

Table 1. Species and concentrations of Se in foods and supplements (concentrations of Se species are expressed in terms of concentration of elemental Se) and the methodology used for species identification

Food/Source	Growth conditions	Species	Typical concentration	Identification methodology ^a	Ref.	
Supplements (also see Se-yeast)	NA	Selenite/selenate	30-100 µg/tablet			
		Selenomethionine	60-200 µg/tablet			
		Se-methyl-selenocysteine	100-200 µg/tablet			
Se-yeast (in supplements; as a food additive; in functional foods)	Medium enriched with inorganic Se	-	Total Se 1200 - 2200 µg/g		4,5,	
		Selenomethionine	60-84%	ESI-MS/MS	9,	
		Selenocysteine	3-5%	Retention time	12,	
		Selenite	<1% total extracted Se	Retention time	23-	
		Se-methyl-selenocysteine	0.5%	ESI-MS/MS	29	
		γ-glutamyl-Se-methyl-selenocysteine	0.5%	ESI-MS/MS		
		Se-adenosyl-selenohomocysteine	0.5-5%	ESI-MS/MS		
		Se-cystathionine	0.5-1%	Retention time		
		Se-lanthionine	0.5%	Retention time		
		Selenocystine	0.5%	Retention time		
		Selenomethionine-selenoxide/hydrate	0.5%	ESI-MS		
		SeMet-Asn-Ala-Gly-Arg				
		Selenodiglutathione & the mixed				

		Selenotrisulphide of glutathione & cysteinylglycine	-	ESI-MS/MS	31
		Se-containing proteins (SIP18 and HSP12)	-	ESI-MS/MS	32
		S-selenomethyl-glutathione glutathione-S-selenoglutathione	-	ESI-MS/MS	33
Cereals		-	0.1-30 µg/g (Western US)		4
		-	0.016-0.021 µg/g (Dk)		34
		-	0.007-0.011 µg/g (Finland, Sweden, Norway)		34
Wheat, corn, barley, oats, rye	N & S Dakota, Nebraska, Kansas, Colorado	-	≤ 30 µg/g		9
	Other parts of US	-	0.1 µg/g		
Wheat grain		Selenate (includes selenite, & selenocysteic acid)	12-19% total eluted Se	Retention time	9
		Selenomethionine	56-83% total eluted Se	Retention time	
		Selenocysteine	4-12% total eluted Se	Retention time	
		Se-methyl-selenocysteine	1-4% total eluted Se	Retention time	

Wheat sprouts		Selenate	≤ 40-50% total Se at ≤100 µg/g dry wt	Retention time	35
Wheat grain	China	Selenomethionine	50.4-81.4% of total Se	Retention time	36
Wheat flour	USA	-	Total: 439 ng/g		37
		Selenomethionine	256 ng/g	ESI-MS/MS	
		Selenate	5.3 ng/g	Retention time	
Corn	Seleniferous soil	-	8.7 (0.6-44.0) µg/g (selenosis)		38
	High Se area of China	-	18 µg/g		39
		Selenomethionine	61-64% of total eluted Se	Retention time	
		Selenocysteine	15-16% of total eluted Se	Retention time	
	China, grain	Selenomethionine	0.01-19.01 µg/g representing 46-82% of the total Se	Retention time	36
Barley	Denmark	-	≤ 0.11 µg/g		4
Rice	Seleniferous soil	-	4.0 (0.3-20.2) µg/g (selenosis)		38
	High Se area of China	-	3.6 µg/g Se		38
		Selenomethionine	68-81% of total eluted Se	Retention time	
		Selenocysteine	6-10% of total eluted Se	Retention time	
		Selenite	5-13 % of total eluted Se	Retention time	
		Selenate	1-3% of total eluted Se	Retention time	

	China, grain	Selenomethionine		Retention time	36
Soy beans			54.9-86.5% of total Se		
	-	Selenomethionine	> 80% of eluted Se	Retention time	4
	China	Selenomethionine	62.9-71.8% of total Se	Retention time	36
Lima beans		Se-methyl-selenocysteine	-	Retention time	4
		γ -glutamyl-Se-methyl-selenocysteine	-	Retention time	
		Se-cystathionine	-	Retention time	
Brazil nuts	Natural	-	2.54 $\mu\text{g/g}$		40
	Acre - Rondonia, Brazil (shelled)	-	3.06 (0.03-31.7) $\mu\text{g/g}$ fresh weight		41
	Manaus - Belem, Brazil (unshelled)	-	36.0 (1.25-512.0) $\mu\text{g/g}$ fresh weight		
	Natural (UK purchased)	-	2.54 (0.85-6.86) $\mu\text{g/g}$		42
	Natural (unshelled)	-	22 $\mu\text{g/g}$		43
	Natural	Selenomethionine	≤ 100 $\mu\text{g/g}$	Retention time	44
	Natural	Selenomethionine	-	Retention time	45

