General, Legal and Safety Aspects of the Use of Flavourings

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The need for protection by food laws can be seen against the background of history. Adulteration of food, which is an offense against both the purchaser and other traders, has been practiced ever since the development of commerce made it profitable. In older times bread and flour were mixed with sand, tea with dust, copper salts have been used to colour green pickles and sulphuric acid to intensify inferior vinegar. Coffee, spices and curry powder have all been extended by worthless ingredients. In 1860 it was said in England that the only food which could be bought unadulterated was an egg and that was only because there was no practicable method for introducing a foreign substance into the egg.

Therefore, from the earliest times, trying to prevent their citizens from being poisoned or swindled by unscrupulous food manufacturers and traders, governments have passed all sorts of food laws. At the beginning food laws were designed quite simply to stop the sale of food which was injurious to health and which had been adulterated.

As society developed, however, to prevent descriptions that could mislead the consumer, it became necessary to extend food laws by issuing standards of identity as well as labeling regulations. At present, modern food laws require extensive consumer information such as listing of ingredients, nutritional value and date marking.

Today the potential hazards of our foods are quite different and have been ranked by several experts[1] from the greatest to the least risk as follows:

—*Microbial contamination,* either *direct,* due to pathogenic microorganisms, resulting from poor sanitary control during preparation or storage in the home or processing plant; or *indirect,* due to metabolic products of microorganisms, called mycotoxins such as botulism toxin, aflatoxin and patulin

—*Malnutrition,* that means in our affluent society an excess of sugar, fat, alcohol and salt

—*Environmental contaminants,* e.g., PAHs, PCBs, DDT, dioxins, lead, cadmium and mercury

—*Natural toxicants,* e.g., glycoalkaloids (solanine in potatoes), cyanogenetic glycosides, quercetin and nitrosamines

—*Pesticide residues,* in particular halogenated hydrocarbons

—*Food additives,* in which category flavouring agents have a very special position.[2]

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A quantification of these risks has been made at the Maribou Symposium on Food and Cancer:[3]

> "Of the potential sources of harm in foods the largest by far are, first, microbiological contamination and, next, nutritional imbalance. Risks from environmental contamination are about 1000 times less and risks from pesticides residues and food additives can be estimated as about a further 100 times smaller again. Naturally occurring compounds in food are far more likely to cause toxicity than intentional additives."

Recently, in Germany, it was calculated that less than 15% of the food consumed per capita per year is flavoured. This quantity of food contained 8.5 g of flavouring substances, that is, about 25 mg per person per day.[4] This 25 mg generally contains ten to hundreds of flavouring substances, therefore the impact on our metabolism is rather small. Consequently, in Europe the greater part of ingested flavourings originates from our daily foods.

Basically, our daily food consists of the nutrients: water, protein, fat, carbohydrates, minerals and vitamins and a characteristic mixture of flavouring substances. This characteristic mixture of flavouring substances distinguishes chicken from vegetable soup, leeks from endives and brussel sprouts, the Dutch from the Idaho potato, beef from pork, Gouda cheese from Cheddar or Camembert, Cognac Napoleon from Remy Martin or Joseph Guy.

Very striking is the large number of individual flavouring ingredients in natural food flavours and the formation of flavouring substances by conventional kitchen heat treatments such as cooking, baking and broiling:[5] The number of identified substances in natural flavours may be listed thus:

Banana: 325 substances
Orange: 250
Tomato: 350
Milk and milk products: 250
Cheddar: 160
White bread: 275
Potato: 125
Potato, baked: 250
Rice: 75
Rice, cooked: 150
Beef, heated: 625
Coffee: 625
Beer: 425
Wine: 475
Cognac: 425

Flavourings

Flavourings are concentrated preparations of flavouring agents, with or without flavour adjuncts, used to impart flavour to a variety of consumer products, such as: *sweets* (alcoholic beverages, chewing gum, chocolate confectionery, flour confectionery, ice cream, soft drinks, sugar confectionery), *savories* (corn curls, dressings, gravies, meat products, snack foods, soups and broths), *dairy products* (yoghurt with fruits, milk drinks, processed cheese) or *miscellaneous products* (margarine, pet food, pharmaceutical products, tobacco, toothpaste).

