Consumption of flavoring materials as food ingredients and food additives

By J. Stofberg, PFW, Middletown, NY, and
J. Stoffelsma, PFW BV, Amersfoort, The Netherlands

It is widely acknowledged that flavoring materials constitute a special class among food additive groups. Safety evaluation and regulation of food additives are generally carried out on an individual basis, considering the available test data, and setting maximum use levels for their use in separate classes of food, or in food in general. From a safety viewpoint establishing an acceptable daily intake (ADI) based on the test result data is an even more accurate approach, although it is a less suitable basis for setting regulatory limits.

No such systematic evaluation has been carried out yet for flavoring materials, even though ADIs have been established for a few.[1] The most basic reason that this classical food additive approach has not been completed for flavoring materials is their great number and variety. Flavoring materials as a group already outnumber all other food ingredients together. With the strict approach now taken toward potential new food additives, it can be anticipated that the number of nonflavor food additives will grow only very slowly in the future. But we can equally anticipate that with every new breakthrough in techniques for the analysis and identification of flavoring materials occurring in traditional foodstuffs, there will be a whole new generation of flavoring materials. Developments in gas liquid chromatography (GLC) and spectrometry over the last thirty years have made possible the discovery of thousands of new flavoring substances, characterized by their volatility. The current development of high performance liquid chromatography (HPLC) will provide us with large numbers of flavoring materials which are not volatile enough, or break down too easily, for detection by gas chromatographical analysis. Further refinement of such techniques will increasingly bring flavor analysis down from the ppm level to the ppb level—and many new flavoring materials will thus be identified that are essential at that level for further improvement or development of nature-identical flavors.

This expectation of future developments also reveals another, even more important reason for flavoring materials to be considered as a special class of food additives. Most of them are not only materials added to food for flavoring purposes, but, actually, ingredients of our traditional foods. The number of flavoring materials that have been identified in food is growing rapidly, whereas the relatively small number of flavoring materials discovered in organic chemical laboratories has become almost constant and is probably now declining.

The importance of food-identity of flavoring materials has been recognized in their safety evaluation in various ways. It has been taken into consideration by the FEMA Panel of Experts as one of their criteria in concluding whether a flavoring material can be generally recognized as safe (GRAS) as defined in the regulations of the Food Drug and Cosmetic Act of the United States.[2] In most other countries, nature-identity in itself is considered sufficient evidence for safe use of a flavoring material.

To exploit fully the true value of the nature-identical concept it is essential first to understand its real meaning, which is frequently misinterpreted. Its main claim as evidence for safe use of a flavoring material has always been long and favorable experience with such a material in human consumption of traditional foods. The fact that a flavoring material occurs in nature in its widest form does not guarantee that such consumption has taken place, unless it occurs in a natural foodstuff. Even if the substance occurs in the natural form of a foodstuff, its consumption can still not be taken for granted, as the food may only have been used in a prepared or cooked form. In that case only its occurrence in the form in which the food is traditionally consumed would provide evidence of use experience. Further, the quantity of the material consumed per day, as the average for a group, or by an entire population, is an essential factor in adducing evidence of safe use.

IOFI, the International Organization of the Flavor Industry, has worked to restore the validity of nature-

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identical status by defining nature-identical flavoring substances as "substances obtained by synthesis or isolated through chemical processes from aromatic raw materials and chemically identical to substances present in natural products intended for human consumption, either processed or not."[3] Virtually the same definition has been accepted by the Code Committee on Food Additives of the Codex Alimentarius (FAO/WHO),[4] and nature-identical flavorings have been temporarily endorsed in the Codex for use in many categories of foodstuffs on this basis.[5]

This understanding of nature-identity has led to the concept of quantitative food-identity.[6] The special attention given to quantifying the natural occurrence of flavoring materials in traditional food leads to a further analysis of the importance of the role of flavoring materials as food ingredients. In 1979, several examples were published comparing the quantities of certain flavoring materials used by the flavor industry in the United States, and the amounts of the same flavoring materials consumed in some of the foods in which they occur.[7]

The main reason this quantitative aspect of food-identity has not previously been explored is almost certainly the lack of reliable quantified data on the occurrence of flavoring materials in foods as consumed. Even this paper must be limited to only a few food categories, on which published quantitative data exist, or on which the flavor research department of PFW has conducted quantitative analyses, unpublished as yet. These quantitative analyses have often been carried out on extracts prepared by steam distillation. As losses during such extraction procedures are unavoidable, the calculation of the quantities actually present in the food will necessarily err on the low side.

