The Flavor of Food—How Natural is Natural?

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Consumers all over the world, but particularly in the more developed countries, are becoming increasingly conscious of the nutritional value and the safety of their food and its ingredients. At the same time, there is an increased preference for natural foods and food ingredients which are generally believed to be safer, more healthful, and less subject to hazards than foods containing artificial food additives.

This preference for natural foods clearly has its roots in a long tradition of food selection, preparation and consumption. It is not surprising, therefore, that "natural" in this context is generally considered to include all foods which have been prepared or processed in a traditional way.

Since what is considered natural depends on the social and cultural history of each civilization, there is no clear agreement among regulating and governing bodies as to what should be the definition and limitation of the term natural.

Among the many ingredients present in prepared, processed and manufactured foods, the flavoring materials form a special category, larger in number than all others together. They may be present as a result of the normal metabolic mechanism of the plant or animal tissue, as a result of food processing, or as added flavoring materials. Fortunately, in the area of flavoring materials there is a clear definition what "natural" stands for.

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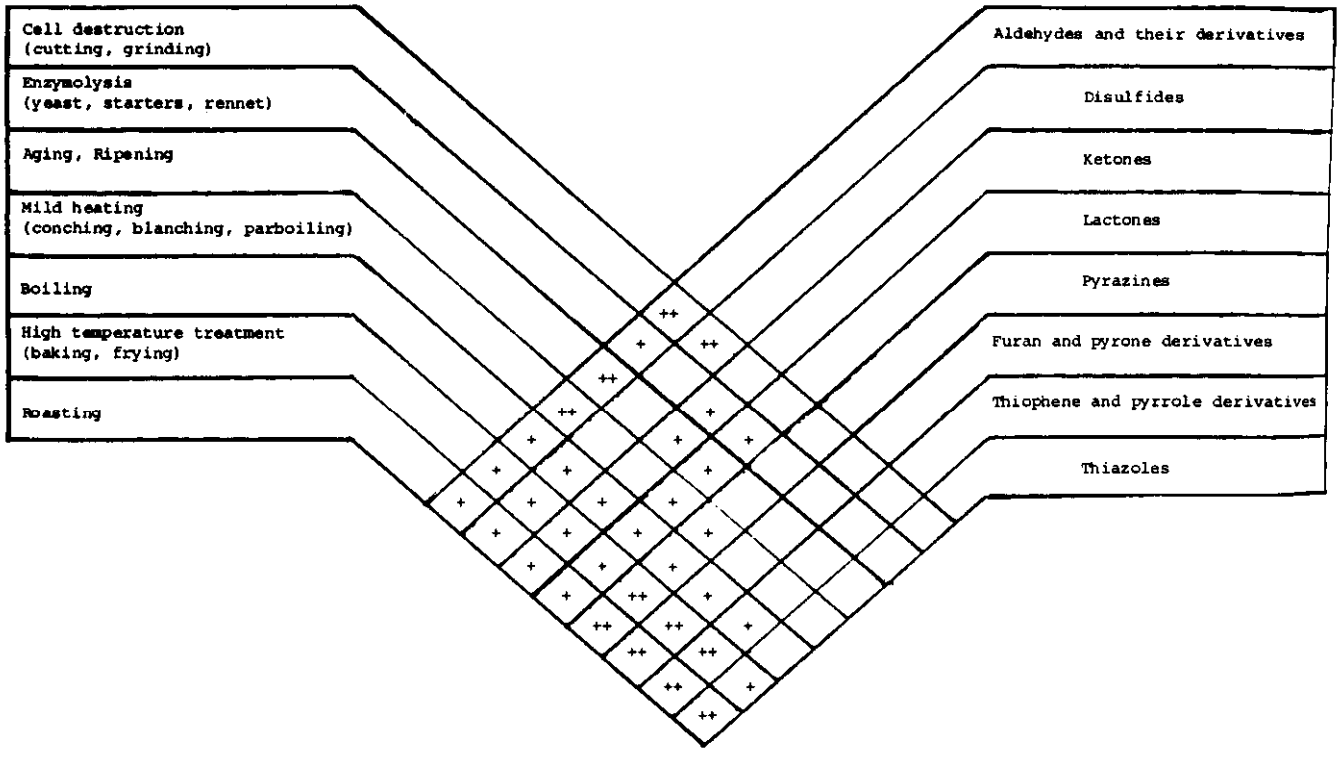

Figure 1. The formation of flavoring materials as a result of food processing (+ or ++ indicates the relative number and importance of the flavoring materials formed).

The Code of Federal Regulations, 21 CFR 101.22.a.3. states, in part, that "the term 'natural flavor' or 'natural flavoring' means the essential oil, oleoresin, essence or extractive, protein hydrolysate, distillate, or any product of roasting, heating or enzymolysis, which contains the flavor constituents derived from a spice, fruit or fruit juice, vegetable or vegetable juice, edible yeast, herb, bark, bud, root, leaf or similar plant material, meat, seafood, poultry, eggs, dairy products, or fermentation products thereof, whose significant function in food is flavoring rather than nutritional." This definition of "natural" clearly includes, in addition to physical treatment, all traditional food processing, including protein hydrolysis, fermentation and other enzymatic procedures. The natural flavoring constituents of food are not limited to those formed by normal metabolism, such as in green tea, milk or raw meat, but include those that have been formed by traditional processing, such as in black tea, cheese or roast beef.

