FAO / INFOODS Guidelines

Guidelines for Converting Units, Denominators and Expressions Version 1.0



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Version 1.0

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List of abbreviations

Abbreviation	Explanation
AA	amino acid
ABV	alcohol by volume
ABW	alcohol by weight
AP	as purchased
Asx	asparagine and aspartic acid
DRI	dietary reference intake
EP	edible portion on fresh weight basis
EuroFIR	European Food Information Resource
FA	fatty acid
FAME	fatty acid methyl ester
FCDB	food composition database
FCT	food composition table
FAO	Food and Agriculture Organization of the United Nations
fl oz	fluid ounce
FW	fresh weight
g	gram
gal	gallon
Gsx	glutamine and glutamic acid
in	inch
INFOODS	International Network of Food Data Systems
IU	International Units
kcal	kilocalories
kJ	kilojoules
L	liter
lb	pound
M	molar mass
mg	milligram
μg	microgram
mL	milliliter
NAS/IOM	National Academy of Science/Institute of Medicine
NV	nutrient value
oz	ounce
ppm	parts per million (1×10^{-6})
ppb	parts per billion (1×10^{-9})
pt	pint (U.S.)
RE	retinol equivalents
RAE	retinol activity equivalents
ShF	Sheppard factor
SR	USDA National Nutrient Database for Standard Reference
TL	total lipid
tsp	teaspoon
tbsp	tablespoon
v/v	volume per volume
w/v	weight per volume

List of INFOODS component identifiers (tagnames)

INFOODS tagname	component
ASN	asparagine
ASP	aspartic acid
CARTA	α-carotene
CARTB	β-carotene
CARTBEQ	β-carotene equivalents
CHOAVL	available carbohydrates, by weight
CHOAVLDF	available carbohydrates, by difference
CHOAVLM	available carbohydrates, expressed as monosaccharide equivalent
CHOCAL	cholecalciferol
CHOCALOH	25-hydroxycholecalciferol
CHOLE	cholesterol
CHOTDF	total carbohydrate, by difference
CRYPXB	β-cryptoxanthin
DGLY	diglycerides (= diacylglycerols)
DM	dry matter
EDIBLE	edible coefficient
ERGCAL	ergocalciferol
F14D0	fatty acid C14:0
F16D1N7	fatty acid C16:1 n-7
F18D1	fatty acid C18:1
F18D2	fatty acid C18:2
F20D5N3	fatty acid C20:5 n-3
FACID	total fatty acids
FAFRE	free fatty acids
FAT	total fat
FIBTG	dietary fibre (Prosky)
FOL	total folate
FOLAC	folic acid (synthetic)
FOLDFE	folate, expressed as dietary folate equivalent
FOLFD	food folate
FRUS	fructose
GALS	galactose
GLN	glutamine
GLU	glutamic acid
GLUS	glucose
GLYLIP	glycolipids
HIS	histidine
ILE	isoleucine
LACS	lactose
LACSM	lactose, monosaccharide equivalent
LEU	leucine
LYS	lysine
MALS	maltose
NSP	non-starch polysaccharides (Englyst)
NT	total nitrogen
PROT	protein

INFOODS tagname	**component**
PHOLIP	phospholipids
RAFS	raffinose
RETOL	retinol
STACHS	stachyose
STARCH	starch
STARCHM	starch, monosaccharide equivalent
SUCS	sucrose
SUCSM	sucrose, monosaccharide equivalent
SUGAR	total sugars
SUGARM	total sugars, monosaccharide equivalent
TAU	taurine
TGLY	triglycerides (= triacylglycerols)
THR	threonine
TOCPHA	D-α-tocopherol
TOCPHB	D-β-tocopherol
TOCPHG	D-γ-tocopherol
TOCPHD	D-δ-tocopherol
TOCTRA	D-α-tocotrienol
TOCTRB	D-β-tocotrienol
TOCTRG	D-γ-tocotrienol
TRP	tryptophan
VERS	verbascose
VITA	vitamin A expressed in retinol equivalents
VITA_RAE	vitamin A expressed in retinol activity equivalents
VITC	vitamin C
VITD	vitamin D
VITDEQ	vitamin D equivalent
VITE	vitamin E
XFA	fatty acid conversion factor
XN	nitrogen-to-protein conversion factor (= Jones factor)

Table index

1. Background

Conversion of food data is done in the areas of nutrition (i.e. food composition and dietary assessment) and food safety (exposure assessment), and when reporting analytical data, including their publication in scientific articles.

Food composition data are expressed in a variety of ways, depending on national conventions, practices of various institutions and journals requirements. However, to aggregate or compare data from diverse sources, it is often necessary to convert them.

A common source of error in the use of compositional data is their conversions from one unit, denominator or expression to another. As there are no comprehensive guidelines available on this topic, FAO/INFOODS decided to develop such guidelines.

2. Objectives

With the goal to increase the quality of compositional data, the guidelines have the following objectives:

- to provide a comprehensive list of possible conversions;
- to standardize component conversions regarding units (e.g. g, mg, or µg), denominators (e.g. per 100 g edible portion) and expressions used in food composition, dietary assessment and exposure assessment;
- to promote the publication, e.g. in scientific journals, of all necessary data to be able to convert them into edible portion on fresh weight bases. For example, to provide water, fat or protein content if data are expressed per dry weight, % of total fatty or amino acid, respectively;
- to motivate researchers and compilers to always accompany their compositional data with explicit units, denominators and expressions to ensure their correct use;
- to motivate users to pay more attention to units, denominators and expressions of compositional data; and
- to make users aware of some unusual conversions (e.g. the use of the Sheppard factors for converting fatty acid methyl ester into fatty acids)

The document is split into two parts, where the first one contains conversions of units and denominators (*Section 3*). The second part describes specific conversions for certain nutrients and components, for which conversions are frequently done.

To express figures, the Anglophonic use of "," and "." is applied in the entire document, i.e. 10,000 means ten thousand, and 1.000 is equal to 1 with 3 decimal places.

3. Changing denominators and units

In general, for food composition purposes it is recommended to use a **metric unit (g, mg or µg).** As food is typically consumed on the fresh weight basis and only the edible portion is eaten, food composition data are usually reported as **'per 100 g edible portion on fresh weight basis (EP)'**. On the other hand, scientific articles often report data as 'per 100 g dry matter (DM)' which is useful for scientific purposes to easily compare food contents in a standardized way without the influence of the changing water content. However, in order to be useful for food composition purposes, the water content is needed so that the values can be converted to EP.

Some **denominators should be avoided**, for example 'individual amino acid (AA) as g per 100 g' because it is not obvious if they refer to, for example, 'per 100 g edible portion' or 'per 100 g protein' or to 'per 100 g dry matter'. To avoid ambiguity, it is therefore recommended to always provide a precise description of the denominator. Examples are:

- per 100 g edible portion on fresh weight basis (preferred expression in food composition)
- per 100 g dry matter of edible food
- per g total protein of edible portion on fresh weight basis
- per g total protein of edible portion on dry matter basis
- per g total lipid of edible portion on dry matter basis
- per g total lipid of edible food on fresh weight basis
- per 100 g total food (edible and inedible parts of the food) on fresh weight basis
- per 100 g total food (edible and inedible parts of the food) on dry matter basis
- per g total lipid of total food (edible and inedible food) on fresh weight basis

In food safety 'per kg food' is the preferred expression in compositional data, sometimes without specifically indicating if total food or edible portion is meant, or if it is on fresh or dry matter basis.

More examples of denominators (also called base unit or matrix unit) are given in the FAO Technical workshop on *Standards for food composition data interchange* (FAO, 2004).

If data are not expressed as 'per 100 g edible portion on fresh weight basis (EP)', additional data should be provided so that values can be calculated as 'per 100 g EP':

- An edible coefficient needs to be reported if data are expressed as 'per total food'.
- Water (or dry matter) content in 100 g EP needs to be reported if data are expressed as 'per percentage or g dry matter of the edible portion'.
- Lipid content in 100 g fresh food needs to be reported if data are expressed as 'per percentage or g fat/total lipid of the edible portion', or as 'per total fatty acids (FA) of the edible portion'.
- Protein content in 100 g fresh food needs to be reported if data are expressed as 'per percentage or g protein of the edible portion'.
- Density needs to be reported if data are expressed per volume, e.g. as 'per 100 mL' or 'per L' (see *FAO/INFOODS Density database 2.0* (FAO, 2012)).

The use of **some units should be avoided** such as ppm (parts per million), ppb (parts per billion), % and International Units (IU); it is better to use true metric units where the unit and the denominator are well defined such as mg/kg or μg/g (while well defining the denominators – see above). In INFOODS, all units are metric units and equivalents are considered nutrient definitions and not units. EuroFIR on the other hand, considers equivalents as units and accompanies them by metric units, e.g. retinol equivalent (RE) as μg,(or other vitamin equivalents), or 'monosaccharide equivalent' as g (Møller et al., 2008). In INFOODS this should be avoided.

In the following tables, formulas and examples are given of how to convert different units and denominators to each other. If appropriate, INFOODS tagnames are used for component identification (see *List of INFOODS component identifiers*).

3.1 Changing denominators (with same units) where no additional data are needed

Table 3.1-1: Changing denominators with same units

From	To	Conversion	Example
per kg EP	per 100 g EP	÷ 10	122 mg/kg ÷ 10 = 12.2 mg/100 g EP
per g EP	per 100 g EP	x 100	0.2 g/g EP x 100 = 20 g/100 g EP

More information on the calculation of EDIBLE is found in *Section 4.8*

3.2 Changing units (with same denominator)

Table 3.2-1: Changing units with same denominator

From	To	Conversion	Example
mg	μg	x 1000	0.10 mg x 1000 = 100 μg
g	mg	x 1000	0.2 g x 1000 = 200 mg
g	μg	x 1,000,000	0.001 g x 1,000,000 = 1000 μg
mg	g	÷ 1000	4500 mg ÷ 1000 = 4.5 g
μg	mg	÷ 1000	6544 μg ÷ 1000 = 6.54 mg (if maximal 2 decimal places*)
μg	g	÷ 1,000,000	7000 μg ÷ 1,000,000 = 0.007 g
% of EP	g/100 g EP	-	0.4 % = 0.4 g/100 g EP
% of EP	mg/100 g EP	x 1000	0.4 % x 1000 = 400 mg/100 g EP
% of EP	g/kg EP	x 10	0.4 % x 10 = 4 g/kg EP
% of EP	mg/kg EP	x 10,000	0.4 % x 10,000 = 4000 mg/kg EP

* for more information on maximal decimal places see the *FAO/INFOODS Compilation Tool, version 1.2.1* (FAO, 2009).