Flavouring agents are substances or products which give when tasted a characteristic flavour sensation. Flavouring agents may be subdivided into seven categories:

—*Aromatic natural products:* products of vegetable, animal or microbial (fermentative) origin, used for their flavouring properties, either as such or processed for human consumption. *Examples:* fruits, wine, cognac, cheese, herbs and spices, vinegar, fried onions.

—*Natural flavouring complexes:* aromatic products obtained from vegetable, animal or microbial (fermentative) origin by physical processes, e.g., distillation, extraction, pressing. *Examples:* essential oils, absolutes, concentrated fruit juices, spice extracts, enzyme modified cheese, autolyzed yeasts, hydrolyzed vegetable proteins.

—*Natural flavouring substances:* single flavouring substances obtained from products of vegetable, animal or microbial (fermentative) origin or from natural flavouring complexes. *Examples:* citral from lemongrass oil, menthol from peppermint oil, anethol from anise or star anise oil, eugenol from clove oil, carvone from caraway or spearmint oil. *Biologically prepared examples:* starter distillate, citric acid, ethyl alcohol, lactic acid, tartaric acid, MSG, IMP and GMP. (In this era of back-to-nature trends, this category is expected to grow significantly.)

—*Nature-identical flavouring substances:* single flavouring substances obtained by chemical synthesis and which are chemically identical to flavouring substances occurring naturally in products of vegetable, animal or microbial (fermentative) origin or in natural flavouring complexes. Yearly, CIVO publishes the booklet "Volatile Compounds in Food." The 5th Edition lists approximately 4000 different substances in 181 specific foods.[5]

—*Artificial flavouring substances:* single flavouring substances obtained by chemical synthesis and which are chemically not identical to flavouring substances occurring naturally in products of vegetable, animal or microbial

(fermentative) origin or in natural flavouring complexes. *Examples* of well-known artificials and specific applications in flavourings:

allyl cyclohexyl propionate/pineapple
ethyl methyl phenyl glycidate/strawberry
anisylacetone/raspberry
6-methylcoumarin/caramel
ethyl vanillin/vanilla
butyl butyryl lactate/butter
methyl heptin carbonate/green note in many fruity flavours

—*Smoke flavourings:* products obtained from the distillate of the pyrolysis of wood. Industrial manufactured smoke flavourings are characterized by a very low α-benzpyrene content.

—*Process flavourings:* products obtained from raw materials which are foodstuffs or constituents of foodstuffs by processes similar to traditional kitchen treatments. In these processes caramelization and Maillard reactions play a dominant role, reactions which, since the invention of the fire, produce significant quantities of flavouring substances via cooking, baking (bread), broiling (meat), frying (potatoes) and roasting (coffee, cacao).[6]

Basically, all these products are on the palette of the flavourist for creating all types of flavourings as well as flavour adjuncts used for compatibility reasons. To make the flavourings easily applicable for the food manufacturer, they are commonly diluted with neutral carriers, liquid or dry. Some liquid carriers are water, ethyl alcohol, isopropyl alcohol, glycerol, acetic esters of glycerol, propylene glycol. Examples of dry carriers are salt, dextrose, rusk, (modified) starch, rice grit, maltodextrins.

The use of emulsifiers, thickening and gelling agents, preservatives, antioxidants, and anticaking agents is self-evident. Flavour enhancers serve some clarification. These substances increase and round off the taste of flavourings significantly when used at concentrations in which they have themselves little or no taste at all.

Monosodium glutamate (MSG) and the ribonucleotides inosine monophosphate (IMP) and guanine monophosphate (GMP) are well-known representatives of this class of food additives. High intakes of MSG have been associated with "Chinese Restaurant Syndrome." Susceptible individuals indeed feel discomfort when consuming large quantities of MSG, but these effects seem related to L-glutamic intolerance. All amino acids, except alanine, have shown to be toxic in large doses. However, humans seem able to tolerate at least ten times the recomended daily intake of essential amino acids with nothing more severe than gastric distress.[7]

International Institutions

Since World War II two political institutions have been established in Western Europe, the Council of Europe (CE, 1949) and the European Community (EC, 1958), also called the Common Market. At present the CE includes twenty-one member states: Austria, Belgium, Cyprus, Denmark, France, The Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, the Netherlands, Norway, Portugal, Sweden, Spain, Switzerland, Turkey and the United Kingdom. After the entry of Greece on January 1, 1981, the EC comprises ten member states: Belgium, France, Denmark, Greece, The Federal Republic of Germany, Ireland, Italy, Luxembourg, the Netherlands and the United Kingdom.