The purpose of this study is to compare the flavoring materials formed during food processing with their synthetic counterparts that are used as flavor additives.

The relation between food processing and flavor formation is represented in a very general way in a wing-chart (figure 1).

The vegetable or animal starting materials are often very low in natural flavoring constituents. Even vegetables we deem flavorful when consumed raw, such as tomatoes, onions and cucumbers, have very little flavor in their intact state. This can be demonstrated by cooling the tissue to a very low temperature to deactivate the enzymes, and then breaking the cells and isolating the flavoring components. At normal room temperature, enzymes almost instantaneously form the flavoring materials with which we are so familiar. After having been released by cutting, the enzymes act on unsaturated fatty acids, (primarily linoleic and linolenic acid), present in other parts of the tissue in the form of triglycerides. Via hydroperoxidation, this leads to a whole series of saturated and unsaturated aldehydes (enals and dienals). These, in turn, are partly converted enzymatically into alcohols, acids, aldol condensation products, esters, acetals and so on. Just a few unsaturated fatty acids lead

to an impressive series of aliphatic flavoring materials as the complex result of simple cutting.

By cutting allium type vegetables (onion, garlic), instantaneous enzymolysis leads to even more dramatic effects: the formation of a lachrymator (thiopropanel S oxide) and dialkyldisulfides: these are mainly dipropyl disulfide in onions and diallyldisulfide in garlic. All these are breakdown products of sulfur containing amino acids present in the raw vegetation.

Enzyme Systems In Food Processing

In many cases, food processing involves the addition of enzyme systems, such as yeast for bread and wine, starter cultures for dairy products and rennet for cheese production. The enzymes also lead to the breakdown of linoleic acid and linolenic acid to aliphatic flavoring materials. In addition, they cause beta oxidation of fatty acids, followed by decarboxylation to methyl ketones, and formation of lactones by ring closure of hydroxyacids.

These same processes continue during the aging of wine and ripening of cheese. The amounts of the flavoring materials formed during the many competing chemical reactions determine the flavor profile of the finished food.

Heat treatment of food, from mild parboiling to intensive roasting, leads to several new classes of flavoring materials by the breakdown of amino acids, sugars, and minor ingredients such as carotenes. Strecker degradation of amino acids during the conching of chocolate and the parboiling of rice, leads to aldehydes with one less carbon atom. At higher temperatures, ketone and lactone formation takes place. The lactones are characteristic of the flavor of many baked foods containing butter.

The breakdown of a minimal amount of citric acid, which occurs naturally in milk, leads to the formation of some of the most important flavoring materials in dairy products, such as acetaldehyde in yogurt and diacetyl in butter.

By recombination of the amino ketones formed during the Strecker degradation, the very important substituted pyrazines are formed in breadcrust, roasted meat, roasted nuts and coffee.

At higher temperatures, decomposition of sugars leads to the important classes of furan and pyrone derivatives such as pineapple ketone and maltol. The formation of furan derivatives becomes even more predominant by the combined reaction of sugar and amino acid degradation products, via the Amadori rearrangement. So far, 107 furan derivatives as well as 80 pyrazine derivatives have been identified in coffee.

Lower sulfur- and nitrogen-containing derivatives result from the breakdown of amino acids. In addition to their own flavor contribution, they are also able to convert the furan derivatives to their sulfur analogs: the thiophenes; and their nitrogen analogs: the pyrroles.

During roasting processes, the recombination of low sulfur and nitrogen breakdown products from amino acids with sugar degradation products leads to thiazole formation. In addition to the well-known acetylthiazole, some 30 thiazoles have been identified in coffee alone.

From this review, it becomes clear that many, or even most, of the 5000 flavoring materials known to occur in traditional foods so far, are not present in the natural state. They are generated by the processing of the food. Especially when they result from heat treatment, they seem to be more related to the type of processing than to the specific food which has been processed.

The similarity of the qualitative lists of flavoring materials identified in cooked pork liver, roast beef, cocoa, roasted nuts and breadcrust, is striking. It is obviously the quantity in which these same identified flavoring materials are present in the various foods that determines the very characteristic flavor of the particular prepared or processed food.

