Chapter 5

Process Flavors

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INTRODUCTION

Flavors may be produced by a large variety of methods, from the purely synthetic approach, to the extraction of volatile components from materials of botanical origin. Science and technology have led us to more sophisticated ways of creating flavors. An area of knowledge that has developed into a major commercial venture for the flavor industry is the production of process flavors. The term "process flavor" has been used to define a group of flavors or flavoring ingredients that are produced from precursor materials via some type of processing technique(s). The major processing techniques in use today are thermal processing and enzyme modification. Both techniques have been in commercial use for approximately 25 years and currently represent a significant part of the flavors industry's commercial and research activities. A summary of the general types of process flavors is given in Table 5-1.

What makes this area of flavor chemistry different from the traditional methods is the relationship of the development of the aroma profiles to knowledge of natural, chemical or biochemical pathways that are known to create aromas. The difference between the occurrence of the flavors in a natural system (e.g., meat, nuts, cheese and butter) and in a process flavor is the intelligent selection of precursors and processing conditions that allow for the optimum production of the aroma profile. These flavors have a close relationship to their natural food-derived counterparts.

Three major factors that support the success of these flavors and flavoring ingredients are inherent in process flavor technology. First, because the creation of the process flavor is based on chemical and biochemical knowledge of the original food, its flavor profile is very close to that of the food it is duplicating. The use of synthetic chemicals to produce a flavor generally exaggerates the flavor profile.

Second, because the flavor is produced from selected precursors and not necessarily the total food, a great degree of control on its production and economy of manufacture may be gained. Typically, less than 0.1 percent of a powerful aroma is necessary to be present in a food to act as a flavor. This is particularly true in the savory/meat flavor area where some of the flavoring components have odor thresholds in the part per billion and trillion level! The definition of a flavor captures the notion that it is a powerful material whose significant function

G. Reineccius (ed.), *Source Book of Flavors*
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TABLE 5-1. Summary of the types of process flavors

Mechanism	Flavor type
Thermally generated	Processed (reaction) flavor
Chemical hydrolysis	Hydrolysates
Controlled of oxidation	Fat flavors
Autolysis—Enzyme conversion with endogenous enzymes	Autolysates
Enzymolysis	Enzyme modified
Fermentation	Flavor

is flavor and not nutrition or functionality (Food and Drug Administration 1990).

Third, because the materials are produced via "natural" mechanisms such as roasting, fermentation and enzymolysis, the final flavor may qualify as a natural flavor or flavoring ingredient. This is particularly true if the precursor is a traditional food or food component, and the processing conditions are those used in traditional food preparation and the resulting product qualifies as a flavor. Newer, more nontraditional uses of process flavor technology come under more discussion when the term "natural" is to be applied. Both the industry and the regulatory groups have been considering a new definition of the term "natural." As of this publication, there has been no resolution of the issue.

During the last 20 years, several hundred patents on process flavors have been granted around the world (see Heath 1981 and Chapter 14 of this text). However, no single patent has provided a rigid specification for the thermally processed flavor. Recently, the International Organization of Flavor Industries (IOFI) has established a guideline for the manufacture of process flavors [International Organization of Flavor Industries, 1990; see Appendix 5.1]. As noted in their guidelines and in the patent literature, the basic compounds used to create a process flavor are amino acids (particularly the sulfur-containing ones), reducing sugars, thiamine (vitamin B1), and known synthetically produced components from the Maillard reaction (i.e., dialdehydes). Many of the resultant components of the reactions have been isolated and identified. These compounds were then synthesized and patented for use as a synthetic flavoring ingredient. Major compounds are pyrazines, thiazolines, furanones, furans, polysulfide compounds (thianes) and thiophenes.

The two major divisions of process flavors are the thermally processed flavors and flavors produced by enzymatic modification.

THE THERMALLY PROCESSED FLAVORS (MEAT AND SAVORY FLAVORS)

The use of thermal methods for flavor development is nearly as ancient as man himself. The use of fire in preparing food has been estimated to be upward of 10,000 years old. However, it is only in recent history that the chemistry of thermally induced flavor development has become well understood.