For several specific flavoring ingredients, consumption data by a large population have been calculated and compared with flavor industry usage in the United States in the accompanying table. In column 1, the name and FEMA GRAS number of these flavoring materials have been listed in numerical sequence. In column 2, the level of the flavoring material occurring in the food has been reported in parts per million. Column 3 gives the average annual per capita consumption in a certain population. In the case of olive oil, the population involved was the total combined populations of Greece, Italy, and Spain (102.8 millions), since these countries are some of the main consumers of the world's olive oil production. In case of all other foodstuffs the population in question was that of the United States (216.4 millions). In column 4, the total annual consumption by this population of the flavoring material as a component of the food is calculated by multiplying the per capita consumption by the number of people involved. Column 5 gives the total annual use of the same flavoring material reported by the United States flavoring industry.

As the table covers only a few food categories, it should be kept in mind that considerable quantities of the flavor materials listed—as well as of very many others—are being consumed in many other foodstuffs as well. In some cases foodstuffs contributing far more to the consumption of the flavoring material (such as fruits, in the case of amyl alcohol) have not yet been included. But even allowing for this reservation, some of the quantitative comparisons are dramatic. This effect will only be increased by extending the study to other foodstuffs. It should be further noted that the consumption via food includes representatives of various large and important classes of flavoring materials discovered and developed over the last few decades: unsaturated alcohols, dienals, pyrazines, phenols, lactones, thiazoles, and others.

In evaluating the safety of flavoring materials, the hazard of their toxicity can be estimated by a decision tree approach to their chemical structure, their dosage, and the metabolic mechanisms involved.[34] This process will result in setting priorities for further testing to be done on certain flavoring ingredients. The costs of long term testing are high and the available laboratory capacity is insufficient. There is increasing doubt about the validity of short term tests. Therefore, all reasonable arguments should be used to decide for which materials such long and short term testing is warranted and meaningful.

Quantitative food identity represents a major new tool in helping us make this decision. The basis of quantitative food identity is the consumption of unavoidable and harmless quantities of flavoring materials in the form of traditional foods. Therefore a comprehensive study is needed of the quantitative occurrence of flavoring materials in all common foods, such as fruits, vegetables, meat, seafood, cereals, and spices. Low priority for further testing should be assigned to those materials, for which use in flavorings would mean only an insignificant addition to their normal consumption in traditional foods which may be considered safe. Priority for the testing of such flavoring materials should be similar to that of the food in which they occur.

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Large Population Consumption of Specific Flavoring Ingredients Compared with Flavor Industry Usage

1	2			3			4		5	
Flavoring material Name FEMA GRAS #	Occurring in	Concentration	Ref	Annual per cap. consumption of this food	Ref	Annual per cap. consumption of flavoring material via this food	Annual total consumption of the flavoring material via this food	By the population of	Total annual usage by the Flavor Industry of the U.S.	
									1973	1977
acetophenone 2009	cocoa	1.5 ppm 1.8 ppm	8 14	1.22 kg	9	1.8 mg 2.2 mg	396 kg 475 kg	U.S.A.	1485 kg	
allyl mercaptan 2035	onion	0.3 ppm	8	6.3 kg	12	1.9 mg	409 kg	U.S.A.	226 kg	
amyl alcohol 2056	cocoa	0.01 ppm 0.05 ppm	8 14	1.22 kg	9	0.012 mg 0.006 mg	2.6 kg 13.2 kg	U.S.A.	1796 kg	
	tomato	0.3 - 1.8 ppm	15	32.9 kg	12	9.9 - 59 mg	2136 - 12815 kg	U.S.A.		
p-cresol 2337	olive oil	0.2 ppm	8	9.3 kg	17	1.86 mg	191 kg	Greece, Italy and Spain	48 kg	
	roasted coffee	1.3 - 13.2 ppm	16	4.85 kg	11	6.3 - 64 mg	1364 - 13854 kg	U.S.A.		
gamma decalactone 2360	butter	1.2 ppm	18	2.0 kg	19	2.4 mg	519 kg	U.S.A.	115 kg	
delta decalactone 2361	butter	15 ppm	18	2.0 kg	19	30 mg	6492 kg	U.S.A.	1449 kg	15 kg
2-decenal 2366	potato chips	0.24 ppm	20	1.99 kg	13	0.48 mg	103 kg	U.S.A.	20 kg	
	olive oil	15 ppm	8	9.3 kg	17	139.5 mg	14340 kg	Greece, Italy and Spain		

