Τοξικές ενώσεις στα τρόφιμα

TABLE 1 Types of Food Toxicants

Inherent toxicants

- Metabolites produced via biosynthesis by food organisms under normal growth conditions

Metabolites produced via biosynthesis by food organisms that are stressed
Contaminants

- Toxicants that directly contaminate foods
- Toxicants that are absorbed from the environment by food-producing organisms
- Toxic metabolites produced by food organisms from substances that are absorbed from the environment
- Toxicants that are formed during food preparation

Τοξικολογία τροφίμων

«Everything is poison. There is nothing without poison. Only the dose makes a thing not poison. For example, every food and every drink, if taken beyond its dose, is poison». Παράκελσος, 1564.

6 Common Foods You Can Overdose On

- Bananas. Bananas make a great morning shake and snack, but consuming too much of it can cause hyperkalemia – a dangerous condition that happens when there's too much potassium in your blood.
- Carrots. ...
- Coffee. ...
- Soy Sauce. ...
- Tuna Sashimi. ...
- Water.

Ορισμοί

Acute toxicity refers to a toxic response, often immediate, induced by a single exposure. A lethal dose of hydrogen cyanide (50–60 mg) induces death within minutes; cicutoxin, the toxic principal of water hemlock, kills so rapidly that cattle that have eaten it often die before the implicated feedstuff has passed beyond the esophageal groove [24]. These are poignant examples of acute toxicity. The acute toxicity of a substance is defined by its LD_{50}, the dose of the substance that will kill 50% of a group of exposed animals.

Chronic toxicity refers to an effect that requires some time to develop, for example, cancer. Testing for chronic toxicity involves continuously feeding the test substance to rodents for 20–24 months. By analogy to LD_{50}, the amount of a carcinogen required to induce cancer in 50% of a group of exposed animals is referred to as the TD_{50} (tumor $dose_{50}$) [13].

Subchronic feeding test is a "ninety day toxicology study in an appropriate animal species" [16]. It is often used to define the MTD and, for noncarcinogens, the NOAEL.

MTD is the acronym for "maximum tolerated dose." It is the highest level of a test substance that can be fed to an animal without inducing obvious signs of toxicity [6]. In chronic toxicity tests, the test substance is typically fed at its MTD and perhaps one or two lower doses. The MTD concept has been criticized because it is based soley on gross measures of toxicity, for example, weight loss. Subtle biochemical indicators of cellular toxicity, which may occur at lower doses, are ignored [22].

NOAEL is the acronym for "no observable adverse effect level." For substances that induce a toxic response (other than cancer) in chronic feeding tests, the NOAEL is used to determine an acceptable daily intake (ADI) [21, 22].

ADI is the acronym for "acceptable daily intake." By convention, for noncarcinogens, it is set at 1/100th of the NOAEL.

Συγκριτική Τοξικολογία

(Μέσα του 20ού αιώνα)
Οι καρκινογόνες ενώσεις είναι λίγες και μπορούν να αποκλειστούν από τα τρόφιμα.

(Σήμερα)
Τρόφιμα 100% χωρίς τοξίνες δεν είναι δυνατόν να παρασκευαστούν.

• Σύγκριση προυπάρχουσων τοξικών ενώσεων σε ένα τρόφιμο με τις τοξίνες ενός νέου τροφίμου που το αντικαθιστά.

• Πρέπει να είναι λιγότερες

TABLE 2 Examples of Inherent Toxicants in Plants

Toxins	Chemical nature	Main food source	Major toxicity symptoms
Protease inhibitors	Proteins (mol. wt. 4000–24,000)	Beans (soy, mung, kidney, navy, lima); chick-pea; peas, potatoes (sweet, white); cereals	Impaired growth and food utilization; pancreatic hypertrophy
Hemagglutinins	Proteins (mol. wt. 10,000–124,000)	Beans (castor, soy, kidney, black, yellow, jack); lentils; peas	Impaired growth and food utilization; agglutination of erythrocytes in vitro; mitogenic activity to cell cultures in vitro
Saponins	Glycosides	Soybeans, sugarbeets, peanuts, spinach, asparagus	Hemolysis of erythrocytes in vitro
Glycosinolates	Thioglycosides	Cabbage and related species; turnips; rutabaga; radish; rapeseed; mustard	Hypothyroidism and thyroid enlargement
Cyanogens	Cyanogenic glucosides	Peas and beans; pulses; linseed; flax; fruit kernels; cassava	HCN poisoning
Gossypol pigments	Gossypol	Cottonseed	Liver damage; hemorrhage; edema
Lathyrogens	β-Aminopropionitrile and derivatives	Chick-pea; vetch	Neurolathyrism (CNS[a] damage)
Allergens	Proteins?	Practically all foods (particularly grains, legumes, and nuts)	Allergic responses in sensitive individuals
Cycasin	Methylazoxy-methanol	Nuts of *Cycas* genus	Cancer of liver and other organs