The first thermally produced flavoring material can be traced to the production of a product called hydrolyzed vegetable protein or, more commonly, HVP. It was developed by Julius Maggi, a Swiss chemist, during the last century (Manley 1989). The first chemical understanding of the development of flavors by heat is associated with the work of Dr. Louis Camille Maillard of the University of Nancey (France) from 1912 to 1936. Significant symposia have been held on the subject of the "Maillard reaction" mechanism (appropriately named for its discoverer, but some 15 years after his death) in the development of aromatic materials from precursors consisting of amino acid and reducing sugars (Hodge 1976; Waller and Feather 1983; Kawamura 1985; Fujimaki, Namiki, and Kato 1986; Buckholz 1989; and Finot et al. 1990). A fundamental discussion of these mechanisms can be found in one of the more recent sym-

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posia on the subject (Parliment, McGorrin, and Ho 1989).

The basic challenge to the scientist in producing thermally generated flavors is in the understanding and selection of the precursor materials and processing conditions. Although the "Maillard reaction" is a major pathway for aroma development, other chemical pathways also make significant contributions to aroma formation. Table 5-2 reviews the types of thermally driven chemical mechanisms that make significant contributions to aroma production. The major literature cited will help in understanding the chemical mechanisms and, to some degree, the usefulness of the aroma profile generated.

Although there is a very diverse amount of chemistry related to thermal processing, it is reported that the heterocyclic aromatics generated during the reactions are the most interesting and useful in the preparation of a flavor (Vernin 1982). These compounds are also generally the most difficult to produce by chemical synthesis.

Although the patent literature is full of references on the manufacture of thermally produced flavors, only approximately 45 are used in commercial production (Buckholz 1989). Table 5-3 indicates the more significant patents protecting the manufacture of process flavors.

The key aromatic compounds of value in creating meat-like, cooked and roasted flavors are the heterocyclic in nature. Table 5-4 lists the types of compounds, their typical aroma character and their ranges of threshold values. Many of these chemicals have been produced by synthetic chemistry and have been approved as GRAS (Generally Recognized As Safe) by FEMA's (Flavor and Extract Manufacturer's Association) Expert Panel or by the FDA. The variety of materials are numerous and their odor thresholds have a very dynamic range. Fors (1981) has prepared a fine review of many of the sensory properties of the volatile Maillard reaction products.

There are various types of process flavors used either singly or in combination with other similar materials to produce the final commercially available flavor. The major types are discussed below.

Protein Hydrolysates

As mentioned earlier, hydrolyzed vegetable proteins (hydrolysates/HVP) were the first

TABLE 5-2. Mechanisms for thermal development of flavor

Reaction types	Major precursor(s)	Typical aroma resultant	Major literature review
"Maillard"	Amino acids and reducing sugars	Various	Waller 1983
Strecker degradation	Amino acids and reducing sugars	Aldehyde	Parliment 1989
Condensation	Dicarbonyl compounds from sugar and amino acids or ammonia	Pyrazines	Maga 1982
Sulfur addition	Furanone compound +5′ Nucleotides w/sulfur containing material	Thiazoles Thiazolines	Van den Ouweland 1975 Shu 1989
Decomposition	Thiamine (vitamin B1)	Thiazoles Thiazolines Thiofurans	Werkhoff et al. 1990 Guntert et al. 1990
Oxidation	Unsaturated fatty acids	Unsaturated aldehydes	Nawar 1989
Hydrolysis	Vegetable and animal protein	Pyrazines (+) plus complex mixture	Manley 1981
Cyclo-Dehydration	Sugars	5 Hydroxy-Furfural +	Hodge 1967

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TABLE 5-3. Major thermal process flavor patents (see Chapter 15)

Major Reactant	Processing (Temp/Time)	Type of Flavor	Patent Cited
1-Cysteine	130°C/3 hrs	Meat-like	May 1960* USA 2,934,435
Furaneol 1-Cysteine	100°C/31 min	Roasted meat	Van den Ouweland USA 3,904,655
Chicken Protein/thiamine	130°C/30 min	Chicken	Chuy USA 4,081,565
2-hydroxy Ethylammonium Hydrogen Sulfide 3-methyl butanol	80°C/5 min	Bacon	Weiner USA 3,645,754
Xylose 1-cysteine HVP	60–180°C 3 min	Roast beef	Baugher USA 3,930,046
HVP 1-cysteine xylose Malic acid Guanylate	100°C/2 hrs	Beef	Van Pottelsbughi USA 3,716,380
Yeast autolysate HVP, lactic acid		Beef	USA 2,109,084
Fried onion	115°C 40 min	Onion	Huth USA 3,424,592

