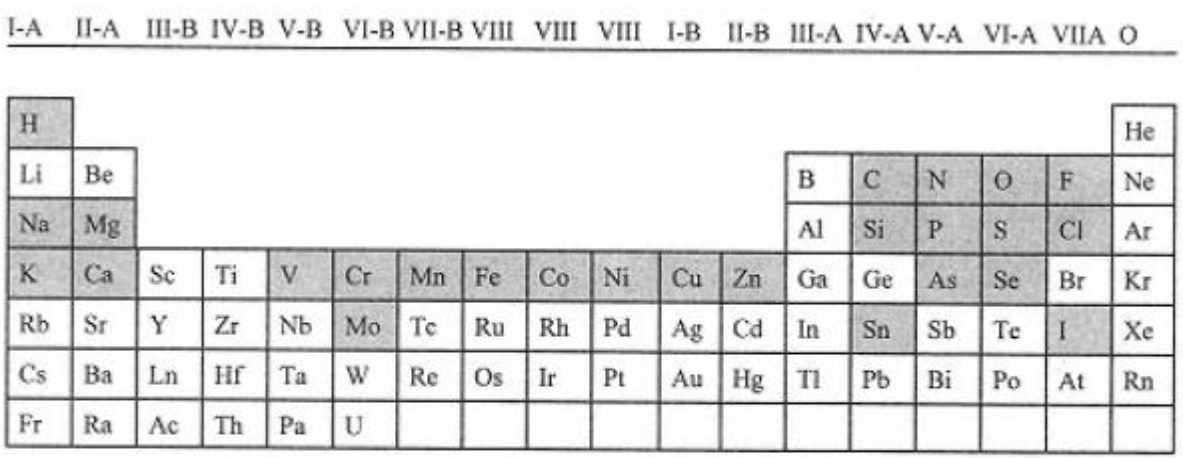
Μεταλλικά στοιχεία

C, H, N, O 99% των ατόμων σε ζωντανούς οργανισμούς



I-A	II-A	III-B	IV-B	V-B	VI-B	VII-B	VIII	VIII	VIII	I-B	II-B	III-A	IV-A	V-A	VI-A	VIIA	O
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Ln	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Th	Pa	U												

FIGURE 1
Periodic table of the naturally occurring elements. Shaded elements are believed to be essential nutrients for animals and humans.

- Αλογόνα: ιόντα
- Άλλα στοιχεία: Σύμπλοκα, χηλικές ενώσεις, οξοανιόντα

Σύμπλοκα

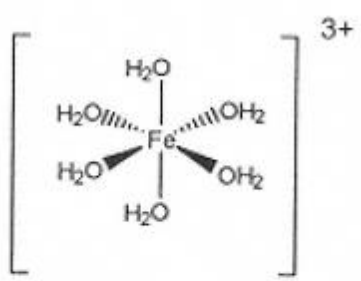


FIGURE 2
Ferric iron with six coordinated water molecules. This is the predominant form of Fe^{3+} in acidic (pH < 1) aqueous solutions.

$$M + L \rightleftarrows ML \qquad K_1 = \frac{[ML]}{[M][L]}$$

$$ML + L \rightleftarrows ML_2 \qquad K_2 = \frac{[ML_2]}{[ML][L]}$$

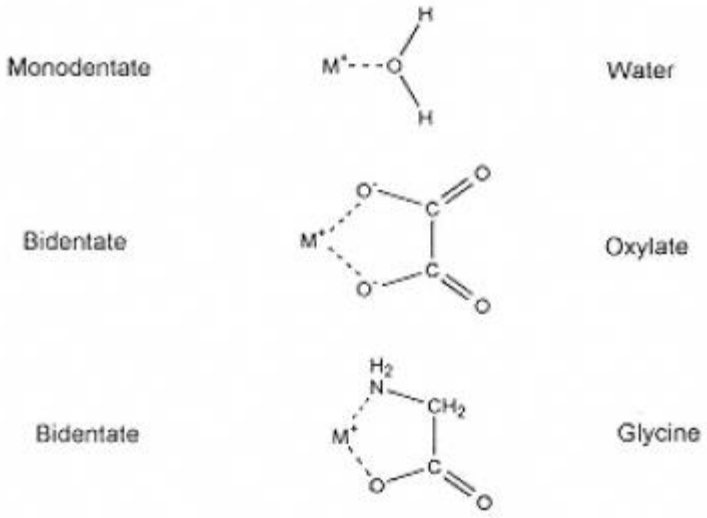


FIGURE 3
Examples of ligands coordinated with a metal ion (M^+)

Σύμπλοκα

TABLE 1 Stability Constants ($\log K$) for Selected Metal Complexes and Chelates

Ligand	Cu^{2+}	Fe^{3+}
OH^-	6.3	11.8
Oxalate	4.8	7.8
Histidine	10.3	10.0
EDTA	18.7	25.1

Note: Values are corrected to a constant ionic strength.

$$M + L \rightleftarrows ML \qquad K_1 = \frac{[ML]}{[M][L]}$$

$$ML + L \rightleftarrows ML_2 \qquad K_2 = \frac{[ML_2]}{[ML][L]}$$

$$\downarrow \quad \downarrow \quad \downarrow$$

$$ML_{n-1} + L \rightleftarrows ML_n \qquad K_n = \frac{[ML_n]}{[ML_{n-1}][L]}$$

$$\beta_n = \frac{[ML_n]}{[M][L]^n}$$

$$\beta_n = K_1 K_2 \ldots K_n$$

Χηλικό φαινόμενο

$$\Delta G = \Delta H - T\,\Delta S$$

1. Ring size. Five-membered unsaturated rings and six-membered saturated rings tend to be more stable than larger or smaller rings.