These use figures (quoted here in kilograms) were reported in "a comprehensive survey of the Industry on the Use of Food Chemicals Generally Recognized as Safe (GRAS), Table II, Part C, Annual Poundage data for FEMA Questionnaire Substances Not Listed in NAS Appendix A (Group III)" NRC, published January 1973, referred to as "total annual usage by the U.S. Flavor Industry, 1973" and in "The 1977 survey of Industry on the Use of Food Additives," NRC/NAS, published in October 1979, referred to as "total annual usage by the U.S. Flavor Industry 1977."

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Flavoring material Name	FEMA GRAS #	Occurring in	Concentration	Ref	Annual per cap. consumption of this food	Ref	Annual per cap. consumption of flavoring material via this food	Annual total consumption of the flavoring material via this food	By the population of	Total annual usage by the Flavor Industry of the U.S. 1973	1977
diacetyl	2370	butter	1.2 ppm	21	2.0 kg	19	2.4 mg	519 kg	U.S.A.	10674 kg	
		butter	0.8 ppm	22	2.0 kg	19	1.6 mg	346 kg	U.S.A.		
		roasted coffee	2.7 ppm	8	4.85 kg	11	13.1 mg	2833 kg	U.S.A.		
gamma dodecalactone	2400	butter	1.6 ppm	18	2.0 kg	19	3.2 mg	692 kg	U.S.A.	395 kg	
delta dodecalactone	2401	butter	35 ppm	18	2.0 kg	19	70 mg	15148 kg	U.S.A.	90 kg	421 kg
ethyl benzoate	2422	cocoa	0.1 ppm	14	1.22 kg	9	0.12 mg	26 kg	U.S.A.	426 kg	
ethyl cinnamate	2430	cocoa	1.1 ppm	8	1.22 kg	9	1.3 mg	290 kg	U.S.A.	483 kg	
4-ethyl guaiacol	2436	roasted coffee	2 ppm	16	4.85 kg	11	9.7 mg	2099 kg	U.S.A.	32 kg	
		olive oil	3 ppm	8	9.3 kg	17	27.9 mg	2868 kg	Greece, Italy and Spain		
ethyl phenylacetate	2452	cocoa	0.1 ppm	8	1.22 kg	9	0.12 mg	26 kg	U.S.A.	547 kg	
furfural	2489	roasted coffee	60 ppm	8	4.85 kg	11	291 mg	62972 kg	U.S.A.	2025 kg	
furfuryl acetate	2490	roasted coffee	5.4 ppm	8	4.85 kg	11	26.2 mg	5667 kg	U.S.A.	27 kg	