* Original processed flavor patent

TABLE 5-4. Threshold ranges of key aromatic compounds in process flavors

Key aromatic compounds	Range of flavor types	Range of thresholds (in water)
Thiazolines	Roasted Cooked onion Meaty	3 ppm to 0.003 ppb
Pyrazines	Roasted Green Popcorn Nutty	25 ppm to 0.006 ppb
Furanones	Caramel Meat-like	1 ppm to 0.03 ppb
Furans	Sweet-burnt Rum-like Green	5 ppm to 6 ppb
Aldehydes	Fruity green	15 ppm to 0.2 ppb
Poly sulfide compounds- e.g., thianes	Onion/garlic	50 ppb to 2 ppb
Thiophenes	Fried onion Mustard-like	200 ppb to 1 ppb

process flavors. These materials are products of acid hydrolysis of proteins (usually of plant origin, but can be from animal protein). They acquire their flavor from the acid hydrolysis of the protein to amino acids and from the heating steps. During the processing, the residue carbohydrate in the protein source is reacted and also generates

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some aroma. The manufacturer of HVP is able to adjust the flavor profile of the resulting material by the degree to which the material has been processed, the substrate used (protein source) and resultant cleanup of the raw hydrolysate. These steps include the use of activated carbon, to remove some color and harsh flavor notes, and the precipitation of hydrophilic amino acids (bitter amino acids) and the general aging of the material (Manley 1981).

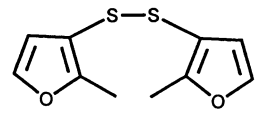
The resulting material can have many flavor characteristics from roasted-bitter to mild-brothy. HVP's have been used for many years as the basis of building meat-like flavors. They contribute not only aroma notes, but also taste character. The taste contribution is related to the amount of salt and monosodium glutamate (MSG). MSG results from the glutamic acid in the protein, and the salt is the product of hydrolysis (HCl) and its neutralization.

The Umami (taste enhancing) properties of MSG are well-known and, in fact, early hydrolysates (particularly produced from wheat) were produced specifically to isolate the MSG for use as a flavor enhancer in foods. This was the industry practice until the late 50's, when fermentation methods proved to be more economical.

Yeast and Autolyzed Yeast Extracts

Yeast products and, in particular, their autolyzed extracts (generally referred to as autolyzed yeast extract AYE) are ingredients quite similar to HVP. In a sense, these are the earliest of process flavorings based on the use of enzymes to create a flavor profile. In the case of AYE, the endogenous enzymes are used to break down the yeast components (proteins, nucleotides, vitamins and carbohydrates) to substrates useful in creating aromas during heating. More recent practice by manufacturers of AYE and process flavors is to add enzymes, not native to the yeast, to develop specific flavor and taste profiles.

The substrates available in a yeast make it an ideal candidate for processing into meat or savory flavorings. The protein content is high, and it contains certain other components, such as thiamine (vitamin B1), nucleic acids and sulfur-containing amino acids, all of which can generate strong flavor profiles when heat activated. One such component of a thermal reaction in yeast is bis (2-methyl-3-furyl)-disulfide:



It has been found to have an aroma threshold of 2 parts in 10^{14} parts of water (Buttery 1984, Hartman 1984).

The nucleic acids themselves are useful as flavor enhancers in savory flavors. The flavor-enhancing properties of these materials are well documented (Boudreau 1979, Cagan 1979, Yamaguchi 1979).

Yeast and AYE find use directly in compounded flavors for their inherent flavor profile, as well as being used in complex process flavor systems where amino acids, thiamine and nucleic acids are reacted to produce strong aromas.

Basic Process Flavorings

The early process flavorings were based on the reaction of selected components such as thiamine, amino acids, reducing sugars and hydrolysates. The first commercially available process flavors were essentially sophisticated hydrolysates. These materials are still the "workhorses" of the industry. They are materials used to bring more character to a savory flavor. They usually produce a general meaty, roasted, or cooked note (Ames 1985). They are considerably more intense than the basic HVP or AYE and deliver more aroma character.

Complex Process Flavorings

The simple process flavors are useful in generating nonspecific aromas. The more

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recent generation of process flavor development has focused on the production of species specific aroma profiles. The use of very specific precursors and thermal profiles allows for the generation of specific chemicals known to be necessary for creating the aroma of a certain species of cooked animal meat. Chemicals, such as the dienals, generated from the thermal breakdown of unsaturated fats and fatty acids, create strong chicken aroma (Van den Ouweland 1980). High amounts of the amino acid proline allow for the generation of bread and/or cracker notes (Schieberle 1989; Tressl, Helak, and Martin 1985; Yong et al. 1989).

