

## FLAVOR AND COLOR COMPOUNDS

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### Summary

A short review is given in this chapter about main flavor compounds playing a characteristic role in formation of flavor, occurring in most important food groups such as fruits, vegetables, and fermented foods, cooked and roasted foods. Synthetic flavors were also treated. The four groups (sweet, sour, salty, bitter) of taste substances and the most characteristic volatile flavor compounds such as acids, alcohols, carbonyl compounds, amines, esters, wide variety of heterocyclic compounds, are discussed. Natural colorants occurring in foods (carotenoids, porphyrin colors, flavonoids, and betalains) are also reviewed. Colorants added to food are also shortly treated. Finally, recent trends regarding substitution of synthetic compounds by natural pigments are

presented.

## 1. Introduction

In a wider sense the term “flavor” implies an overall integrated perception of all the contributing senses (smell, taste, sight, feeling, and sound) at the time of food consumption. However for the consumer flavor means primarily the taste and odor of food. Taste buds located on the tongue and back of the oral cavity enable humans to sense sweetness, sourness, saltiness, and bitterness and these sensations contribute to the taste component of flavor. Even trace amounts of volatile odorants are detected by the specific cells of olfactory epithelium of nasal cavity. The sensation of taste and odor is connected with presence of different chemical compounds. In the framework of this chapter substances that yield taste/odor responses will be discussed. However, it should be noted that other non specific factors influence the perception of tastes and smells, and hence food acceptances, but discussion of these effects is beyond the scope of this chapter.

Bearing in mind that the number of substances which contribute to flavor of individual foods is very high (e.g. flavor of a fruit may be a result of effect of more hundred substances), it is not possible to give a full review of such compounds. The aroma of food is nearly always due to a complex of many volatile compounds, among which key substances (i.e. cases when the character of the odor is due to one or few substances only) are exceptions. Aroma active substances are partly present already in raw material, and partly formed during food processing and storage. Aromatic substances are often present in the raw material and/or in the food product in their bound form, from which they are released during food processing and storage. The most important processes leading to the production are listed in Table 1.

Reaction	Main classes of compounds formed
Hydrolysis	Acids and alcohols
Oxidation	Aldehydes, ketones, hydrocarbons, lactones
Decarboxylation	Amines, hydrocarbons, ketones
Strecker degradation	Aldehydes, heterocycles
Maillard reactions	Heterocycles, aldehydes
Pyrolysis	Heterocycles, hydrocarbons
Fermentation	Esters, acids, acetals

Table 1: Main Reactions of Aroma-active Compounds Formation

This chapter deals with the chemistry of selected compounds playing characteristic role in formation of flavor. In addition to the chemistry of natural flavor compounds, the synthetic flavorings and their use in food production will be also shortly treated.

Although majority of natural coloring compounds (pigments) of foods and none of synthetic colorants used in food production has no nutritive value, among factors (indices) determining the quality of foods we can found generally the color. This is because, no matter how nutritious, flavorful, or well textured a food, it is unlikely to be eaten unless it has a right color. Acceptability of color in a given food is influenced by

many factors, including cultural, geographic, and sociological aspects of the population. It means that certain foods are acceptable only if their color corresponds to requirements of consumers in a given region.

Moreover acceptability is reinforced by economic worth since in many cases raw food materials are judged as to value by their color. Color compounds may be classified from different viewpoints.

Based on chemical structure pyrrol compounds, carotenoids, flavonoids, quinons etc. may be distinguished. The food industry describes three types of colorants used in food production: (i) natural colorants which are normal constituents of foods, (ii) “nature identical” colorants which are produced synthetically but which are chemically identical to the natural product, and (iii) totally synthetic colorants (not naturally found in the nature). In the framework of this chapter the main groups of natural pigments will be described and a short overview of synthetic ones will be given. The current trends regarding substitution of synthetic compounds by natural pigments will be also treated.

## 2. Taste Substances in Foods

### 2.1. Sweet Compounds in Foods

The traditionally used sweet compounds belong- from chemical point of view, to the group of mono- and oligosaccharides (See *Carbohydrates*). Among common foods honey, sugar from sugar-cane or sugar-beet, corn syrup, glucose and fructose preparations are used as traditional sweeteners. Their sweet constituents (sucrose, glucose, fructose, and maltose) are easily metabolized and serve as energy sources of human organism. Table 2 gives some information concerning relative sweetness of sugars and some sugar alcohols (alditols).

Sugar	Relative Sweetness
Rafinose	15
Lactose	25
Maltose	40
Galactose	50
Sorbitol	55
Mannitol	53
Glucose	56
Fructose	132
Invert sugar	85

Table 2: Relative Sweetness of Sugars and Sugar alcohols (based on sucrose=100)

Unfortunately the excess caloric consumption is one of the main factors being responsible for obesity and other health problems. As mentioned earlier another disadvantage of traditional sweeteners is that they promote tooth decay. That’s why *alternative sweeteners* have been developed to allow consumers to have their cake and eat it without an excessive caloric penalty of worrying about tooth decay.

Alternative sweeteners have a sweet taste, but are effectively noncaloric. The name non-nutritive or low-caloric is also often used. Their sweetening effect is much higher than that of traditional sweeteners. Consequently much smaller quantities are needed for achieving the same sense. E.g. the saccharin, one of the oldest alternative sweeteners, is about 300 times as sweet as sucrose. Due to intensive research, the number of known alternative sweeteners is steadily growing. It should be also mentioned that, as a result of growing requirements concerning food safety, only few compounds are approved for use in foods. Here some of most known and used compounds will be treated.

