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ACROPOLIS

Aggregate and Cumulative Risk Of Pesticides: an On-Line Integrated Strategy

SEVENTH FRAMEWORK PROGRAMME

Deliverable 2.2 Guidance document on converting food as consumed including an annex on how the food has been converted using nation-specific recipes.

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Abstract

This report addresses the conversion of foods coded according to the FoodEx classification system to raw agricultural commodity (RAC) level to make it possible to use this data for the exposure assessment to pesticide residues as analysed in RACs of vegetables, fruits, cereals, nuts and seeds. The Dutch RAC conversion model was used as a starting point for this. The conversion should be performed according to two steps: 1 conversion of FoodEx codes to ingredient using national recipe information and 2) conversion of ingredients to their RAC counterpart using information on national food conversion factors. The results of this are to be included in a national FoodEx conversion database, consisting of a part in which FoodEx codes are converted to ingredient level, including weight percentages, and a part in which ingredients are converted to e-RAC level, including weight percentages.

Within the ACROPOLIS project such a database will be generated by the different partners in the project, including the Czech Republic, Italy, Netherlands, Sweden and UK, and will be used to assess the (cumulative) exposure to pesticide residues at a national level. By converting FoodEx codes to ingredient and subsequently RAC level, other countries that have also organised their data at FoodEx level can very easily borrow or update recipes / conversion factors using the national databases generated within ACROPOLIS and make their food consumption data also suitable for pesticide exposure assessment, covering all possible foods that may contain these chemicals.

Contents

1 Introduction

To asses whether a population with a certain dietary pattern may be at risk or not food consumption data are combined with concentrations of adverse chemicals in foods. To perform such exposure assessments the products consumed and those analysed should be recorded at the same level, i.e. at the level of the food, ingredient or raw agricultural commodity (RAC). Most food consumption data of national dietary surveys are formatted at the level of foods as consumed (e.g. bread) and / or ingredient (e.g. flour). Chemicals can be analysed at these levels (e.g. nutrients, acrylamide), but also many are analysed (partly) at RAC level, e.g. mycotoxins, environmental contaminants, veterinary drugs and pesticide residues.

Pesticide residues are analysed at the level of the RAC destined for human consumption. EU Member States regularly perform analytical analyses of pesticides on RACs to monitor the occurrence of these residues and to check compliance of RACs with the maximum residue limits (MRLs) as set in Regulation (EC) No. 299/2008. These analyses are performed as part of national monitoring programmes undertaken by the Member States' authorities and of an EU-wide programme co-ordinated by the European Commission (EFSA, 2009; EFSA, 2010; EFSA, 2011a). To use these analyses for exposure assessment purposes, a link should be made between the concentrations analysed in RACs with foods / ingredients as recorded in the individual national food consumption databases.

In the Netherlands, a RAC conversion model is in place, which converts the foods and ingredients recorded in the different national food consumption surveys into their RAC ingredients. This model was developed in 1995, and has been updated ever since to include new food and ingredient entries as used in later Dutch dietary surveys (Boon *et al.*, 2009a; van Dooren *et al.*, 1995). In the EU project SAFE FOODS this conversion model was used to convert foods and ingredients coded in several national food consumption surveys to their RAC ingredients (Boon *et al.*, 2009a) and subsequently used to assess the exposure to different chemicals (Boon *et al.*, 2009b; Müller *et al.*, 2009; Muri *et al.*, 2009; Ruprich *et al.*, 2009). For this the recipes and conversion factors applicable to the Netherlands were applied to the food / ingredients recorded in food consumption databases of other countries. In another project, the Dutch RAC conversion model was used to convert the food and ingredient codes present in the EFSA Comprehensive database to their RAC ingredients (Boon *et al.*, 2011; EFSA, 2011b; EFSA, 2011c). The use of one national RAC conversion model to convert foods and ingredients into their RAC counterparts may be useful for foods / ingredients that do not show national variation. However, this is not very likely for the majority of foods, and information on national recipes and conversion factors are therefore essential to cover the national variation in the composition of foods.