Table 3.2-2: Changing International Units with same denominator

<table>
<tr><th>From</th><th>To</th><th>Conversion</th><th>Example</th></tr>
<tr><td rowspan="5">β-carotene equivalents (IU) (CARTBEQ)</td><td>μg CARTBEQ</td><td rowspan="2">x 0.6</td><td>300 IU x 0.6 = 180 μg CARTBEQ</td></tr>
<tr><td>μg β-carotene (CARTB)</td><td>300 IU x 0.6 = 180 μg CARTB (assuming that all CARTBEQ origins from CARTB)</td></tr>
<tr><td>μg α-carotene (CARTA)</td><td rowspan="3">x 1.2</td><td>300 IU x 1.2= 360 μg CARTA (assuming that all CARTBEQ origins from CARTA)</td></tr>
<tr><td>μg β-cryptoxanthin (CRYPXB)</td><td>300 IU x 1.2= 360 μg CRYPXB (assuming that all CARTBEQ origins from CRYPXB)</td></tr>
<tr><td>μg other carotene with vitamin A activity*</td><td>300 IU x 1.2= 360 μg carotene with vitamin A activity (assuming that all CARTBEQ origins from these other carotenes)</td></tr>
<tr><td>CARTBEQ (IU)</td><td>μg vitamin A retinol equivalent (VITA)</td><td>x 0.1</td><td>300 IU x 0.1 = 30 μg VITA (assuming that there is no retinol)</td></tr>
<tr><td>CARTBEQ (IU)</td><td>μg vitamin A retinol activity equivalent (VITA_RAE)</td><td>x 0.05</td><td>300 IU x 0.05 = 15 μg VITA_RAE (assuming that there is no retinol)</td></tr>
</table>

From	To	Conversion	Example
Vitamin A (IU)	µg retinol (RETOL)	x 0.3	300 IU x 0.3 = 90 µg RETOL (assuming that all vitamin A origins from RETOL)
	µg VITA	x 0.3	300 IU x 0.3 = 90 µg VITA (assuming that all vitamin A origins RETOL)
	µg VITA_RAE	x 0.3	300 IU x 0.3 = 90 µg VITA_RAE (assuming that all vitamin A origins from RETOL)
Vitamin A (IU)	µg VITA	Can only be done if % of retinol and/or carotenes are known	Milk has 130 IU vitamin A value, with 70 % of RETOL and 30 % CARTB 130 × 70 % = 91 IU of RETOL 130 × 30 % = 39 IU of CARTB 91 × 0.3 = 27 µg RETOL 39 × 0.6 = 23 µg CARTB µg VITA = RETOL + 1/6 CARTB = 27 + 1/6 x 23 = 31 µg VITA
Vitamin A (IU)	µg VITA_RAE	Can only be done if % of retinol and/or carotenes are known	Milk has 130 IU vitamin A value, with 70 % of RETOL and 30 % CARTB 130 × 70 % = 91 IU of RETOL 130 × 30 % = 39 IU of CARTB 91 × 0.3 = 27 µg RETOL 39 × 0.6 = 23 µg CARTB µg VITA = RETOL + 1/12 CARTB = 27 + 1/12 x 23 = 29 µg VITA
Vitamin D (IU) (VITD)	µg VITD	÷ 40 or x 0.025	300 IU ÷ 40 = 300 IU x 0.025 = 7.5 µg VITD or CHOCAL or ERGCAL
	µg cholecalciferol (CHOCAL)		
	µg ergocalciferol (ERGCAL)		
IU of natural vitamin E (VITE) (RRR-α-tocopherol, RRR-α-tocopheryl acetate, RRR-α-tocopheryl succinate)	mg D-α-tocopherol (TOCPHA)	x 0.67	300 IU x 0.67 = 201 mg TOCPHA (assuming that all VITE origins from TOCPHA)
	mg VITE		300 IU x 0.67 = 201 mg VITE
IU of synthetic vitamin E (*all rac*-α-tocopherol, *all rac*-α-tocopheryl acetate, *all rac*-α-tocopheryl succinate)	mg TOCPHA	x 0.45	300 IU x 0.45 = 135 mg TOCPHA (assuming that all VITE origins from TOCPHA)
	mg VITE		300 IU x 0.45 = 135 mg VITE

* Other carotenes such as α-cryptoxanthin or γ-carotene are considered to have vitamin A activity too (see *Section 4.6.1*).

Source for IU conversions: USDA (2012), Food Standards Agency (2002), Institute of Medicine (2000), USDA/FAO (1968).

3.3 Changing units and denominator at the same time

Table 3.3-1: Changing units and denominators

From	To	Conversion	Example
ppm (mg/kg EP)	g/100 g EP	÷ 1000 ÷ 10 = ÷ 10,000	20 ppm ÷ 10,000 = 0.002 g/100 g EP
ppm (mg/kg EP)	mg/100 g EP	÷ 10	20 ppm ÷ 10 = 2 mg/100 g EP
ppm (mg/kg EP)	µg/100 g EP	x 1000 ÷ 10 = x 100	20 ppm x 100 = 2000 µg/100 g EP
% alcohol by volume (v/v)*	% alcohol by weight (w/v) = g/100 mL**	x 0.789***	15 % alcohol x 0.789 = 11.85 g/100 mL
% alcohol by volume (v/v)*	g/100 g EP	x 0.789*** ÷ density of beverage (g/mL)	Wine, white, medium has a density of 1.005 g/mL; 15 % alcohol x 0.789 ÷ 1.005 = 11.79 g/100 g EP
% fatty acid (FA)	g FA/100 g EP	See *Section 4.4*, *Table 4.4-3*, *Table 4.4-4* and *Table 4.4-6*	
% amino acid (AA)	g AA/100 g EP	See *Section 4.5*, *Table 4.5-5* and *Table 4.5-6*	

* % alcohol by volume (v/v) = ABV = °GL (degree Gay-Lussac)
** % alcohol by weight (w/v) = ABW
*** since density of ethyl alcohol is 0.789 g/mL at 25 °C (FAO, 2012).

3.4 Changes between unit systems: From American units (e.g. ounce, pound, inch) to metric units (gram, liter)

Table 3.4-1: Changes between unit systems

American Unit	Metric unit
1 fluid ounce (fl oz)	29.57 milliliter (mL)
1 ounce (dry) (oz)	28.35 gram (g)
2.21 pound (lb)	1 kilogram (kg)
1 pound = 16 ounces (oz)	453.6 g
1 quarts = 2 pints = 4 cups	946 mL
1 quarts (dry) = 67.2 cubic inches	1101.21 cubic centimeter (cc or cm^3)
1 quarts (liquid) = 57.7 cubic inches	945.53 cc or mL
1.0567 quarts	1 Liter (L)
1 pint (pt) = 2 cups	473 mL
1 gallon (gal) = 4 quarts (liquid)	3.785 L
1 inch (in)	2.54 centimeters (cm)
1 cubic inch	16.39 cc
1 cup = 48 teaspoons = 16 tablespoons = 8 fluid ounces (fl oz)	237 mL
1 tablespoon (tbsp) = 3 teaspoons	15 mL
1 teaspoon (tsp)	5 mL

Table adapted from USDA (2009).

3.5 Change of denominator where additional data are needed

Conversion of nutrient values (NV) from 'per 100 g food as purchased (AP), also called total food, to 'per 100 g edible portion on fresh weight basis (EP)'

Normally this cannot be done as the nutrient composition of the inedible part is not known.

Table 3.5-1: NV per 100 g food AP → NV per 100 g EP

Data needed	• Nutrient value (NV) per 100 g food as purchased (AP) • Edible portion as % of total food or as edible coefficient
Formula	NV (mg/100 g EP) = NV (mg/100 g food AP) x edible coefficient (EDIBLE) Note: This conversion is only possible when the inedible part has the same nutrient composition as the edible part, which normally is not the case.
Example	A banana has 80 % edible portion (EDIBLE = 0.8) and vitamin C (VITC) value of 20 mg/100 g food AP Calculation: 20 mg AP x 0.8 = 16 mg VITC/100 g EP
Note	If in addition the food is to be cooked, yield and retention factors should be applied.

More information on the calculation of EDIBLE is found in *Section 4.8*

Conversion of nutrient values (NV) from 'per 100 g dry matter (DM)' to 'per 100 g EP'

Table 3.5-2: NV per 100 g DM → NV per 100 g EP

Data needed	• Water value or DM as g/100 g EP • NV per 100 g DM
Formula	NV (g/100 g EP) = NV (g/100 g DM) x (100 – water content in g/100 g EP) ÷ 100 Note: DM (g/100 g EP) = (100 – water content in g/100 g EP)
Example	Water = 80 g/100 g EP, which is equal to 20 g DM/100 g EP; protein = 10 g/100 g DM Calculation: 10 g x (100 - 80) ÷ 100 = 2 g protein/100 g EP or 10 g x 20 g DM ÷ 100 = 2 g protein/100 g EP
Approximation	If data are only given per 100 g DM, it is possible to estimate the water content by averaging different water contents for the same food from other sources and to use this estimated water content to convert the data to per 100 g EP. This approximation will lower the quality of the data when expressed per 100 g EP.
Suggestion	Scientific journals and laboratories should urge the publication of water values for all data when expressed per 100 g DM.

Conversion of nutrient values (NV) from 'per g dry matter (DM') to 'per 100 g EP'

Table 3.5-3: NV per g DM → NV per 100 g EP

Data needed	• Water value or DM as g/100 g EP. • NV per g DM
Formula	NV (g/100 g EP) = NV (g/g DM) x (100 – water as g/100 g EP) Note: DM (g/100 g EP) = (100 – water content as g/100 g EP)
Example	Water = 80 g/100 g EP, which is equal to 20 g DM/100 g EP; protein = 0.1 g/g DM Calculation: 0.1 g x (100 - 80) = 2 g protein/100 g EP or 0.1 g x 20 g DM = 2 g protein/100 g EP
Approximation	If data are only given per g DM, it is possible to estimate the water content by averaging different water contents for the same food from other sources and use this estimated water content to convert the data to per 100 g EP. This approximation will lower the quality of the data when expressed per 100 g EP.
Suggestion	Scientific journals and laboratories should urge the publication of water values for all data when expressed per 100 g DM.
Alternative	Multiply values on a per gram basis by 100, then convert as above (conversion from per 100 g DM to per 100 g EP).

Conversion from food volume as 'mL' to food weight as 'g'

Table 3.5-4: Food volume (mL) → food weight (g)

Data needed	• Volume of food as mL • Density, volume of food as mL (see the *FAO/INFOODS Density Database version 2.0* at http://www.fao.org/infoods/projects_en.stm)
Formula	Weight of food (g) = volume of food (mL) x density factor (g/mL)
Example	Density of ice cream is 0.554 g/mL 100 mL of ice cream x 0.554 = 55.4 g ice cream

Conversion of nutrient values (NV) from 'mg per mL' to 'mg per 100 g EP'

Table 3.5-5: NV (mg/mL) → NV (mg/100 g EP)

Data needed	• NV as mg/mL • Density (see the *FAO/INFOODS Density Database version 2.0* at http://www.fao.org/infoods/projects_en.stm)
Formula	NV (mg/100 g EP) = NV (mg/mL) ÷ density factor (g/mL) x 100 Note: The formula needs to be 'x 100' to convert from 'g EP' to '100 g EP'.
Example	The vitamin C (VITC) content in grape juice is 0.2 mg/mL; density of grape juice = 1.054 g/mL Calculation: 0.2 mg/mL ÷ 1.054 x 100 = 18.97 mg VITC/100 g EP

Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see above).

Conversion of nutrient values (NV) from 'µg per mL' to 'mg per 100 g EP'

Table 3.5-6: NV (µg/mL) → NV (mg/100 g EP)

Data needed	• NV as µg/mL • Density (see the *FAO/INFOODS Density Database version 2.0* at http://www.fao.org/infoods/projects_en.stm)
Formula	NV (mg/100 g EP) = NV (µg/mL) ÷ density factor (g/mL) x 100 ÷ 1000 Note: The formula needs to be 'x 100' to convert from 'g EP' to '100 g EP' and '÷ 1000' to convert the NV from µg to mg.
Example	The VITE content of orange juice is 170 µg/mL; density of orange juice = 1.038 g/mL Calculation: 170 µg/mL ÷ 1.038 x 100 ÷ 1000 = 16.38 mg VITE/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see above).

Conversion of nutrient values (NV) from 'mg per 100 mL' to 'mg per 100 g EP'

Table 3.5-7: NV (mg/100 mL) → NV (mg/100 g EP)

Data needed	• NV as mg/100 mL • Density (see the *FAO/INFOODS Density Database version 2.0* at http://www.fao.org/infoods/projects_en.stm)
Formula	NV (mg/100 g EP) = NV (mg/100 mL) ÷ density factor (g/mL)
Example	The VITC content in orange juice is 45 mg/100 mL; density of orange juice= 1.038 g/mL Calculation: 45 mg/100 mL ÷ 1.038 = 43.35 mg VITC/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see above).

Conversion of nutrient values from moles to 'per 100 g EP' (see 4.7 Inorganic constituents)

4. Specific components

4.1 Energy

It is recommended to calculate energy from the energy-yielding macronutrients using the appropriate energy conversion factors:

Table 4.1-1: Metabolized energy conversion factors, also called General Atwater factors (FAO, 2003)

	kJ/g	kcal/g
Protein	17	4
Fat	37	9
Available/total carbohydrates	17	4
Available carbohydrates in monosaccharide equivalents	16	3.75
Dietary fibre*	8	2
Alcohol (i.e. ethanol)	29	7

* in case only a total carbohydrate value is available, no energy is attributed to the fibre value

Even though 1 kcal equals 4.1868 kJ, a conversion from kcal to kJ or vice versa is not recommended because the individual energy conversion factors are not an exact conversion between them using 4.1868. For example, 17 kJ/g would be 4.06 kcal/g if divided by 4.1868 and not 4 kcal/g which is only an approximation. Therefore, it is best to calculate energy in kcal and kJ separately from the energy-yielding macronutrients and their conversion factors.