CALCULATION OF THE CONSUMPTION RATIO

Flavoring substance: 2-METHYL PYRAZINE **FEMA No.** 3309

Occurring in:	Concentration ppm	Ref.	Annual per cap. consumption of this food	Ref.	Annual per cap. cons. of this flav. subst. in this food	Annual total cons. of this flavoring subst. calculated for the population of the U.S.		CONSUMPTION RATIO:
						VIA FOOD	AS ADDED FLAVOR	
Roasted beef	0.07	1	34.9 kg	5	2.44 mg	74112 kg	235 kg	315
Beer	0.07	2	94 kg	6	6.58 mg			
Coffee	65.0	1,3	4.85 kg	7	312.82 mg			
Potato chips	0.2	4	1.9 kg	8	0.380 mg			

REFERENCES:
1 - PFW unpublished data
2 - Proceedings of the 16th Congress of the European Brewery Convention (Amsterdam 1977) 693; Tressl, Renner, Kossa and Koppler
3 - Thesis, Berlin (1982); Silwar
4 - J. Sci. Food Agric. 23 (1972) 1435; Buttery et al.
5 - National Cattlemen's Association
6 - Beverage Industry, May 20, 1983, pg 32; J. Maxwell
7 - Advertising Age, April 30, 1979, page 70 (data from USDA)
8 - The Potato Chip/Snack Food Assoc., Arlington, Virginia

Figure 2: Calculation of the Consumption Ratio of 2-methyl pyrazine

Nature Identical Flavors

Most of the so-called natural flavoring ingredients of food are not present in the natural state of the food. They result from processing by what can only be called chemical reactions taking place during food preparation. Some of these chemical reactions, such as the roasting of food, are extremely complex and virtually uncontrolled. Nevertheless, it is a fact that the flavoring ingredients resulting from this kitchen-chemistry are readily accepted as "natural flavors;" whereas, there is considerable emotional resistance against "artificial" flavoring of food.

The flavoring materials used by the flavor industry are, however, not new and innovative chemical substances. With very few exceptions, they are exactly the same flavoring substances identified in food by the research groups working on the analysis of the flavoring materials in food, using mass spectroscopy, GLC and HPLC. They are what is generally known as "nature-identical," i.e., they occur in food as consumed.

Of course, there would be reason for concern if such nature-identical flavoring materials were added and consumed in quantities that are considerably larger than the quantity of the same flavoring components occurring naturally in traditional food. In order to compare these two quantities, I introduce the Consumption Ratio concept.

Consumption Ratio

The Consumption Ratio is the ratio between the quantity of a flavoring material normally consumed as part of the traditional diet, and the quantity of exactly the same material used by the flavor industry. If this Ratio is greater than 1, then the average consumption in the traditional diet is larger than the quantity deliberately added. I have called such a flavoring material: "Food Predominant." If the Consumption Ratio is over 10, then the quantity of such a flavoring material added deliberately is less than 10% of the average traditional consumption, and this can be called an insignificant increase in any respect, including safe consumption.

The fact that a flavoring material is widely consumed as a food ingredient does not prove its safety in the sense of a scientific test program. However, based on the assumption that our traditional food consumption is safe in practice, this same degree of safety can be claimed for flavoring materials that are consumed far more as food ingredients than as food additives.

As an example, the calculation of the Consumption Ratio of one of the flavoring materials formed during food processing, 2-methyl pyrazine, is given in figure 2. The total intake, per year in the U.S., of 2-methyl pyrazine as a "natural" ingredient of roast beef, beer, coffee and potato chips is over 74,000 kg. The total usage by the flavor industry per year as reported in the 1982 NAS/FEMA study is 235 kg, which leads to a Consumption Ratio of 315.

By this method, the Consumption Ratio has been calculated for 347 flavoring substances. 80% of them had a Consumption Ratio of more than 1, and are therefore predominantly consumed as natural ingredients of traditional food. 60% had a Consumption Ratio of over 10, which means that their additional intake as artificial flavoring materials is insignificant.

The true character of most flavoring materials traditionally considered natural is that they are the result of deliberate chemical processes known as food preparation. The true character of most artificial flavoring materials is that they are exactly the same substances as those present in traditional food, but consumed in smaller quantities.

From these considerations, it is clear that the simple, subjective and emotional distinction between "natural" and "artificial" flavorings is not justified. Growing food crops which have been genetically changed, and processing food using flavor precursors will make the distinction between natural and artificial flavors increasingly meaningless from both ends. No longer will it be the clear contrast between a raspberry and a candy made with amyl acetate, but between a genetically engineered botanical material, physically and enzymatically processed, versus a food manufactured with added flavoring complexes prepared by thermal and enzymatic processes, or even flavor precursors.

Consumers will have to realize that "nature" is not just there as an optimal source of nutrition for humans. Some of the most poisonous materials known, the botulins, are purely natural. The fact that a food is "natural" does not mean that it is safe nor that it represents the best possible nutritional value for man.

In practice, our food, including its traditional preparation, can be considered safe. Nevertheless, it is a fact that our food contains many ingredients that are virtually useless, and that many foods contain chemicals which, at certain dose levels, are known to be harmful. Examples of these are oxalic acid in spinach, and solanin in potatoes. In using added flavoring materials, no ingredients will be added that do not have a specific function in improving the flavor of the food.

The consumer will have to be informed about the true value and benefit of food and its ingredients. A marketing strategy inclined to label as many foods as possible "naturally flavored" to fit in easily with preconceived ideas is not going to achieve this goal. Consumer understanding should lead to the acceptance of prepared flavorings as normal and safe food ingredients. Only in this way will it be possible to develop new and better foods, with higher nutritional value per dollar, and to make more foods available for a world population, which, for the most part, has as its prime concern—to get enough food.

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