Favism	Vicine and convicine (pyrimidine β-glucosides)	Fava beans	Acute hemolytic anemia
Phytoalexins	Simple furans (ipomeamarone)	Sweet potatoes	Pulmonary edema; liver and kidney damage
	Benzofurans (psoralins)	Celery; parsnips	Skin photosensitivity
	Acetylenic furans (wyerone)	Broad beans	
	Isoflavonoids (pisatin and phaseollin)	Peas, french beans	Cell lysis in vitro
Pyrrolizidine alkaloids	Dihydropyrroles	Families Compositae and Boraginaccae; herbal teas	Liver and lung damage carcinogens
Safrole	Allyl-substituted benzene	Sassafras; black pepper	Carcinogens
α-Amantin	Bicyclic octapeptides	*Amanita phalloides* mushrooms	Salivation; vomiting; convulsions; death
Atractyloside	Steroidal glycoside	Thistle (*Atractylis gummifera*)	Depletion of glycogen

[a]Central nervous system.

TABLE 3 Some Naturally Occurring Carcinogens Inherent in Food

Rodent carcinogen	Plant food	Concentration (ppm)
5-/8-Methoxypsoralen	Parsley	14
	Parsnip, cooked	32
	Celery	0.8
	Celery, new cultivar	6.2
	Celery, stressed	25
p-Hydrazinobenzoate	Mushrooms	11
Glutamyl *p*-hydrazinobenzoate	Mushrooms	42
Sinigrin (allyl isothiocyanate)	Cabbage	35–590
	Collard greens	250–788
	Cauliflower	12–66
	Brussels sprouts	110–1560
	Mustard (brown)	16,000–72,000
	Horseradish	4500
Estragole	Basil	3800
	Fennel	3000
Safrole	Nutmeg	3000
	Mace	10,000
	Pepper, black	100

Ethyl acrylate	Pineapple	0.07
Sesamol	Sesame seeds (heated oil)	75
α-Methylbenzyl alcohol	Cocoa	1.3
Benzyl acetate	Basil	82
	Jasmine tea	230
	Honey	15
	Coffee (roasted beans)	100
Caffeic acid	Apple, carrot, celery, cherry, eggplant, endive, grapes, lettuce, pear, plum, and potato	50–200
		>1000
	Absinthe, anise, basil, caraway, dill, marjoram, rosemary, sage, savory, tarragon, and thyme	1800
	Coffee (roasted beans)	50–500
	Apricot, cherry, peach, and plum	
Chlorogenic acid (caffeic acid)	Coffee (roasted beans)	21,600
Neochlorogenic acid (caffeic acid)	Apple, apricot, broccoli, brussels sprouts, cabbage, cherry, kale, peach, pear, and plum	50–500
	Coffee (roasted beans)	11,600

TABLE 4 Plant Toxicants Documented as Causing Harm in Normal Human Diets

Substance (category/name/number of substances)	Plant source	Methods of risk reduction
Honey toxicants (7)	Rhododendron/andromeda/azalea family	Monitoring; prohibition of beekeeping
Acetylandromedel, andromedol, anhydroandromedol, and desacetylpireistoxin B		
Gelsamine	Yellow jasmine	
Tutin	Tutu tree	
Hyenanchin		
Forage and meat/milk toxicants (4) Cicutoxin	Water hemlock	Proper grazing and forage practices; avoidance
Coniine	Hemlock	
Methylconiine		
Conhydrine		

Toxicants from poor choice, handling, or processing of local diet (5+)		
Hypoglycin A	Ackee fruit (immature)	Avoidance
Linamarin and Lotaustralin	Lima beans and cassava root	Selection and breeding (and proper processing for cassava)
β-N-Oxalylamino-L-alanine	Chick-pea	Reduced usage
(-)-Sparteine and related alkaloids	Lupine	Proper processing
Plant genetic factors/poor handling (1) Solanine	Potato	Selection and breeding, monitoring, proper handling
Human genetic factors (2) Vicine Convicine	Fava bean	Reduced usage
Other (2)	Squash, cucumber	Breeding isolation
Cucurbitacin E		
Nitrates	Spinach and other green, leafy vegetables	Proper fertilizing practices and handling; monitoring
Total (21+)		

