CFW FEATURE


# Overview of Caramel Colors

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There are more than 6,000 additives available to the food industry. More than half are flavors, both natural and synthetic, while the remainder includes colorants, preservatives, antioxidants, emulsifiers, thickeners, acids, bases, anticaking agents, flavor enhancers, glazing agents, improvers, bleaching agents, sweeteners, solvents, and a miscellaneous category (8).

Color has always played a vital role in food selection and acceptance, and colorants are added to foods 1) to make up for color that may be lost during processing, 2) to color products that are colorless by themselves but can be made more appealing to consumers when color is added (an orange-flavored beverage for instance), 3) to allow consumers to identify what taste to expect from a product, and 4) to protect sensitive flavors from light. Colorants added to foods must also be proven safe, stable, legally permitted, and effective in a particular application.

Caramel color, from the palest yellows to the deepest browns, accounts for more than 80% (by weight) of all colorants added to the foods we eat and drink. Annual global consumption exceeds 200,000 tons.

## Browning Reactions

There are two types of caramelization reactions in food products: enzymatic browning, which is seen when damaged or cut fruit darkens at the exposed surface, and nonenzymatic browning, which occurs when food products, such as coffee beans, meats, breads, or sugars, are heated (7,11).

Desired brown color formation is generally associated with nonenzymatic browning, which occurs in several ways. Two of the most important are

1) The Maillard reaction, in which sugars, aldehydes, and ketones react with naturally occurring nitrogen-containing compounds, such as amines and proteins, to form brown pigments known as melanins.
2) Caramelization reactions, in which sugars are heated in the absence of nitrogen-containing compounds.

During a caramelization reaction, the sugars initially undergo dehydration and then condensation or polymerization into complex molecules of varying molecular weights. Lightly colored, pleasant-tasting caramel flavors are produced during the initial stages, but as the reaction continues more high molecular weight color bodies are produced, and the flavor characteristics become more bitter.

Caramel color first gained commercial importance as an additive in brewery products (e.g., porter, stout, dark beers, and ales) and as a colorant for brandy. In 1858, the French chemist M. A. Gelis authored the first known published technical study of caramel color (2). Gelis' work indicated that caramelized sucrose contains three main products: a dehydration product, caramelan $C_{12}H_{18}O_9$; and two polymers, caramelen $C_{36}H_{50}O_{25}$ and caramelin $C_{96}H_{102}O_{51}$. Greenshields (3) indicated that it is common for both Maillard and caramelization reactions to yield aldehydes and dicarbonyl compounds, but the former reaction incorporates nitrogen-containing components. For this case, Hodge and Greenshields (4) grouped the reaction mechanisms as follows:

1) Starting reactions
   a) Sugar-amino condensation
   b) Amadori or Heyns rearrangement
2) Degradative reactions causing the formation of colorless or yellow products with strong ultraviolet absorbance and the release of carbon dioxide
   a) Sugar dehydration
   b) Ring splitting (Strecker degradation)
3) Polymerizing or condensing reactions forming strongly colored components of relatively high molecular weight
   a) Aldol condensations
   b) Aldehyde/amino polymerization and formation of heterocyclic nitrogen compounds

## Caramel Standards

Caramel colors have been used for so long and in such a wide variety of food products that consumers tend to think of them as a single substance, when in reality they are a family of similar materials with slightly different properties. There are, in fact, four distinct types of caramel color to satisfy the requirements of different food and beverage systems (5,9): Caramel Color I (also known as plain or spirit caramel), Caramel Color II (caustic sulfite caramel), Caramel Color III (ammonia or beer caramel, bakers and confectioners caramel), and Caramel Color IV (known as sulfite-ammonia, soft drink caramel, or acid proof caramel). Each type of caramel color has specific functional properties that ensure compatibility with a product and eliminate undesirable effects, such as haze, flocculation, and separation.

Caramel colors are dark brown to black liquids or solids having an odor of burnt sugar and a pleasant, somewhat bitter taste. They are totally miscible with water and contain colloidal aggregates that account for most of their coloring properties and characteristic behavior toward acids, electrolytes, and tannins.