Specific Atwater factors are listed in Merrill and Watt (1955, 1973). In the food composition database of the United States Department of Agriculture standard releases (USDA SR), specific Atwater factors are used in addition to the general Atwater factors. When used, the specific Atwater factors are reported in the food description file for each food. It appears that all other food composition tables/databases use the above mentioned general Atwater factors (some attributing energy to dietary fibre while some do not).

Calculation of energy values (kJ) from energy-contributing nutrient values as ‘g per100 g EP’

Table 4.1-2: Energy calculation (kJ)

Data needed	• NV as g/100 g EP for protein, fat, carbohydrates, dietary fibre and alcohol • Energy conversion factor for kJ
Formula for available carbohydrates	Energy (kJ/100 g EP) = protein (g/100 g EP) x 17 + fat (g/100 g EP) x 37 + available carbohydrates (g/100 g EP) x 17 + dietary fibre (g/100 g EP) x 8 + alcohol (g/100 g EP) x 29
Formula for total carbohydrates	Energy (kJ/100 g EP) = protein (g/100 g EP) x 17 + fat (g/100 g EP) x 37 + total carbohydrates (g/100 g EP) x 17 + alcohol (g/100 g EP) x 29
Formula for available carbohydrates in monosaccharide equivalents	Energy (kJ/100 g EP) = protein (g/100 g EP) x 17 + fat (g/100 g EP) x 37 + available carbohydrates as monosaccharide equivalents (g/100 g EP) x 16 + dietary fibre (g/100 g EP) x 8 + alcohol (g/100 g EP) x 29
Example	White wheat bread contains per 100 g EP: 6.7 g protein (PROT); 1.0 g fat (FAT), 48.7 g available carbohydrates by weight (CHOAVL); 2 g total dietary fibre (FIBTG) and 0 g alcohol (ALC) Calculation: (6.7 g PROT x 17) + (1.0 g FAT x 37) + (48.7 g CHOAVL x 17) + (2 g FIBTG x 8) + (0 g ALC x 29) = 995 kJ/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see *Section 3.5*).

Calculation of energy values (kcal) from energy-contributing nutrient values as ‘g per 100 g EP’

Table 4.1-3: Energy calculation (kcal)

Data needed	• NV as g/100 g EP for protein, fat, carbohydrates, dietary fibre and alcohol • Energy conversion factor for kcal
Formula for available carbohydrates	Energy (kcal/100 g EP) = protein (g/100 g EP) x 4 + fat (g/100 g EP) x 9 + available carbohydrates (g/100 g EP) x 4 + dietary fibre (g/100 g EP) x 2 + alcohol (g/100 g EP) x 7
Formula for total carbohydrates	Energy (kcal/100 g EP) = protein (g/100 g EP) x 4 + fat (g/100 g EP) x 9 + total carbohydrates (g/100 g EP) x 4 + alcohol (g/100 g EP) x 7
Formula for available carbohydrates in monosaccharide equivalents	Energy kcal/100 g EP) = protein (g/100 g EP) x 4 + fat (g/100 g EP) x 9 + available carbohydrates in monosaccharide equivalents (g/100 g EP) x 3.75 + dietary fibre (g/100 g EP) x 2 + alcohol (g/100 g EP) x 7
Example	White wheat bread contains per 100 g EP: 6.7 g PROT; 1.0 g FAT, 48.7 g CHOAVL, 2 g FIBTG and 0 g ALC Calculation: (6.7 g PROT x 4) + (1.0 g FAT x 9) + (48.7 g CHOAVL x 4) + (2 g FIBTG x 2) + (0 g ALC x 29) = 235 kcal/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see *Section 3.5*).

4.2 Carbohydrates

The content of carbohydrates in foods can be expressed in different ways: total carbohydrates (including dietary fibre) and available carbohydrates (without dietary fibre), as 'by weight' or as 'monosaccharide equivalents'. Values are calculated either as the sum of analytically analyzed carbohydrate components or as the difference of 100 minus the sum of the other proximates.

Conversion from available carbohydrates by weight (CHOAVL) to available carbohydrates expressed as monosaccharide equivalents (CHOAVLM)

Table 4.2-1: CHOAVL (g/100 g EP) → CHOAVLM (g/100 g EP)

<table>
<tr><td rowspan="6">Data needed</td><td colspan="2">Individual available carbohydrates by weight as g/100 g EP
conversion factor from available carbohydrates (by weight) as g/100 g EP to available carbohydrates expressed as monosaccharide equivalents (ME) as g/100 g EP</td></tr>
<tr><td>Available carbohydrates by weight or by difference</td><td>Conversion to obtain available carbohydrates expressed as monosaccharide equivalents</td></tr>
<tr><td>Monosaccharide e.g. glucose (GLUS), fructose (FRUS) and galactose (GALS)</td><td>No conversion necessary (factor = 1)</td></tr>
<tr><td>Disaccharides e.g. sucrose (SUCS), lactose (LACS) and maltose (MALS)</td><td>x 1.05</td></tr>
<tr><td>Oligosaccharides e.g.
Raffinose (RAFS; a trisaccharide)
Stachyose (STACHS; a tetrasaccharide)
Verbascose (VERS; a pentasaccharide)</td><td>
x 1.07
x 1.08
x 1.09</td></tr>
<tr><td>Polysaccharides e.g. starch (STARCH)</td><td>x 1.10</td></tr>
<tr><td>Formula</td><td colspan="2">Individual carbohydrates (ME/100 g EP) = individual carbohydrates (g/100 g EP) x conversion factor
CHOAVLM g/100 g EP = sum of individual carbohydrates as ME g/100 g EP</td></tr>
<tr><td>Example</td><td colspan="2">Shortbread contains per 100 g EP: 43.3 g STARCH, 0.2 g GLUS, 14.6 g SUCS and 1.5 g LACS.

Calculation:
0.2 g GLUS/100 g EP x 1 = 0.2 g GLUS/100 g EP
14.6 g SUCS/100 g EP x 1.05 = 15.33 g SUCSM/100 g EP
1.5 g LACS/100 g EP x 1.05 = 1.58 g LACSM/100 g EP
43.3 g STARCH/100 x 1.1 = 47.63 g STARCHM/100 g EP
(0.2 x 1)+ ((14.6 +1.5) x 1.05) + (43.3 x 1.1) = 64.74 g CHOAVLM/100 g EP

Note:
In INFOODS tagnames for carbohydrates 'M' is added at the end of the tagname to indicate that it is expressed as monosaccharide equivalents, e.g. STARCH and STARCHM. For monosaccharides (e.g. glucose), no different tagnames exist as ME equals the values by weight.</td></tr>
<tr><td>Note for data in DM</td><td colspan="2">If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see Section 3.5).</td></tr>
</table>

Conversion from available carbohydrates expressed as monosaccharide equivalents (CHOAVLM) to available carbohydrates by weight (CHOAVL)

Table 4.2-2: CHOAVLM (g/100 g EP) → CHOAVL (g/100 g EP)

Data needed	• Individual available carbohydrates expressed as monosaccharide equivalents (ME) • Conversion factor from available carbohydrates as monosaccharide equivalents as g/100 g EP to available carbohydrates by weight	
	Available carbohydrates expressed as monosaccharide equivalents	**Conversion to obtain available carbohydrates by weight**
	Monosaccharide e.g. GLUS, FRUSM and GALSM	No conversion necessary (factor = 1)
	Disaccharides e.g. SUCSM, LACSM and MALSM	÷ 1.05
	Oligosaccharides e.g. RAFSM (a trisaccharide) STACHSM (a tetrasaccharide) VERSM (a pentasaccharide)	 ÷ 1.07 ÷ 1.08 ÷ 1.09
	Polysaccharides e.g. STARCHM	÷ 1.10
Formula	Individual carbohydrates ME (g/100 g EP) = individual carbohydrates by weight (g/100 g EP) ÷ conversion factor	
Example	Shortbread contains per 100 g EP: 47.6 g STARCHM, 0.2 g GLUS, 15.3 g SUCSM and 1.6 g LACSM. Calculation: 0.2 g GLUS/100 g EP ÷ 1 = 0.2 g GLUS/100 g EP 15.3 g SUCSM/100 g EP ÷ 1.05 = 14.57 g SUCS/100 g EP 1.6 g LACSM/100 g EP ÷ 1.05 = 1.52 g LACS/100 g EP 47.6 g STARCHM/100 g EP ÷ 1.1 = 43.27 g STARCH/100 g EP (0.2 ÷ 1) + ((15.3 + 1.6) ÷ 1.05) + (47.6 ÷ 1.1) = 59.56 g CHOAVL/100 g EP Note: In INFOODS tagnames for carbohydrates 'M' is added at the end of the tagname to indicate that it is expressed as monosaccharide equivalents, e.g. STARCH and STARCHM. For monosaccharides (e.g. glucose), no different tagnames exist as ME equals the values by weight.	
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see *Section 3.5*).	

Conversion from available carbohydrates by difference (CHOAVLDF) to total carbohydrates by difference (CHOTDF)

Table 4.2-3: CHOAVLDF (g/100 g EP) → CHOTDF (g/100 g EP)

Data needed	• Available carbohydrates by differences (CHOAVLDF) (g/100 g EP) • Dietary fibre (g/100 g EP)
Formula	CHOTDF (g/100 g EP) = CHOAVLDF (g/100 g EP) + dietary fibre (g/100 g EP)
Example	Quinoa contains per 100 g EP: 66.6 g CHOAVLDF and 12.2 g total dietary fibre content (FIBTG) Calculation: 66.6 g + 12.2 g = 78.8 g CHOTDF/100 g EP Note: In the past, the INFOODS tagname for total carbohydrates by difference was CHOCDF, which became CHOTDF to increase clarity.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see *Section 3.5*).

Conversion from total carbohydrates by difference (CHOTDF) to available carbohydrates by difference (CHOAVLDF)

Table 4.2-4: CHOTDF (g/100 g EP) → CHOAVLDF (g/100 g EP)

Data needed	• Total carbohydrates by differences (CHOTDF) (g/100 g EP) • Dietary fibre (g/100 g EP)
Formula	CHOAVLDF (g/100 g EP) = CHOTDF (g/100 g EP) - dietary fibre (g/100 g EP)
Example	Quinoa contains per 100 g EP: 78.8 g CHOTDF and 12.2 g total dietary fibre content (FIBTG) Calculation: 78.8 g - 12.2 g = 66.6 g CHOAVLDF/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see *Section 3.5*).

Conversion from carbohydrate components to available carbohydrates by weight (CHOAVL)

Table 4.2-5: Conversion to CHOAVL (g/100 g EP)

Data needed	• Individual carbohydrate components as g/100 g EP: STARCH and total sugars (SUGAR)
Formula	CHOAVL (g/100 g EP) = STARCH (g/100 g EP) + SUGAR (g/100 g EP) Note: CHOAVLM (g/100 g EP) = STARCHM (g/100 g EP) + SUGARM (g/100 g EP)
Example	Whole grain wheat flour contains per 100 g EP: 57.8 g STARCH and 0.4 g SUGAR Calculation: 57.8 g + 0.4 g = 58.2 g CHOAVL/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values from DM basis to per 100 g EP (see *Section 3.5*).