2. Number of rings. The greater the number of rings in the chelate, the greater the stability.

3. Lewis base strength. Stronger Lewis bases tend to form stronger chelates.

4. Charge of Ligand. Charged ligands form more stable chelates than uncharged ligands. For example, citrate forms more stable chelates than citric acid.

5. Chemical environment of the donating atom. Relative strengths of metal-ligand bonds are shown below in decreasing order.

   Oxygen as donor: $H_2O > ROH > R_2O$

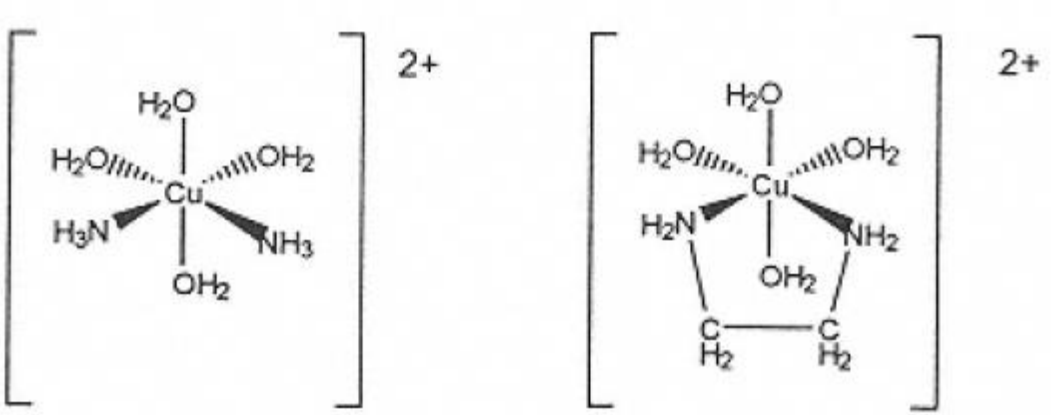
   Nitrogen as donor: $H_3N > RNH_2 > R_3N$

   Sulfur as donor: $R_2S > RSH > H_2S$

6. Resonance in chelate ring. Enhanced resonance tends to increase stability.

7. Stearic hindrance. Large bulky ligands tend to form less stable chelates.

Χηλικό φαινόμενο



$$Cu(H_2O)_6^{2+} + 2NH_3 \rightarrow [Cu(H_2O)_4(NH_3)_2]^{2+} + 2H_2O$$

(ΔH = -46 kJ mol^{-1}; ΔS = -8.4 J K^{-1}; mol^{-1}; and log β = 7.7.)

$$Cu(H_2O)_6^{2+} + NH_2CH_2CH_2NH_2 \rightarrow [Cu(H_2O)_4(NH_2CH_2CH_2NH_2)]^{2+} + 2H_2O$$

(ΔH = -54 kJ mol^{-1}; ΔS = +23 J K^{-1} mol^{-1}; and log K = 10.1)