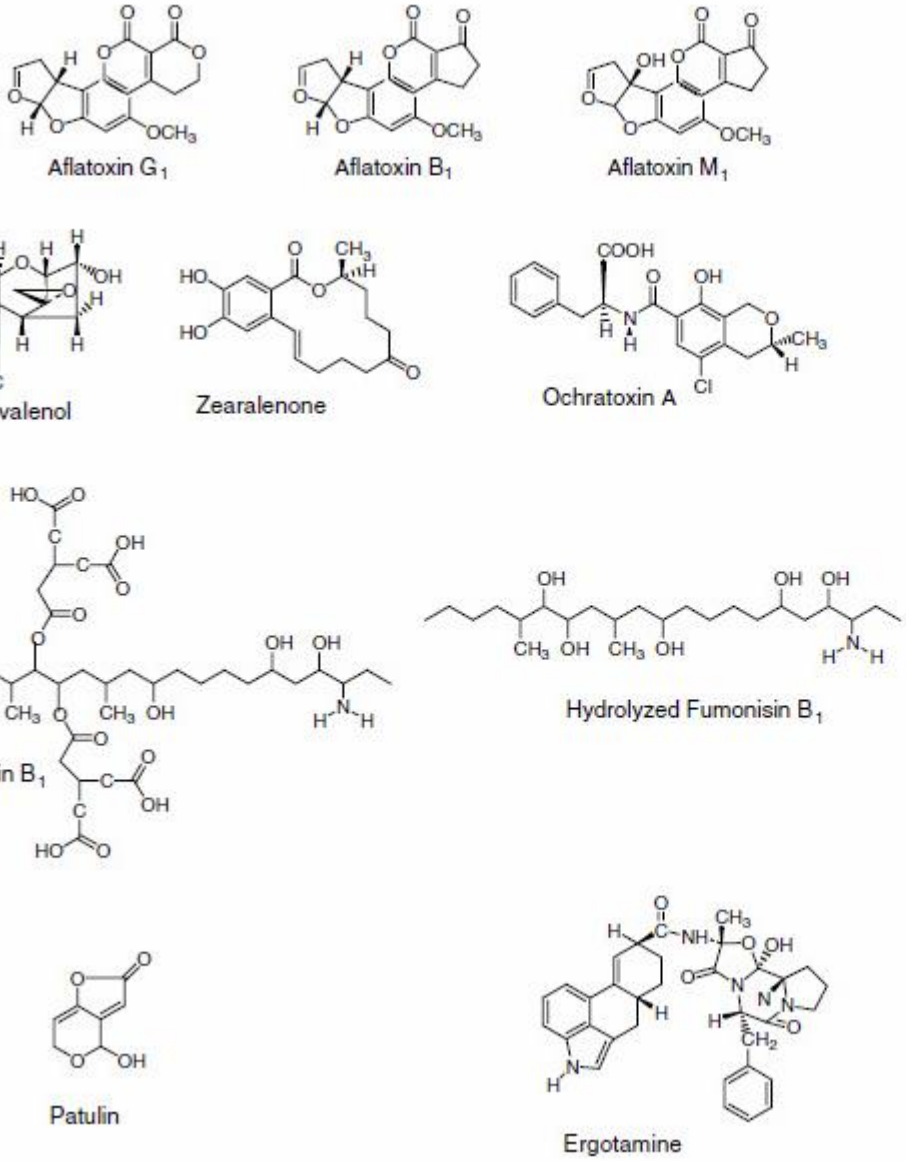

Figure 1 – Chemical structures of mycotoxins found in foods

TABLE 5 Natural Occurrence of Selected Common Mycotoxins

Mycotoxins[a]	Major producing fungi	Typical substrate in nature	Biological effect
Alternaria (AM) mycotoxins	Alternaria alternata	Cereal grains, tomato, animal feeds	M, Hr
Aflatoxin (AF) B_1 and other aflatoxins	*Aspergillus flavus, A. parasiticus*	Peanuts, corn, cottonseed, cereals, figs, most tree nuts, milk, sorghum, walnuts	H, C, M, T
Citrinin (CT)	*Penicillum citrinum*	Barley, corn, rice, walnuts	Nh, (C?), M
Cyclopiazonic acid (CPA)	*A. flavus, P. cyclopium*	Peanuts, corn, cheese	Nr, Cv
Deoxynivalenol (DON)	*Fusarium graminearum*	Wheat, corn	Nr
Cytlochlorotine (CC)	*P. islandicum*	Rice	H, C
Fumonisins (FM)	*F. moniliforme*	Corn, sorghum	H, Nr, C(?), R
Luteoskyrin (LT)	*P. islandicum, P. rugulosum*	Rice, sorghum	H, C, M