Conversion from contributing values to available carbohydrates by difference (CHOAVLDF)

Table 4.2-6: Conversion to CHOAVLDF (g/100 g EP)

Data needed	• Following values as g/100 g EP: water, protein, fat, ash, alcohol and dietary fibre
Formula	CHOAVLDF (g/100 g EP) = 100 – (water (g/100 g EP) + protein (g/100 g EP) + fat (g/100 g EP) + ash (g/100 g EP) + alcohol (g/100 g EP) + dietary fibre (g/100 g EP))
Example	Whole grain wheat flour contains per 100 g EP: WATER = 11.9 g, PROT = 10.3 g, FAT = 1.0 g, ASH = 0.5 g, ALC = 0 g, FIBTG = 2.7 g Calculation: 100 – (11.9 + 10.3 + 1.0 + 0.5 + 0 + 2.7) = 73.6 g CHOAVLDF/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for fat from DM basis to per 100 g EP (see *Section 3.5*).

Conversion from contributing values to total carbohydrates by difference (CHOTDF)

Table 4.2-7: Conversion to CHOTDF (g/100 g EP)

Data needed	• Following values as g/100 g EP: water, protein, fat, ash and alcohol
Formula	CHOTDF (g/100 g EP) = 100 – (water (g/100 g EP) + protein (g/100 g EP) + fat (g/100 g EP) + ash (g/100 g EP) + alcohol (g/100 g EP))
Example	Whole grain wheat flour contains per 100 g EP: WATER = 11.9 g, PROT = 10.3 g, FAT = 1.0 g, ASH = 0.5 g, ALC = 0 g, Calculation: 100 – (11.9 + 10.3 + 1.0 + 0.5 + 0) = 76.3 g CHOTDF/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for fat from DM basis to per 100 g EP (see *Section 3.5*).

4.3 Fibre

The conversion from Total Dietary Fibre (FIBTG - Prosky method and similar) to Non-Starch Polysaccharides fibre according to Englyst et al. methods (NSP) and vice versa is generally not possible. One exception is wholemeal cereals where the regression equation from Mongeau and Brassard (1989) can be used:

$$\frac{FIBTG + 0.02}{1.28} = NSP$$

However, it might be better to estimate fiber value from a similar food.

4.4 Fat and related components

Fat-related components are seldom reported as 'per 100 g EP' in the scientific literature, but are predominately expressed using denominators such as 'per total lipid' or 'per total fatty acids'. Attention has to be paid to always identify the denominator correctly when applying conversion factors.

INFOODS provides two tagnames for total fat (which is the sum of triglycerides, phospholipids, sterols and related compounds), depending on the extraction method used: FAT (mixed solvent extraction) and FATCE (continuous extraction). Fat, which is extracted by acid hydrolysis or by continuous extraction, is normally not recommended to be used for further FA analysis. Often, the terms 'fat' and 'lipids' are used as synonyms, although sometimes they are used differently.

Conversion from lipid fraction* as '% per total fat' (= lipid fraction as 'g per 100 g total fat') to lipid fraction as 'g per 100 g EP'

Table 4.4-1: Lipid fraction (% per total fat) → lipid fraction (g/100 g EP)

Data needed	• Values for the lipid fraction as % of total fat (= lipid fraction as g/100 g fat) • Fat as g/100 g EP
Formula	Individual lipid fraction (g/100 g EP) = individual lipid fraction (% of fat) ÷ 100 x fat (g/100 g EP)
Example	The cholesterol (CHOLE) content of chicken egg is 3.9 % of fat; fat = 9.5 g/100 g EP Calculation: (3.9 ÷ 100) x 9.5 g = 0.37 g CHOLE/100 g EP
Approximation	If no value for total fat is given, it is possible to estimate it by averaging fat values for the same food from different sources or by using the fat value in the FCDB from a similar food. This fat value can be used to calculate the lipid fractions per 100 g EP. However, this method will lower the quality of the data.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for fat from DM basis to per 100 g EP (see *Section 3.5*).

*Total fat is composed of different lipid fractions, e.g. triglycerides (TGLY), phospholipids (PHOLIP), diglycerides (DGLY), glycolipids (GLYLIP), free fatty acids (FAFRE) and cholesterol (CHOLE).

Conversion from individual fatty acid (FA) as 'g per 100 g total lipid (TL)' to individual FA as 'g per 100 g EP'

Table 4.4-2: FA (g/100 g TL) → FA (g/100 g EP)

Data needed	• Values for individual FA as g per 100 g fat • Fat as g/100 g EP
Formula	Individual FA (g/100 g EP) = individual FA (g/100 g fat) x fat (g/100 g EP) ÷ 100
Example	FA C16:1-n7 (F16D1N7) in pike-perch is 0.4 g of fat; fat = 1.3 g/100 g EP Calculation: 0.4 g x 1.3 g ÷ 100 = 0.005 g F16D1N7/100 g EP
Approximation	If no value for total fat is given, it is possible to estimate it by averaging fat values for the same food from different sources or by using the fat value in the FCDB from a similar food. The resulting fat value can be used to calculate the lipid fractions per 100 g EP. However, this method will lower the quality of the data.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for fat and/or FACID from DM basis to per 100 g EP (see *Section 3.5*).

Conversion from individual fatty acid (FA) as '% of total fatty acids (FACID)' (= FA as 'g per 100 g FACID') to individual FA as 'g per 100 g EP' (applicable if the value for FACID is given per 100 g EP)

Table 4.4-3: FA (% of FACID) → FA (g/100 g EP), value for FACID (per EP) given

Data needed	• Values for individual FA as % of FACID (= FA as g/100 g FACID) • FACID as g/100 g EP
Formula	Individual FA (g/100 g EP) = individual FA (% of FACID) ÷ 100 x FACID (g/100 g EP)
Example	Feta cheese contains 12.7 % FA C14:0 (F14D0) of FACID; FACID = 21.3 g/100 g EP Calculation: (12.7 ÷ 100) x 21.3 g = 2.705 g F14D0/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for FACID from DM basis to per 100 g EP (see *Section 3.5*).

Conversion from individual fatty acid (FA) as '% of total fatty acids (FACID)' (= FA as 'g per 100 g FACID') to individual FA as 'g per 100 g EP' (applicable if the value for FACID per fat is given)

Table 4.4-4: FA (% of FACID) → FA (g/100 g EP), value for FACID (per fat) given

Data needed	• FACID as mg of g fat* • Fat as g/100 g EP • Values for individual FA as % of FACID (= FA as g/100 g FACID)
Formula-step 1	FACID (g/100 g EP) = FACID (mg/g fat) x fat (g/100 g EP) ÷ 1000 Note: The formula needs to be '÷ 1000' to convert the content of FACID from mg to g.
Formula-step 2	Individual FA (g/100 g EP) = individual FA (% of FACID) ÷ 100 x FACID (g/100 g EP)
Example	The fat content of hazelnuts is 60 g/100 g EP; FACID = 956 mg/g fat; 13.6 % of FACID is FA C18:2 (F18D2) Calculation step 1: 956 mg x 60 g ÷ 1000 = 57.36 g FACID/100 g EP Calculation step 2: (13.6 ÷ 100) x 57.36 g = 7.801 g F18D2/100 g EP
Approximation	If no value for total fat is given, it is possible to estimate it by averaging fat values for the same food from different sources or by using the fat value in the FCDB from a similar food. The resulting fat value can be used to calculate the lipid fractions per 100 g EP. However, this method will lower the quality of the data.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for fat and/or FACID from DM basis to per 100 g EP (see *Section 3.5*).

* FACID (mg/g fat) ÷ 1000 = FACID (g/g fat), which equals the definition of the fatty acid conversion factor (XFA), see below.

Conversion from individual fatty acid (FA) as '% of total fatty acids (FACID)' (= FA as 'g per 100 g FACID') to individual FA as 'g per 100 g EP' (applicable if the FACID content per fat or food is not given)

When the content of total fatty acids in food or fat is not given, it is necessary to calculate it by using fatty acid conversion factors (XFA). The conversion factor reflects the ratio between the sum of fatty acids and total lipids (TL) in the food (Weihrauch, Posati, Anderson, & Exler, 1977).

$$FACID\ (g/100\ g\ EP) = TL\ \ (g/100\ g\ EP)\ \ x\ XFA$$

Fatty acid conversion factors were derived for various food products. The following factors are suggested to calculate values for total fatty acids in the food, as summarized by Greenfield and Southgate (2003):

Table 4.4-5: Fatty acid conversion factors (XFA)

Food	XFA	Food	XFA
Wheat, barley, rye		Beef	
wholegrain	0.72	lean	0.916
flour	0.67	fat	0.953
bran	0.82	Lamb, take as beef	
Oats, whole	0.94	Pork	
Rice, milled	0.85	lean	0.910
Milk and milk products	0.945	fat	0.953
Eggs	0.83	Poultry	0.945
Fats, oils (all except coconut)	0.956	Brain	0.561
Coconut oil	0.942	Heart	0.789
Vegetables and fruits	0.80	Kidney	0.747
Avocado pears	0.956	Liver	0.741
Nuts	0.956		

As fatty acid conversion factors (XN) are given only for lean (0.7) and fatty fish (0.9) (without indication of corresponding fat content) and not for crustaceans and molluscs, FAO/INFOODS (Nowak, Rittenschober, Exler, & Charrondière, 2012) made further investigations on these factors. The findings conclude that instead of using fixed factors it is more accurate to use the formula proposed by Weihrauch et al. (1977), who also proposes formulas for crustaceans and molluscs. The resulting conversion factors are more flexible and better reflect the great range of fat and their contributing fractions.

Two ways to estimate fatty acid conversion factors are proposed:

1. If fat is ≥ 0.55 g/100 g EP, the formulas of Weihrauch et al. (1977) should be used:

$$Finfish: XFA = 0.933 - \frac{0.143}{TL}$$

$$Crustaceans: XFA = 0.956 - \frac{0.237}{TL}$$

$$Molluscs: XFA = 0.956 - \frac{0.296}{TL}$$

Total lipids (TL) should be expressed as g/100 g EP.

2. If fat is < 0.55 g/100 g EP, the following fatty acid conversion factors should be applied to avoid negative values for the conversion factors (Nowak et al., 2012):

$$Finfish: XFA = 0.673$$
$$Crustaceans: XFA = 0.459$$
$$Molluscs: XFA = 0.417$$

Table 4.4-6: FA (% of FACID) → FA (g/100 EP), value for FACID not given

Data needed	• Values for individual FA as % of FACID (= FA as g/100 g FACID) • Fat as g/100 g EP • XFA
Formula	Individual FA (g/100 g EP) = individual FA (% of FACID) ÷ 100 x fat (g/100 g EP) x XFA Note: FACID (g/100 g EP) = fat (g/100 g EP) x XFA
Example *chicken meat*	The content of FA C18:1 (F18D1) in chicken meat is 26 % of FACID; the fat value = 3.3 g/100 g EP; the FA conversion factor for poultry is 0.945 Calculation: (26 ÷ 100) x (3.3 g x 0.945) = 0.811 g F18D1/100 g EP
Example *salmon*	The FA C20:5-n3 (F20D5N3) in salmon is 5.1 % of FACID; fat is 6.3 g/100 g EP Calculation XFA for finfish: 0.933 - (0.143 ÷ 6.3) = 0.910 Calculation: (5.1 ÷ 100) x (6.3 g x 0.910) = 0.292 g F20D5N3/100 g EP
Suggestion	Higher data quality of FA contents in foods could be achieved if scientific articles would publish total fatty acid values per gram fat or per 100 g EP of their analysis. The estimation of the content of total fatty acids by applying conversion factors could then be avoided.
Approximation	If no value for total fat is given, it is possible to estimate it by averaging fat values for the same food from different sources or by using the fat value in the FCDB from a similar food. The resulting fat value can be used to calculate the lipid fractions per 100 g EP. However, this method will lower the quality of the data.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for fat from DM basis to per 100 g EP (see *Section 3.5*).

Conversion from individual fatty acid methyl esters (FAME) as '% of total fatty acid methyl esters' (= FAME as 'g per 100 g total FAME') to individual FA as 'g per 100 g EP'

Fatty acids analysis always generates fatty acid data as fatty acid methyl esters (FAME). In laboratory reports and scientific articles, a clear statement in the methodology is needed, whether the presented data are FAME or if data have already been converted to FA, i.e. without methyl group. If fatty acid data are given in FAME, they need to be transformed (i.e. subtract the methyl group weights) to FA (without methyl groups).
Another important issue is whether FAME includes unknown fatty acids, which normally should be the case. This needs to be clearly stated.

