavor regulations, or countries may demand prior government approval before a material can be used.

Countries that use a positive list, eg, Japan, Switzerland, the former Soviet Union, and the United States, list all substances allowable in flavor and foods; any material not listed is not allowable. Any material included on a positive list is considered safe for its intended use. This system works well only if there is a specific procedure to allow for the addition of new materials. In the United States there is the Food Additive Petition and the GRAS route. No new material can be used in flavor or foods unless it undergoes one of these two procedures. This assures that any new technology can be added and used after it is reviewed for safety.

Countries with a negative list system, eg, Australia, Brazil, Canada, Chile, India, New Zealand, and Singapore, define flavoring substances that cannot be used or may only be used in very limited and strictly defined ways. All materials not on such lists may be used without limitation. This system works well with all natural and nature identical flavor materials, but it is not good for controlling the use of new artificial materials. Any new flavor material created will not be specifically listed, and can theoretically be used.

Countries that use a mixed-system, eg, Argentina, Germany, Italy, Spain, and the Netherlands, have a positive list for artificial flavor materials, and a restricted list of natural and nature identical flavor materials. This system addresses some of the shortcomings of the positive and negative list systems.

Several countries have no specific flavor regulations, eg, Austria, Belgium, Denmark, Ireland, France, Greece, Jamaica, Luxembourg, Norway, Portugal, South Africa, Sweden, and the United Kingdom. This can cause difficulty when trading with these countries. Although these countries have no codified legislation, they have definite ideas as to what can be used. It is best to consult with the specific agencies in these countries before selling flavors or foods to these countries.

In some countries, eg, Finland, Hungary, Peru, Poland, and Bulgaria, one must petition the appropriate government agency and receive permission to manufacture or sell a flavor or a flavored product. Newly emerging countries, although they have no specific regulations, often accept other countries' legislation. This is often the case when dealing with the countries of Africa.

11. Sensory Evaluation

The type of food and its processing affect flavoring efficiency; therefore, flavor materials must be taste-tested in the food itself. Because there has been a lack of standardization of testing techniques, a committee on sensory evaluation of the Institute of Food Technologists has offered a guide (112) which is designed to help in developing standard procedures.

For each type of problem, appropriate taste tests are suggested together with the type of panel, number of samples per test, and analysis of data. This useful summary eliminates a large amount of difficult to interpret data and contains a list of original references. Specific tests are outlined for new product development, product and process improvement, cost reduction, selection of new source of supply, quality or rating selection of the best sample, market testing of new or improved product, consumer preference tests, and selection of trained panelists (113–116). Ten types of test, designed for trained, untrained, semitrained, and highly trained panels, are explained (117,118). The methods of sample presentation include single-sample, paired-comparison, and triangle test, ie, three samples are employed, two of them alike. Other methods are fitted to the attainment of specific objectives; for these, the type of panel and number of panelists are also suggested. Flavor evaluation is adequate only when the origin of flavor is known and differences can be measured by a scientific method based on units or significant qualities of flavor.

The order of sample presentation has been shown to lead to errors in judgment (119), eg, the later samples in a series were rated lower; serving good samples first lowered the rating of poor samples and serving poor samples first lowered the rating of good samples. The literature on sensory testing includes References (120–123) (see FLAVOR CHARACTERIZATION).

12. Glossary

Aftertaste. The experience that, under certain conditions, follows removal of the taste stimulus; it may be continuous with the primary experience or may follow as a different quality after a period during which swallowing, saliva, dilution, and other influences may have affected the stimulus substance. The result of the persistence of a flavor note, particularly after swallowing.

Ageusia. Lack or impairment of sensitivity to taste stimuli.

Agnosia. Inability to recognize sensations; may be primarily in one sense, eg, olfactory agnosia.

Anosmia. Inability to smell, either totally or a particular substance or group of substances.

Antetaste. A prior taste, or foretaste, usually of short duration, preceding the main taste or flavor characteristic.

Aroma. The fragrance or odor of food, perceived by the nose by sniffing. In wines, the aroma refers to odors derived from the variety of grape, eg, muscat aroma. It is the overall odor impression as perceived by the nasal cavity.

Autosmia. Disorder of the sense of smell in which odors are perceived when none are present.