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Flavoring material Name	FEMA GRAS #	Occurring in	Concen-tration	Ref	Annual per cap. consumption of this food	Ref	Annual per cap. consumption of flavoring material via this food	Annual total consumption of the flavoring material via this food	By the population of	Total annual usage by the Flavor Industry of the U.S. 1973	1977
furfuryl alcohol	2491	roasted coffee	226 ppm	8	4.85 kg	11	1096 mg	237196 kg	U.S.A.	80 kg	
guaiacol	2532	roasted coffee	2.7 - 10.6 ppm	16	4.85 kg	11	13.1 - 51 mg	2834 - 11125 kg	U.S.A.	114 kg	
gamma heptalactone	2539	roasted beef	0.01 ppm	8	40.3 kg	9	0.4 mg	87 kg	U.S.A.	336 kg	
2,3-hexanedione	2558	roasted coffee	0.33 ppm	8	4.85 kg	11	1.6 mg	346 kg	U.S.A.	166 kg	
2-hexenal	2560	cucumbers	0.3-3 ppm	23	4.76 kg	12	1.4 - 14 mg	309 - 3090 kg	U.S.A.	407 kg	
3-hexen-1-ol	2563	tomatoes	4-30 ppm	15	32.9 kg	12	132 - 987 mg	28478 - 213586 kg	U.S.A.	1593 kg	
indole	2593	olive oil	0.1 ppm	8	9.3 kg	17	0.9 mg	95.6 kg	Greece, Italy and Spain	193 kg	
2-methoxy-4-methyl phenol	2671	roasted coffee	0.1 ppm	16	4.85 kg	11	0.5 mg	105 kg	U.S.A.	23 kg	24.5 kg
2-methoxy-4-vinylphenol	2675	roasted coffee	7.9-9.6 ppm	16	4.85 kg	11	38.3 - 46.5 mg	8291 - 10075 kg	U.S.A.	5.4 kg	
alpha methylbenzyl alcohol	2685	cocoa	1.3 ppm	14	1.22 kg	9	1.6 mg	343 kg	U.S.A.	35 kg	
3-methylbutyraldehyde	2692	cocoa	21 ppm	8	1.22 kg	9	26 mg	5544 kg	U.S.A.	157 kg	
		roasted coffee	6.7 ppm	8	4.85 kg	9	32.5 mg	7031 kg	U.S.A		

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Flavoring material Name	FEMA GRAS #	Occurring in	Concentration	Ref	Annual per cap. consumption of this food	Ref	Annual per cap. consumption of flavoring material via this food	Annual total consumption of the flavoring material via this food	By the population of	Total annual usage by the Flavor Industry of the U.S. 1973	1977
5-methylfurfural	2702	roasted coffee	39 ppm	8	4.85 kg	11	189 mg	40932 kg	U.S.A.	18 kg	
methyl mercaptan	2716	potatoes	0.04 - 0.08 ppm	35	56 kg	24	2.2 - 4.5 mg	485 - 970 kg	U.S.A.	41 kg	
methyl o-methoxybenzoate	2717	cocoa	0.09 ppm	8	1.22 kg	9	0.1 mg	23.8 kg	U.S.A.	8.2 kg	
methyl sulfide	2746	tomatoes	0.4 - 10.9 ppm	25	32.9 kg	12	13.2 - 359 mg	2848 - 77603 kg	U.S.A.	150 kg	
3-methylthiopropionaldehyde	2747	potato chips	0.4 ppm	20	1.99 kg	13	0.8 mg	172 kg	U.S.A.	66 kg	
2,6-nonadien-1-ol	2780	cucumbers	0.05 ppm	23,26	4.76 kg	12	0.24 mg	51.5 kg	U.S.A.	12 kg	
gamma octalactone	2796	butter	0.5 ppm	18	2.0 kg	19	1 mg	216 kg	U.S.A.	297 kg	
1-octen-3-ol	2805	olive oil	1.1 ppm	8	9.3 kg	17	10.2 mg	1052 kg	Greece, Italy and Spain	138 kg	
2,3-pentanedione	2841	roasted coffee	4 ppm	8	4.85 kg	11	19.4 mg	4198 kg	U.S.A.	369 kg	
2-pentanone	2842	blue cheese	14-41 ppm	27	0.09 kg	19	1.3 - 3.7 mg	273 - 799 kg	U.S.A.	59 kg	
phenethyl acetate	2857	cocoa	1 ppm	14	1.22 kg	9	1.2 mg	264 kg	U.S.A.	251 kg	