Within the EU project ACROPOLIS[1] a cumulative dietary exposure model will be developed (and applied) to assess the exposure to groups of pesticides belonging to a common assessment group. For this pesticide residue concentrations as analysed in national monitoring programmes will be used as

[1] www.acropolis-eu.com

well as national food consumption data. Countries involved are Czech Republic (CZ), Italy (IT), Netherlands (NL), Sweden (SE) and United Kingdom (UK)[2]. To link these monitoring data with the food consumption data, the different partners will convert their national food / ingredient entries into RAC ingredients using national information on recipes and conversion factors. To tune in with the work performed by the European Food Safety Authority (EFSA), the FoodEx classification system as used in the Comprehensive database (EFSA, 2011b) will be the point of departure for the national conversion to RAC ingredients.

This document contains information on how to convert foods / ingredients to their RAC ingredients to ensure a standardised approach for doing this. The starting point of the conversion is the principles as laid down in the Dutch RAC conversion model (Boon *et al.*, 2009a; van Dooren *et al.*, 1995).

[2] Since the start of the project, three other countries have joined the project on a voluntary basis, namely Denmark, France and Cyprus. This report only addresses the partners that have a contractual obligation within the project.

2 Input data for the conversion to RAC

2.1 FoodEx codes

FoodEx is a food classification system that was developed by the Data Collection and Exposure Unit (DATEX) of the European Food Safety Authority (EFSA) to codify all foods and beverages present in the Comprehensive database. The main objective of FoodEx is to facilitate the assessment of dietary exposure to hazardous chemicals by allowing accurate matching of the datasets on chemical occurrence and food consumption. FoodEx is a hierarchical system based on 20 main food categories that are further divided into subgroups up to a maximum of 4 levels (Table 1). It builds on different food description and classification systems (EFSA, 2011b).

Data providers (which do not necessarily have to be the ones working within the ACROPOLIS project) that have submitted national food consumption data to EFSA as input for the Comprehensive database have linked their national food and ingredient codes as satisfactory as possible to a corresponding FoodEx code, at the most disaggregated level possible. The items from the "Composite food (including frozen products)" category in FoodEx were only used if no other possibilities were available. The analysis of the Comprehensive dataset by EFSA showed that most countries managed to split most composite foods into their ingredients with the exception of Latvia, Sweden and Slovakia (10 %, 8 % and 7 % of food records classified under the "Composite foods" category, respectively). Furthermore, all data providers were able to codify the large majority of foods at least at the 2nd level of FoodEx. The number of FoodEx codes used to codify the national foods ranged from 233 for the Danish database to 813 for the German one (EFSA, 2011b).

2.2 National food consumption databases

For an overview of the national food consumption databases used in the ACROPOLIS project, see Table 2. All these databases covered all seasons of the year as well as all days of the week, excluding holidays and festive periods due to divergent food habits during those periods. Apart from food consumption data also non-food characteristics were obtained in all surveys, including sex, age and body weight. All of these databases have been provided to EFSA as input for the Comprehensive database and have therefore been categorised according the FoodEx classification system.

In the ACROPOLIS project, the FoodEx codes as used in the different national food consumption databases will be converted to their RAC ingredient level using national information on recipes and conversion factors. In this way, identical FoodEx codes may be converted to different RAC ingredients, or amounts of RAC ingredients, depending on national information. Since the ACROPOLIS project focuses on the dietary exposure to pesticides, the exercise is limited to the FoodEx codes that refer to products of plant origin. The food groups belonging to the main food groups listed below will not be addressed in this guideline.

- Meat and meat products (6)
- Fish and other seafood (7)

Table 1: Main food groups of the FoodEx classification according to the number of subgroups for each of the three hierarchical levels

No	Main food group	Number of subgroups at		
		Level 2	**Level 3**	**Level4**
1	Grains and grain-based products	7	59	247
2	Vegetables and vegetable products (including fungi)	16	133	0
3	Starchy roots and tubers	2	16	0
4	Legumes, nuts and oilseeds	5	52	0
5	Fruit and fruit products	9	120	53
6	Meat and meat products (including edible offal)	12	92	39
7	Fish and other seafood (including amphibians, reptiles, snails and insects)	6	65	0
8	Milk and dairy products	9	234	59
9	Eggs and egg products	2	12	0
10	Sugar and confectionary	7	59	12
11	Animal and vegetable fats and oils	6	41	0
12	Fruit and vegetable juices	8	67	0
13	Non-alcoholic beverages (excepting milk based beverages)	5	22	36
14	Alcoholic beverages	7	31	0
15	Drinking water (water without any additives except carbon dioxide; includes water ice for consumption)	4	2	0
16	Herbs, spices and condiments	10	124	0
17	Food for infants and small children	6	26	0
18	Products for special nutritional use	5	35	0
19	Composite food (including frozen products)	11	54	22
20	Snacks, desserts, and other foods	3	16	0
	Total	140	1260	468