EDTA

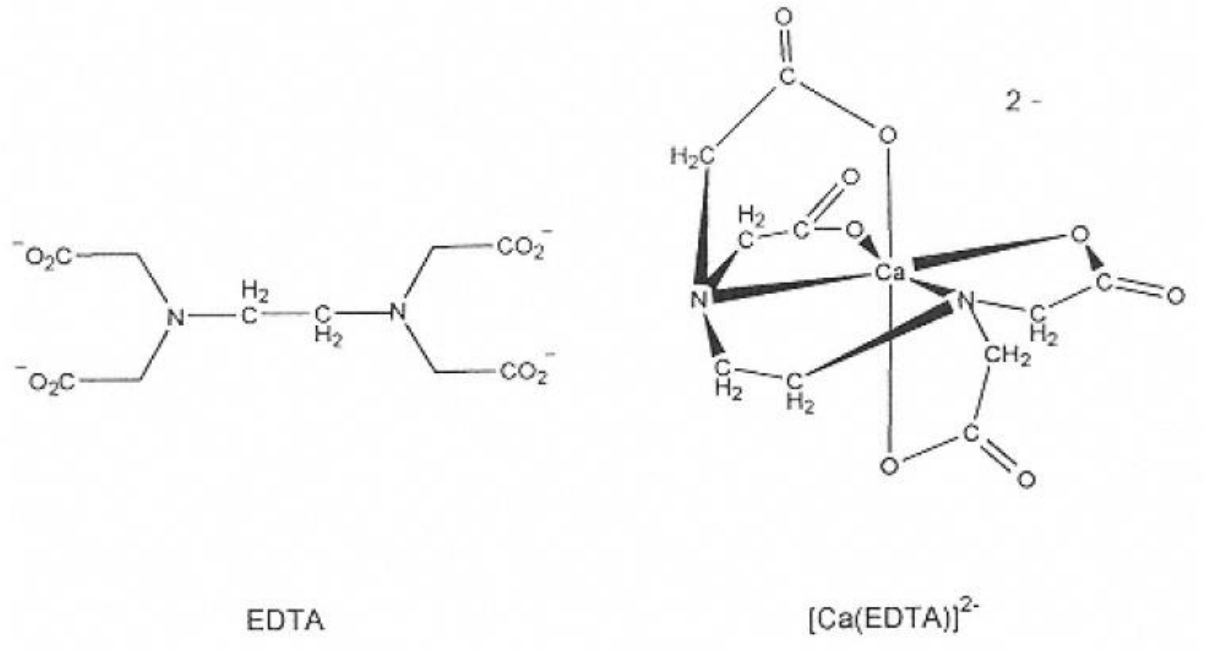


FIGURE 6
Ethylenediamine tetraacetic acid (EDTA) and calcium (Ca^{2+}) chelated with EDTA.

Απαραίτητα μεταλλικά στοιχεία

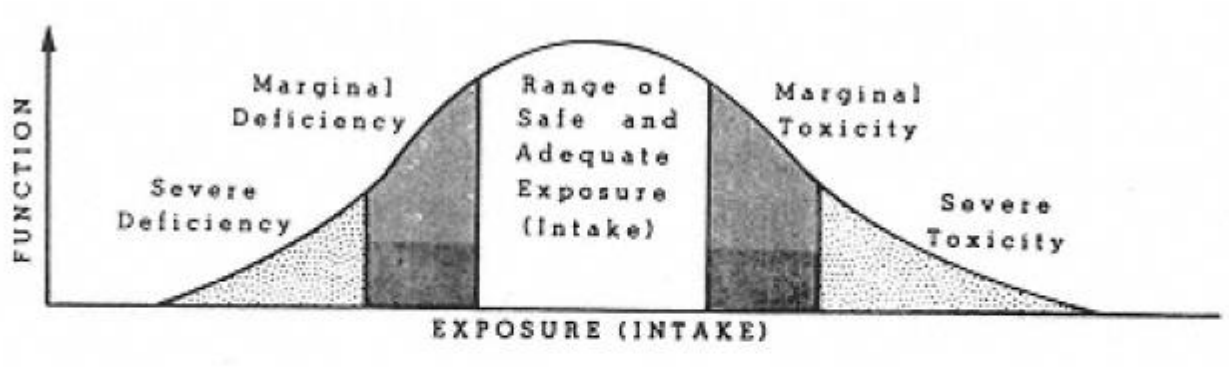


FIGURE 7
Dose-response relationship between mineral intake (dose) and an associated physiological function. Function is impaired at both excessively low and excessively high intakes of most mineral nutrients. (From Ref. 42.)

TABLE 2 Recommended Dietary Allowances (RDAs) for the Mineral Nutrients

		Minerals						
Category	Age (years) or condition	Calcium (mg)	Phosphorus (mg)	Magnesium (mg)	Iron (mg)	Zinc (mg)	Iodine (μg)	Selenium (mg)
Infants	0.0–0.5	400	300	40	6	5	40	10
	0.5–1.0	600	500	60	10	5	50	15
Children	1–3	800	800	80	10	10	70	20
	4–6	800	800	120	10	10	90	20
	7–10	800	800	170	10	10	120	30
Males	11–14	1200	1200	270	12	15	150	40
	15–18	1200	1200	400	12	15	150	50
	19–24	1200	1200	350	10	15	150	70
	25–50	800	800	350	10	15	150	70
	51+	800	800	350	10	15	150	70
Females	11–14	1200	1200	280	15	12	150	45
	15–18	1200	1200	300	15	12	150	50
	19–24	1200	1200	280	15	12	150	55
	25–50	800	800	280	15	12	150	55
	51+	800	800	280	10	12	150	55
Pregnant		1200	1200	320	30	15	175	65
Lactating	1st 6 months	1200	1200	355	15	19	200	75
	2nd 6 months	1200	1200	340	15	16	200	75

TABLE 3 Estimated Minimum Requirements for Electrolytes

Age	Weight (kg)	Sodium (mg)	Chloride (mg)	Potassium (mg)
Months				
0.–5	4.5	120	180	500
6–11	8.9	200	300	700
Years				
1	11.0	225	350	1000
2–5	16.0	300	500	1400
6–9	25.0	400	600	1600
10–18	50.0	500	750	2000
>18	70.0	500	50	2000

TABLE 4 Estimated Safe and Adequate Daily Dietary Intakes of Selected Minerals

Category	Age (years)	Cu (mg)	Mn (mg)	F (mg)	Cr (μg)	Mo (μg)
Infants	0.–0.5	0.4–0.6	0.3–0.6	0.1–0.5	10–40	15–30
	0.5–1	0.6–0.7	0.6–1.0	0.2–1.0	20–60	20–40
Children and adolescents	1–3	0.7–1.0	1.0–1.5	0.5–1.5	20–80	25–50
	4–6	1.0–1.5	1.5–2.0	1.0–2.5	30–120	30–75
	7–10	1.0–2.0	2.0–3.0	1.5–2.5	50–200	50–150
	11+	1.5–2.5	2.0–5.0	1.5–2.5	50–200	5–250
Adults		1.5–3.0	2.0–5.0	1.5–4.0	50–200	75–250