Bland. Having no distinctive taste or odor property.

Cacogeusia. Persistent or intermittent unpleasant taste in the mouth.

Cacosmia. Perception of persistent or intermittent unpleasant odor.

Cloying. A taste sensation that stimulates beyond the point of satiation; frequently used to describe overly sweet products.

Compatibility. In flavor terminology the ability of one substance to enhance the flavor characteristic of another.

Compensation. The result of interaction of the components in a mixture of stimuli, each component of which is perceived as less intense than it would be alone.

Convergence. The tendency of a test sample, regardless of quality, to be perceived as similar to prior sample(s); sometimes called the halo effect.

Cryptosmia. Impairment of olfaction by obstruction of the nasal passages.

Dysosmia. Difficulty in ability to smell.

Essential Oil. The volatile material, derived by a physical process, usually distillation, from odorous plant material of a single botanical form and spices with which it agrees in name and odor.

Flavor. The sensation produced by a material taken into the mouth, perceived principally by the senses of taste and smell, but also by the common chemical sense produced by pain, tactile, and temperature receptors in the mouth.

Flavor or Flavorant. A substance, added to food, whose significant function is to affect odor, imparting a characteristic flavor to that food.

Flavors. Those mixtures of ingredients whose exact composition is usually known only to their suppliers, sold in bulk to food and beverage manufacturers.

They are to be labeled as flavors per CFR 21 part 101 and may contain adjuncts that are nonflavor ingredients.

Flavoring Ingredient. Any single chemical entity or natural mixture added to food, drugs, or other products taken in the mouth, the clearly predominant purpose and effect of which is to provide all or part of the particular flavor of the final product.

Flavor Adjunct. A substance used in or with a flavor but not essentially a part of it. These include solvents, antioxidants, enzymes, adjusting agents, emulsifiers, and acidulants.

Flavor Enhancer. A substance added to supplement, modify, or enhance the original taste and/or aroma of a food without imparting a characteristic taste or odor of its own.

Fold. Strength of concentrated flavoring materials. The concentration is expressed as a multiple of a standard, eg, citrus oil is compared to cold pressed oil. In the case of vanilla, folded flavors are compared to a standard extract with minimum bean content.

Gustation. A taste sense, the receptors of which lie in the mucous membrane covering the tongue, and the stimuli for which consist of certain soluble chemicals, eg, salts, acid, and sugar.

Hyperosmia. Unusually keen olfactory sensitivity.

Hypogeusia. Diminished sense of taste.

Hyposmia. Diminished sense of smell.

Insipid. Tasteless, flat, vapid.

Isolate. A relatively pure chemical produced from natural raw materials by physical means, eg, distillation, extraction, crystallization, etc, and therefore natural; or by chemical means, ie, via hydrolysis, bisulfite addition products, and regeneration, etc, and therefore artificial by 1993 U.S. labeling regulations.

Macrosmatic. Abnormally keen olfactory sense.

Merosmia. A condition analogous to color blindness, in which certain odors are not perceived.

Microsmatic. Having a poorly developed sense of smell.

Nature Identical Flavor Material. A flavor ingredient obtained by synthesis, or isolated from natural products through chemical processes, chemically identical to the substance present in a natural product and intended for human consumption either processed or not; eg, citral obtained by chemical synthesis or from oil of lemongrass through a bisulfite addition compound.

Odor and Odorant. That which is smelled. Odor may refer to the odorant or to the sensation resulting from the stimulation of olfactory receptors in the nasal cavity by gaseous material.

Odoriphore (Osmophore). Odor-producing group.

Osmics. The science of smell.

Osmyl. An odorant.

Parageusia. Gustatory disturbance resulting in erroneous identification of taste stimuli.

Parosmia. A disturbance to the sense of smell resulting in smelling the wrong odors, usually perceived as repulsive.

Sapid. Having the power of affecting the taste receptor.

Savory. Appetizing; having an agreeable flavor.

Sensory Analysis. The science of measuring and evaluating the properties of food products by one or more human senses.

Stevens Power Law, $S = I^n$. The increase in perceived intensity, S, is equal to the concentration, I, to the nth power.

Volatile Oil. That portion of a botanical that codistills with water during steam distillation and is generally flavorful.

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