Objectives of the CE and EC are to achieve more harmonization between its members aimed at safeguarding and realizing the ideals and principles of their common heritage and facilitating their economic and social progress.

The scope of both political institutions deals

with almost every activity of daily life in Europe, since only defense questions are excluded. While agreements in the CE are optional, EC agreements called Directives have to be enforced in the national legislation of the member states.

Council of Europe

A group of experts has reviewed the safety-in-use of flavouring agents, which are published in the "Blue Book".[8] It includes a list of natural sources of flavourings classified into four categories: N1, edible foods; N2, kitchen herbs and spices; N3, traditional sources of flavourings; N4, other sources. Toxicologically active principles present in these naturals are given and limitations in foods and drinks are set. Single chemical flavouring substances are categorized in two lists: fully evaluated substances and materials for which further toxicological information is required. Very likely due to enforcement problems, the "Council of Europe List" has not been used as a basis for flavour regulations in any member state, however, worldwide it is recognized as a useful reference guide.

European Community

In the framework of harmonization of food laws of the EC member states, EC Directives have been published on the following classes of food additives: antioxidants, colours, emulsifiers, stabilizers, thickeners and gelling agents and preservatives. Draft Directives on acids, bases and salts, chemically modified starches and flavourings are under discussion. In these Directives the positive list principle is applied, i.e., only the listed substances may be used, which are characterized by E-numbers and classified as follows:

Colours: E 100-199
Preservatives: E 200-299
Antioxidants: E 300-399

Emulsifiers, stabilizers, thickeners and gelling agents: E 400-499

An essential feature of the EC Directives is that they do not prescribe maximum limits or specify foods in which the additives may be used. This is a national prerogative; use levels and foods allowed to contain various additives are regulated in the food laws of the member states. Obviously, this provision leads in practice to barriers of trade since products which are legally manufactured and marketed in a member state may not be exported to other countries due to differences in legislations. Since all major flavour houses export most of their production, benefits

of a fully harmonized market are lost at the cost of expensive reformulation work and production capacity losses.

EC Directives on food commodities have been published on: cocoa and chocolate products, coffee extracts, certain sugars, honey, fruit juices and similar products and preserved milk. Draft Directives for further commodities exist but not much progress has been made in recent years.

A Directive on the "Labelling, presentation and advertising of foodstuffs for sale to the ultimate consumer" is in force in the EC as of January 1, 1983.

The Scientific Committee on Food has advised the competent EC officials in establishing the positive lists of additives. This group of experts has recommended to restrict the use of natural aromatic products which contain "active principles," in particular: β-azarone, coumarin, hydrocyanic acid, safrole and iso-safrole and thujone (α- and β-).[9]

Codex Committee on Food Additives

One of the subsidiary bodies of the Codex Alimentarius Commission (established in 1963 by FAO and WHO, to develop international food standards) is the Codex Committee on Food Additives. This committee considers all the food additive provisions in Commodity Standards being developed by other subsidiary bodies such as the Committees on Processed Fruit and Vegetables, Cocoa Products and Chocolate, Sugars, Fats and Oils, Meat, Processed Meat Products, Fish and Fishery Products and Edible Ices. Information as to the safety-in-use of food additives is made available to the Committee by the Joint FAO/WHO Expert Committee on Food Additives (JECFA). Food additive categories evaluated by JECFA are:

Acidity regulators	Flavours
Anticaking agents	Flavour enhancers
Antifoaming agents	Modified starches
Antioxidants	Phosphates
Artificial sweeteners	Preservatives
Colours	Stabilizers
Emulsifiers	Thickening/Gelling agents
Emulsifying salts	Miscellaneous
Enzymes	