Table 2. *Characteristics of the dietary surveys included in the ACROPOLIS project*[1]

Country[1]	**Name survey**	**Survey period**	**Age range (years)**	**Number of subjects**	**Method**	**Repli-cates**	**Amount reported**	**Reference**
CZ	SISP04	2003-04	> 4	4,118	24-h recall	2	As raw	(Ruprich *et al.*, 2006)
IT	INRAN-SCAI 2005–06	2005-06	> 0.1	3,323	Food record	3	As raw	(Leclercq *et al.*, 2009)
NL	VCP-kids	2005-6	2-6	1,279	Food record	3	As raw	(Ocké *et al.*, 2008)
	DNFCS-2003	2003	19-30	750	24-h recall	2	As raw	(Ocké *et al.*, 2005)
SE	NFA	2003	3-18	2,495	24-h recall	4	As consumed	(Enghardt-Barbieri *et al.*, 2006)
	RIKSMATEN 1997-98	1997-98	18-74	1,210	Food record	7	As consumed	(Becker and Pearson, 2002)
UK	NDNS	2000-01	19-64	1,724	Food record	7	As cooked	(Henderson *et al.*, 2002)

[1] Includes the food consumption data brought into the project of the partners with a contractual obligation. Since the start of the project also data of Denmark, France and Cyprus as present in the EFSA Comprehensive database (EFSA, 2011c) have been included in the project.
[1] CZ – Czech Republic; IT – Italy; NL – Netherlands; SE – Sweden; UK – United Kingdom.

- Milk and dairy products (8), except for some level 3 and 4 food groups including fruit, such as 'Quark with fruit', 'Whey with fruit', etc., and some level 3 food groups belonging to 'Milk and milk product imitates'.
- Eggs and egg products (9)
- Sugar and confectionary (10), except level 2 food group 'Honey', and level 3 foods groups 'Chocolate with nuts or fruits' and 'Fruit sauce'.
- Animal and vegetable fats and oils (11), except the level 2 food groups 'vegetable fat' and 'vegetable oil', the main food group if self (without the underlying animal fats), and the level 3 food groups 'Margarine, normal fat' and 'Margarine, low fat'.
- Non-alcoholic beverages (13)
- Alcoholic beverages (14), except the level 2 food groups 'Beer and beer-like beverages', 'Wines', 'Fortified and liqueur wines (e.g. Vermouth, Sherry, Madeira)' and 'Wine-like drinks (e.g. Cider, Perry)'.
- Drinking water (15)
- 'Herbs, spices and condiments' (16), except the level 2 food groups 'Herbs', 'Spices', 'Herb and spice mixtures', and 'Chutney and pickles', and the level 3 food groups 'Tomato ketchup', 'Oil-based sauce (Pesto, Aioli sauce)', 'Vegetable sauce', and 'Vanilla pods'.
- Food for infants and small children (17), except the level 2 food groups 'cereal-based food for infants and young children', 'Ready-to-eat meal for infants and young children', and 'Fruit juice and herbal tea for infants and young children'.
- Products for special nutritional uses (18)

In addition, also the level 2 food groups 'Meat-based meals', 'Fish and seafood based meals', 'Egg-based meals (except Omelette with vegetables' and 'Ratatouille'), and 'Ready-to-eat soups' of the main food group 'Composite food' (19), and of the main food group 'Snacks, desserts, and other food' (20) the level 2 food groups 'Ices and desserts' and 'Other foods (foods which cannot be included in any other group)' and the level 3 food groups 'Fish-based snacks' and 'Seafood chips' are not addressed.