Βιοδιαθεσιμότητα

TABLE 6 Calcium Content and Bioavailability in Selected Foods

Food	Serving size (g)	Calcium content (mg)	Fractional absorption[a](%)	Estimated absorbable Ca/serving (mg)	Servings to equal 240 ml n (*n*)
Milk	240	300	32.1	96.3	1.0
Almonds	28	80	21.2	17.0	5.7
Pinto beans	86	44.7	17.0	7.6	12.7
Broccoli	71	35	52.6	18.4	5.2
Cabbage, green	75	25	64.9	16.2	5.9
Cauliflower	62	17	68.6	11.7	8.2
Citrus punch, with CCM[b]	240	300	50.0	150	0.064
Kale	65	47	58.8	27.6	3.5
Soy milk	120	5	31.0	1.6	60.4
Spinach	90	122	5.1	6.2	15.5
Tofu, Ca set	126	258	31.0	80.0	1.2
Turnup greens	72	99	51.6	31.1	1.9
Water cress	17	20	67.0	13.4	7.2

[a]Percent absorption adjusted for calcium load.

[b]Calcium-citrate-maleate.

Ανεπάρκειες

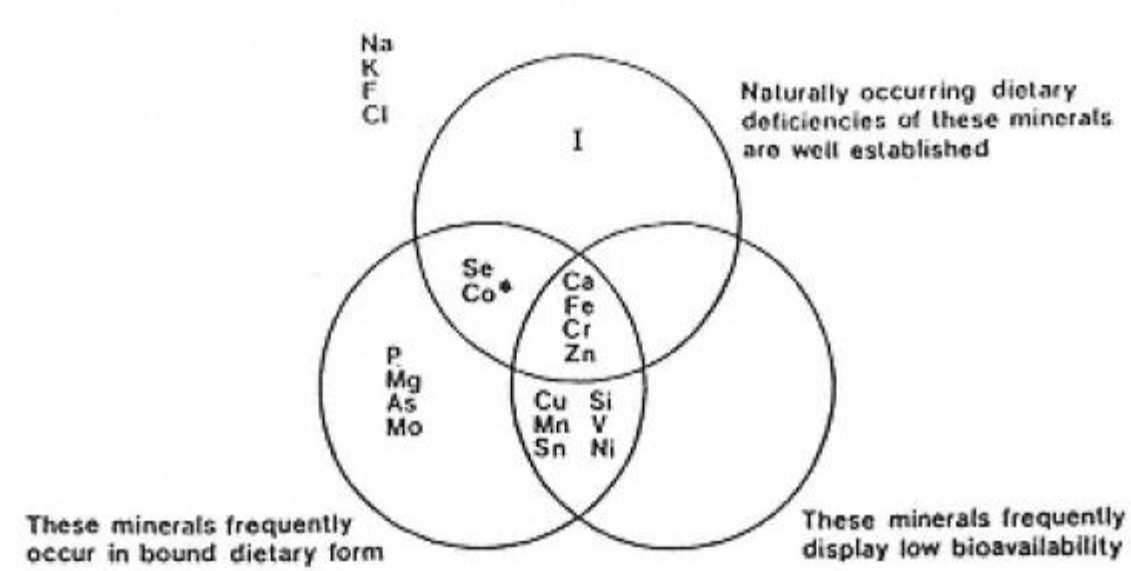


FIGURE 8

Essential minerals grouped by chemical form (free ions in solution or bound to food ligands), bioavailability, and occurrance of nutritional deficiency. *As vitamin B_{12}. (From Ref. 17.)

Ash (στάχτη)

- Μέτρο της συνολικής ποσότητας μεταλλικών στοιχείων σε ένα τρόφιμο
- Υπερεκτίμηση (σε μορφή οξειδίων)
- Διάλυση της στάχτης σε οξέα και μέτρηση κάθε μεταλλικού στοιχείου ξεχωριστά
- Ατομική απορρόφηση
- Επαγωγικά συζευγμένο πλάσμα

7-1 table **Ash Content of Selected Foods**

Food Item	*Percent Ash (Wet Weight Basis)*
Cereals, bread, and pasta	
Rice, brown, long-grain, raw	1.5
Corn meal, whole-grain, yellow	1.1
Hominy, canned, white	0.9
White rice, long-grain, regular, raw, enriched	0.6
Wheat flour, whole-grain	1.6
Macaroni, dry, enriched	0.9
Rye bread	2.5
Dairy products	
Milk, reduced fat, fluid, 2%	0.7
Evaporated milk, canned, with added vitamin A	1.6
Butter, with salt	2.1
Cream, fluid, half-and-half	0.7
Margarine, hard, regular, soybean	2.0
Yogurt, plain, low fat	1.1
Fruits and vegetables	
Apples, raw, with skin	0.2
Bananas, raw	0.8
Cherries, sweet, raw	0.5
Raisins	1.9
Potatoes, raw, skin	1.6
Tomatoes, red, ripe, raw	0.5
Meat, poultry, and fish	
Eggs, whole, raw, fresh	0.9
Fish fillet, battered or breaded, and fried	2.5
Pork, fresh, leg (ham), whole, raw	0.9
Hamburger, regular, single patty, plain	1.9
Chicken, broilers or fryers, breast meat only, raw	1.0
Beef, chuck, arm pot roast, raw	1.1