About 350 additives have been reviewed including eighty-seven flavouring substances. Due to the large number of flavouring substances (approx. 3000) the Committee recommended at its twentieth session to set priorities by a procedure that will classify these materials in decreasing order of potential risk.[10] Recently Volume XIV of the Codex Alimentarius Commission dealing with Food Additives has been published.[11]

A draft, "General Requirements for Natural Flavourings," is under discussion. Active principles listed are: agaric acid, aloin, β-azarone, berberine, cocaine, coumarin, hydrocyanic acid, hypericine, pulegone, quassine, quinine, safrole, santonin, and thujone (α- and β-).[12]

International Organization of the Flavour Industry

IOFI, representing twenty national organizations of flavour manufacturers, has published a booklet "Basic Features of Modern Flavour Regulations."[13] It extensively discusses three principal systems to regulate flavouring agents. The first is *the negative list system,* any substance may be used unless explicitly prohibited. Next, *the positive list system,* any substance may be used if it is explicitly authorized and, finally, *the combined or mixed-list system,* i.e., any substance which occurs naturally in the diet may be used unless prohibited or restricted and any substance not naturally occurring in the diet may not be used unless explicitly permitted.

In their view the negative list is of academic interest only and the positive list is impracticable. Therefore, they strongly advocate the mixed-list system, which essentially is based on an appraisal both from toxicological findings and human experience of long history-of-use.

The IOFI Code of Practice[14] lists as natural and nature-identical active principles:

agaric acid	hypercine	safrole
β-azarone	pulegone	santonin
berberine	quassine	spartein
coumarin	quinine	thujone

with limitations in foods and drinks. In addition maximum contributions by flavourings to final foods for 3,4-benzopyrene (0,03 ppb) and hydrocyanic acid (1 ppm) are given.

The IOFI positive list of artificial flavouring substances presents about four hundred substances, of which all have been authorized by FDA/FEMA and/or the Council of Europe, while some have been cleared by the Dutch competent authorities.

Further, the IOFI Code contains listings of flavour adjuncts necessary for the production, storage and application of flavourings and defines good manufacturing practice in the flavour industry.

In addition, IOFI has established guidelines

for the production and labeling of process flavourings.[15]

IOFI sponsors two CIVO publications on the occurrence of flavouring substances in our daily foods, Volatile Compounds in Food, Qualitative Data[5] and Volatile Compounds in Food, Quantitative Data.[16] Quantitative data on flavourings in food are essential for the calculation of Consumption Ratios which will be discussed later.

National Legislation

This section highlights only certain characteristics of national regulations on flavourings and gives label declarations of flavoured pre-packaged food. From the classification as "natural," "nature-identical" and "artificial" the following label declarations apply:

—natural flavouring (NN), the flavouring contains exclusively natural flavouring complexes and natural flavouring substances
—nature-identical flavouring (NI), the flavouring contains nature-identical flavouring substances with or without natural flavouring complexes and natural flavouring substances
—artificial flavouring (AA), the flavouring contains artificial flavouring substances with or without natural flavouring complexes, natural flavouring substances and nature-identical flavouring substances.

Western-European countries with mixed-list type systems include Germany, Italy, The Netherlands, and Spain.

Germany BRD has the following specific flavour regulations: a list of prohibited substances and products, a restrictive list of five active principles, a list of fifteen artificial substances, a list of flavour adjuncts, labeling of flavourings or flavoured pre-packaged foods as "natural," "nature-identical" or "artificial" flavouring. In addition, in natural flavourings vanillin may be used for rounding off effects without affecting the declaration "natural."

In Italy specific flavour regulations require that only nature-identical flavouring substances present in edible vegetable materials may be used. Of a list of seventeen artificial substances, seven out of the seventeen enjoy natural occurrence in foods at the present time. There is also a list of flavour adjuncts, and regulations for labeling of flavourings and flavoured pre-packaged food as "aromi naturali" (naturals + nature-identicals), "aromi artificiali" (artificials).