This technology requires the chemical knowledge of the actual foods and their processing conditions. The substrates and processing conditions may be very complex. It is an area of development that is very close to food itself. In fact, the development of gravies, roux and many basic sauces are the classical analogy in the food preparation area to the process flavor. Much of the knowledge in this area is not covered in patents, but is maintained as trade secrets by the companies manufacturing the flavors. Because of their complexity, it is generally very difficult to reproduce these flavors without specific knowledge of the formulation and processing steps. In some cases, the final products use meat, meat and vegetable protein, or fat that has been enzymatically converted to thermally reactable precursor materials prior to the thermal processing step(s).

As noted above, many of the aromatic materials used in creating meat and savory flavors, which have been generated by thermal processing, have been synthesized and approved as GRAS.

The Final Flavor

The final commercial flavor may be a mixture of any of the flavors or flavoring ingredients noted above with the addition of carriers, antioxidants, solvents, other flavors, flavor adjuncts and flavor enhancers. These materials are noted in Table 5-5.

TABLE 5-5. Optional materials used in the manufacture of reaction flavors

Sodium chloride	Antioxidants
Monosodium glutamate	Modified starch
Ribotides (5′nucleotide)	Gums
Maltol and ethyl maltol	

TABLE 5-6. Food products using meat and savory flavors

Soups	Sausages
Gravies	Syrups
Sauces	Pot pies
Snacks	
Meat products	Beverages
Boullions	Toppings
Broths	Confectionery products

These flavors have seen significant sales growth in the past 15–20 years. The estimated sales volume of these materials in 1990, including HVP and AYE, is estimated to be in the $250 million range (Manley 1991). They find use in a great array of final food products as noted in Table 5-6.

Now let us turn our attention to the use of enzymes and microorganisms in the production of dairy flavors.

ENZYME MODIFICATION AND FERMENTATION—THE DAIRY FLAVORS

Dairy products are some of the oldest of man's foods and are certainly one of the most important classes of food for nutrition. There is a great array of dairy products based upon the species of animal used for the milk, the processing conditions and the enzymes and/or microorganisms used to develop the desired texture and flavor character. Table 5-7 notes the types and some of the specific dairy products available around the world. It is interesting to note that the types of dairy products available are

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TABLE 5-7. Types of dairy products available on the world market

Milk	
• Fresh	
• Pasteurized	
• UHT	
• Canned	
Cream	
Butter	
• Ghee	(Buffalo Milk)
• Margarine	(Imitation)
Cultured Products	
• Yogurt	
• Butter Milk	
• Acidophilus Milk	
• Bulgarian Milk	
• Yakult	
• Leben	
• Kifur	
Ice Cream	
Cheeses	
• Fresh Soft Low-Fat Cheese	
• Cream/Neufchatel	
• Gouda/Munster	
• Port du Salut (Flavored)	
• Brie/Camembert	
• Blue Cheeses	
• Goat Cheese	
• Emmental	
• Cheddar	
• Parmesan/Romano	
• Whey/Ricotta	

strongly related to national and ethnic references. In many cases, that reference is specific to the geographic or ethnic niche. For example, Yakult in Japan and Kifur in Russia are dairy products which are little known outside their principal area of consumption, whereas, butter, Cheddar cheese and yogurt have found nearly world-wide consumer acceptance.

The creation of dairy flavors has been closely related to the understanding of the precursor chemistry (substrate) and processing (biochemical conversion) to create desirable aromatic chemicals. The universal substrate for dairy products is milk. Although milk may come from any of many mammals, its most common sources around the world are the cow, goat, water buffalo and sheep.

Milk is a very complex natural material containing fats, sugars (mainly lactose), proteins (such as lactalbumin) and salts (such as calcium phosphate). The taste and aroma of fresh milk is minimal, with most of the taste coming from the fat and salt system. The aroma is faint, but is due to a combination of feed notes inhaled by the cow and directly tansferred to the milk and cooked notes coming from the pasteurization process.