Furthermore, when converting foods to their RAC ingredients only the commodities as listed in Annex I of Commission Regulation (EC) No 178/2006 belonging to the groups 'Fruit fresh or frozen; nuts' (1), 'Vegetables fresh or frozen'(2), 'Pulses, dry' (3), 'Oilseeds and other oil fruits' (4), 'Cereals' (5), 'Tea, coffee herbal infusions and cocoa' (6)' and 'Spices' (8). Excluded from the conversion are the RACs belonging to the groups 'Hops' (7), 'Sugar plants' (9) (except 'Chicory roots'), 'Products of animal origin-terrestrial animals' (10) (except 'Honey'), 'Fish, fish products, shell fish, molluscs and other marine and freshwater food products' (11), and 'Crops exclusively used for animal feed' (12). The group 'Sugar plants' (including sugar beet, sugar cane, and chicory roots) was not addressed since these foods are hardly monitored within Europe for pesticides due to low expected levels.

2.3 Dutch RAC conversion database

In the Netherlands a RAC conversion database has been developed to convert foods and ingredients entered in the Dutch food consumption databases to RAC level (Boon *et al.*, 2009a; van Dooren *et al.*, 1995). This database will be used as a starting point to convert 'national' FoodEx codes as used in the Comprehensive database to RAC level based on national information.

3 Guidance on conversion to RAC

In this section we will describe the conversion of foods and ingredients as entered in the food consumption databases to their RAC ingredient level. This description is strongly based on Boon et al. (2009). The resulting database can then be used to translate consumption levels of foods and ingredients to RAC consumption estimates.

For the description the following terminology is used:

- Food and ingredient (FI): (raw and prepared) foods and ingredients ready for consumption as recorded in food consumption surveys. For example, cooked spinach, flour, orange without peel, salad and bread.
- Edible part of RAC (e-RAC): raw agricultural commodity without non-edible parts. For example, banana and orange without peel, apple without core and stem, and vegetables without outer leaves.
- RAC as analysed: raw agricultural commodity analysed in the laboratory according to rules set in legislation. For example, orange and banana with peel, cauliflower with outer leaves and wheat.

It is clear from these definitions that most products cannot be exclusively defined by one term. For example orange without peel can both be defined as 'food-as-eaten' and 'e-RAC'. Orange and banana, both with peel, can only be defined as 'RAC as analysed'.

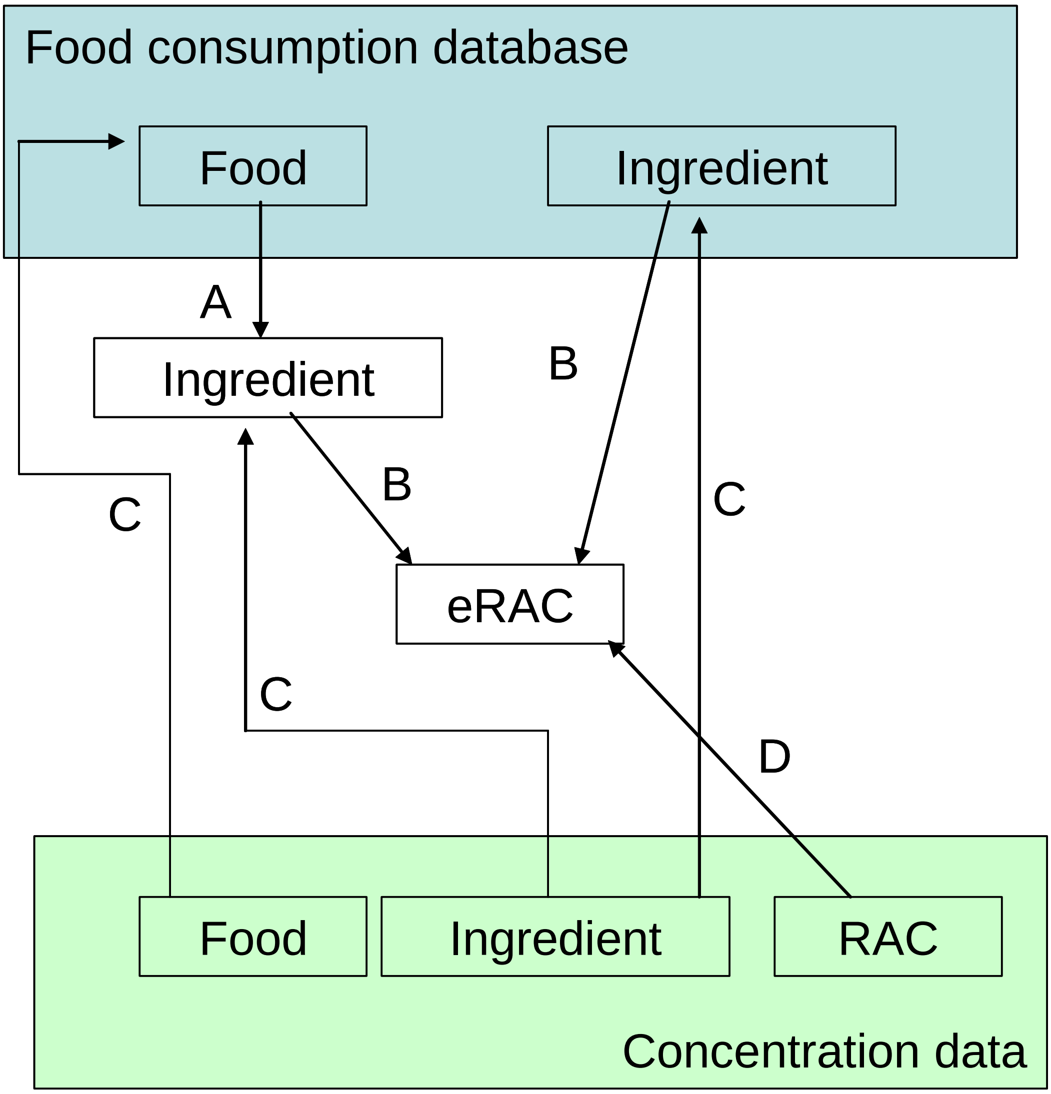
In the Dutch RAC conversion database FIs are converted to their e-RAC counterpart, and not to 'RAC as analysed' level, the level at which pesticides are analysed. The reason for this is that consumption estimates at 'RAC as analysed' level will result in an overestimation of exposure when used to assess the exposure to chemicals analysed in RACs. For example, a consumption estimate of 100 g 'orange without peel' would be equal to 167 g 'orange, including peel and waste' (Donders-Engelen *et al.*, 1997), a much higher amount than actually consumed. The corresponding consumption estimate at e-RAC level would be 100 g. Since several chemicals, such as pesticides, are analysed in RACs, a link should be made with chemical concentrations analysed in RACs and consumption levels at e-RAC level when using this information for exposure calculations. This can be achieved by converting the chemical concentrations to those in the edible part of the RACs. For this processing factors may be used. See Figure 1 for an overall graphical overview of the linkage of concentration data to consumed estimates at FI level.