The Netherlands has specific flavour regulations such as a restrictive list of natural and nature-identical flavouring substances, a positive

list of 256 artificials, a list of flavour adjuncts, labeling of flavourings as "natural," "nature-identical" and "artificial" flavouring, in natural and nature-identical flavourings, vanillin (ethyl vanillin) may be used for rounding off effects. Labeling of flavoured pre-packaged food "flavouring" is also required.

Spain's specific flavour regulations include a list of prohibited plants, a restrictive list of ten natural and nature-identical flavouring substances, a list of 294 artificial substances, a list of flavour adjuncts, labeling of flavourings as "natural," "natural reforzado" (containing 4 g of nature-identical flavouring substances per liter), "aroma al gusto de . . ." (containing nature-identical flavouring substances) and "aroma artificial." Labeling of flavoured pre-packaged food as "natural flavourings," "authorized flavourings" (nature-identicals), "authorized artificial flavourings" (artificials) is also required.

Austria and Switzerland have no specific flavour regulations or no label requirements for flavourings. However, lists of generally permitted food additives and labeling of flavoured pre-packaged food "natural" and "artificial" have been established.

Belgium also has no specific flavour regulations or label requirements for flavourings but lists of additives which may be used in flavourings and labeling of flavoured pre-packaged food with "flavouring" and "artificial flavouring" is standard.

Although Denmark has no specific flavour regulations or no labeling requirements for flavourings, there are a list of prohibited substances and plant materials, a restrictive list of active principles, lists of generally permitted food additives and labeling of flavoured pre-packaged food as "flavourings."

Finland, with no specific flavour regulations, still maintains lists of generally permitted food additives, labeling of flavourings and flavoured pre-packaged food as "natural", "nature-identical" or "artificial." In addition certain essential oils and spices, vanillin, ethyl vanillin and diacetyl must always be labeled.

France has no specific flavour regulations. Lists of generally permitted food additives apply here, as well as labeling of flavourings as "natural" and "artificial" flavouring. 4001, 4002 and 4004 flavourings may contain 1, 2 and 4 g of nature-identical flavouring substances per kg 4 times concentrated natural flavourings. Their use is authorized for specific flavourings and end-use applications. The label must declare "flavourings." Labeling of flavoured pre-packaged food is the same as for flavourings.

In Greece, Norway, Sweden, United Kingdom there are no specific flavour regulations or no labeling requirements for flavourings. Lists of generally permitted food additives and labeling of flavoured pre-packaged food "flavourings" are established.

Portugal has no specific flavour regulations or labeling requirements for flavourings. It does have lists of generally permitted food additives and labeling of flavoured pre-packaged food "natural", "nature-identical" and "artificial."

The Eastern-European countries of Bulgaria, Poland, Rumania and the Soviet Union have flavour regulations based on the positive list system, characterized by very short lists of flavouring agents. These regulations do not apply to imported flavourings, which have to be registered at the Ministry of Health.

The food additive policy in the United States is based on the "Generally Recognized As Safe" (GRAS) principle, which requires that every new additive before usage has to be evaluated by experts qualified by scientific training and experience. GRAS substances are published in the Code of Federal Register of the Food and Drug Administration (FDA) and in lists published by the Flavor and Extract Manufacturers Association (FEMA).[17] The FEMA safety evaluations have been carried out by a non-industry related "Expert Panel" of scientists.

Just as in Austria, France and Switzerland, only two categories of flavouring agents are defined, "naturals" and "artificials." The GRAS lists include approximately 375 natural flavouring agents and about 1375 artificial substances.

Calamus and its derivatives, sassafras oil, safrole and its derivatives and coumarin are prohibited.

Clearance of Flavouring Agents

The review of flavour regulations in Western Europe justifies the conclusion that regulations are rather liberal, i.e., the usage of flavouring agents is the full responsibility of the manufacturer. Key words in most regulations are natural, nature-identical and artificial and clearance of these categories will be briefly discussed.

- *Naturals (NN)*

Natural flavouring agents may be derived from food and non-food sources. The food category includes flavouring agents derived from basic foods, e.g., vegetables, fruits, nuts, meat, fish poultry, seafood, and dairy products. Also included in this category are herbs, spices and condiments, e.g., dill, basil, celery, mint, nutmeg,

pepper, cloves, vanilla, ginger, licorice, or others. Alcoholic beverages, e.g., beer, wine, brandy, whiskey, and rum, as well as stimulants, e.g., coffee, tea, cocoa, are additional food sources for natural flavorings. Essentially, these products are our daily foods and therefore generally permissible.