Milk fat is the major source of flavors particularly when the milk is processed further or is treated with enzymes or microorganisms. Table 5-8 notes the types of fats and lipid material contained in milk fat. The fatty acid composition of milk lipids is also very complex and unique among food products. Over 60 fatty acids have been reported in cows' milk (Herb 1962). Quantities of butyric, caproic, caprylic and capric acids (fatty acids with 4, 6, 8, and 10 carbon atoms respectively) are unique to milk and of great importance in the development of dairy flavors. For example, the oxidation of unsaturated octadecadienoic acid (linoleic acid) leads to the formation of 4-cis-heptenal that has been reported as a cream-like flavor component in milk and butter (Haverkamp-Begeman 1964). Small amounts of free butyric acid are important to butter flavor as well as to most cheese flavors. One should

TABLE 5-8. Fats and lipids in milk

Type of fats	Range of occurrence (%) in cow's milk
Triglycerides	97.0–98.0
Diglycerides	0.25–0.48
Monoglycerides	0.015–0.038
Keto acid glycerides	0.85–1.28
Aldehydo glycerides	0.011–0.015
Glyceryl ethers	0.011–0.023
Free fatty acids	0.10–0.44
Phospholipids	0.2–1.0
Cerebrosides	0.013–0.066
Sterols	0.12–0.4

[Kurtz 1965]

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also note that milk fat contains a small amount of bound hydroxy and keto acids, which are readily hydrolyzed by either microbial lipases or theraml treatment. Free hydroxy acids readily cyclize into lactones and the keto acids degrade into methyl ketones.

The mechanisms of flavor development are reviewed in Table 5-9. This table is an indication of the complexity that was noted above. A number of comprehensive reviews on these mechanisms exist in the literature (Manley 1991, Vernin 1982).

In order to get a better understanding of the nature of dairy flavors, it is best to review categories that relate to specific flavor profiles or routes of flavor development.

TABLE 5-9. Mechanisms of dairy flavor formation

Thermally Directed Reactions
- Maillard reactions
- Sulfur release
- Triglyceride hydrolysis
- Oxidation of unsaturated fatty acids
- Caramelization (high temperature)

Enzymatically Directed Reactions
- Lipases—release of fatty acids and hydroxy fatty acids for lactone formation
- Esterases—same as lipases
- Proteases—release of peptides for aged taste of cheeses

Microbiologically Directed Reactions
- Lactic-producing organisms' lactic acid taste—pH change
- Molds—Roquefort—blue cheese with methyl ketones
- Propionbacteria—Swiss type with propionic acid

Milk and Cream Flavors

These flavors are representatives of dairy products that are minimally processed. Typically, they are heat treated in either a pasteurization step (15 seconds at 72°C) or ultrahigh temperature treated (UHT—a few seconds at 135°C to 150°C). This thermal exposure gives rise to flavor development from:

TABLE 5-10. Milk and cream aroma components

Component	Flavor Note
Fatty acids	Milk taste components
4-cis-heptenal	Cream-like
Methyl ketones	Low levels—(below threshold) together give cream-like; also cause stale off-flavor at higher levels
Lactones (high carbon #8–12)	Cooked-butter notes Coconut flavor character
Maillard reaction products	Heated milk produces caramel notes
Dimethyl sulfide (from s-methyl methionine sulfonium salt) from cow's diet	Malty or cowy flavor detect in milk
Oxidation of Lipids (Aldehydes and Ketone e.g., hexenal and 1-octen-3-one)	"Card-boardy" off odor-defect
Degradation of methionine producing methional, methyl sulfide, dimethyl sulfide and dimethyl disulfide	Sunlight defect
Sugars	Sweeteners
Diacetyl	Buttery notes
Lactic acid	Sourness
C10 and C12	Sweet
Fatty acids	Cream
Butyric acid	Higher levels give rancidity note and character

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- Degradation of thermally liable precursors found in milk.
- Product of sugar/protein (amino acid) reactions.
- The release of sulfur-containing components.
- Degradation and mild oxidation of triglycerides in fat.

Table 5-10 outlines the aromatic components generated that are related to a specific flavor profile in creating milk or cream flavor. This is one of the most delicate of flavor profiles, and one that needs the skilled flavor chemists to blend the chemical components or materials from processing to achieve an acceptable final flavor.

Cultured Dairy Flavors

Cultured products are some of the first products developed from milk. Originally, fermentation occurred naturally to milk set aside for later consumption. The spoilage organisms in the milk produced the proper conditions for the presentation of the final cultured product. The basic fermentation is due to lactic acid bacteria. Originally, the fermentation was performed with a mixed or "unknown" culture or "back-slop"; modern technology has developed the pure cultures with their predictable performance potentials.