Caramel colors are prepared by controlled heat treatment of carbohydrates. The carbohydrate raw materials used are commercially available food-grade nutritive sweeteners, which are the monomers glucose and fructose or polymers thereof (e.g., glucose syrups, sucrose or invert sugars, and dextrose). To promote caramelization, food-grade acids, alkalis, and salts may be used in amounts consistent with Good Manufacturing Practices (GMP) and subject to the following stipulations. Ammonium and sulfite compounds cannot be used as reactants for Class I caramel colors. Sulfite compounds must be used and ammonium compounds cannot be used as

Publication no. W-2003-0205-01F.

reactants for Class II caramel colors. Ammonium compounds must be used and sulfite compounds cannot be used as reactants for Class III caramel colors. Both ammonium and sulfite compounds must be used as reactants for Class IV caramel colors.

The ammonium compounds used are hydroxides, carbonates, bicarbonates, phosphates, sulfates, sulfites, and bisulfites. The sulfite compounds are sulfurous acid and sulfites and bisulfites of potassium, sodium, and ammonium. Sulfuric and citric acid and sodium, potassium, and calcium hydroxide are compounds that can be used for all four types of caramel color. Food-grade polyglycerol esters of fatty acids may be used as processing aids (antifoam) in amounts not greater than those required to produce the intended effect.

## Caramel Color Classification

According to international standards, color intensity is defined as the absorbance of a 0.1% (w/v) solution of caramel color solids in water in a 1-cm cell at 610 nm. To express a parameter on a color equivalent basis, the parameter is determined for the caramel color as is and expressed in terms of a product having a color intensity of 0.10 absorbance units. For example, if a caramel color has 0.70% total nitrogen as is and a color intensity as is of 0.15, then the percent total nitrogen expressed on an equivalent color basis is $0.7 \times 0.1/0.15 = 0.47\%$. Table I lists the analytical requirements for classification of caramel colors.

The complete analytical methodology for each of the above specifications can be found in the *Compendium for Caramel Color* (5) and the *Food Chemicals Codex* (9). The requirements listed in the *Food Chemicals Codex* (9), are shown in Fig. 1.

The Eighth Amendment to the Colors Directive of the European Union (10) makes it clear that these four classes of caramel color are intended for coloring and are to be distinguished from and do not correspond to the sugary aromatic products obtained from heating sugar and used for flavoring foods and drinks (known as burnt or caramelized sugars).

In the United States the specifications for caramel color are found in the *Code of Federal Regulations* (CFR), Title 21, Section 73.85, and are very similar to those discussed above. The limits for all four types of caramel color are not more than 3 ppm of arsenic, not more than 10 ppm of lead, and not more than 0.1 ppm of mercury.

Caramel color is listed as generally recognized as safe (GRAS) as a general-purpose food additive in CFR 21, Section 182.1235. It is permanently listed and exempt from certification for use in coloring cosmetics, including those applied to the area of the eye in CFR 21, Section 73.2085. According to CFR 21, Section 73.1085, caramel may be used for coloring ingested or topically applied drugs.

## Labeling

In the United States, the responsibility for food safety and labeling rests with the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA) of the Department of Health, Education and Welfare. Finished food labeling of caramel color is and has been relatively

**Table I. Codex classification of caramel colors**

| Parameter[a] | Class I – E150 a | Class II – E150 b | Class III – E150 c | Class IV – E150 d |
|---|---|---|---|---|
| Color intensity | 0.01–0.12 | 0.06–0.10 | 0.08–0.36 | 0.10–0.60 |
| Total nitrogen (%) | <0.1 | <0.2 | 1.3–6.8 | 0.5–7.5 |
| Total sulfur (%) | <0.3 | 1.0–3.5 | <0.3 | 1.4–10.0 |

[a] Expressed on a solids basis.

straightforward. The Nutrition Labeling and Education (NLEA) Act of 1992 indicates that color additives not subject to certification may continue to be declared as "artificial color," "color added," or by an equally informative term that makes clear that a color additive is present in the food. Alternatively, such color additives may be declared as "colored with _____" or "_____ color," with the blank filled in with the name of the color additive. The *Federal Register* (page 2870, January 6, 1993), indicates that full label disclosure requirements for caramel are met with the words "caramel color."