Conversion of FIs to their e-RAC counterparts consists of two steps when the FI relates to a food consisting of more than one ingredient.

1. Conversion to their ingredient(s).
2. Conversion of each ingredient to its e-RAC counterpart

When the FI refers to just one ingredient (e.g. flour) the first step can be skipped.

Below we will address both steps of the conversion in more details. Since the goal of this exercise is to convert FIs coded according to the FoodEx classification to e-RAC level, the description will take this classification system as point of departure.



A. Recipe data: composition of foods

B. Conversion ingredients to edible part of RAC (eRAC) (considering e.g. weight changes due to processing)

C. Direct link concentration / consumption data

D. Conversion RAC as analysed (including inedible parts) to edible RAC using processing factors

Figure 1. Graphical overview of linkage between food consumption data and concentration data for dietary exposure assessments.

3.1 Conversion of FoodEx codes to their ingredient(s)

3.1.1 Conversion into ingredient(s)

In the case of converting FoodEx codes into their ingredients, there are two types of codes to be distinguished:

1. Codes that refer to one ingredient (e.g. codes used to identify single vegetables, fruits, meats, fishes, etc).
2. Codes that refer to one food consisting of more than one ingredient, the so-called composite foods, such as bread, prepared dishes, canned fruit, etc.

Note that in the definition of the two types of FoodEx codes used above, a food consisting of one ingredient is defined as being an ingredient (type 1).