Moniliformin (MN)	*F. moniliforme*	Corn	Nr, Cv
Ochratoxin A (OTA)	*A. ochraceus, P. verrucosum*	Barley, beans, cereals, coffee, feeds, maize, oats, rice, rye, wheat	Nh, T Nr, C(?),D, T
Patulin (PT)	*P. patulum, P. urticae, A. clavatus*	Apple, apple juice, beans, wheat	Nr, C(?), M
Penicillic acid (PA)	*P. puberrulum, A. ochraceus*	Barley, corn	Nr
Penitrem A (PNT)	*P. palitans*	Feedstuffs, corn	Nr
Roquefortine (RQF)	*P. roqueforti*	Cheese	H, T
Rubratoxin B (RB)	*P. rubrum, P. purpurogenum*	Corn, soybeans	H, C, M
Sterigmatocystin (ST)	*A. versicolor, A. nidulans*	Corn, grains, cheese	D, ATA, T
T-2 Toxin	*F. sporotrichioides*	Corn, feeds, hay	D, Nr
12-/13-Epoxytrichothecenes (TCTC) other than T-2 and DON	*F. nivale*	Corn, feeds, hay, peanuts, rice	
Zearalenone (ZE)	*F. graminearum*	Cereals, corn feeds, rice	G, M

*Note:*ATA, Alimentary toxic aleukia; C, carcinogenic; C(?), carcinogenic effect still questionable; Cv, cardiovascular lesion; D, dermatoxin; G, genitotoxin and estrogenic effects; H, hepatotoxic; Hr, hemorrhagic; M. mutagenic; Nh, nephrotoxin; Nr, neurotoxins; R, respiratory; T, tetratogenic.

Βακτηριακές τοξίνες

- Πρωτεϊνες (μεγάλο MW)
- Άμεση εμφάνιση συμπτωμάτων
- Δεν υπάρχουν σε ζωοτροφές (χαμηλή υγρασία)

TABLE 6 Bacterial Toxins That Cause Food-Borne Illness

Toxin	Estimated cases of illness per year in United States
Staphylococcal enterotoxins	1,155,000
Bacillus cereus enterotoxins	84,000
Botulinal neurotoxins	270
All food-borne causes	12,581,270

Human Exposure Rodent Potency

TABLE 7 Prioritizing Commonly Encountered Carcinogen Exposures

Daily human exposure	HERP (%)
PCBs, daily dietary intake	0.0002
EDB[a], daily dietary intake	0.0004
Alar[a], 1 apple (230 g)	0.0002
Tap water, 1 L (chloroform)	0.001
Cooked bacon, 100 g (nitrosamines)	0.003
Worst well water in Silicon Valley (trichloroethylene)	0.004
Peanut butter (one sandwich) (aflatoxin)	0.03
One glass of wine (ethanol)	4.7

*Note:*EDB refers to ethylene dibromide, a pesticide.

[a]Banned because of health concerns; HERP value based on exposure prior to ban.