Three steps are necessary to convert FAME data to fatty acid data per 100 g EP (adapted from (Møller, n.d.; Nowak et al., 2012), as given below:

First step: Conversion of FAME (% of FAME) to FA (% of FAME) by applying Sheppard Factors (ShF). In order to convert the methyl ester to the corresponding fatty acid, individual Sheppard Factors (ShF) are applied. These factors are based on the molecular weight of the fatty acids and their fatty acid esters, assuming, that the corresponding triglyceride would contain the same fatty acid three times (Sheppard, 1992). The factors are calculated as following, with the molecular weights (see *Annex 1* with the table of calculated ShF per FA):

$$ShF = \frac{FA\ (g/mol)}{FAME\ (g/mol)}$$

In this way, the weight of the fatty acid is corrected to represent the weight of the free form of the fatty acid, i.e. the weight of the methyl group from the triglyceride is subtracted.

Table 4.4-7: FAME (% of total FAME) → FA (g/100 g EP) – step 1

Data needed	• Value for individual FAME as % of total FAME (= individual FAME as g/100 g total FAME) • ShF (see *Annex 1*)
Formula-step 1	Individual FA (g/100 g total FAME) = individual FAME (g/100 g total FAME) x ShF Note: Sum of individual FA is needed in second step: =Σ of all individual FA as g/100 g total FAME
Example	The value for FAME C14:0 (F14D0) is 1.51 g/ 100 g total FAME, the corresponding ShF is 0.942134 Calculation: 1.51 g x 0.942134 = 1.423 g F14D0 /100 g total FAME

Second step: Normalization of the FA data. The individual fatty acid is recalculated give the fatty acid value as g per 100 g total fatty acids.

Table 4.4-8: FAME (% of total FAME) → FA (g/100 g EP) – step 2

Data needed	• Individual FA as g/100 g total FAME (resulting from step 1) • Σ of all individual FA as g/100 g total FAME (resulting from step 1)
Formula-step 2	Individual FA (g/100 g FACID) = individual FA (g/100 g total FAME) x 100 ÷ ΣFA (g/100 g total FAME)
Example	FA C14:0 (F14D0) = 1.423 g/100 g total FAME; ΣFA= 90 g/100 g total FAME Calculation: 1.423 g x 100 ÷ 90 g = 1.581 g F14D0/100 g FACID

Third step: Conversion to 'per 100 g EP'

Table 4.4-9: FAME (% of total FAME) → FA (g/100 g EP) – step 3

Data needed	• Values for individual FA as g/100 g FACID (= FA as % of FACID) • Fat as g/100 g EP • XFA
Formula	Individual FA (g/100 g EP) = individual FA (% FACID) ÷ 100 x fat (g/100 g EP) x XFA
Example *chicken meat*	The content of F14D0 in chicken meat is 1.58 % of FACID = 1.58 g/100 g FACID; the FAT value = 3.3 g/100 g EP; the FA conversion factor for poultry is 0.945 Calculation: (1.58 ÷ 100) x (3.3 g x 0.945) = 0.049 g F14D0 /100 g EP
Example *salmon*	The F14D0 in salmon is 1.58 % of FACID = 1.58 g/100 g FACID; FAT is 6.3 g/100 g EP Calculation XFA for finfish: 0.933 - (0.143 ÷ 6.3) = 0.910 Calculation: (1.58 ÷ 100) x (6.3 g x 0.910) = 0.091 g F14D0/100 g EP
Suggestion	Higher data quality of FA contents in foods could be achieved if scientific articles would publish total fatty acid values per gram fat or per 100 g EP of their analysis. The estimation of the content of total fatty acids by applying conversion factors could then be avoided.
Approximation	If no value for total fat is given, it is possible to estimate it by averaging fat values for the same food from different sources or by using the fat value in the FCDB from a similar food. The resulting fat value can be used to calculate the lipid fractions per 100 g EP. However, this method will lower the quality of the data.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values for fat from per g DM to per 100 g EP (see *Section 3.5*).

4.5 Protein and related components

For food composition purposes, protein is normally not measured directly, but is determined by measuring the total nitrogen (NT) content of the food, which is then multiplied by the appropriate nitrogen-to-protein conversion factors (XN). NT is normally measured by the Kjeldahl technique, which gives the total organic nitrogen, whereas the Dumas technique measures also inorganic nitrogen. The general conversion factor of 6.25 (1/0.16 = 6.25) is based on the premise that protein contains 16 % nitrogen (Greenfield & Southgate, 2003). Non-protein nitrogen (NPN) comprises free amino acids, nucleotides, creatine and choline (FAO, 2003; Greenfield & Southgate, 2003). Only a small part of NPN is available for the synthesis of (non-essential) amino acids. Furthermore, the nitrogen content of proteins actually varies from about ~13 % to ~19 %. Therefore, the factor 6.25 was replaced by specific factors for certain foods based on the work of Jones (1941), referred to as "Jones factors" or nitrogen factor (see *Annex 2*).

It is also possible to base the protein content on amino acid (AA) data because proteins are made up of chains of amino acids joined by peptide bonds. They can be hydrolysed to their AA, which can then be measured (FAO, 2003). The sum of the AA then represents the protein content (by weight) of the food, sometimes referred to as a "true protein". However, care has to be taken to specify if the protein value is expressed in hydrous (including the water which is added when hydrolysing the AAs from the protein) or anhydrous form (excluding the added water through hydrolysis to AAs corresponding to the real weight of the protein). The current recommendation (FAO, 2003) is that protein in foods be measured as the sum of anhydrous AA (the molecular weight of each amino acid less the molecular weight of water) plus free amino acids, whenever possible. Free amino acids are nutritionally equivalent to protein amino acids (Greenfield & Southgate, 2003). However, this is not yet implemented in food composition tables and databases, as this analysis is more expensive and time consuming.

In scientific articles and laboratory reports, AAs are usually expressed as mg per g of NT or as g per 16 g NT. However, for the user food composition database data need to be transformed to mg/100 g EP. The documentation of all compositional data (user database, article, laboratory report etc) should include the protein definition and XN used per food.

Conversion from total nitrogen (NT) as 'g per 100 g EP' to protein as 'g per 100 g EP'

Table 4.5-1: NT (g/100 g EP) → protein (g/100 g EP)

Data needed	• Total nitrogen (NT) as g/100 g EP • Nitrogen-to-protein conversion factor (XN) also called Jones factor (see *Annex 2*)
Formula	Protein (g/100 g EP) = NT (g/100 EP) x XN
Example	Milk has 0.96 g NT/100 g EP. The XN for milk is 6.38 Calculation: 0.96 g/100 g EP x 6.38 = 6.12 g protein/100 g EP
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion from protein as 'g per 100 g EP' to total nitrogen (NT) as 'g per 100 g EP'

Table 4.5-2: Protein (g/100 g EP) → NT (g/100 g EP)

Data needed	• Protein content as g/100 g EP • Nitrogen-to-protein conversion factor (XN) also called Jones factor (see *Annex 2*)
Formula	NT (g/100 g EP) = Protein (g/100 g EP) ÷ XN
Example	Milk contains 3.3 g protein/100 g EP. The XN for milk is 6.38 Calculation: 3.3 g/100 g EP ÷ 6.38 = 0.52 g NT/100 g EP
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion from individual amino acid (AA) as 'mg per 100 g protein' to individual AA as 'mg per 100 g EP'

Table 4.5-3: AA (mg/100 g protein) → AA (mg/100 g EP)

Data needed	• Values for individual AA as mg/100 g protein • Protein as g/100 g EP
Formula	Individual AA (mg/100 g EP) = individual AA (mg/100 g protein) x protein (g/100 g EP) ÷ 100
Example	In reindeer milk, leucine (LEU) is present at 5990 mg/100 g protein; protein = 10.7 g/100 g EP Calculation: 5990 mg/100 g protein x 10.7 g/100 g EP ÷ 100 = 641 mg LEU/100 g EP Note: This procedure is repeated for all amino acids in the food, using the values for individual AA to build the sum of AA.
Approximation	If protein content is not given it is possible to estimate this. One option is to sum up all proteinogenic amino acids (i.e. the protein building AA), if analyzed. Another option is to average different total protein contents for the same food from other sources and use this estimated protein content to convert the data to per 100 g EP. These approximations will lower the quality of the data.
Suggestion	When AA data are reported per 100 g protein, the protein content per 100 g EP should always be reported.
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion from individual amino acids (AA) as 'mg per g protein' to individual AA as 'mg per 100 g EP'

Table 4.5-4: AA (mg/g protein) → AA (mg/100 g EP)

Data needed	• Values for individual AAs per g protein • Protein as g/100 g EP
Formula	Individual AA (mg/100 g EP) = individual AA (mg/g protein) x protein (g/100 g EP)
Example	In corn, threonine (THR) = 30.4 mg/g protein; protein = 6.9 g/100 g EP Calculation: 30.4 mg/g protein x 6.9 g/100 g EP = 210 mg THR/100 g EP Note: This procedure is repeated for all amino acids in the food, using the values for individual AA to build the sum of AA.
Approximation	If protein content is not given it is possible to estimate this. One option is to sum up all proteinogenic amino acids (i.e. the protein building AA), if analyzed. Another option is to average different total protein contents for the same food from other sources and use this estimated protein content to convert the data to per 100 g EP. These approximations will lower the quality of the data.
Suggestion	When AA data are reported per 100 g protein, the protein content per 100 g EP should always be reported.
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (*see Section 3.5*).

Conversion from individual amino acids (AA) as '% of total AA' (= AA as 'g per 100 g total AA') to individual AA as 'mg per 100 g EP'

Table 4.5-5: AA (% of total AA) → AA (mg/100 g EP)

Data needed	• Values for individual AA as % of total AA (= individual AA as g/100 g total AA) • Sum of all individual AA as g per 100 g EP
Formula	Individual AA (mg/100 g EP) = individual AA (% of total AA) ÷ 100 x ΣAA (g/100 g EP) x 1000 Note: The formula needs to be 'x 1000' to convert the individual AA from g to mg.
Example	Isoleucine (ILE) in cow milk is 5.03 % of total AA. ΣAA is 2.96 g/100 g EP Calculation: (5.03 ÷ 100) x 2.96 g/100 g EP x 1000 = 149 mg ILE/100 g EP Note: This procedure is repeated for all amino acids in the food, using the values for individual AA to build the sum of AA.

Approximation	If the sum of all AA per 100 g EP is not available, or not all the AAs have been analyzed*, then protein per 100 g EP could be used as an approximation. The protein can be estimated from average different total protein contents for the same food from other sources, as explained previously. This is however, not recommended.
Note	When expressing AA data per % total AA it is crucial that all AA are analyzed. If all AA have been analyzed, the sum of all AA per 100 EP gives the "true" protein content. This is the most accurate measure of true protein. Cost and experience with the method are issues: some amino acids (e.g. the sulphur-containing amino acids and tryptophan) are more difficult to determine than others.
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*)

* Free amino acids are nutritionally equivalent to protein amino acids (Greenfield & Southgate, 2003).

Conversion from individual amino acids (AA) as a percentage of the requirement pattern* to individual AA as 'mg per 100 g EP'

Table 4.5-6: AA (% of requirement pattern) → AA (mg/100 g EP)

Data needed	• Values for individual AAs as % of the requirement pattern • Requirement pattern (mg/g protein) • Protein as g/100 g EP
Formula-step 1	Individual AA (mg/g protein) = % of requirement of AA ÷ 100 x amount in requirement pattern of this AA
Formula-step 2	Individual AA (mg/100 g EP) = individual AA (mg/g protein) x protein (g/100 g EP)
Example	Lysine (LYS) in wheat bread is 41.8 % of requirement pattern. Protein in wheat bread is 12.8 g/100 g EP. LYS requirement is 58 mg/g protein (requirement patterns used are FAO/WHO/UNU 1985 for Pre-School Child, 2-5 yrs) Calculation: Step 1: (41.8 ÷ 100) x 58 mg/g protein = 24.2 mg LYS/g protein. Step 2: 24.2 mg LYS /g protein (from step 1) x 12.8 g/100 g EP = 310 mg LYS/100 g EP Note: This procedure should be repeated for all amino acids in the food, using the values for individual AAs in each case.
Approximation	If protein content is not given it is possible to estimate this. One option is to sum up all proteinogenic amino acids (i.e. the protein building AA), if analyzed. Another option is to average different total protein contents for the same food from other sources and use this estimated protein content to convert the data to per 100 g EP. These approximations will lower the quality of the data.
Suggestion	The requirement pattern used must be specified (ideally giving the actual values for the population group used, rather than just the reference).