FoodEx codes belonging to type 1 can be simply converted to 100 % of its clean (raw or processed) ingredient (e.g. orange peeled, apple juice, tomato paste). For FoodEx codes identifying foods consisting of more than one ingredient (type 2), the first step of the conversion to their ingredients is to examine the national foods linked to these FoodEx codes during the preparation of the data for inclusion in the Comprehensive database. When there is just one national food linked to the FoodEx code, this food can be used to determine the composition of the FoodEx. When however more foods are linked to one FoodEx code, the composition of the FoodEx code can be established by either identifying a common food that represents the different foods linked to the one FoodEx code or by averaging the recipes of more foods belonging to the corresponding FoodEx code. For FoodEx codes based on just a very limited number of foods or a very homogeneous group of foods the first approach can be taken. For FoodEx codes based on a more heterogeneous group of foods the second approach may be more appropriate to result in the best possible quantification of the ingredients present. A general rule which approach to take is hard to give. The approach taken should be determined per FoodEx code, using expert-judgement regarding the composition of national foods and possibly the relevance of the code in relation to its expected contribution to the exposure. For example, a food that is hardly consumed may be less important than a food that is coded frequently in the food consumption database. Important is that the choices made are well documented and can be adjusted when new knowledge comes available.

3.1.2 Information needed to convert FoodEx codes to ingredients

Different sources of information can be used to convert foods to their ingredients, including information of the label, manufacturer or website, and recipes from cook books. In the Dutch RAC conversion model also recipes developed and used by the NEVO Foundation to calculate nutrient concentrations present in FIs as listed in the Dutch food composition tables were used (NEVO-Foundation, 1996; NEVO-Foundation, 2001; NEVO-Foundation, 2006). This information may also be available for the other national food consumption surveys.

Below we give some examples of how different sources were used to establish the ingredients of recorded FIs in the Dutch RAC conversion model:

1. Nutrient concentrations as listed in the Dutch food composition table
   For example, 'ringlings' (crisps) contains 68 g carbohydrates. The only source of carbohydrate in this food according to the label is maize starch.
2. Recipes of the NEVO Foundation or from cook books.
   For example, according to the recipe of the NEVO Foundation food 'nuts mixed unsalted' consists of the following ingredients: 55 % of peanuts, 55 %

of cashew, 10 % of almond and 10 % of hazelnut (NEVO-Foundation, 1996; NEVO-Foundation, 2006)
3. Label information
   For example, 'apple sauce' contains according to label 90 % apples and 10 % sugar.
4. Using rules as set in food act.
   For example, according to the Dutch food act 'jam household' should contain 60 % of sugar.

Depending on the food different sources of information can be used to establish its ingredients. Sometimes one source suffices (e.g. label information), but often more may be needed. Mostly different sources need to be evaluated, and those supplying relevant information about ingredients are selected. The sources selected will depend on the food. For example, label information may give useful details about the components of a food (including weight fractions) while for other foods label information may be too minimal for that purpose.

3.1.3 Processing information

When identifying the ingredient(s) of a FoodEx code it is important to also identify the processing type per ingredient. There are two reasons for that:
1. The processing type may determine the conversion of the ingredient to its e-RAC counterpart. For example, whether ingredient 'endive' is consumed raw or after cooking will determine how much e-RAC endive is needed to produce 100 g raw or cooked endive.
2. Processing information is needed to convert the concentrations of toxic chemicals analysed in RACs to that in e-RACs so that these concentrations can be linked to e-RAC consumption levels in exposure calculations (Figure 1). For this, per ingredient – e-RAC combination the type of processing should be identified.

Many ingredients undergo different processing steps before consumption. For example, an apple that is part of an apple pie is washed, peeled, and baked before consumption, and a boiled potato is peeled, washed and boiled (and maybe even soaked for some time in water to reduce cooking time). Which processing type should be linked in these cases to the ingredient? In the Dutch RAC conversion database only one processing type is identified per ingredient, most often the most predominant processing step. So the apple in an apple pie is linked to processing type 'baking' and the boiled potato is linked to 'boiling'. However, if desirable it should be possible to also identify more than one processing type if applicable. When information is available on one of these processing effects, this can be used to adjust the concentration in an exposure assessment.

When there is no processing information available in the name of the FoodEx code (e.g. all raw vegetables and fruits) assume the most likely processing type in your country or the processing type that results in a worst-case estimation of the exposure. For example, citrus fruits are very likely at least peeled before consumption and some vegetables cannot be eaten raw (e.g. cauliflower, beetroots). Apple on the other hand can both be consumed with or without peel, and carrots raw, peeled and / or boiled. If you have no information on the processing type or the code includes national codes that include all processing types, use processing type 'raw' (worst case). Appendix A lists the different processing types that were used in the Dutch RAC conversion model. This list is not exhaustive. New processing types can be used if necessary.