Non-food sources for the preparation of flavouring agents include ten groups. Among these are balsam exudates (Copaiba, Peru, Tolu), and gum-oleoresin exudates (asafoetida, galbanum, labdanum, mastic, myrrh, styrax). Flowers (boronia, cassie, cananga, davana, jasmin, chamomille, lavender, mimosa, violet, rose), leaves (bay, buchu, eucalyptus, geranium, camphor, clove), wood (amyris, bois de rose, guaiac), needles and twigs (cypress, pine, spruce) and barks (birch, cascarilla, cinnamon) are sources. Also there are grasses (citronella, lemongrass, palmarosa), roots + rhizomes (angelica, costus, orris, calamus, vetivert) and peels (orange, lemon, lime, grapefruit, mandarin).

Flavouring agents belonging to this group are acceptable only if they are present on CE, FDA/FEMA lists, or when it can be proven that such a material has a long history-of-use, i.e., has been present in the traditional diet of a large population.

- *Nature-Identicals (NI)*

Based on the long history-of-use of our basic and traditional foods we have to assume that our daily food is not hazardous to health. This means that the ingredients, including the flavouring substances, are "safe" when applied in consumer products at a level at which they occur in our daily foods. This Stofberg concept is the essence of the Consumption Ratio.

At the session of the Codex Committee on Food Additives in April in The Hague (1984), Dr. Stofberg presented a paper on Consumption Ratios of flavouring substances.[18] The Consumption Ratio (CR) is defined as the ratio between the quantity of a flavouring substance consumed as an ingredient of basic and traditional foods and the quantity of the same flavouring substance consumed as a component of added flavourings by the same population over the same period. The CR of 347 flavouring substances has been calculated, 296 of these naturally occurring substances have a CR >1 and 205 have a CR >10. Some striking examples are presented in Table I, in which also the number of foods are given of additional qualitative occurrence.[5] In general, the numerical value of the CR will increase if more quantitative data become available. The CIVO publication, "Volatile Compounds in Food, Qualitative Data",[16] is a good start but contribution from research of flavour companies is essential. The CR concept in my opinion underpins adequately the validity of the mixed-list system.

To prevent that NIs with an irreversible toxic effect will be used for food flavouring purposes, they should be run through the "decision tree". This procedure proposed by Cramer et al. establishes the potential hazard of a chemical structure using currently available biological data.[19] It con-

Table I. Consumption Ratios

Flavouring Substance	FEMA Number	Number of Foods with Quantitative Occurence	Annual Consumption Via These Foods U.S. Population in kg	Annual Usage U.S. Flavour Industry in kg	CR	Number of Foods with Qualitative Occurence
2-Acetyl pyrrole	3202	beef, beer, coffee, chips	45,293	0.2	126,465	28
2-Methyl phenol	3480	beer, coffee	7,415	0.1	74,150	12
2-Undecenal	3423	olive oil, chips	12,869	0.2	64,345	13
3,4-Dimethoxy-1-vinyl benzene	3138	coffee	3,347	0.1	33,470	rum, bonito
Phenol	3223	beer, butter, coffee				50
Butyric acid	2221	cheese, coffee, beer, butter, white bread, fish, yogurt, apple juice, strawberry	843,152	26,636	31	50
1-Hexanal	2557	16	90,589	1,884	48	81
Isoamyl alcohol	2057	10	1,076,000	16,308	66	78
Ethyl acetate	2414	9	967,426	14,405	67	85
Methyl sulfide	2746	7	57,205	2,092	27	46

sists of a "decision tree" of 33 questions, each answered by "Yes" or "No." Each answer leads to a final classification into three classes (I, II and III) reflecting a presumption of low, moderate or serious toxicity. All recognized carcinogens and natural toxicants are in Class III.

In an exercise with 227 substances causing cancer in two or more species, 226 fall into Class III, with the single exception of xanthine which falls into Class I. This classification was not regarded as an aberrant by the authors, since the testing of xanthine which produced neoplasms involved not the oral route, but subcutaneous administration and implantation.