* The use of a reference protein with an 'ideal' AA composition is necessary to define the pattern of human AA requirements as given by e.g. WHO/FAO/UNU (2007) or FAO/WHO/UNU (1985).

Conversion from individual amino acid (AA) as 'g per g total nitrogen (NT)' to individual AA as 'mg per 100 g EP'

Table 4.5-7: AA (g/g NT) → AA (mg/100 g EP)

Data needed	• Individual AA as g/g NT • Protein as g/100 g EP • XN (see Annex 2)
Formula	Individual AA (mg/100 g EP) = individual AA (g/g NT) x protein (g/100 g EP) ÷ XN x 1000 Note: The formula needs to be 'x 1000' to convert the individual AA from g to mg.
Example	THR in cod is 0.25 g/g NT, the protein content is 15 g/100 g EP. The XN for fish is 6.25 Calculation: 0.25 g/g NT x 15 g/100 g EP ÷ 6.25 x 1000= 600 mg THR/100 g EP Note: This procedure is repeated for all amino acids in the food, using the values for individual AA to build the sum of AA.
Suggestion	Always report the nitrogen factor used, when expressing amino acid content in this manner.
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion from individual amino acid (AA) as 'g per16 g total nitrogen (NT)' to individual AA as 'mg per 100 g EP'

Table 4.5-8: AA (g/16 g NT) → AA (mg/100 g EP)

Data needed	• Individual AA as g per 16 g NT • Protein as g/100 g EP • XN (see Annex 2)
Formula	Individual AA (mg/100 g EP) = individual AA (g/16 g NT) x protein (g/100 g EP) ÷ 16 x XN x 1000 Note: The formula needs to be 'x 1000' to convert the individual AA from g to mg.
Example	Histidine (HIS) in apple is 1.79 g/16 g NT, protein is 0.26 g/100 g EP, XN for apple is 6.25 Calculation: 1.79 g/16 g NT x 0.26 g/100 g EP ÷ 16 x 6.25 x 1000= 182 mg HIS/100 g EP Note: This procedure is repeated for all amino acids in the food, using the values for individual AA to build the sum of AA.
Suggestion	Always report the XN used, when expressing amino acid content in this manner.
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion from sum of hydrous form of AA as 'mg per 100 g EP' to protein as 'g per 100 g EP' (=sum of anhydrous form of AA as mg 'per 100 g EP')

If for a food all values of the relevant proteinogenic amino acids are given (i.e. the protein building AA), the protein content can be calculated by summing up the individual amino acid values. In food composition tables and databases, values for the individual AA are normally given in their hydrous form. However, through peptide binding of two amino acids, one molecule of water is released, so the molar mass of water has to be subtracted from each AA in order to not overestimate the protein content (= anhydrous form = AA residue).

Table 4.5-9: Sum of hydrous AA (mg/100 g EP) → Protein (g/100 g EP)

Data needed	• Individual hydrous AA as mg/100 g EP (including water) • Molar mass (M) of individual hydrous AA (g/mol) • Molar mass of water (18 g/mol) • Molar mass of individual anhydrous AA (g/mol) = molar mass of individual hydrous AA (g/mol) – molar mass of water (g/mol) Note: Exception: Cystine is made up from 2 molecules of cysteine. If cystine is reported, therefore two molecules of water have to be subtracted to get the anhydrous form of cystine: Molar mass of anhydrous cystine (g/mol) = molar mass of hydrous cystine (g/mol) – 2 x molar mass of water (g/mol)
Formula	Step 1: Individual anhydrous AA (mg/100 g EP) = molar mass of individual anhydrous AA ÷ molar mass of individual hydrous AA x individual hydrous AA (mg/100 g EP) Step 2: Protein (g/100 g EP) = ∑ individual anhydrous AA (mg/100 g EP) ÷ 1000
Example	Example for bread (see *Table 4.5-10* for content of individual AA in bread and molar masses). Alanine (ALA) in bread is 200 mg/100 g EP, the molecular weight of ALA (hydrous form) is 89 g/mol Calculation step 1: 71 ÷ 89 x 200 = 160 mg anhydrous ALA/100 g EP Note: Molar mass of anhydrous ALA (g/mol) = molar mass of hydrous ALA (g/mol) – molar mass of water (g/mol) = (89-18) = 71 g/mol Calculation step 2: ∑ individual anhydrous AA (g/100 g EP) = 5946 mg ÷ 1000 = 5.9 g protein/100 g EP Note: Build the ∑ individual anhydrous AA (g/100 g EP) for bread by adding up all values as given in *Table 4.5-10*, column 5.

Approximation	If the sum of AA is available but not the individual AA, the mean molecular weight of amino acids can be considered (137 g/mol AA). Asparagine (ASN) and aspartic acid (ASP) are often analysed together and expressed as (Asx), which is the same case for glutamine (GLN) and glutamic acid (GLU), which are then reported as (Gsx). In those cases, the mean molar mass of the amino acids can be used: Asx = 114.5 g/mol; Gsx = 128.5 g/mol.
Note for data in DM	If data are presented on a DM basis, the preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).
Suggestion	It must be made very clear in analytical reports or scientific papers if the data concern hydrous or anhydrous AA.

Table 4.5-10: Molar masses of individual anhydrous and hydrous AA and corresponding AA content in bread

AA (INFOODS tagname)	Hydrous AA content (mg/100 g EP) of bread	Molar mass of hydrous AA* (g/mol)	Molar mass of anhydrous AA (g/mol)**	Anhydrous AA content (mg/100 g EP) of bread
Alanine (ALA)	200	89	71	160
Arginine (ARG)	240	174	156	215
Asparagines (ASN)	254	132	114	219
Aspartic acid (ASP)	200	133	115	173
Cysteine (CYSTE)	30	121	103	26
Glutamine (GLN)	785	146	128	688
Glutamic acid (GLU)	610	147	129	535
Glycine (GLY)	144	75	57	109
Histidine (HIS)	112	155	137	99
Isoleucin (ILE)	345	131	113	298
Leucine (LEU)	602	131	113	519
Lysine (LYS)	520	146	128	456
Methionine (MET)	164	149	131	144
Phenylalanine (PHE)	331	165	147	295
Proline (PRO)	722	115	97	609
Serine (SER)	385	105	87	319
Threonine (THR)	294	119	101	250
Tryptophan (TRP)	142	204	186	129
Tyrosine (TYR)	371	181	163	334
Valine (VAL)	434	117	99	367
total	6885			5946

* Source of molecular weights: ChEBI website http://www.ebi.ac.uk/chebi/

**= molar mass of hydrous AA - molar mass of water

4.6 Vitamins

Vitamins are often expressed in equivalents. To calculate them, it is necessary to have values and conversion factors for all contributing components. Nowadays, metric units are used (mg or μg). In the past, International Units (IU) were used for vitamin A, D, and E, which is often continued supplement labeling.

4.6.1 Vitamin A

Vitamin A is reported in μg retinol activity equivalent (VITA_RAE) or as retinol equivalent (VITA) in food composition tables/databases. However,International Units (IU) are frequently used for nutrition labeling especially for supplements. No direct conversion is possible from VITA, VITA_RAE, β-carotene equivalents in μg (CARTBEQ) to IU, as there is no single conversion factor, but specific ones for retinol and the pro-vitamin A carotenoids. For the same reason, no direct conversion from VITA, VITA_RAE in IU to mg retinol (RETOL), β-carotene (CARTB), and to other carotenes with vitamin A activity is possible without knowing the ratio of the contributing components. Along with CARTB, α-carotene (CARTA) and β-cryptoxanthin (CRYPXB) are considered as the main carotenes with vitamin A activity. However, other forms such as α-cryptoxanthin and γ-carotene are also considered to have vitamin A activity (Bauernfeind, 1972; Food Standards Agency, 2002) and could therefore be included in the below equations.

See Section 3.2 for the conversion from International Units (IU) for vitamin A to μg retinol, β-carotene or other pro-vitamin-A carotenoids (α-carotene, β-cryptoxanthin).

Conversion from components with vitamin A activity as 'μg per 100 g EP' to vitamin A-retinol activity equivalent (VITA_RAE) as 'μg per 100 g EP' (see also section 3.2)

Table 4.6.1-1: Components with vitamin A activity (μg/100 g EP) → VITA_RAE (μg/100 g EP)

Data needed	• Individual component values as μg/100 g EP of retinol, β-carotene, α-carotene and β-cryptoxanthin
Formula	VITA_RAE (μg/100 g EP) = retinol (μg/100 g EP) + 1/12 β-carotene (μg/100 g EP) + 1/24 α-carotene (μg/100 g EP) + 1/24 β-cryptoxanthin (μg/100 g EP)
Example	A mixed dish contains per 100 g EP: 2 μg retinol (RETOL), 921 μg β-carotene (CARTB), 35 μg α-carotene (CARTA) and 24 μg β-cryptoxanthin (CRYPXB) Calculation: 2 μg +(921 μg ÷ 12) + (35 μg ÷ 24) + (24 μg ÷ 24) = 81 μg VITA_RAE/100 g EP
Note	The conversion factors used can be country-specific, e.g. in India the conversion factor for β-carotene is 1/8. However, in most countries 1/12 is used.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion of components with vitamin A activity as ‘μg per 100 g EP’ to vitamin A-retinol equivalent (VITA) as ‘μg per 100 g EP’

Table 4.6.1-2: Components with vitamin A activity (μg/100 g EP) → VITA (μg/100 g EP)

Data needed	• Individual values as μg/100 g EP of retinol, β-carotene, α-carotene and β-cryptoxanthin
Formula	VITA (μg/100 g EP) = retinol (μg/100 g EP) + 1/6 β-carotene (μg/100 g EP) + 1/12 α-carotene (μg/100 g EP) + 1/12 β-cryptoxanthin (μg/100 g EP)
Example	A mixed dish contains per 100 g EP: 2 μg RETOL, 921 μg CARTB, 35 μg CARTA and 24 μg CRYPXB Calculation: 2 μg + (921 μg ÷ 6) + (35 μg ÷ 12) + (24 μg ÷ 12) = 160 μg VITA/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion from components with β-carotene activity as ‘μg per 100 g EP’ to β-carotene equivalents (CARTBEQ) as ‘μg per 100 g EP’

Table 4.6.1-3: Components with β-carotene activity → CARTBEQ (μg/100 g EP)

Data needed	• Individual values as μg/100 g EP of β-carotene, α-carotene and β-cryptoxanthin
Formula	CARTBEQ (μg/100 g EP) = β-carotene (μg/100 g EP) + 0.5 x α-carotene (μg/100 g EP) + 0.5 x β-cryptoxanthin (μg/100 g EP)
Example	A mixed dish contains per 100 g EP: 921 μg CARTB, 35 μg CARTA and 24 μg CRYPXB Calculation: 921 μg + (0.5 x 35 μg) + (0.5 x 24 μg) = 951 μg CARTBEQ/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

4.6.2 Vitamin D

Vitamin D can be defined in different ways (as sum of components or as equivalent) and is usually expressed as µg. Vitamin D as IU are not preferred however, if IU are used it must be stated explicitly.

A direct conversion between vitamin D (VITD) and vitamin D equivalents (VITDEQ) is only possible, if a value for 25-hydroxycholecaliferol is given.

See Section 3.2 for the conversion from IU for vitamin D to 'µg per 100 g EP'.