In 1986, the United States made the labeling of sulfites in finished foods mandatory if the residual sulfites from all sources, based on the Monier-Williams analytical method, exceeded 10 ppm. Canada enacted the same legislation in 1992, and the European Union is considering the same 10-ppm threshold. Because Class II and IV caramel colors contain residual sulfites, products containing these two types of caramel colors should be checked to ensure that they comply with the regulations.

When dealing with the issue of natural versus artificial colorants, in the United States caramel color is defined as a noncertified color additive. According to the FDA, all added colorants, regardless of source, result in an artificially colored food. The example used by the FDA is the addition of beet juice to lemonade to make it pink, which would preclude the product being called natural.

While in the past it has not been necessary in all member states of the European Union to label additives, the European Union does have a Harmonization Program for additive labeling, and in 1962, the European Scientific Community for Foods (ESCF) developed a simple labeling system to identify the additives used in food products using either the additive's proper name or a number assigned to it. This was the origin of the E numbering system, in which each additive is assigned a number within one of four groups so consumers who need to avoid a certain additive can easily find the additive on the label without having to remember the exact chemical name. The four groupings are Colors, E100–E180 (caramel color is in this group and is known as E150); Preservatives, E200–E290; Antioxidants, E300–E321; and Emulsifiers, stabilizers, and other additives, E322–E494. Before an additive is given an E number, it must be proven safe to the regulatory agencies. The permitted colorants are governed by European Parliament and Council Directive 94/36/EC of June 30, 1994, on colorants for use in foodstuffs. Everywhere that caramel colors are listed, they are permitted at *quantum satis* levels.

This directive requires that color additives used in a food product must be indicated on the list of ingredients according to their function. This functionality must be expressed by the legal class name "color" followed by either the E number or full common name of the additive.

Caramel color is PCR negative, because any trace of protein in corn syrup raw material is denatured under the high temperatures used in caramel manufacturing. In North America, caramel color from non-GM sources (e.g., cane sugar) is an available alternative for food and beverage processors willing to pay a premium price. Most caramel color outside of North America is manufactured from non-GM sourced carbohydrates.

## Safety

In June 1985, the International Technical Caramel Association (ITCA) submitted toxicological and safety data on caramel color, along with specifications, to the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the European Economic Community (EEC), the FDA, and other interested regulatory agencies throughout the world. The work was extensive, with mutagenicity, short-term, and range finding studies performed. In January 1985, 24-month-long studies (feeding Fisher 344 rats and B6C3F1 mice 0.0, 2.5, 5.0, 7.5, and 10.0 g of caramel color per kilogram of body weight in the drinking water) were completed. Three laboratories carried out the bulk of the studies: Hazelton Laboratories America (Madison, WI), BioResearch Laboratories of Canada, and the Central Institute for Nutrition Research (TNO/CIVO) in the Netherlands. As a result of these studies, JECFA, established acceptable daily intakes (ADI) for each type of caramel color: Class I, unlimited; Class II, III, and IV, 0–200 mg/kg body weight.

In the United States, after careful review of the submitted toxicological and safety data, the FDA reaffirmed the GRAS status of caramel color. The specifications for caramel color are found in the *Food Chemicals Codex* (9).

## Color Determination Methodology

A common method of caramel color determination in Europe involves the use of a colorimeter or comparator to match a solution of caramel color to a series of standardized colored glasses and the use of the appropriate multiplier determine color strength in European brewery convention (EBC) units (1). The color of the glass standards used has a hue that is the same as beer, and solutions of Class III, which is the caramel color type used in beer, exactly match the hue of the glass, making it easy to determine their EBC value. The other three classes of caramel color have varying hues, and determining a match between solution and glass can be very difficult.