	Purchased with shells	-			46
		Selenomethionine	Total Se: 35.1 µg/g	Retention time	
		Weakly protein-bound Se	Major Se species, 25% total Se		
		Low Mol Wt compounds	12% total Se		
			3.1% total Se		
	Purchased without shells	-	Total Se: 8.3 µg/g		
		Selenomethionine		Retention time	
		Weakly protein-bound Se	Major Se species, 21% total Se		
		Low Mol Wt compounds	12.0% total Se		
			5.0% total Se		
	Natural	15 Se-containing peptides (14 selenomethionine-containing peptides + 1 Se-cysteine-containing peptide)	Total Se: 82.9 µg/g	ESI-MS/MS	47
Walnuts	Black and white	-	Total Se: 0.38 and 0.20 µg/g resp.		46
		Selenomethionine	19% and 23% respectively of total Se	Retention time	
		Low Mol Wt compounds	15% and 10% respectively of total Se		
	Unspecified	-	Total Se: 0.031 (0.012-0.060) µg/g		42
Cashew nuts	Natural	-	Total Se: 0.27 µg/g		46
		Selenomethionine	22% of total Se	Retention time	
		Low Mol Wt compounds	12% of total Se		
	Natural	-	Total Se: 0.27 (0.17-0.39) µg/g		42

Pecan nuts	Natural	-	Total Se: 0.10 µg/g		46
		Selenomethionine	25% of total Se	Retention time	
		Low Mol Wt compounds	not detected		
Monkeypot nuts	Natural		Total Se: 4.5 mg/g		48
		Selenocystathionine	-	ESI-MS/MS	
		Isoforms of γ-glutamyl-selenocystathionine	-		
Pumpkin seeds	Enriched by leaf spraying	Selenomethionine	81±8% total Se	Retention time	49
Vegetables	Natural	-	<0.01 µg/g		40
Vegetables: rutabagas, cabbage, peas, beans, carrots, tomatoes, beets, potatoes, cucumbers	Seleniferous soil	Selenate	≤ 6 µg/g total Se	Retention time	4
Vegetables:	Sludge-amended soil	-			
		Selenate	up to 50% of total Se		4
Asparagus	UK Seleniferous soil	-	0.001-0.064 µg/g 11 µg/g		42 4
Broccoli	Enriched	-	Total Se 345 µg/g		50
		Se-methyl-selenocysteine:SeCys	Ratio 2:1	Retention time	
		Selenomethionine	Minor amounts	Retention time	

Broccoli florets & leaves	Enriched	Selenate	$\leq 44\%$ & $\leq 38\%$ total Se respectively	Retention time	9
Broccoli sprouts	Enriched	-	Total Se $62.3 \pm 0.6 \mu\text{g/g}$ dry weight	Retention time	51
		Se-methyl-selenocysteine	45%	Retention time	
		Selenate	20%	Retention time	
		Selenomethionine	12%	Retention time	
		Adenosyl-selenohomocysteine	3%	Retention time	
Broccoli roots	Grown in hydroponic culture with Na_2SeO_3	Selenomethionine	Major species	Retention time	52
Broccoli florets		Se-methyl-selenocysteine	Major species	Retention time	
Cabbage (<i>Brassica oleracea capitata</i>)	Enriched	Se-methyl-selenocysteine-selenoxide	$\leq 21.5\%$ of total extractable Se	Retention time	53
	Sludge-amended soil	Selenate	$\leq 40\%$ of total Se	Retention time	9
				Retention time	
Cabbage	Enriched	-			b
		Se-methyl-selenocysteine	Total: $94 \mu\text{g/g}$		
		Selenomethionine	30 ng/g	Retention time	
		Selenate	302 ng/g	Retention time	
			$38 \mu\text{g/g}$	Retention time	
Radish (<i>Raphanus sativus</i>)	Hydroponic culture with (i) Na_2SeO_3 (ii) Na_2SeO_4	-	(i) Total $112 \pm 7 \mu\text{g/g}$	Retention times	54
		-	(ii) Total $120 \pm 6 \mu\text{g/g}$		
		Secystine	$\mu\text{g/g}$ fresh wt (i) 6 ± 1 (ii) 19 ± 2		
		Se-methyl-selenocysteine	83 ± 7 7 ± 1		