Conversion from components with vitamin D activity as 'µg per 100 g EP' to vitamin D (VITD) as 'µg per 100 g EP'

Table 4.6.2-1: Components with vitamin D activity (µg/100 g EP) → VITD (µg/100 g EP)

Data needed	• Individual values in µg/100 g EP of vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol)
Formula	VITD (µg/100 g EP) = vitamin D2 (µg/100 g EP) + vitamin D3 (µg/100 g EP)
Example	A mixed dish contains per 100 g EP: 2 µg vitamin D2 (ERGCAL) and 3 µg vitamin D3 (CHOCAL) Calculation: 2 µg + 3 µg = 5 µg VITD/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion of components with vitamin D activity as 'µg per 100 g EP' to vitamin D equivalent (VITDEQ) as 'µg per 100 g EP'

Table 4.6.2-2: Components with vitamin D activity (µg/100 g EP) → VITDEQ (µg/100 g EP)

Data needed	• Individual values as µg/100 g EP of vitamin D2, vitamin D3 and 25-hydroxycholecalciferol
Formula	VITDEQ (µg/100 g EP) = vitamin D2 (µg/100 g EP) + vitamin D3 (µg/100 g EP) + 5 x 25-hydroxycholecalciferol (µg/100 g EP) = VITD (µg/100 g EP) + 5 x 25-hydroxycholecalciferol (µg/100 g EP)
Example	A dish with mushrooms and pork contains per 100 g EP: 2 µg ERGCAL, 3 µg CHOCAL and 1.5 µg 25-hydroxycholecalciferol (CHOCALOH) Calculation: 2 µg + 3 µg + (5 x 1.5 µg) = 12.5 µg VITDEQ/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

4.6.3 Vitamin E

To calculate vitamin E expressed as α-tocopherol equivalents (VITE), the conversion factors of the different active tocopherols and tocotrienols has to be known and values for all contributing components should exist. However, some FCDB and FCT do not include tocotrienols as the values and vitamin E activity are low. No international consensus exists on the definition of vitamin E. The latest version of the dietary reference intake (DRI) published by the Institute of Medicine of the U.S. National Academy of Science (NAS/IOM) states that α- tocopherol (TOCPHA) is the active form of vitamin E (Institute of Medicine, 2000). Vitamin E expressed in IU is obsolete.

See also Section 3.2 for the conversion from IU for vitamin E to 'mg per100 g EP'.

Conversion of components with vitamin E activity as 'mg per 100 g EP' to vitamin E-tocopherol equivalents (VITE) as 'mg per 100 g EP'

Table 4.6.3-1: Components with vitamin E activity (mg/100 g EP) → VITE (mg/100 g EP)

Data needed	• Individual values as mg/100 g EP of α-tocopherol, β-tocopherol, γ-tocopherol, δ-tocopherol, α-tocotrienol, β-tocotrienol and γ- tocotrienol
Formula	vitamin E expressed as tocopherol equivalent VITE (mg/100 g EP) = α-tocopherol (mg/100 g EP) + 0.4 β tocopherol (mg/100 g EP) + 0.1 γ-tocopherol (mg/100 g EP) + 0.01 δ-tocopherol (mg/100 g EP) + 0.3 α-tocotrienol (mg/100 g EP) + 0.05 β-tocotrienol (mg/100 g EP) + 0.01 γ- tocotrienol (mg/100 g EP)
Example	Palm oil contains per 100 g EP: 14.1 mg α-tocopherol (TOCPHA), 0 mg β-tocopherol (TOCPHB), 3.7 mg γ-tocopherol (TOCPHG), 0 mg δ-tocopherol (TOCPHD), 23.8 mg α-tocotrienol (TOCTRA), 0 mg β-tocotrienol (TOCTRB) and 40.5 mg γ- tocotrienol (TOCTRG) Calculation: 14.1 mg + (0.4 x 0 mg) + (0.1 x 3.7 mg) + (0.01 x 0 mg) + (0.3 x 23.8 mg) + (0.05 x 0 mg) + (0.01 x 40.5 mg) = 22.02 mg VITE/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

4.6.4 Folate

It is important to clearly state which definition/expression of folate is used as their values are significantly different. Folic acid (FOLAC) is the synthetic form used in fortification and is therefore not present in foods in their natural state.

Conversion from food folate (FOLFD) and folic acid (FOLAC) as 'µg per 100 g EP' to total folate (FOL) as 'µg per 100 g EP'

Table 4.6.4-1: FOLFD (µg/100 g EP) + FOLAC (µg/100 g EP) → FOL (µg/100 g EP)

Data needed	• Individual values of food folate and folic acid as µg/100 g EP
Formula	FOL (µg/100 g EP) = food folate (µg/100 g EP) + folic acid (µg/100 g EP)
Example	Wheat flour, enriched, contains per 100 g EP: 29 µg food folate (FOLFD) and 154 µg folic acid (FOLAC) Calculation: 29 µg + 154 µg = 183 µg FOL/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

Conversion from food folate (FOLFD) and folic acid (FOLAC) as 'µg per 100 g EP' to folate as dietary folate equivalent (FOLDFE) as 'µg per 100 g EP'

Table 4.6.4-2: FOLFD (µg/100 g EP) + FOLAC (µg/100 g EP) → FOLDFE (µg/100 g EP)

Data needed	• Values of food folate and folic acid as µg/100 g EP
Formula	FOLDFE (µg/100 g EP) = food folate (µg/100 g EP) + 1.7 x folic acid (µg/100 g EP)
Example	Wheat flour, enriched, contains per 100 g EP: 29 µg FOLFD and 154 µg FOLAC Calculation: 29 µg + (1.7 x 154 µg) = 291 µg FOLDFE/100 g EP Note: This calculation takes the higher folate activity of folic acid into account.
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

4.6.5 Niacin

Niacin (NIA) is only preformed niacin, while niacin equivalents (NIAEQ) also include the contribution of tryptophan, a niacin precursor (60 mg tryptophan is equivalent to 1 mg niacin).

Conversion from niacin (NIA) and tryptophan (TRP) as 'mg per 100 g EP' to niacin equivalents (NIAEQ) as 'mg per 100 g EP'

Table 4.6.5-1: NIA (mg/100 g EP) + TRP (mg/100 g EP) → NIAEQ (mg/100 g EP)

Data needed	• Individual values as mg/100 g EP of niacin and tryptophan
Formula	NIAEQ (mg/100 g EP) = niacin preformed (mg/100 g EP) + 1/60 tryptophan (mg/100 g EP)
Example	Mango, raw, contains per 100 g EP: 0.669 mg niacin (NIA) and 13 mg tryptophan (TRP) Calculation: 0.669 mg + (13 mg ÷ 60) = 0.886 mg NIAEQ/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

4.6.6 Vitamin C

Vitamin C (VITC) is the sum of L-ascorbic acid (ASCL) and L-dehydro-ascorbic acid (ASCLD). In unprocessed foods L-ascorbic acid and vitamin C show comparable results since the L-dehydro-ascorbic acid content (if existing) is very low. In processed foods dehydro-ascorbic acid is present and therefore VITC and ASCL can have significantly different values.

Conversion of components with vitamin C activity as 'mg per 100 g EP' to vitamin C (VITC) as 'mg per 100 g EP'

Table 4.6.6-1: Components with vitamin C activity (mg/100 g EP) → VITC (mg/100 g EP)

Data needed	• Individual values as mg/100 g EP of L-ascorbic acid and L-dehydro-ascorbic acid
Formula	VITC (mg/100 g EP) = L-ascorbic acid (mg/100 g EP) + L-dehydro-ascorbic acid (mg/100 g EP)
Example	Mango puree contains per 100 g EP: 42 mg L-ascorbic acid (ASCL) and 5 mg L-dehydro-ascorbic acid (ASCLD) Calculation: 42 mg + 5 mg = 47 mg VITC/100 g EP
Note for data in DM	If data are presented on a DM basis, a preliminary step is to convert the values on DM basis to per 100 g EP (see *Section 3.5*).

4.7 Inorganic constituents

Inorganic constitutes including minerals and inorganic contaminants are found to be expressed in different ways in the literature. In food composition tables they are expressed as mg or µg/100 g EP.

Conversion of inorganic constituents from mol to mg or µg per 100 g EP

Table 4.7-1: Inorganic constituents (mol) → per 100 g EP

Data needed	• NV (mmol or mol) per EP • Molar mass (Atomic weight) as g/mol (see table below) • Density (if data are expressed as per volume)	
From	To	Conversion
mmol/g EP	mg/100 g EP	NV (mmol/g EP) x molar mass (g/mol) x 100
mmol/g EP	µg/100 g EP	NV (mmol/g EP) x molar mass (g/mol) x 100,000
mmol/kg EP	mg/100 g EP	NV (mmol/kg EP) x Molar mass (g/mol) ÷ 10
mmol/mL EP	mg/100 g EP	NV (mmol/mL EP) x molar mass (g/mol) x 100 x density
mol/g EP	mg/100 g EP	NV (mol/g EP) x molar mass (g/mol) x 100,000
mol/kg EP	mg/100 g EP	NV (mol/kg EP) x molar mass (g/mol) x 100
mol/mL EP	mg/100 g EP	NV (mol/mL EP) x molar mass (g/mol) x 100,000 x density
Example	For Zinc (ZN): Zinc content in lean meat is 0.8 mmol/kg EP. The value needs to be converted to mg/100 g EP (see *Table 4.7-2* below for recommended unit); molar mass of zinc is 65.39000 (g/mol) Calculation: 0.8 mmol/100 kg EP x 65.39000 g/mol ÷ 10 = 5.23 mg ZN/100 g EP	

Table 4.7-2: Molar masses (g/mol) of inorganic constituents and recommended units for FCT and FCDB

Inorganic constituents (INFOODS Tagname)	Molar mass (atomic weight) g/mol	Recommended unit in FCT
Boron (B)	10.81100	µg
Calcium (CA)	40.078 00	mg
Chloride (CL)	35.45270	mg
Chromium (CR)	51.99610	µg
Cobalt (CO)	58.93320	µg
Copper (CU)	63.54600	mg
Fluoride (FD) (Synonym Fluorine)	18.99840	µg
Iodine (ID)	126.90447	µg
Iron (FE)	55.84500	mg
Ferrous (FE2+)	55.84500	mg
Ferric (FE3+)	55.84500	mg
Magnesium (MG)	24.30500	mg
Manganese (MN)	54.93805	mg
Molybdenum (MO)	95.94000	µg
Phosphorus (P)	30.97376	mg
Potassium (K)	39.09830	mg
Selenium (SE)	78.96000	µg
Sodium (NA)	22.98977	mg
Sulfur (S)	32.06600	mg
Zinc (ZN)	65.39000	mg
Inorganic contaminants		
Aluminum (AL)	26.98154	µg
Arsenic (AS)	74.92160	µg
Cadmium (CD)	112.41100	µg
Lead (PB)	207.20000	µg
Mercury (HG)	200.59000	µg
Nickel (NI)	58.69340	µg

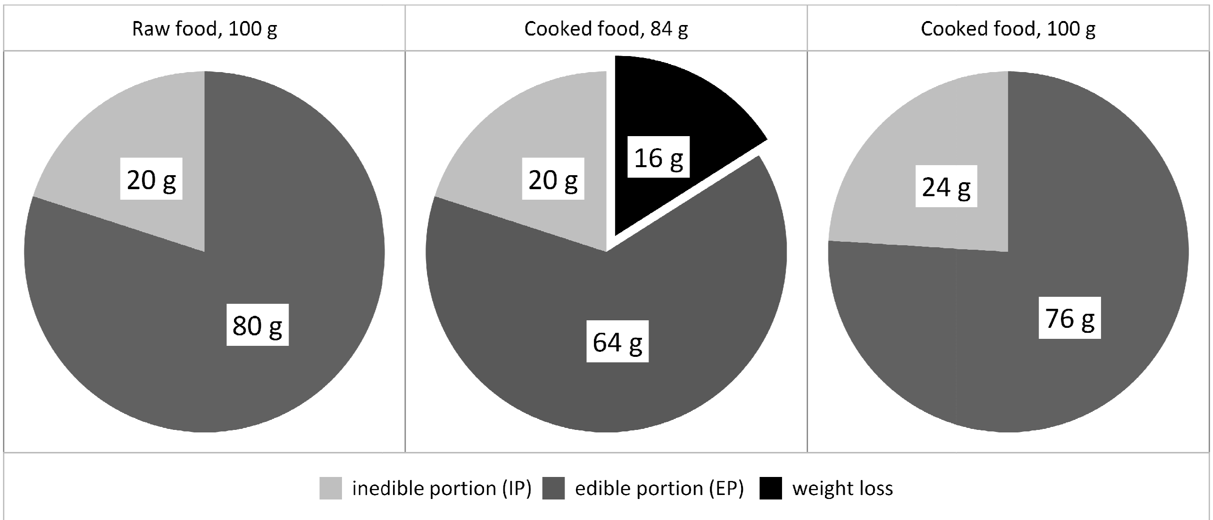
Source of molar mass: ChEBI website http://www.ebi.ac.uk/chebi/ (ChEBI, 2012)
The list of inorganic constituents and contaminants is adapted from Greenfield & Southgate, (2003).