Possible hazard: HERP (%)	Average daily US exposure	Human dose of rodent carcinogen	Potency TD_{50} (mg/kg/day) [a] Rats	Mice
140	EDB: production workers (high exposure) (before 1977)	Ethylene dibromide, 150 mg	1.52	(7.45)
17	Clofibrate	Clofibrate, 2 g	169	.
14	Phenobarbital, 1 sleeping pill	Phenobarbital, 60 mg	(+)	6.09
6.8	1,3-Butadiene: rubber industry workers (1978-86)	1,3-Butadiene, 66.0 mg	(261)	13.9
6.2	**Comfrey-pepsin tablets, 9 daily (no longer recommended)**	**Comfrey root, 2.7 g**	626	.
6.1	Tetrachloroethylene: dry cleaners with dry-to-dry units (1980-90)	Tetrachloroethylene, 433 mg	101	(126)
4.0	Formaldehyde: production workers (1979)	Formaldehyde, 6.1 mg	2.19	(43.9)
2.4	Acrylonitrile: production workers (1960-1986)	Acrylonitrile, 28.4 mg	16.9	.
2.2	Trichloroethylene: vapor degreasing (before 1977)	Trichloroethylene, 1.02 g	668	(1580)
2.1	**Beer, 257 g**	**Ethyl alcohol, 13.1 ml**	9110	(–)
1.4	Mobile home air (14 hours/day)	Formaldehyde, 2.2 mg	2.19	(43.9)
1.3	**Comfrey-pepsin tablets, 9 daily (no longer recommended)**	**Symphytine, 1.8 mg**	1.91	.
0.9	Methylene chloride: workers, industry average (1940s-80s)	Methylene chloride, 471 mg	724	(1100)
0.5	**Wine, 28.0 g**	**Ethyl alcohol, 3.36 ml**	9110	(–)
0.5	Dehydroepiandrosterone (DHEA)	DHEA supplement, 25 mg	68.1	.
0.4	Conventional home air (14 hours/day)	Formaldehyde, 598 μg	2.19	(43.9)
0.2	Fluvastatin	Fluvastatin, 20 mg	125	.
0.1	**Coffee, 13.3 g**	**Caffeic acid, 23.9 mg**	297	(4900)
0.1	***d*-Limonene in food**	***d*-Limonene, 15.5 mg**	204	(–)
0.04	**Lettuce, 14.9 g**	**Caffeic acid, 7.90 mg**	297	(4900)
0.03	**Safrole in spices**	**Safrole, 1.2 mg**	(441)	51.3
0.03	**Orange juice, 138 g**	***d*-Limonene, 4.28 mg**	204	(–)
0.03	**Comfrey herb tea, 1 cup (1.5 g root) (no longer recommended)**	**Symphytine, 38 μg**	1.91	.
0.03	**Tomato, 88.7 g**	**Caffeic acid, 5.46 mg**	297	(4900)
0.03	**Pepper, black, 446 mg**	***d*-Limonene, 3.57 mg**	204	(–)
0.02	**Coffee, 13.3 g**	**Catechol, 1.33 mg**	88.8	(244)
0.02	**Furfural in food**	**Furfural, 2.72 mg**	(683)	197
0.02	**Mushroom (*Agaricus bisporus* 2.55 g)**	**Mixture of hydrazines, etc. (whole mushroom)**	-	20,300
0.02	**Apple, 32.0 g**	**Caffeic acid, 3.40 mg**	297	(4900)