		Selenomethionine	18±1	20±1		
		Selenate	1±0	68±5		
Mushrooms (<i>Agaricus bisporus</i> & <i>Lentinula edodes</i>)	Enriched		Total Se dry weight:- <i>Agaricus bisporus</i> 0.77 µg/g; <i>Lentinula edodes</i> 0.043 µg/g			55
		Selenocystine	-		Retention times	
		Selenomethionine	-			
		Se-methyl-selenocysteine	-			
		Inorganic Se	-			
<i>Lentinula edodes</i> (shiitake mushrooms)	Enriched	Selenomethionine	40.6% of the total water-soluble Se		ESI-MS/MS	56
<i>Agaricus bisporus</i>	Enriched	-	69 µg/g total Se			
		Se-methyl-selenocysteine	114 ng/g			b,57
		Selenomethionine	17 µg/g		ESI-MS/MS	
		Selenate	61 ppb		ESI-MS/MS	
					Retention time	
Onions (<i>Allium cepa</i>)	Natural (USA)	-	Total Se < 0.5 µg/g			23
		Selenate	100% of total enzymatic extract of Se		Retention time	
Onions (<i>Allium cepa</i>)	Seleniferous soil	-	17 µg/g			4
	Enriched	Selenocystine	Total Se 96 µg/g; equal amounts of both compounds		Retention time	50
		Se-methyl-selenocysteine			Retention time	
	Enriched	-	Total Se	96 140 µg/g of		23

which % distribution as follows:

γ -glutamyl-Se-methyl-selenocysteine	35	63 %
Selenomethionine	10	5 %
Se-methyl-selenocysteine	5	1 %
Selenate	33	10 %
Se-cystathionine	4	0.5 %
Selenocystine	-	1 %
Sum	92	96 %

Retention times

Enriched with 15 μ g/g Se IV added to growth medium	-	30.3 μ g Se/g of plant tissue	58	
	Selenocystine	-	Retention time	
	Se-methyl-selenocysteine	-	Retention time	
	SeMet	-	Retention time	
	γ -glutamyl-Se-methyl-selenocysteine	-	ESI-MS/MS	
	Inorganic Se	-	Retention time	
	Garlic (<i>Allium sativum</i>)	Natural	Selenocystine	Total Se 0.02 μ g/g
Natural	-	Total Se < 0.5 μ g/g; % distribution:	23	
	γ -glutamyl-Se-methyl-selenocysteine	31%	Retention times	
	Selenomethionine	53%		
	Se-methyl-selenocysteine	12%		
	Selenate	4%		
Garlic (<i>Allium sativum</i>)	Supplement	-	Total Se < 0.5 μ g/g; % distribution:	23
	γ -glutamyl-Se-methyl-selenocysteine	48%	ESI-MS	

		Selenomethionine	28%	ESI-MS	
		Se-methyl-selenocysteine	14%	ESI-MS	
		Selenate	10%	Retention time	
Garlic (<i>Allium sativum</i>)	Enriched	Selenocysteine	Total Se 68 µg/g		50
	Enriched	-	Total Se 1355 µg/g		50
		Se-methyl-selenocysteine	-	Retention times	
		Selenocysteine	-		
		Selenomethionine	-		
	Enriched	-	Total Se 1355 and 235 µg/g		59, 9
		Se-methyl-selenocysteine (γ -glutamyl- Se-methyl-selenocysteine)	predominant form	Retention times	
		Selenocystine	-		
		Selenomethionine	-		
		Selenoethionine	-		
		Se-propyl-selenocysteine?	-		
		Selenate	-		
		Selenite	-		
					60
	Enriched	-	296 µg/g Se		
		γ -glutamyl-Se-methyl-selenocysteine	73% of total eluted Se	ESI-MS	
		Selenomethionine	13% of total eluted Se	ESI-MS	
		γ -glutamyl-selenomethionine	4% of total eluted Se	Retention time	
		Se-methyl-selenocysteine	3% of total eluted Se	ESI-MS	

	Selenate	2% of total eluted Se	Retention time	
	Selenocystine	0.5% of total eluted Se	Retention time	
	Selenocystathionine	0.5% of total eluted Se	Retention time	
Enriched	-	28.3µg/g wet wt; 96µg/g lyophilised		61
	γ-glutamyl-Se-methyl-selenocysteine	49.7% Se in hot water extract	ESI-MS/MS	
	Se-methyl-selenocysteine	28.8% Se in hot water extract	ESI-MS/MS	
	Selenomethionine	15.5% Se in hot water extract	ESI-MS/MS	
	Selenocystine	6.0% Se in hot water extract	Retention time	
Enriched	-	Total Se, 68 112 235 296 1355 µg/g, of which % distribution as follows:		23
	γ-glutamyl-Se-methyl-selenocysteine	68 52 70 73 8%	ESI-MS/MS	
	Selenomethionine	18 28 17 13 13%	ESI-MS/MS	
	Se-methyl-selenocysteine	2.5 3.0 3.0 3.0 60%	ESI-MS/MS	
	Selenate	1.0 0.1 1.5 2.0 4.0%	Retention time	
	Se-cystathionine	0.5 1.5 0.5 0.5 1.5%	Retention time	
	Selenocystine	0.5 1.0 0.5 0.5 - %	Retention time	
	sum	93 93 95 96 87%		
Grown on seleniferous soil	-	Total: 205 µg/g		62
	γ-glutamyl-Se-methyl-selenocysteine	> 78% of total Se	ESI-MS/MS	
Enriched	-	Total: 1.980 µg/g		b
	γ-glutamyl-Se-methyl-selenocysteine	496 ng/g	ESI-MS/MS	
	Se-methyl-selenocysteine	35 ng/g	ESI-MS/MS	