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phenylacetaldehyde	2874	potato chips	3.6 ppm	20	1.99 kg	13	7.2 mg	1550 kg	U.S.A.	491 kg	
		cocoa	0.5-3 ppm	8	1.22 kg	9	0.6 - 3.7 mg	132 - 792 kg	U.S.A.		
3-phenylpropyl acetate	2890	cocoa	0.5 ppm	8	1.22 kg	9	0.6 mg	132 kg	U.S.A.	149 kg	
piperidine	2908	roasted coffee	1 ppm	28	4.85 kg	11	4.9 mg	1050 kg	U.S.A.	32 kg	308 kg
pyridine	2966	roasted coffee	49 ppm	8	4.85 kg	11	238 mg	51427 kg	U.S.A.	70 kg	
			0.1 ppm	8	40.3 kg	9	4.0 mg	872 kg	U.S.A.		
acetylpyrazine	3126	roasted coffee	1.3 ppm	8	4.85 kg	11	6.3 mg	1364 kg	U.S.A.	6.8 kg	
2-isobutyl thiazole	3134	tomatoes	59-140 ppb	29	32.9 kg	12	1.9 - 4.6 mg	420 - 997 kg	U.S.A.	23 kg	
2-t-4-t-decadienal	3135	olive oil	1.4 ppm	8	9.3 kg	17	13 mg	1338 kg	Greece, Italy and Spain	39 kg	38 kg
		potato chips	1.5 ppm	20	1.99 kg	13	3.0 mg	646 kg	U.S.A.		
2-ethyl-3,5 or 6-dimethyl pyrazine	3149	potato chips	0.67 ppm	30	1.99 kg	13	1.3 mg	288 kg	U.S.A.	12 kg	
		cocoa	2.8 ppm	14	1.22 kg	9	3.4 mg	739 kg	U.S.A.		
		roasted beef	0.12 ppm	8	40.3 kg	9	4.8 mg	1046 kg	U.S.A.		
		beer	0.02 ppm	31	90 kg	10	1.8 mg	390 kg	U.S.A.		

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									1973	1977
3-ethyl-2,6 dimethyl pyrazine 3150	potato chips	0.1-1.4 ppm	30	1.99 kg	13	0.2 - 2.8 mg	43 - 603 kg	U.S.A.	12 kg	0.3 kg
2-ethyl-5-methylpyrazine 3154	potato chips	0.1-2.5 ppm	30	1.99 kg	13	0.2 - 5.0 mg	43 - 1076 kg	U.S.A.	6.8 kg	
	roasted beef	0.07 ppm	8	40.3 kg	9	2.8 mg	610 kg	U.S.A.		
p-ethylphenol 3156	olive oil	3.8 ppm	8	9.3 kg	17	35.3 mg	3633 kg	Greece, Italy and Spain	32 kg	
2-furyl methyl ketone 3163	roasted coffee	10 ppm	8	4.85 kg	11	48.5 mg	10495 kg	U.S.A.	18 kg	
2,4-heptadienal 3164	olive oil	0.4 ppm	8	9.3 kg	17	3.7 mg	382 kg	Greece, Italy and Spain	26 kg	
2-heptenal 3165	potato chips	0.36 ppm	20	1.99 kg	13	0.7 mg	155 kg	U.S.A.	51 kg	
	olive oil	6 ppm	8	9.3 kg	17	55.8 mg	5736 kg	Greece, Italy and Spain		
1-methylnaphthalene 3193	olive oil	0.1 ppm	8	9.3 kg	17	0.93 mg	95.6 kg	Greece, Italy and Spain	2.7 kg	
2-methyl-2-pentenal 3194	onions	0.7 ppm	8	6.3 kg	12	4.4 mg	954 kg	U.S.A.	23 kg	0.4 kg