From US Department of Agriculture, Agricultural Research Service (2009) USDA National Nutrient Database for Standard Reference. Release 22. Nutrient Data Laboratory Home Page: http://www.ars.usda.gov/ba/bhnrc/ndl

Τροφές προερχόμενες από φυτά

Fe, Se, I

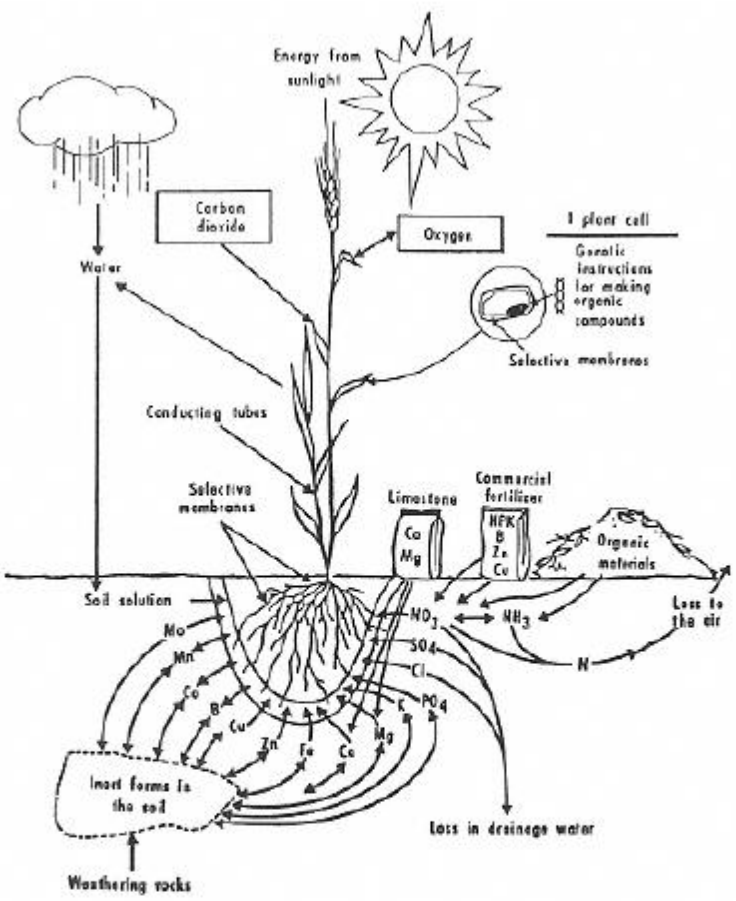


FIGURE 9
Plants obtain mineral nutrients from the soil solution surrounding the roots. Sources of these minerals include fertilizer, decaying organic materials, and weathering rocks. The minerals are taken up in the roots by a selective process and transported upward to all parts of the plant. The whole process is regulated according to instructions encoded in the plants genetic material. (From Ref. 1.)

-Ca (ρύζι)
-Fe (βιοδιαθεσιμότητα)

TABLE 7 Mineral Composition of Selected Foods

Quantity	Food	Weight (g)	kcal[2]	Ca	Mg	P	Na	K	Fe	Zn	Cu	Se
1 egg	Scrambled	100	157	57	13	269	290	138	2.1	2.0	0.06	8
1 slice	White bread	28	75	35	6	30	144	31	0.8	0.2	0.04	8
1 slice	Whole wheat bread	28	70	20	26	74	180	50	1.5	1.0	0.10	16
0.5 cup	Spaghetti, cooked without salt	70	99	5	13	38	1	22	1.0	0.4	0.07	19.0
0.5 cup	Brown rice, cooked	98	108	10	42	81	5	42	0.4	0.6	0.01	13.0
0.5 cup	White rice, parboiled, cooked	88	100	17	11	37	3	32	1.0	0.3	0.08	8.30
0.5 cup	Black beans, cooked	86	113	24	61	120	1	305	2.0	1.0	0.18	6.9
0.5 cup	Red kidney beans	89	112	25	40	126	2	356	3.0	0.9	0.21	1.9
1 cup	Whole milk	244	150	291	33	228	120	370	0.1	0.9	0.05	3.0
1 cup	Skim milk/nonfat milk	245	86	302	28	247	126	406	0.1	0.9	0.05	6.6
1.5 oz.	American cheese, processed	43	159	261	10	316	608	69	0.2	1.3	0.01	3.8
1.5 cup	Cheddar cheese	43	171	305	12	219	264	42	0.3	1.3	0.01	6.0
0.5 cup	Cottage cheese, creamed, small curd	105	108	63	6	139	425	89	0.1	0.4	0.03	6.3
1 cup	Yogurt, low-fat, plain	227	144	415	10	326	159	531	0.2	2.0	0.10	5.5
0.5 cup	Ice cream, regular vanilla	67	134	88	9	67	58	128	0.1	0.7	0.01	4.7
1 each	Baked potato with skin	202	220	20	55	115	16	844	2.8	0.7	0.62	1.8