The major flavor and taste component in these products is the lactic acid produced by the fermentation of the sugar by the bacteria. The preferred metabolite, in flavor terms, is the L (+) Lactic acid (Kielwein 1979). The D (−) enantiomer has a harsh off-flavor note. The acid note is the most significant one in this category. One exception is the product from Russia, called Kifur, which undergoes a secondary fermentation to create ethyl alcohol. This product is often called, with good reason, the "Champagne of Milk" (Shahani 1983).

The flavor of yogurt is also influenced by the amount of another fermentation product, acetaldehyde. There is no agreement on the acetaldehyde values that give optimum flavor effect (Groux 1973). Levels from 13 to 41 ppm have been reported as optimum (Badings 1980, Green 1982).

The last compound of flavor interest in cultured milk products is diacetyl: a metabolite of citrate by the action of Streptococci or Leuconostoc organisms (Collins 1972). This component contributes strongly to a buttery-type flavor at levels of 1–2 ppm (Steinholt 1971).

Butter Flavor

Butter is a product of the concentration of the fat in the milk by mechanical separation. The resultant product is a water in oil emulsion with a reasonably mild characteristic flavor. During the process, a small portion

TABLE 5-11. Recent butter/cheese flavor patents (see Chapter 14)

Brief description	Patent citation
Butter oil/lipase—blue cheese-like	Shay et al. 1990 EP 357812
Lactones from lipids for margarine	Haring 1989 EP 321055
Diketone precursors as a butter-like flavor	Doornbos 1988 EP 293957
Heated fatty acids at 150–475°C to give a dairy flavor	Chen 1988 EP 295509
Hydrolyzing butter and coconut oil with lipases	Shukunobe 1988 J 63240755
Butter/cream/cheese flavor from fat treated with lipases from Chromobacterium	Tojo 1988 J 64002549
Green notes from soybean with lipases	Kanisawa 1988 USA 4769243
Acetyllacetic acid is converted to diacetyl during baking	Unilever 1987 NL 8601078
Lipolyzed butter fat by Leuconostoc cremoris	Chang 1987 USA 4670267
Sugar and butter heated at 150–250°F to produce aqueous soluble butter flavor	Izzo 1987 USA 4684532
Omega-alkenyl methyl ketone for butter flavor	Mei ji Foods J 59039822
Lipolyzed cultured cream	Bakal 1983 USA 4414229

J = Japan EP = Europe NL = Holland

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of the fats are broken down to fatty acids by enzymes. Lactones are also formed from the small amount of δ-hydroxy acids occurring in the milk fat. The γ-lactones may also form from the unsaturated C18 fatty acids via hydration and β-oxidation.

The major flavor components used to create butter flavors are diacetyl, lower carbon number fatty acids and higher carbon number lactones. Some of the flavor notes in sweet cream butter may be due to the deca and dodecanoic acids (Ramshaw 1974) and the methyl ketones (Langler 1965).

Margarine, an imitation butter, is one of the major uses for butter flavors. Because margarine is used in cooking, it is desirable to create a flavor that generates a butter flavor upon heating. The heated butter flavor is due to the thermal generation of certain flavor components (usually lactones). Certain lactone precursors have been synthesized so that margarine may have the same flavor profile as butter after heating. A number of patents have been issued that cover butter flavor; some significant ones are summarized in Table 5-11.

Cheese Flavors

The many varieties of cheese represent centuries of cultivation of the art of cheese making, with its creation of many different flavors, tastes and textures. The different types of cheese are the result of many types of microorganisms (yeast, bacteria and mold) working together with the basic milk sources (which are typically cow's, goat's or sheep's milk).

The basic families of cheeses are noted in Table 5-12 with their corresponding flavor character noted and the major components contributing to their aroma profile. By far, the most popular cheese in the USA is Cheddar cheese. It is an English invention that uses a unique process, "cheddaring," introduced to repress the growth of spoilage organisms by piling and repiling blocks of warm cheese curd in the cheese vat, leading to rapid increase of lactic acid. During this