3.2 Conversion of ingredients including processing type to e-RAC

3.2.1 Conversion into e-RACs

After the FoodEx codes have all been described in terms of their ingredients (including weight percentages and processing information), these ingredients in turn need to be converted to their e-RAC counterpart. For this step it is important to make a distinction between two types of ingredients:

1. *Ingredients that are identical to their e-RAC counterpart*.
   This is the case for raw ingredients and for ingredients that have been processed in such a way that no weight change in relation to its e-RAC counterpart occurred (such as washing and peeling). For example, a consumed banana is equal to 100 % e-RAC banana, since both are without peel.
2. *Ingredients that have been processed in such a way that a weight change (e.g. water loss during cooking / drying, oil extraction) occurred in relation to its e-RAC counterpart.*
   Below we list some of the most important conversion factors and assumptions used to convert these types of ingredients to their e-RAC ingredients.

- Shrinkage factors to convert cooked vegetables (including canned and frozen vegetables) to their uncooked e-RAC. For example, the shrinkage factor of spinach is 40 % when boiled (Donders-Engelen et al., 1997). This results in a conversion factor of 1.67 (= 1/(1-0.4)), meaning that 167 g e-RAC spinach is needed to produce 100 g cooked spinach.
- For the conversion of cooked pulses, beans and rice to their dry counterpart. For example, in the Dutch RAC conversion model the following equation is used: boiled = 2.5 x dry weight.
- For the conversion of fruit / vegetable juices to their clean e-RAC. For the Netherlands we use the conversion factors as listed in Appendix B. These were obtained from the FAO (conversion of raw product (including non-edible parts) to juice (FAO-Statistics, 2000)) and as implemented in EPIC-Soft (conversion from non-edible to edible part).
- Potatoes are considered similarly to vegetables, with a shrinkage percentage of 0 %, except for fried potatoes. Here a shrinkage percentage of 17 % was assumed in the Dutch RAC conversion database.
- Vegetable oils, such as sunflower oil, olive oil, etc are all converted to their e-RAC ingredient based on the oil content of this ingredient as listed in van der Velde et al (2010). For example, the oil content of olives is 50 %. The conversion factor to produce 100 g olive oil is thus (100/50=) 2. Based on import information published by the Dutch Product Board for Margarines, Fats and Oils, also a distribution of different oil types has been estimated to be present in the FIs 'vegetable oils and fats' and 'animal and vegetable fats and oils' (van der Velde-Koerts *et al.*, 2010). See Appendix C for the distribution and conversion factors used.
- Factors used to convert dried fruits / vegetables to their e-RAC counterpart were based on water concentrations as listed in the Dutch food composition table (NEVO Foundation, 2006). For example, raisins have a water content of 27 %, while grapes without stem (e-RAC counterpart) have a water content of 83 %, resulting a drying factor equal to 3.1. For a complete list of drying factors applied in the Dutch RAC conversion model see Appendix D.
- Cereal ingredients (independent of processing types) are converted to 100 % of their e-RAC counterpart. So e.g. 'wheat' with processing type 'bran' is

converted to 100 % e-RAC wheat and 'rye' with processing type 'meal' to 100 % e-RAC rye[3]. To identify at the level of the e-RAC which part of the kernel was consumed, we specified this per relevant entry using the following terms: wholemeal, flour, meal, bran and starch. For the definition of these terms see Table 3. Identification of which part of the kernel was consumed is of interest when the chemical is analysed in just a part of the kernel or when the chemical concentrates in a certain part of the kernel (e.g. the bran).

Table 3. *Definition cereals*

Cereal type	Part cereal kernel		
	Flour endosperm	Bran	Germ
Wholemeal	80 %	18 %	2 %
Flour	100 %	0 %	0 %
Meal	90 %	9 % [1]	1 % [2]
Bran	0 %	100 %	0 %
Starch	100 %	0 %	0 %

[1] = 50 % of 18 %
[2] = 50 % of 2 %

3.2.2 *Information needed to convert ingredients to e-RAC*

Information on conversion factors of processed ingredients (including weight changes) to their corresponding e-RAC counterpart can be obtained from different sources, such as literature, guidance documents used in food consumption surveys to recode food consumption data (e.g. EPIC-Soft), internet and information on nutrient composition of the processed ingredient in relation to its e-RAC (e.g. water content).