Quantity	Food	Weight (g)	kcal[2]	Ca	Mg	P	Na	K	Fe	Zn	Cu	Se
1 each	Peeled potato, boiled	135	116	10	26	54	7	443	0.4	0.4	0.23	1.2
3 each	Broccoli, raw spears	453	126	216	114	297	123	1470	4.0	2.0	0.40	0.9
3 each	Broccoli spear, cooked from fresh	540	151	249	130	318	141	1575	4.5	2.1	0.23	1.1
0.5 cup	Raw carrot, grated	55	24	15	8	24	19	178	0.3	0.1	0.03	0.8
0.5 cup	Cooked carrots, from frozen	73	26	21	7	19	43	115	0.4	0.2	0.05	0.9
1 each	Tomato, fresh, whole, average	123	26	6	14	30	11	273	0.6	0.1	0.09	0.6
0.75 cup	Tomato juice, canned	183	31	17	20	35	661	403	1.0	0.3	0.18	0.4
0.75 cup	Orange juice prepared from frozen	187	83	17	18	30	2	356	0.2	0.1	0.08	0.4
1 each	Orange, average, 2 5/8 in diameter	131	60	52	13	18	0	237	0.1	0.1	0.06	1.2
1 each	Apple with peel, 2.75 in diameter	138	80	10	6	10	1	159	0.3	0.1	0.06	0.6
1 each	Banana (peeled weight)	114	85	7	32	22	1	451	0.4	0.2	0.12	1.1
3 oz.	Beef round, roasted	85	205	5	21	176	50	305	1.6	3.7	0.08	–
3 oz.	Veal, round, roasted	85	160	6	28	234	68	389	0.9	3.0	0.13	–
3 oz.	Chicken, white meat, roasted	85	140	13	25	194	63	218	0.9	0.8	0.04	–
3 oz.	Chicken, leg meat, roasted	85	162	10	20	156	77	206	1.1	2.4	0.07	–
3 oz.	Salmon, cooked	85	183	6	26	234	56	319	0.5	0.4	0.06	–
3 oz.	Salmon, canned, with bones	85	130	203	25	277	458	231	0.9	0.9	0.07	–

[2]kcal × 4.186 = kJ.

Note: Values are mg per serving, except Se is μg per serving.

Ενίσχυση τροφίμων

Fe, I, Ca, Zn

$FeSO_4$

TABLE 8 FDA Standards for the Enrichment of Cereal Products with Iron and Calcium

Food	Iron (mg/lb) (shall contain)	Calcium (mg/lb) (may contain)
Enriched flour	20	960
Enriched rice	Not less than 16	Not less than 500
	Not more than 32	Not more than 750
Enriched corn grits	Not less than 13	Not less than 500
	Not more than 26	Not more than 1000
Enriched macaroni products	Not less than 13	Not less than 500
	Not more than 16.5	Not more than 625
Enriched bread, rolls, and buns	12.5	600

Note: Forms of iron and calcium used must be harmless and assimilable.

Ενίσχυση τροφίμων

TABLE 9 Iron Sources Used in Food Fortification and Their Bioavailabilities

Chemical name	Formula	Fe content (g/kg fortificant)	Relative biological value[a]	
			Human	Rat
Ferrous sulfate	$FeSO_4 . 7H_2O$	200	100	100
Ferrous lactate	$Fe(C_3H_5O_3)_2 . 3H_2O$	190	106	—
Ferric phosphate	$FePO_4 . xH_2O$	280	31	3-46
Ferric pyrophosphate	$Fe_4(P_2O_7)_3 . 9H_2O$	250	—	45
Ferric sodium pyrophosphate	$FeNaP_2O_3 . 2H_2O$	150	15	14
Ferric ammonium citrate	$Fe_xNH_4(C_6H_8O_7)_x$	165-185	—	107
Elemental Fe	Fe	960-980	13-90	8-76

[a]Relative biological value is the bioavailability relative to ferrous sulfate which is set at 100.

Ενίσχυση τροφίμων

TABLE 11 Protein, Calcium, and Phosphate Contents of Selected Cheeses

Cheese variety	Protein (%)	Ca (mg/100 g)	Ca:protein (mg:g)	PO_4 (mg/100 g)	PO_4:protein (mg:g)
Cottage	15.2	80	5.4	90	16.7
Cheddar	25.4	800	31.5	860	27.3
Emmenthal	27.9	920	33.1	980	29.6

Ashing: Wet or Dry

7-1 figure Microwave closed-vessel digestion system. (Courtesy of CEM Corporation, Matthews, NC.)

7-3 figure Microwave muffle furnace. (Courtesy of CEM Corporation, Matthews, NC.)