During the 1970s, JECFA and industry came up with a tentative correlation that relates a certain amount of absorbance of a 0.1% (w/v) caramel color solution at 610 nm for each class of caramel to 20,000 EBC units. For example, for Class I 0.053 absorbance units correlates to 20,000 EBC; the correlation for Class III is 0.076 absorbance units; and the correlation for Class IV is 0.085 absorbance units. Experience has shown that the correlation value for a double-strength Class IV (color intensity 0.200–0.270) caramel color should be 0.104. This system works well; however, the analyst has to know which type of caramel colorant is being checked.

Satish Chandra at the University of Louisville in Kentucky, using regression analysis on a database of 106 samples, produced a mathematical model to correlate the absorbance of a 0.1% (w/v) caramel color solution at 510 nm to EBC values. The regression equation, EBC = 2,145 +

| | |
|---|---|
| Ammoniacal nitrogen: | Not more than 0.6%* |
| Arsenic: | Not more than 1 mg/kg** |
| Color intensity: | 0.010–0.600*** |
| Heavy metals: | Not more than 25 mg/kg** |
| Lead: | Not more than 2 mg/kg** |
| Mercury: | Not more than 0.1 mg/kg** |
| 4-Methylimidazole: | Not more than 0.025%* |
| Sulfur dioxide: | Not more than 0.2%* |
| Total nitrogen: | Not more than 3.3%* |
| Total sulfur: | Not more than 3.5%* |

* Calculated on an equivalent color basis that permits the values to be expressed in terms of caramel having a color intensity of 0.1 absorbance.
** Measured as is.
*** Color intensity is defined as the absorbance of a 0.1% (w/v) solution of caramel in water measured in a 1-cm cell at 610 nm and is expressed on a total solids basis.

**Fig. 1.** Purity specifications for caramel color in the United States and Canada (9).

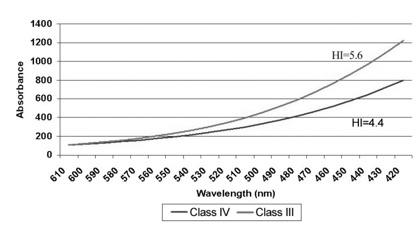


**Fig. 2.** Diagram illustrating Class IV (bottom curve) and Class III (top curve) caramel colors with the same color intensity but different hue index.

(65,132 × absorbance at 510 nm), gives $R^2$ values of 98.1 and is an excellent predictor of EBC values when using spectrophotometric analysis.

Linner (6) developed an equation based on spectrophotometric readings at 510 and 610 nm to determine the hue index or the "redness" of a particular caramel color:

$$\text{Hue Index} = 10_{\log}(\text{Absorbance at 510 nm}/\text{Absorbance at 610 nm})$$

For example, for a solution of caramel color with an absorbance of 0.123 at 610 nm and an absorbance of 0.434 at 510 nm, the hue index would be 5.48. The range of the hue index for caramel color is approximately 3.5–7.5; generally, the higher the value the redder or more yellow the color. Figure 2 illustrates the hue index by showing the amount of variation in absorbance for a Class IV (color intensity 0.104, hue index 4.4) and Class III (color intensity 0.104, hue index 5.6) caramel color. The colors have been equalized at 610 nm. The plots follow each other closely from 610 to 580 nm. The lines then diverge rapidly with the Class III (top curve) color absorbing more rapidly at the lower or blue wavelengths, producing a redder visual impression. A word of caution is necessary: in Class I caramel colors with color intensities of approximately 0.015, the hue index is approximately 7, which would typically indicate an extremely red product. However, these colors when diluted are, in fact, quite yellow and are sometimes used as replacements for FD&C yellow (tartrazine) and combined with FD&C blue (Brilliant Blue FCF) to produce a green color.