TABLE 5-12. Components related to specific cheese flavor character

Component	Cheese Variety	Flavor Note
Small peptides	Swiss Gouda/Muenster	Sweet taste
Fresh milk components	Cream Cheese Neufchatel	Mild milk
Small peptides, proponic acid	Emmental	Sweet taste low level (<1%)
4-mercapto-4-methyl Pentanone-2	Gouda	Fatty note as a defect
Bitter-hydrophilic peptides	Aged Cheddar	Higher amount of peptides related to rough aging character
Acetic acid	Sharp Cheddar	Sharp character
Medium chain fatty acids (C6 to C18)	Mild Cheddar	Overall cheddar character
Methanethiol	Aged note Cheddar	Aged note (threshold at 0.02 ppb)
Acetylpyrazine 2-methoxy-3-ethyl pyrazine	Aged Cheddar	Aged note-nutty (microbial origins)
Relatively large amount of C8 and C10 saturated fatty acids	Blue	Background aroma
Methyl ketone	Blue	Characterizing aroma

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period, the rapid increase in acid destroys the coliform (spoilage) bacteria.

Aged cheese, particularly Cheddar, owes most of its taste character to the peptides formed during curing. These components contribute to the bitter and umami taste of the aged product. The sharpness is generally related to the release of acetic acid during the ripening process. The medium-chain fatty acids (C6 to C18) that are released during the ripening process have also been shown to be important in Cheddar cheese flavor character (Bills and Day 1964).

Creation of Dairy Flavors

The significant aroma and taste components discussed above may be blended to produce various dairy flavors. These components may be generated by chemical synthesis, extraction from natural material or produced by biotechnology (enzymolysis or fermentation).

The major chemicals found in dairy flavors have been synthesized and placed on the FEMA or FDA GRAS List. Other materials such as starter cultures (concentrated diacetyl), enzyme modified cheese and other fermentation products are allowed. All of these materials allow the flavor chemist to create the specific dairy flavor profiles for use in a variety of food products.

REGULATORY ISSUES

General regulatory issues related to flavors are covered in another section; however, the specific issues related to savory flavors and dairy flavors need some discussion in this section. These flavors are generally regulated, over all, by the Food and Drug Administration under either the GRAS (21 CFR section 172.510–172.590) or the natural flavor section (21 CFR section 101.22). Natural flavor claims can be made when the flavor is made from natural substrate by methods indicated in the regulation.

When the savory flavors are produced with amounts of meat or meat by-products exceeding 2 percent of the flavor, their production comes under the supervision of the US Department of Agriculture's Meat Inspection Department (MID). Flavor manufacturing facilities that produce flavorings with meat/poultry or their by-products must have their plants qualified as a USDA-inspected plant and have USDA field inspection.

A flavor not containing the maximum allowed meat/poultry or by-product may also come under USDA's regulations when the flavor is used by a meat- or poultry-producing plant that is under USDA MID inspection. As an aid to having the flavor qualified for use in such a plant, it is useful to have the formulation reviewed by the Proprietary Mix Committee (PMC) of USDA in Washington, D.C. A standard form for submission of information for review of the flavor's formula can be arranged by writing the chairman of the Proprietary Mix Committee, Food Safety and Inspection Service of the United States Department of Agriculture at 300 12th St. SW, Washington, D.C. 20250-3700.

There are specific ingredients used to make savory and dairy flavors that must be identified to the PMC during the formula review procedure. Table 5-13 indicates those ingredients that need to be acknowledged in a formula disclosure to the PMC. The basis of the disclosure is to indicate to the consumer the presence of any of the following materials: (1) materials of religious or ethnic interest (Kosher); (2) materials of health concern in terms of allergic activities (proteins); (3) materials

TABLE 5-13. Materials used in process flavorings that must be labeled

- Proteinaceous materials
- Food materials
- Functional (in final product) ingredients
- Fats or oils
- Materials that are under religious review

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that are personal aversions (MSG); and (4) materials that have water binding capabilities or make a significant nutritional contribution to the final food.

The new regulation regarding labeling of flavors for USDA products was issued in 1990 (US Department of Agriculture 1990). At the time of this text's publication, the FDA had not made changes to its regulation regarding these products. It is believed that such changes will be made shortly so that one should review the regulation regarding the current rules for making and labeling these flavors.

APPENDIX 5.1. IOFI Guidelines for the production and labeling of process flavors

I. INTRODUCTION

Process flavorings are produced by heating raw materials that are foodstuffs or constituents of foodstuffs in similarity with the cooking of food.

The most practical way to characterize process flavorings is by their starting materials and processing conditions, since the resulting composition is extremely complex, being analogous to the composition of cooked foods. They are produced every day by the housewife in the kitchen, by the food industry during food processing and by the flavor industry.