0.02	**Coffee, 13.3 g**	**Furfural, 2.09 mg**	(683)	197
0.01	BHA: daily US avg (1975)	BHA, 4.6 mg	606	(5530)
0.01	**Beer (before 1979), 257 g**	**Dimethylnitrosamine, 726 ng**	0.0959	(0.189)
0.008	**Aflatoxin: daily US avg (1984-89)**	**Aflatoxin, 18 ng**	0.0032	(+)
0.007	**Cinnamon, 21.9 mg**	**Coumarin, 65.0 μg**	13.9	(103)
0.006	**Coffee, 13.3 g**	**Hydroquinone, 333 μg**	82.8	(225)
0.005	Saccharin: daily US avg (1977)	Saccharin, 7 mg	2140	(–)
0.005	**Carrot, 12.1 g**	**Aniline, 624 μg**	194 [b]	(–)
0.004	**Potato, 54.9 g**	**Caffeic acid, 867 μg**	297	(4900)
0.004	**Celery, 7.95 g**	**Caffeic acid, 858 μg**	297	(4900)
0.004	**White bread, 67.6 g**	**Furfural, 500 μg**	(683)	197
0.003	*d*-Limonene	Food additive, 475 μg	204	(–)
0.003	**Nutmeg, 27.4 mg**	***d*-Limonene, 466 μg**	204	(–)
0.003	Conventional home air (14 hour/day)	Benzene, 155 μg	(169)	77.5
0.002	**Coffee, 13.3 g**	**4-Methylcatechol, 433 μg**	248	.
0.002	**Carrot, 12.1 g**	**Caffeic acid, 374 μg**	297	(4900)
0.002	Ethylene thiourea: daily US avg (1990)	Ethylene thiourea, 9.51 μg	7.9	(23.5)
0.002	BHA: daily US avg (1987)	BHA, 700 μg	606	(5530)
0.002	DDT: daily US avg (before 1972 ban) [c]	DDT, 13.8 μg	(84.7)	12.8
0.001	**Plum, 2.00 g**	**Caffeic acid, 276 μg**	297	(4900)
0.001	**Pear, 3.29 g**	**Caffeic acid, 240 μg**	297	(4900)
0.001	[UDMH: daily US avg (1988)]	[UDMH, 2.82 μg (from Alar)]	(–)	3.96
0.0009	**Brown mustard, 68.4 mg**	**Allyl isothiocyanate, 62.9 μg**	96	(–)
0.0008	DDE: daily US avg (before 1972 ban) [d]	DDE, 6.91 μg	(–)	12.5
0.0006	**Bacon, 11.5 g**	**Diethylnitrosamine, 11.5 ng**	0.0266	(+)
0.0006	**Mushroom (*Agaricus bisporus* 2.55 g)**	**Glutamyl-*p*-hydrazinobenzoate, 107 μg**	.	277
0.0005	**Bacon, 11.5 g**	**Dimethylnitrosamine, 34.5 ng**	0.0959	(0.189)
0.0004	**Bacon, 11.5 g**	***N*-Nitrosopyrrolidine, 196 ng**	(0.799)	0.679
0.0004	EDB: Daily US avg (before 1984 ban) [d]	EDB, 420 ng	1.52	(7.45)
0.0004	Tap water, 1 liter (1987-92)	Bromodichloromethane, 13 μg	(72.5)	47.7
0.0004	TCDD: daily US avg (1994)	TCDD, 6.0 pg	0.0000235	(0.0001
0.0003	**Mango, 1.22 g**	***d*-Limonene, 48.8 μg**	204	(–)
0.0003	**Beer, 257 g**	**Furfural, 39.9 μg**	(683)	197
0.0003	Tap water, 1 liter (1987-92)	Chloroform, 17 μg	(262)	90.3
0.0003	Carbaryl: daily US avg (1990)	Carbaryl, 2.6 μg	14.1	(–)
0.0002	**Celery, 7.95 g**	**8-Methoxypsoralen, 4.86 μg**	32.4	(–)
0.0002	Toxaphene: daily US avg (1990) [c]	Toxaphene, 595 ng	(–)	5.57
0.00009	**Mushroom (Agaricus bisporus, 2.55 g)**	***p*-Hydrazinobenzoate, 28 μg**	.	454 [b]

Possible hazard: HERP (%)	Average daily US exposure	Human dose of rodent carcinogen	Potency TD_{50} (mg/kg/day) [a] Rats	Mice
0.5	**Wine, 28.0 g**	**Ethyl alcohol, 3.36 ml**	9110	(–)
0.5	Dehydroepiandrosterone (DHEA)	DHEA supplement, 25 mg	68.1	.
0.4	Conventional home air (14 hours/day)	Formaldehyde, 598 μg	2.19	(43.9)
0.2	Fluvastatin	Fluvastatin, 20 mg	125	.
0.1	**Coffee, 13.3 g**	**Caffeic acid, 23.9 mg**	297	(4900)
0.1	***d*-Limonene in food**	***d*-Limonene, 15.5 mg**	204	(–)
0.04	**Lettuce, 14.9 g**	**Caffeic acid, 7.90 mg**	297	(4900)
0.03	**Safrole in spices**	**Safrole, 1.2 mg**	(441)	51.3
0.03	**Orange juice, 138 g**	***d*-Limonene, 4.28 mg**	204	(–)
0.03	**Comfrey herb tea, 1 cup (1.5 g root) (no longer recommended)**	**Symphytine, 38 μg**	1.91	.
0.03	**Tomato, 88.7 g**	**Caffeic acid, 5.46 mg**	297	(4900)
0.03	**Pepper, black, 446 mg**	***d*-Limonene, 3.57 mg**	204	(–)
0.02	**Coffee, 13.3 g**	**Catechol, 1.33 mg**	88.8	(244)
0.02	**Furfural in food**	**Furfural, 2.72 mg**	(683)	197
0.02	**Mushroom (*Agaricus bisporus* 2.55 g)**	**Mixture of hydrazines, etc. (whole mushroom)**	-	20,300
0.02	**Apple, 32.0 g**	**Caffeic acid, 3.40 mg**	297	(4900)

297 mg/Kg/day rodent
70kg x 297 = 20790 mg

HERP = 100*(23.9/20790) = 0.115

HERP = 100*(human dose/70*TD_{50})