**Stability**

Colloidal charge is an important feature of caramel color and in many applications determines which product must be used. Each caramel molecule carries an electrical charge formed during processing. Class I, which has the fewest reactants, carries a slightly negative charge. Class II and IV, which have sulfites in the catalyst, are strongly negative, and Class III, which has only ammonium compounds in the catalyst, is strongly positive. Colloidal charge is strongly influenced by pH. By changing the pH of caramel solutions, the isoelectric point (where the charge is neutralized) can be reached. Further pH adjustments will cause the charge to switch to the opposite polarity. For example, the Class III charge is usually positive up to around pH 5, and the isoelectric point will be between pH 5 and 7 depending on the product and will be negative above that. In contrast, Class IV has a negative charge above pH 2, and the isoelectric point will usually be between pH 0.5 and 2 and will be positive below that.

The shelf life for a caramel color under ambient storage conditions will normally be listed as either one or two years depending on the class. The caramelization reaction continues at a slow rate during ambient temperature storage, with both color and viscosity increasing with time. For example, a Class IV double-strength liquid stored at ambient temperature increases in color intensity from 0.235 to 0.282 over 33 months, and a Class III caramel color increases in color intensity from 0.111 to 0.143 over 36 months.

Caramel color, as produced, is essentially a sterile product. With its relatively high solids and low pH, it is usually not subject to microbial attack until diluted. The typical microbiological specifications for caramel color are total plate count: <200/g; yeast: <10/g; mold: <10/g; coliform: negative; and salmonella: negative.

The minimum temperature a caramel color can be subjected to and still flow depends primarily on the specific gravity (SG) of the product. For example, two caramel colors, one with an SG of 1.320 and viscosity of 300 cps at 15.5°C and the other with an SG of 1.270 and viscosity of 80 cps at 15.5°C were subjected to –5.5 and –16°C temperatures for three days. At –5.5°C, both samples were fluid, with viscosities of 1,525 and 775 cps, respectively. At –16°C, the sample with a SG of 1.270 was frozen, although a

**Table II. Typical nutrition profiles for two caramel color products**

| Component | Class IV Single-Strength | Class IV Double-Strength |
|---|---|---|
| Ash (%) | 2.0 | 2.0 |
| Protein (%) | Nil | Nil |
| Moisture (%) | 29.6 | 43.5 |
| Fats (%) | Nil | Nil |
| Fiber (%) | Nil | Nil |
| Carbohydrates (%) | 68.4 | 54.5 |
| kcal/g[a] | 1.5 | 0.2 |
| Vitamins (%) | Nil | Nil |
| Copper (ppm) | 1 | 1 |
| Iron (ppm) | 10 | 8 |
| Calcium (ppm) | 30 | 25 |
| Sodium (ppm) | 3,300 | 5,000 |

[a] In North America, kcal/g is often denoted as calories.

**Table III. Suggested usage levels (%) in typical applications for different classes of caramel color**

| Application | Class I Liquid (CI 35)[a] | Class III Liquid (CI 110) | Class III Powder (CI 190) | Class IV Powder Double-Strength (CI 440) |
|---|---|---|---|---|
| Bagels | | 1.0 | 0.5 | |
| Bread, mix | | | 0.5 | |
| Bread, multigrain | | 1.0 | 0.5 | |
| Bread, rye | | 2.0 | 1.0 | |
| Bread, pumpernickel | | 3.0 | 1.5 | |
| Breakfast cereal, golden | 0.5–1.0 | | | |
| Breakfast cereal, chocolate | | | 2.0 | |
| Cake mix, spice | | | | 2.0 |
| Cake mix, dark | | | | 5.0 |
| Cinnamon filling | | | 1.0 | |
| Cocoa extender | | | 7.5 | |
| Cookies/biscuits | | | 0.5–5.0 | |
| Ice cream, cones | | 1.0 | | |
| Muffin mix | | | 1.0 | |
| Muffins, banana | | | 1.0 | |
| Muffins, chocolate | | | 1.0–3.0 | |
| Nutrition/energy bars | 1.0–2.0 | | | |
| Rice cakes, golden | 0.5–1.0 | | | |
| Croutons/stuffing | 0.5 | | | |
| Snack dusting | | | 1.0–2.0 | 1.0–2.0 |
| Frosting | | | 1.0–3.0 | 1.0–3.0 |

[a] Color intensity value.

glass thermometer could be inserted into the mass. The sample with a SG of 1.320 was thick but pourable, with a viscosity of 100,000 cps. Freezing did not appear to damage the sample with a SG of 1.270, as all analysis appeared normal after thawing.