The member associations of IOFI have adopted the following Guidelines in order to assure the food industry and the ultimate consumer of food of the quality, safety and compliance with legislation of process flavorings.

II. SCOPE

1.1 These Guidelines deal with thermal process flavorings; they do not apply to foods, flavoring extracts, defined flavoring substances or mixtures of flavoring substances and flavor enhancers.

1.2 These Guidelines define those raw materials and process conditions that are similar to the cooking of food, and which give process flavorings that are admissible without further evaluation.

III. DEFINITION

A thermal process flavoring is a product prepared for its flavoring properties by heating food ingredients and/or ingredients permitted for use in foodstuffs or in process flavorings.

IV. BASIC STANDARDS OF GOOD MANUFACTURING PRACTICE

Chapter 3 of the Code of Practice for the flavor industry is also applicable to process flavorings.

V. PRODUCTION OF PROCESS FLAVORINGS

Process flavorings shall comply with national legislation and shall also conform to the following:

A. Raw Materials for Process Flavorings

Raw materials for process flavorings shall consist of one or more of the following:

4.1.1 A protein nitrogen source:
—Protein nitrogen containing foods (meat, poultry, eggs, dairy products, fish, seafood, cereals, vegetable products, fruits, yeasts) and their extracts.

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—Hydrolysis products of the above, autolyzed yeasts, peptides, amino acids and/or their salts.

4.1.2 A carbohydrate source:
—Foods containing carbohydrates (cereals, vegetable products and fruits) and their extracts.
—Mono-, di- and polysaccharides (sugars, dextrins, starches and edible gums).

4.1.3 A fat or fatty acid source:
—Foods containing fats and oils.
—Edible fats and oils from animal, marine, or vegetable origin.
—Hydrogenated, transesterified and/or fractionated fats and oils.
—Hydrolysis products of the above.

4.1.4 Materials listed in Appendix Table A5-1.

4.2 Ingredients of process flavorings.

4.2.1 Natural flavorings, natural and nature-identical flavoring substances and flavor enhancers, as defined in the IOFI Code of Practice for the flavor industry.

4.2.2 Process flavor adjuncts

Suitable carriers, antioxydants, preserving agents, emulsifiers, stabilizers and anticaking agents listed in the lists of flavor adjuncts in Annex II of the IOFI Code of Practice for the flavor industry.

B. Preparation of Process Flavorings

Process flavorings are prepared by processing together raw materials listed under 4.1.1 and 4.1.2 with the possible addition of one or more of the materials listed under 4.1.3 and 4.1.4.

4.3.1 The product temperature during processing shall not exceed 180°C.

4.3.2 The processing time shall not exceed 1/4 hour at 180°C, with correspondingly longer times at lower temperatures.

4.3.3 The pH during processing shall not exceed 8.

4.3.4 Flavorings, flavoring substances and flavor enhancers (4.2.1) and process flavor adjuncts (4.2.2) shall be added only after processing is completed.

APPENDIX TABLE A5-1. Materials used in processing

Herbs and spices and their extracts
Water
Thiamine and its hydrochloric acid salt
Ascorbic acid
Citric acid
Lactic acid
Fumaric acid
Malic acid
Succinic acid
Tartaric acid
The sodium, potassium, calcium, magnesium, and ammonium salts of the above acids
Guanylic acid and Inosinic acid and its sodium, potassium and calcium salts
Inositol
Sodium, potassium- and ammoniumsulfides, hydrosulfides and polysulfides
Acids, bases and salts as pH regulators:
Acetic acid, hydrochloric acid, phosphoric acid, sulfuric acid
Sodium, potassium, calcium and ammonium hydroxyde
The salts of the above acids and bases
Polymethylslloxane as antifoaming agent (not participating in the process).

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C. General Requirements for Process Flavorings

4.4.1 Process flavorings shall be prepared in accordance with the General Principles of Food Hygiene (CAC/Vol A-Ed.2(1985)) recommended by the Codex Alimentarius Commission.

4.4.2 The restrictive list of natural and nature-identical flavoring substances of the |OF| Code of Practice for the flavor industry applies also to process flavorings.

D. Labeling

The labeling of process flavorings shall comply with national legislation.

5.1 Adequate information shall be provided to enable the food manufacturer to observe the legal requirements for his products.

5.2 The name and address of the manufacturer of the distributor of the process flavoring shall be shown on the label.

5.3 Process flavor adjuncts have to be declared only in case they have a technological function in the finished food.

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