Ramps (wild leeks, <i>Allium tricoccum</i>)	Enriched		Total Se, 48 77 ^c 230 252 405 524	23
			µg/g, of which % distribution as follows:	Retention times
		γ-glutamyl-Se-methyl-selenocysteine	- 3 1 1 1.5 1.5%	
		Selenomethionine	10 21 8 8 5 5%	
		Se-methyl-selenocysteine	35 34 50 50 44 44%	
		Selenate	25 1 15 15 25 22%	
		Se-cystathionine	3 1 2 2 0.5 1.5%	
		sum	73 60 76 76 76 74%	
		Se-methyl-selenocysteine	35-50% total Se (at 48-524 µg/g)	Retention times 63
		Selenate	15-25%	
		Se-cystathionine	0.5-3%	
		γ-glutamyl-Se-methyl-selenocysteine	1-2%	
Chives (<i>Allium schoenoprasum</i>) leaves	Enriched with Se IV	-	Total: 222 µg g ⁻¹	Retention times 64
		Selenocystine	49% of total Se	
		Se-methyl-selenocysteine	38% of total Se	
		Selenomethionine	5% of total Se	
		Inorganic Se (Se IV + Se VI)	8% of total Se	
	Enriched with Se VI	-	Total: 613 µg g ⁻¹	
		Selenocystine	24% of total Se	
		Se-methyl-selenocysteine	22% of total Se	
		Se VI	> 50% of total Se	

	Enriched with SeMet	-	Total: 265 $\mu\text{g g}^{-1}$		
		Selenocystine	44% of total Se		
		Se-methyl-selenocysteine	52% of total Se		
		Selenomethionine	3% of total Se		
Horseradish	Enriched	Selenosinigrin (a glucosinolate)	-	Unknown	65
Meat and poultry		Selenocysteine, selenomethionine	Selenocysteine is predominant	Retention times	10
		selenotrisulphide, selenopersulphide			66
		metallic selenide			9
Meats	US	-	0.3 $\mu\text{g/g}$		40
Beef, pork, lamb	UK	-	0.03-0.15 $\mu\text{g/g}$		42
Turkey (raw)	UK	-	0.1-0.2 $\mu\text{g/g}$		
Liver, kidney (raw)	UK	-	0.2-2.0 $\mu\text{g/g}$		
Fish (whole)	109 US stations	-	0.42 $\mu\text{g/g}$	-	40
Fish: black marlin blue marlin	US	-	0.4-4.3 $\mu\text{g/g}$	-	40
			2.5-4.2 $\mu\text{g/g}$		
Fish: mackerel, octopus	Spain/Portugal	-	0.26, 0.13 $\mu\text{g/g}$ resp	-	67
Fish: Sardine, swordfish, tuna	Spain/Portugal	Selenomethionine	Total Se 0.43, 0.47, 0.92 $\mu\text{g/g}$ respectively	Retention time	67

Fish: tuna	Canned	Selenate Se(-II), Se(IV)	7.6 - 44.8% of total Se (at 0.36-1.33 µg/g)	Retention time	68
Several fish, mollusks, crustaceans and pods	Canned, edible tissue	Selenate Se(-II), Se(IV)	4 - 47% of total Se (at 0.15-4.15 µg/g)	Retention time	69
Several species of marine and freshwater fish	Muscle	Selenate Se(-II), Se(IV)	14 - 36% of total Se (at 0.14-0.83 µg/g)	Retention time	70
Cod	Cooked	Selenite	12%of total Se at 1.5 µg/g	Retention time	71
Cod muscle	Dried and powdered	Selenomethionine	70% of the total Se	Retention time	72

^a ESI-MS: Electrospray ionisation mass spectrometry; ESI-MS/MS: electrospray ionisation mass spectrometry with fragmentation of the precursor/molecular ion.

^bGoenaga Infante et al. unpublished work

^cSample from 2nd year of growth