## Nutrition

The percentage of caramel needed to impart the desired color is normally so low that it would have no measurable impact on the nutritional profile of a product. Even though caramel is made from edible carbohydrates, the metabolic calorie content of a double-strength Class IV caramel is <1 kcal/g because the starting carbohydrates are converted by caramelization to high molecular weight color bodies that are not readily absorbed or metabolized. The residual sugars, as profiled by the Ontario Research Foundation (ORF), for a typical single-strength Class IV caramel, color absorbance 0.094, are 23.4% glucose, 11.2% maltose and isomaltose, and 4% other di- and tri-saccharides; the residual sugars for a double-strength Class IV caramel, color absorbance 0.240, are 3% glucose, 1% maltose and isomaltose, and 1% other di- and tri-saccharides (Ontario Research Foundation, *unpublished data*) A typical nutritional profile for two products similar to these two types of caramel is shown in Table II.

Kjeldahl methods indicate total nitrogen on the order of 0.7 and 2.5%, respectively, but again the nitrogen is tied up in higher molecular weight substances. True protein is very low.

Caramel colors made following ITCA specifications contain no substances forbidden by the Jewish Dietary Code and are certified as Kosher, but because most caramel colors are made from corn syrup, they are not acceptable for use during Passover. To be certified as "Kosher for Passover," a caramel color needs to be made from cane or beet sugar under rabbinical supervision. Caramel colors also contain no substances forbidden by the Islamic Dietary Code and can be certified as Halal.

## Applications

Typical usage levels for different classes of caramel colors in various applications are shown in Table III.

**Baked Goods and Mixes.** Bakers have been using caramel color to enhance the color and appeal of baked goods for decades. Caramel's high dispersibility in water and dough systems makes it well suited for such applications. Class III or IV caramel color is most often used in bakery applications.

Caramel color can also be used to help reduce batch-to-batch color variations. It is much darker than alternatives such as malt syrup (extract) and food-grade molasses and is often used for this reason. The wide selection of available caramel colors makes it a versatile tool for use in designing visually appealing baked products, ranging from tannish yellow to reddish brown to nearly black.

Bakers can choose either liquid or powdered caramel colors depending on their process layout and equipment. Some select powder for its handling ease, longer shelf life, and performance in dry mixes. The drying process used by caramel manufacturers raises caramel solids from 50–65% to higher than 96%. The resulting powder is darker than liquid, so less powdered caramel (by volume) is required in baking formulas. Given the same caramel color, for every 1.0 kg of liquid, bakers can substitute 0.5–0.6 kg of powder to achieve the same color intensity (darkness).

Dry mix blending is a growing industry characterized by ready-to-use mixes, premixes, and concentrates. Powdered caramel allows mix manufacturers to standardize the color of baking mixes. Bread, cake, and muffin mixes frequently contain caramel color to enhance the visual appeal of the final product.

Before the advent of powdered caramel colors, dry mixes for brown cakes, puddings, and other desserts contained several synthetic colorants used to replace cocoa. Today, bakers concerned with labeling often formulate using powdered caramel in dry mixes to "clean" the ingredient label by reducing or eliminating certified colorants.

Caramel color can also be used in pet foods to replace a combination of three certified colorants, FD&C Red #40, FD&C Yellow #5 (or #6), and FD&C Blue #1, which are blended together to make brown. The result is a product with a cleaner label and a meaty appearance at a cost equivalent to that for synthetic colorants. Using caramel to replace synthetic colorants also solves a common problem in digestion that occurs when the body absorbs red colors, leaving the blue and yellow to show as a "green effect" in pet stools.

