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, caramel an C_{4}H_{8}O_{4}; and two polymers, caramel 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 burned 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...
reactants for Class II caramel colors. Ammonium compounds must be used and sul-
fite compounds cannot be used as reactants for Class III caramel colors. Both ammo-
nium and sulfite compounds must be used as reactants for Class IV caramel colors.

The ammonium compounds used are hy-
droxides, carbonates, bicarbonates, phos-
phates, 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 poly-
glycerol 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 ex-
press a parameter on a color equivalent ba-
sis, 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 × 0.1/0.15 = 0.47%. Table I lists the analytical require-
ments 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 re-
quirements 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 corre-
spond to the sugary aromatic products ob-
tained 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, Sec-
tion 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 rec-
ognized 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. Accord-
ing to CFR 21, Section 73.1085, caramel
may be used for coloring ingested or topi-
cally 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, Edu-
cation and Welfare. Finished food labeling
of caramel color is and has been relatively

Table I. Codex classification of caramel colors

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Class I – E150 a</th>
<th>Class II – E150 b</th>
<th>Class III – E150 c</th>
<th>Class IV – E150 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color intensity</td>
<td>0.01–0.12</td>
<td>0.06–0.10</td>
<td>0.08–0.36</td>
<td>0.10–0.60</td>
</tr>
<tr>
<td>Total nitrogen (%)</td>
<td>&lt;0.1</td>
<td>&lt;0.2</td>
<td>1.3–6.8</td>
<td>0.5–7.5</td>
</tr>
<tr>
<td>Total sulfur (%)</td>
<td>&lt;0.3</td>
<td>1.0–3.5</td>
<td>&lt;0.3</td>
<td>1.4–10.0</td>
</tr>
</tbody>
</table>

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, \( EBC = 2.145 + \)

### Table 1: Purity Specifications for Caramel Color

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammoniacal nitrogen</td>
<td>Not more than 0.6%*</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Not more than 1 mg/kg**</td>
</tr>
<tr>
<td>Color intensity</td>
<td>0.010–0.600***</td>
</tr>
<tr>
<td>Heavy metals</td>
<td>Not more than 25 mg/kg**</td>
</tr>
<tr>
<td>Lead</td>
<td>Not more than 2 mg/kg**</td>
</tr>
<tr>
<td>Mercury</td>
<td>Not more than 0.1 mg/kg**</td>
</tr>
<tr>
<td>4-Methylimidazole</td>
<td>Not more than 0.025%*</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Not more than 0.2%*</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>Not more than 3.3%*</td>
</tr>
<tr>
<td>Total sulfur</td>
<td>Not more than 3.5%*</td>
</tr>
</tbody>
</table>

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* 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.

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**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:

\[
\text{Hue Index} = 10 \log \left( \frac{\text{Absorbance at 510 nm}}{\text{Absorbance at 610 nm}} \right)
\]

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 depend-
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 single-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 per the Ontario Research Foundation (ORF), for a typical single-strength Class IV caramel are 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 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.

**Applications**

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

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Class IV Single-Strength</th>
<th>Class IV Double-Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash (%)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>29.6</td>
<td>43.5</td>
</tr>
<tr>
<td>Fats (%)</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Fiber (%)</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Carbohydrates (%)</td>
<td>68.4</td>
<td>54.5</td>
</tr>
<tr>
<td>kcal/g</td>
<td>1.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Vitamins (%)</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Copper (ppm)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Iron (ppm)</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Calcium (ppm)</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Sodium (ppm)</td>
<td>3,300</td>
<td>5,000</td>
</tr>
</tbody>
</table>

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

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

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* In North America, kcal/g is often denoted as calories.

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**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.

**References**


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**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.

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