*Saccharin* (see Figure 1a) was discovered in 1878. Many years following its discovery this compound was the only alternative sweetener. Saccharin is approved for use in foods in majority of countries, however in some of them with limitations.

*Cyclamates* were discovered in 1937 (See Figure 1b). Cyclamates are 30 times sweeter than sucrose, taste much like sugar and are heat stable and are frequently used in low-calorie nonalcoholic drinks.

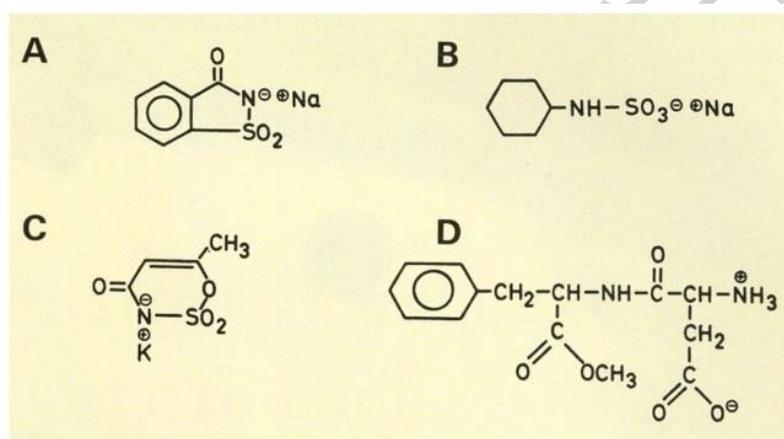


Figure 1: Intensive sweeteners; A-saccharin, B-cyclamate, C- acesulfam-K, D- aspartame

*Acesulfam-K*: This compound, discovered in 1967 (See Figure 1c), is about 200 times sweeter than sugar. At higher concentrations may have bitter side-taste.

*Aspartame*: From chemical point of view this alternative sweetener is a dipeptide (See Figure 1d). Aspartame is about 180 times as sweet as sucrose and its use in foods is approved in majority of countries. Two disadvantages of aspartame is its instability in acidic conditions and sensibility to heat. Unlike saccharin, cyclamates, acesulfam and aspartame which have no nutritive value, aspartame can be utilized in the body like other proteins, but it is used in such small quantities that its caloric value is insignificant.

Among peptide type alternative sweeteners *alitame* and *thaumatins* may be mentioned. These compounds are 2000 times sweeter than sucrose. Alitame is a crystalline, odorless, nonhygroscopic powder formed from amino acids L-aspartic acid and D-alanine. Thaumatinins are sweet proteins obtained from the fruit of the West African plant *Thaumatococcus daniellii*. There are at least five thaumatins, and a mixture of two

thaumatococins is marketed under trade name.

*Dihydrochalcones* are derived from the bitter citrus flavanones, naringin and neohesperidin, found in peel. This compound is several hundred times sweeter than sucrose, and have a slow onset of sweetness, a lingering aftertaste, and an apparent decrease in sweetening power relative to that of sucrose as concentration increases. A special virtue of the dihydrochalcones is their ability to decrease the perception of bitterness in beverages and pharmaceuticals. Dihydrochalcones are stable over wide range of temperature and acidic conditions, and are especially suited for use in soft drinks and chewing gums.

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### Biographical Sketch

**Jiří Davídek**, PhD., Dr Sc., is a Professor of Food Science in the Faculty of Food and Biochemical Technology, and is a member of the Department of Food Chemistry and Analysis, Institute of Chemical Technology, Prague, Czech Republic.

Prof. Davídek received his M. Sc. degree from the Institute of Chemical Technology, Faculty of Food and Biochemical Technology in 1954. He obtained his Ph.D. in 1969 from the same Institute under the direction of Prof. Dr. G. Janíček. After doing postdoctoral work with Dr. J. Fragner at the Research Institute of Food Industry in Prague and with Dr. A. W. Khan at National Research Council, Division of Biosciences in Ottawa, Canada He was appointed Associate Professor of Food Chemistry and Analysis at the Faculty of Food and Biochemical Technology, Institute of Chemical Technology, Prague in 1960 and became a full Professor there in 1970.

Prof. Jiří Davídek is a member of the Czech Chemical Society and the chairman of the Division of Food

and Agricultural Chemistry. He is a national representative in Food Chemistry Division, Federation of European Chemical Societies (FECS) and is member of Czech Biochemical Society, the American Institute of Food Technologists and numerous other scientific societies. He is also a member of the editorial board of the Czech Journal of Food Sciences, German European Research and Technology and Chinese Biomedical and Environmental Sciences. He has served as the head of the Department of Food Chemistry and Analysis, dean of the Faculty of Food and Biochemical Technology in Prague, and the vice chairman of the Czechoslovak Academy of Agriculture. In 1972 he received the State Prize for Research, and in 1982 he was awarded both the Gold Medal from the Czechoslovak Academy of Agriculture and Silver Medal of Professor Jaroslav Heyrovsky from the Czechoslovak Academy of Science.

Prof. Davídek has published over 330 papers and is author of 16 books published variously in Czech, English, German and Polish. He has also delivered more than 350 lectures at scientific conferences and symposiums. He often works as a chairman at the International meetings organized by Food Chemistry Division of FECS (Euro Food, Chemical Reactions in Foods, etc.). His research interests focus on food quality, food analysis, on Maillard reactions, formation of sensory active compounds, food additives and natural toxic compounds.