4.8 Edible portion coefficient/refuse values of cooked foods

The edible portion coefficient (EDIBLE), also called refuse, should preferably be measured by weighing the edible and inedible parts of foods, including cooked foods.
In case measuring is not possible, there are two different approaches of estimating EDIBLE for cooked foods when the inedible part is still part of the cooked food:

1. If weight loses are similar between the edible portion (EP) and the inedible portion (IP), the EDIBLE is the same for the cooked as for the raw food. For example: The EDIBLE of a raw food with skin is 0.80, the EDIBLE of the same cooked foods would be 0.80 as well.

2. If the inedible portion loses no or only an insignificant amount of weight (e.g. stones in fruits, bones in meat) meaning that all weight loss occurs in the edible portion, the following calculation can be applied:



edible portion (EP) = 80 g inedible portion (IP) = 20 g YF_{EP}= weight yield factor for the EP = 0.8 EDIBLE = EP (g/100 g)/100 = 0.80	application of YF_{EP} on the edible portion: EP (cooked food) = EP (raw food) x YF_{EP} EP = 64 g IP = 20 g weight loss = YF_{EP}x EP = 16 g [YF = cooked food (g)/raw food (g) = 0.84]	calculation from per 84 g food to per 100 g food: EP (g/100 g) = EP (g/84) g ÷ 84 x 100 IP (g/100 g) = IP (g/84) g ÷ 84 x 100 EP = 76 g IP = 24 g EDIBLE = EP (g/100 g)/100 = 0.76

Figure 4.8-1: Calculation of edible portion coefficient

The calculation steps illustrated in *Figure 4.8-1* can be summarized in the following equation:

$$Edible\ portion\ in\ cooked\ food = \frac{EP - (\mathrm{YF_{EP}} \times EP)}{X + 1} \times X + (EP \times \mathrm{YF_{EP}})$$

EP = edible portion
IP = inedible portion
$\mathrm{YF_{EP}}$ = weight yield factor applicable on the edible portion

$$\mathrm{X} = \frac{\mathrm{EP} \times \mathrm{YF_{EP}}}{\mathrm{IP}}$$

$$Edible\ portion\ coefficient\ (EDIBLE) = \frac{Edible\ portion\ in\ cooked\ food}{100}$$

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Annex 1

List of molecular weights of individual fatty acids (FA) and fatty acid methyl esters (FAME) and their corresponding Sheppard factors (ShF)

	Molecular weight		Sheppard factor		Molecular weight		Sheppard factor
C:D*	FA	FAME	FAME → FA	C:D*	FA	FAME	FAME → FA
C01:0	46.027	60.054	0.766427	C04:1	86.108	100.135	0.859919
C02:0	60.054	74.081	0.810653	C05:1	100.135	114.162	0.877131
C03:0	74.081	88.108	0.840798	C06:1	114.162	128.189	0.890576
C04:0	88.108	102.135	0.862662	C07:1	128.189	142.216	0.901368
C05:0	120.135	116.162	0.879246	C08:1	142.216	156.243	0.910223
C06:0	116.162	130.189	0.892257	C09:1	156.243	170.270	0.917619
C07:0	130.189	144.216	0.902736	C10:1	170.270	184.297	0.923889
C08:0	144.216	158.243	0.911358	C11:1	184.297	198.324	0.929272
C09:0	158.243	172.270	0.918575	C12:1	198.324	212.351	0.933944
C10:0	172.270	186.296	0.924706	C13:1	212.351	226.378	0.938037
C11:0	186.297	200.324	0.929978	C14:1	226.378	240.405	0.941653
C12:0	200.324	214.351	0.934561	C15:1	240.405	254.432	0.944869
C13:0	214.351	228.378	0.938580	C16:1	254.432	268.459	0.947750
C14:0	228.378	242.405	0.942134	C17:1	268.459	282.486	0.950344
C15:0	242.405	256.432	0.945299	C18:1	282.486	296.513	0.952693
C16:0	256.432	270.459	0.948136	C19:1	296.513	310.540	0.954830
C17:0	270.459	284.486	0.950694	C20:1	310.540	324.567	0.956782
C18:0	284.486	298.513	0.953010	C21:1	324.567	338.594	0.958573
C19:0	298.513	312.540	0.955119	C22:1	338.594	352.621	0.960221
C20:0	312.540	326.567	0.957047	C23:1	352.621	366.648	0.961743
C21:0	326.567	340.594	0.958816	C24:1	366.648	380.675	0.963152
C22:0	340.594	354.621	0.960445	C25:1	380.675	394.702	0.964462
C23:0	354.621	368.648	0.961950	C26:1	394.702	408.729	0.965681
C24:0	368.648	382.675	0.963345	C27:1	408.729	422.756	0.966820
C25:0	382.675	396.702	0.964641	C28:1	422.756	436.783	0.967886
C26:0	396.702	410.729	0.965849	C29:1	436.783	450.810	0.968885
C27:0	410.729	424.756	0.966976				
C28:0	424.756	438.783	0.968032				
C29:0	438.783	452.810	0.969022				
C30:0	452.810	466.837	0.969953				

	Molecular weight		Sheppard factor		Molecular weight		Sheppard factor
C:D*	FA	FAME	FAME → FA	C:D*	FA	FAME	FAME → FA
C08:2	140.216	154.243	0.909059	C18:3	278.486	292.513	0.952047
C09:2	154.243	168.270	0.916640	C19:3	292.513	306.540	0.954241
C10:2	168.270	182.297	0.923054	C20:3	306.540	320.567	0.956243
C11:2	182.297	196.324	0.928552	C21:3	320.567	334.594	0.958078
C12:2	196.324	210.351	0.933316	C22:3	334.594	348.621	0.959764
C13:2	210.351	224.378	0.937485	C23:3	348.621	362.648	0.961321
C14:2	224.378	238.405	0.941163	C24:3	362.648	376.675	0.962761
C15:2	238.405	252.432	0.944433	C25:3	376.675	390.702	0.964098
C16:2	252.432	266.459	0.947358	C26:3	390.702	404.729	0.965342
C17:2	266.459	280.486	0.949990	C27:3	404.729	418.756	0.966503
C18:2	280.486	294.513	0.952372	C28:3	418.756	432.783	0.967589
C19:2	294.513	308.540	0.954537	C29:3	432.783	446.810	0.968606
C20:2	308.540	322.567	0.956514				
C21:2	322.567	336.594	0.958327	C11:4	178.297	192.324	0.927066
C22:2	336.594	350.621	0.959994	C12:4	192.324	206.351	0.932024
C23:2	350.621	364.648	0.961533	C13:4	206.351	220.378	0.936350
C24:2	364.648	378.675	0.962958	C14:4	220.378	234.405	0.940159
C25:2	378.675	392.702	0.964281	C15:4	234.405	248.432	0943538
C26:2	392.702	406.729	0.965513	C16:4	248.432	262.459	0.946555
C27:2	406.729	420.756	0.966662	C17:4	262.459	276.486	0.949267
C28:2	420.756	434.783	0.967738	C18:4	276.486	290.513	0.951716
C29:2	434.783	448.810	0.968746	C19:4	290.513	304.540	0.953940
				C20:4	304.540	318.567	0.955968
C08:3	138.216	152.243	0.907864	C21:4	318.567	332.594	0.957825
C09:3	152.243	166.270	0.915637	C22:4	332.594	346.621	0.959532
C10:3	166.270	180.297	0.922201	C23:4	346.621	360.648	0.961106
C11:3	180.297	194.324	0.927816	C24:4	360.648	374.675	0.962562
C12:3	194.324	208.351	0.932676	C25:4	374.675	388.702	0.963913
C13:3	208.351	222.378	0.936923	C26:4	388.702	402.729	0.965170
C14:3	222.378	236.405	0.940665	C27:4	402.729	416.756	0.966342
C15:3	236.405	250.432	0.943989	C28:4	416.756	430.783	0.967438
C16:3	250.432	264.459	0.946960	C29:4	430.783	444.810	0.968465
C17:3	264.459	278.486	0.949631				

C:D*	Molecular weight FA	Molecular weight FAME	Sheppard factor FAME → FA	C:D*	Molecular weight FA	Molecular weight FAME	Sheppard factor FAME → FA
C16:5	246.432	260.459	0.946145	C16:6	244.432	258.459	0.945728
C17:5	260.459	274.486	0.948897	C17:6	258.459	272.486	0.948522
C18:5	274.486	288.513	0.951382	C18:6	272.486	286.513	0.951042
C19:5	288.513	302.540	0.953636	C19:6	286.513	300.540	0.953327
C20:5	302.540	316.567	0.955690	C20:6	300.540	314.567	0.955409
C21:5	316.567	330.594	0.957570	C21:6	314.567	328.594	0.957312
C22:5	330.594	344.621	0.959297	C22:6	328.594	342.621	0.959060
C23:5	344.621	358.648	0.960889	C23:6	342.621	356.648	0.960670
C24:5	358.648	372.675	0.962361	C24:6	356.648	370.675	0.962158
C25:5	372.675	386.702	0.963727	C25:6	370.675	384.702	0.963538
C26:5	386.702	400.729	0.964996	C26:6	384.702	398.729	0.964821
C27:5	400.729	414.756	0.966180	C27:6	398.729	412.756	0.966016
C28:5	414.756	428.783	0.967286	C28:6	412.756	426.783	0.967133
C29:5	428.783	442.810	0.968323	C29:6	426.783	440.810	0.968179

C:D= number of carbons:number of double bonds

Annex 2

Factors for the conversion of nitrogen values to protein (per g N)
Nitrogen-to-protein conversion factors (XN) are also called Jones factors. Where a specific factor is not listed, 6.25 should be used until a more appropriate factor has been determined (Greenfield & Southgate, 2003).

Factors for the conversion of nitrogen values to protein (per g total nitrogen) adapted from Jones (1941) unless indicated.

Animal products			
Foodstuff	**Factor**	**Foodstuff**	**Factor**
Meat and fish	6.25	**Eggs**	
Gelatin	5.55	whole	6.25
Milk	6.38	albumin**	6.32
Casein**	6.40	vitellin**	6.12
Human milk **	6.37		

Plant products			
Foodstuff	**Factor**	**Foodstuff**	**Factor**
Wheat -whole kernel	5.83	Millet#	5.83
Wheat -bran	6.31	Sorghum#	6.25
Wheat -embryo	5.80	Beans	6.25
Wheat -endosperm	5.70	Soya	5.71
Rice	5.95	Castor beans	5.3
Rye	5.83	Mushrooms*	4.38
Barley	5.83	Chocolate and cocoa*	4.74
Oats	5.83	Yeast*	5.7
Maize (corn)	6.25	Coffee*	5.3
Beans: adzuki; jack; lima; mung; navy; velvet	6.25		
Nuts			
Almond			5.18
Brazil			5.46
Peanuts (groundnut)			5.46
Others (butternuts; cashew; chestnut; coconut; hazelnut; hickory; pecans; pine nuts; pistachio; walnuts)#			5.30
Seeds (cataloup; cottonseed; flaxseed; hempseed; pumpkin; sesame; sunflower)			5.30

* From USDA SR24 documentation (USDA, 2011)
# From Merrill and Watt (1973)
** From Greenfield and Southgate (2003)