- *Artificials (AA).*

Artificials, flavouring substances which have not been identified in foods, are foreign to the human body. Therefore, these so-called xenobiotics should be fully toxicologically evaluated before they can be used in flavourings. Such evaluations are carried out by FDA/FEMA, CE and JECFA.

- *Process Flavourings (PF).*

Process flavourings are generally permissible if the raw materials are exclusively foods, eventually reinforced with a limited number of components present in these foods, and when the processing-conditions are comparable with normal kitchen treatments.

Flavourings manufactured with other raw materials or different processing conditions should be toxicologically evaluated fully.

Risks and Common Sense

To be alive is to be at risk and to take risks. Almost every aspect of life including vehicular transportation, working, sports, eating, drinking and smoking is accompanied by some degree of risk. However, the degree of risk depends upon the way these activities are performed. Public transport is safer than car driving, working in an office means taking less risks than working in a plant, playing football is less dangerous than rock climbing, and health risks are small when eating a nutritious, sober but palatable meal. A glass of wine is consistent with good health practices; drinking to excess involves health problems.

In discussions on food and health, emotion predominates many times over common sense. Existential estrangement, fear for the unknown, cancer and death are narrowly linked with these emotional approaches. Peto and Doll have estimated the proportions of cancer deaths attributed to different factors (see Table II).[20] The highest contributions are the diet (35%), smoking (30%), infections (10%) and sex and pregnancy (7%). Food additives account for less than 1%, with a range of −5 to +2%. The range dips into the negative because some additives help to prevent cancer, such as BHA, β-carotene, ascorbic acid and tocopherols.

Table II. Factors and Percentages of Cancer Deaths

Factor	Mean %	Range %
Diet	35	10-70
Smoking	30	25-40
Infections	10	?
Sex and pregnancy	7	1-13
Occupation	4	2-8
Geophysical	3	2-4
Alcohol	3	2-4
Pollution	2	1-5
Pharmaceuticals and medical treatments	1	0.5-3
Food additives	1	-5 to +2

Since all types of in vitro mutagenicity tests have been established, a large number of chemicals have been published, among them food components, which show mutagenicity in one or more test systems. That sounds alarming, however, here also common sense may be enlightening. If all the test results did induce the changes the tests suggest, humans as a species would probably have perished long ago. Obviously, mankind has survived, partly because the hazards detected by new tests are not new to human physiology. Humans have met them before and evolved substantial defense mechanisms over time. The main defenses depend upon the following:[21]

—*Dose.* Usually even food chemicals are encountered at very low dosage and metabolic capability is easily able to cope. Available test systems, using high dosage, might be misleading.

—*Bacteria.* The bacteria in the alimentary canal are able to break down chemicals and thereby prevent their absorption.

—*The Immune System.* A particularly potent human immune system is able to remove foreign material which gains access to the body, or which is generated by abnormal processes. For example, some cancer cells are treated as foreign when they first appear and must survive the immune attack in order to grow.

—*DNA Repair.* The human system seems to be more efficient at repairing DNA than that of many other species and thus preserves its genetic integrity to a greater extent.

Another important factor in survival are the anticarcinogenic substances present in our daily foods. According to Ames, substances such as tocopherols, β-carotene, selenium, glutathion and ascorbic acid have anticarcinogenic properties.[22]

Conclusions

As far as safety is concerned, flavourings are as safe as our daily foods; the toxicology of flavourings is inseparably linked with the toxicology of food.

Unfortunately the general public perceives flavourings as "cosmetic products" that are dispensible. They ignore, however, the effect of flavourings on human physiology and deny that flavourings add significantly to the acceptability and pleasure of foods and in this way contribute to human daily life. Hence, flavourings are safe and useful.

Therefore I full heartedly quote Goddijn's conclusion in the lecture on the "Netherlands View on Flavours" at the European Toxicology Forum:[23]

> "Given the 'paralyzing' number of chemicals of all kinds in the environment which need your attention and consequently the need for identifying the most urgent issues, my advice to you is stop worrying about flavours."

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