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Flavoring material Name FEMA GRAS #	Occurring in	Concentration	Ref	Annual per cap. consumption of this food	Ref	Annual per cap. consumption of flavoring material via this food	Annual total consumption of the flavoring material via this food	By the population of	Total annual usage by the Flavor Industry of the U.S. 1973	1977
5-methyl-2-phenyl-2-hexenal 3199	cocoa	0.5 ppm	8	1.22 kg	9	0.6 mg	132 kg	U.S.A.	11.3 kg	
methyl propyl disulfide 3201	onions	11 ppm	8	6.3 kg	12	69 mg	14996 kg	U.S.A.	25 kg	
methyl-2-pyrrolyl ketone 3202	roasted beef	0.35 ppm	8	40.3 kg	9	14 mg	3052 kg	U.S.A.	5.4 kg	
		1.4 ppm	31	90 kg	10	126 mg	27266 kg	U.S.A.		
2-methylthioacetaldehyde 3206	potato chips	0.02 ppm	20	1.99 kg	13	0.04 mg	8.6 kg	U.S.A.	2.7 kg	
2,4-nonadienal 3212	potato chips	0.04 ppm	20	1.99 kg	13	0.08 mg	17.2 kg	U.S.A.	42 kg	
2-nonenal 3213	potato chips	0.3 ppm	20	1.99 kg	13	0.6 mg	129 kg	U.S.A.	34 kg	
	cucumbers	3 ppm	26	4.76 kg	12	14.3 mg	3,090 kg	U.S.A.		
delta octalactone 3214	butter	2.6 ppm	18	2.0 kg	19	5.2 mg	1125 kg	U.S.A.	130 kg	
2-octenal 3215	potato chips	0.14 ppm	20	1.99 kg	13	0.28 mg	60 kg	U.S.A.	77 kg	3.2 kg
phenol 3223	roasted coffee	13-60 ppm	16	4.85 kg	11	63 - 291 mg	13644 - 62972 kg	U.S.A.	6.8 kg	
propenyl propyl disulfide 3227	onions	9.7 ppm	8	6.3 kg	12	61 mg	13224 kg	U.S.A.	40 kg	

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propyl disulfide	3228	onions	19.9 ppm	8	6.3 kg	12	125 mg	27130 kg	U.S.A.	164 kg	
Styrene	3233	olive oil	0.08 ppm	8	9.3 kg	17	0.74 mg	76.5 kg	Greece, Italy and Spain	26 kg	
2,3,5,6-tetramethyl-pyrazine	3237	cocoa	1.6-4.0 ppm	32	1.22 kg	9	2.0 - 4.9 mg	422 - 1056 kg	U.S.A.	8 kg	4.4 kg
			10.1 ppm	14			12.3 mg	2666 kg			
2,3,5-trimethylpyrazine	3244	roasted coffee	4 ppm	8	4.85 kg	11	19.4 mg	4198 kg	U.S.A.	16 kg	
		cocoa	0.6-1.5 ppm	32	1.22 kg	9	0.7 - 1.8 mg	158 - 396 kg	U.S.A.		
			10.5 ppm	14			12.8 mg	2772 kg			
		roasted beef	0.26 ppm	8	40.3 kg	9	10.5 mg	2267 kg	U.S.A.		
2,6-xylenol	3249	roasted coffee	0.2 ppm	16	4.85 kg	11	1.0 mg	210 kg	U.S.A.	5.4 kg	
2-acetylpyridine	3251	roasted coffee	4 ppm	8	4.85 kg	11	19.4 kg	4198 kg	U.S.A.		30 kg
2,3-dimethylpyrazine	3271	roasted coffee	4 ppm	8	4.85 kg	11	19.4 mg	4198 kg	U.S.A.		11 kg
		potato chips	0.1-1.7 ppm	30	1.99 kg	13	0.2 - 3.4 mg	43 - 732 kg	U.S.A.		