Caramel color is 2–6 times darker than most cocoa powders in baking systems. A direct comparison is difficult, however, because cocoa powder is not soluble in water. If the purpose of adding extra cocoa powder is to darken a product, as opposed to adding flavor to the baking system, then using caramel color is a cost-effective way to reduce the amount of cocoa required. For example, 50% of the cocoa powder in a baking formula could be replaced using 50% cocoa powder; 41.1% flour or maltodextrin; 7.5% Class III caramel color powder; and 1.4% chocolate flavor.

**Breakfast Cereals and Snack Foods.** Compared with other natural colorants, caramel does not deteriorate under the high temperatures and pressures of extrusion processes. Typically Class I, III, or IV caramel color is used in these types of applications. More than 50 different breakfast cereal products found on U.S. supermarket shelves list caramel color on their ingredient labels.

Snack and confectionery processors use powdered caramel color to standardize the color of spice mixes and other seasoning blends. Processors also apply liquid or powder forms of caramel in water-soluble, extruded products to boost adhesion in rice cakes, granola, and energy bars.

## Research and Development

In recent years the caramel color industry has developed new products to broaden the range in terms of redder and more yellow tones, especially for use in Asian sauces. Research efforts using GC-MS equipment have led to discoveries about the flavor profile of caramel color, enabling manufacturers to further standardize existing caramels.

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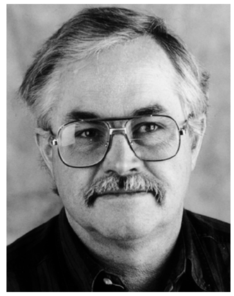
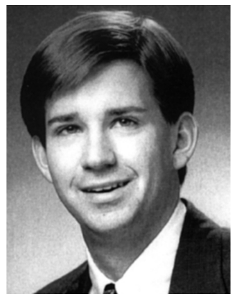
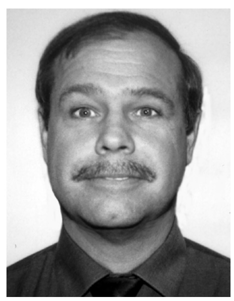
### The Authors

**William Kamuf** began his career at D.D. Williamson in 1978 and has since held a variety of positions with technical and sales management responsibilities. Presently, Kamuf serves as vice president, technical services. For more than two decades, he has served as D.D. Williamson's representative to the International Technical Caramel Association. He is a member of the Institute of Food Technologists (and former chair of its Bluegrass Section), as well as the International Society of Beverage Technologists. Kamuf earned a B.S. degree in chemistry from Brescia College.



**Alexander R. Nixon** joined D.D. Williamson in 1992 and currently serves as president and chief operating officer of the company's North American subsidiaries—D.D. Williamson & Co., Inc. in the United States and D.D. Williamson (PR) Ltd. in Puerto Rico. His previous positions within the organization include global technical manager, sales manager, and president and chief operating officer of the company's African subsidiary headquartered in Swaziland. Nixon, a member of the Institute of Food Technologists, received a B.E. degree in biomedical engineering from Vanderbilt University and a MBA degree from the University of Louisville.



**Owen D. Parker** began his career at D.D. Williamson in 1978. Since then, he has served the company in a number of capacities, including quality assurance manager, plant manager, and manufacturing manager. Parker's current position is vice president, research and development. A member of the Institute of Food Technologists since 1983, he has served as chair of its Bluegrass Section, as well as on its National Scientific Lectureship Committee. Parker holds a B.A. degree in biology from the University of Louisville.

**G. Campbell Barnum, Jr.** has visited 30 countries on behalf of D.D. Williamson since joining the company in 1993. He has served in a number of domestic and international sales and marketing positions. His current roles include global vice president, sales and marketing, as well as president and chief operating officer of the company's African subsidiary, headquartered in Swaziland. Barnum, a member of the Institute of Food Technologists since 1995, served on its initial Exhibitor Advisory Subcommittee until 1997. He earned a B.S. degree in foreign service from Georgetown University in Washington, DC, and was named to Phi Alpha Theta (International Honor Society in History).