Ion exchange chromatography

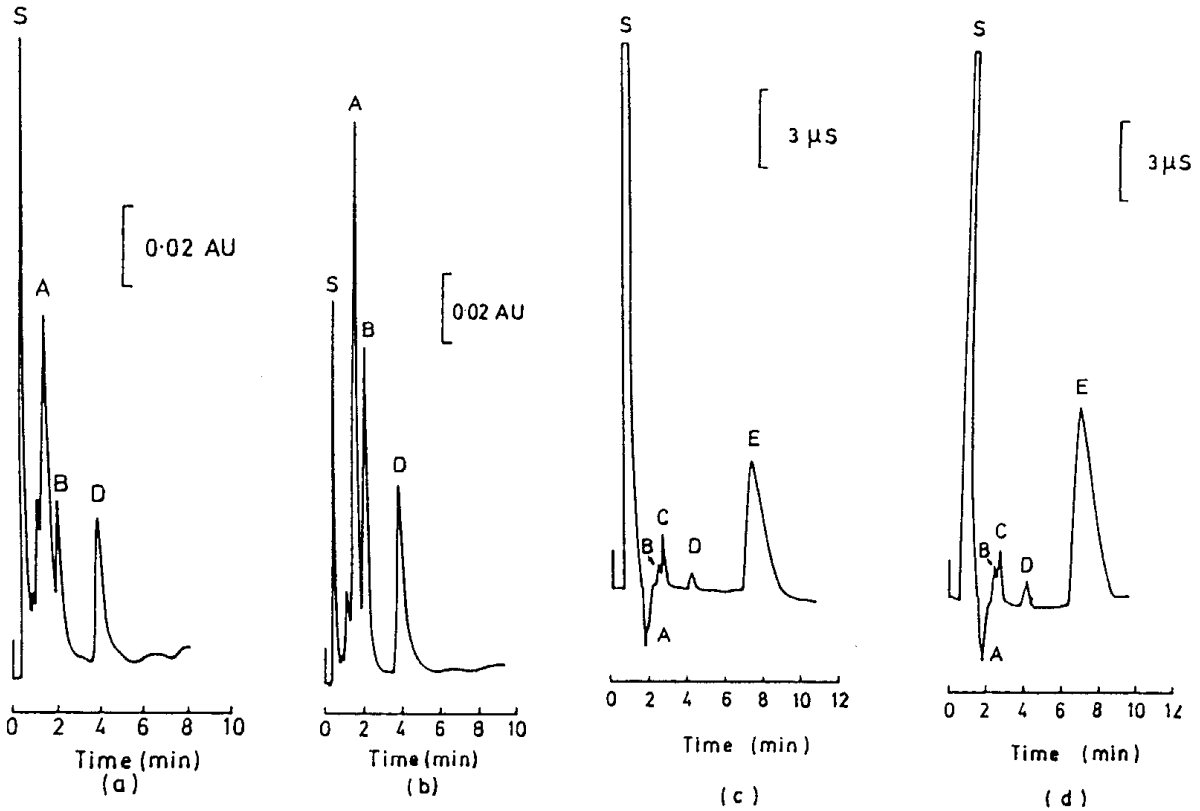


Fig. 2 Determination of ascorbate (A), bromate (B), chloride (C), bromide (D), and sulfate (E) in bread improver extract (a, c) and spiked bread improver (b, d) with UV absorption (a, b) and conductivity (c, d) detection (S = solvent). Conditions: column, TSK IC anion PW (50 × 4.6 mm); mobile phase, 7 mM chloromethanesulfonate, pH 5.5, flow rate, 4.5 ml/min; chart speed, 5 mm/min; injection volume, 10 μl; detector sensitivities, 0.2 AUFS or 25 μSFSD; sample concentrations, 200–500 mg/L. (Reprinted by permission from Ref. 22.)