1	2			3			4		5	
Flavoring material Name FEMA GRAS #	Occurring in	Concentration	Ref	Annual per cap. consumption of this food	Ref	Annual per cap. consumption of flavoring material via this food	Annual total consumption of the flavoring material via this food	By the population of	Total annual usage by the Flavor Industry of the U.S.	
									1973	1977
2,5-dimethylpyrazine 3272	roasted coffee	17 ppm	8	4.85 kg	11	82.5 mg	17842 kg	U.S.A.		9.5 kg
	roasted beef	0.18 ppm	8	40.3 kg	9	7.2 mg	1570 kg	U.S.A.		
		0.11 ppm	31	90 kg	10	9.9 mg	2142 kg	U.S.A.		
2,6-dimethylpyrazine 3273	roasted coffee	19 ppm	8	4.85 kg	11	92.2 mg	19941 kg	U.S.A.		2.3 kg
	roasted beef	0.19 ppm	8	40.3 kg	9	7.7 mg	1657 kg	U.S.A.		
	beer	0.035 ppm	31	90 kg	10	3.15 mg	682 kg	U.S.A.		
dimethyl trisulfide 3275	onions	2.4 ppm	8	6.3 kg	12	15.1 mg	3272 kg	U.S.A.		0.6 kg
dipropyl trisulfide 3276	onions	23.8 ppm	8	6.3 kg	12	150 mg	32447 kg	U.S.A.		13 kg
N-furfurylpyrrole 3284	roasted coffee	2 ppm	8	4.85 kg	11	9.7 mg	2099 kg	U.S.A.		0.3 kg
	beer	0.01 ppm	31	90 kg	10	0.9 mg	195 kg	U.S.A.		
4-hydroxybutanoic acid lactone 3291	roasted coffee	4.7 ppm	8	4.85 kg	11	22.8 mg	4933 kg	U.S.A.		19 kg
methyl propyl trisulfide 3308	onions	20.4 ppm	8	6.3 kg	12	129 mg	27812 kg	U.S.A.		1.8 kg
2-methylpyrazine 3309	roasted coffee	25 ppm	8	4.85 kg	11	121 mg	26238 kg	U.S.A.		4.5 kg
	beer	0.07 ppm	31	90 kg	10	6.3 mg	1363 kg	U.S.A.		

1		2			3			4		5	
Flavoring material Name	FEMA GRAS #	Occurring in	Concentration	Ref	Annual per cap. consumption of this food	Ref	Annual per cap. consumption of flavoring material via this food	Annual total consumption of the flavoring material via this food	By the population of	Total annual usage by the Flavor Industry of the U.S. 1973	1977
2-acetyl thiazole	3328	cocoa	0.06 ppm	8	1.22 kg	9	0.07 mg	15.8 kg	U.S.A.		2.3 kg
2-methoxy-3 (5 and 6)-isopropylpyrazine	3358	tomatoes	0.1 ppb	33	32.9 kg	12	0.003 mg	0.7 kg	U.S.A.		0.2 kg
2-methyltetrahydro-furan-3-one	3373	potato chips	0.06 ppm	20	1.99 kg	13	0.12 mg	25.8 kg	U.S.A.		0.15 kg
nona-2-trans,6-cis-dienal	3377	cucumbers	3.3 ppm	23	4.76 kg	12	15.7 mg	3399 kg	U.S.A.		1.36 kg
pyrrole	3386	roasted coffee	2.7 ppm	8	4.85 kg	11	13.1 mg	2834 kg	U.S.A.		0.15 kg
		roasted beef	0.02 ppm	8	40.3 kg	9	0.8 mg	174 kg	U.S.A.		
2-undecenal	3423	potato chips	0.14 ppm	20	1.99 kg	13	0.28 mg	60 kg	U.S.A.		0.15 kg
		olive oil	6 ppm	8	9.3 kg	17	56 mg	5736 kg	Greece, Italy and Spain		
cis-6-nonen-1-ol	3465	cucumbers	0.05 ppm	26	4.76 kg	12	0.2 mg	51 kg	U.S.A.		2.0 kg
o-cresol	3480	roasted coffee	1.2-12.4 ppm	16	4.85 kg	11	5.8 - 60 mg	1259 - 13014 kg	U.S.A.		2.5 kg
propanethiol	3521	onions	0.3 ppm	8	6.3 kg	12	1.9 mg	409 kg	U.S.A.		2.5 kg
pyrrolidine	3523	roasted coffee	6 ppm	28	4.85 kg	11	29 mg	6297 kg	U.S.A.		12 kg