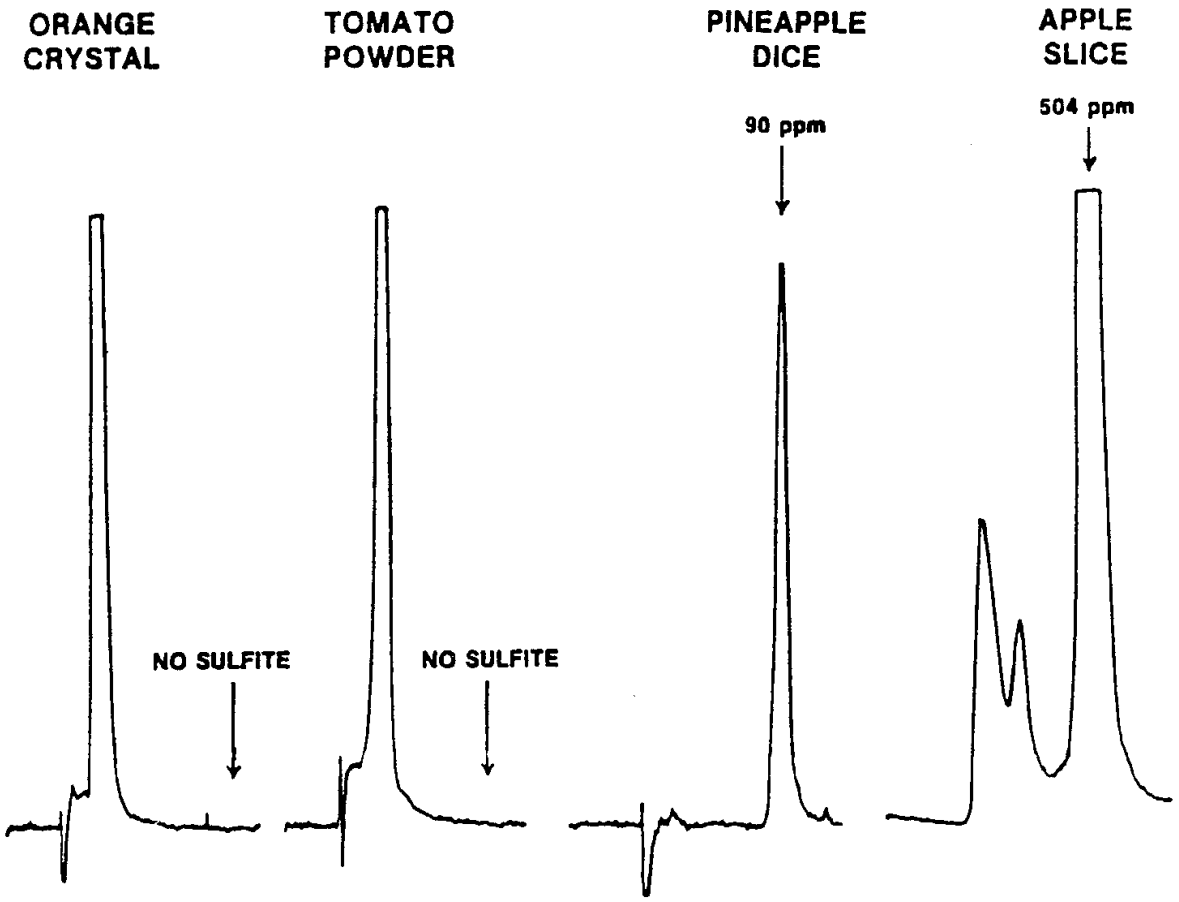


Fig. 4 Determination of sulfite by ion exclusion chromatography with electrochemical detection in dehydrated foods. Sulfite peak retention time about 2 min. Conditions: Column, Brownlee Polypore H (sulfonated polystyrene-divinylbenzene, 4.6 × 100 mm); mobile phase, 6 mM H_2SO_4; flow rate, 1 ml/min; sample size, 20 μl. Platinum electrode: +0.4 V vs. Ag/AgCl electrode. (Reprinted by permission from Ref. 52.)

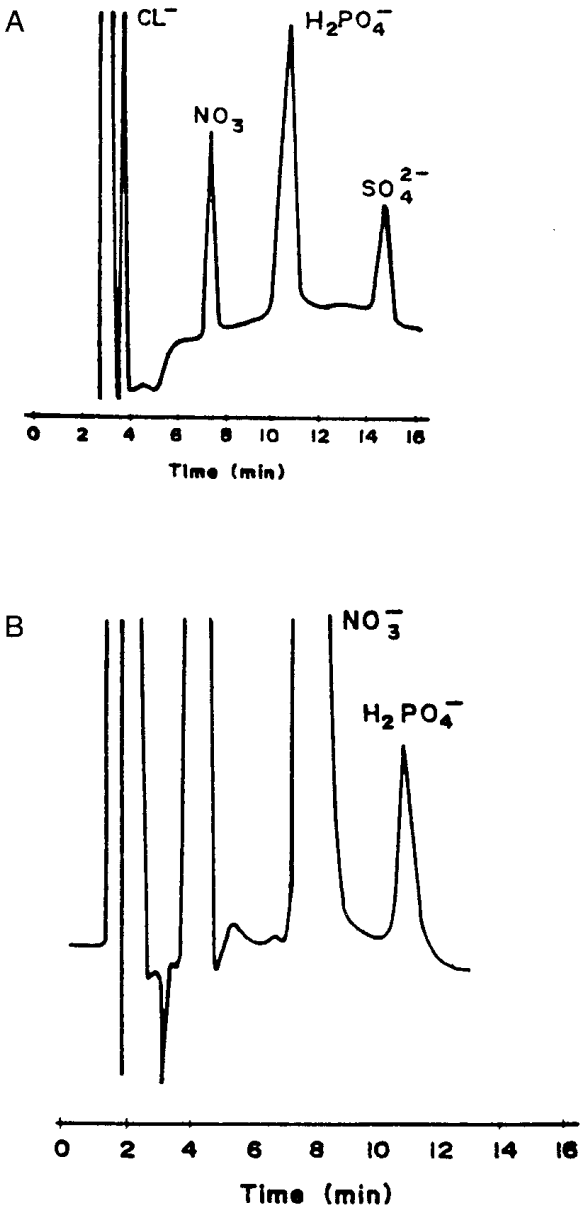


Fig. 5 (A) Chromatogram of a tomato extract. (B) Chromatogram of a chard sample with a high nitrate concentration (4500 μg/g). Separations were done using a Waters IC–PAK anion-exchange column with a sodium borate/gluconate, pH 8.5, eluent and conductivity detection. (Reprinted by permission from Ref. 59C.)