3.2.3 *Processing*

As explained in section 3.1.3 processing information is important to determine the conversion of a processed ingredient to its e-RAC counterpart, but also to adjust the concentration analysed in RACs to that in e-RAC when performing an exposure assessment using e-RAC consumption estimates.

Note however that the effect of processing on the chemical concentration is both due to weight changes (e.g. concentration may increase during drying due to water loss) and changes in the chemical itself (e.g. degradation via heating). Changes in chemical concentrations due to weight changes are also part of the RAC conversion database when converting ingredients to their e-RAC counterpart (section 3.2.1). This should not be addressed twice. To avoid this, two approaches can be taken:

a. Use the processing factor to address the effect of weight change and link the resulting concentration to the consumption estimates at the relevant ingredient level (so no conversion to e-RAC).
b. Correct the processing factor for the weight change, based on the information on the relevant conversion factors. For example, the conversion factor of raisins to grape is 4.5, meaning that 450 g grape is needed to

[3] Derived ingredients of cereals including not the whole kernel (flour, meal, bran, and starch) are converted to 100 % of their e-RAC counterpart, ignoring that more than 100 g whole cereal is needed to produce 100 g flour. The reason for this is that otherwise the conversion of cereals would result in a higher consumed amount of the cereal than was actually consumed, resulting in an over-estimation of the exposure via cereals when used in an exposure assessment. For example, to produce 100 g bran more than 500 g cereal is needed. Using this amount in an exposure assessment instead of the only 100 g bran consumed would not result in a realistic exposure result.

produce 100 g raisins, and the processing factor is 1.5. The corrected processing factor equals then 1.5/(350/100) = 0.43.

Since processing information, by default, already includes weight changes, a valid approach could be to always ignore weight changes when converting ingredients to their e-RAC counterpart. However, in practice processing information is rather scarce, due to the large number of chemical – RAC – processing type combinations possible. In those cases with no information on the effect of processing on the chemical concentration, but it is known that processing results at least in an effect via weight change, you want to be able to take this effect on the chemical concentration into account. It is therefore important to have information on weight changes (via conversion factors) and not to rely solely on the availability of processing factors to address this effect on chemical concentrations.

3.3 Some examples of conversions via ingredient to e-RAC

Potatoes fried:
- Food composition table: 15.4 g fat.
- Ingredient potato fried (without fat) = 100 – 15.4 = 84.6 g.
- Processing type potato = frying
- Shrinkage factor = 17 %
- **e-RAC potato** = (100-15.4) x 1/(1.00-0.17) = 102 g

Endive boiled without salt
- Shrinkage factor = 33 % (Donders-Engelen et al., 1997)
- Processing type = boiling
- **e-RAC endive** = 100 x 1/0.67 = 149 g

Green peas and carrots, canned/glass
- Label: 50 % peas, 50 % carrots
- Processing type = canned
- Shrinkage factor: peas = 8 % and carrots = 10 % (Donders-Engelen et al., 1997)
- **e-RAC green peas** = 50 x 1/0.92 = 54 g
- **e-RAC carrots** = 50 x 1/0.90 = 56 g

Beans brown, canned/glass
- Boiled = 2.5 x dry weight
- Processing type = boiling
- **e-RAC bean brown dry harvested** = 100/2.5 = 40 g

Apricots dried
- Food composition table: water % apricots raw = 87, apricot dried = 25
- Processing type = drying
- **e-RAC apricots** = 87/25 x 100 g = 348 g

Fruit in syrup, glass
- Label info: 15 % pear, 15 % peach, 15 % grape, 15 % pineapple, sugar, water
- Processing type = peeling
- **e-RAC pear, peach, grape and pineapple** = 15 g.

4 What to do?

4.1 Food conversion to ingredients and e-RAC

Following the instructions as described in section 3, partners within ACROPOLIS will convert the FoodEx codes used in their national databases to classify the FIs consumed to their e-RAC ingredients. For this they will use national information to translate the FoodEx codes into their ingredients and to subsequently convert these ingredients to the e-RAC counterparts, respectively steps 1 and 2 as described in section 3.1 and 3.2. During this process also information on processing will be recorded as described in section 3.1.2.

The derived ingredients will be coded according to the FoodEx system and the e-RACs will be coded according to the codes used in the CODEX system (Codex-Alimentarius, 1993). CODEX system was selected from a practical point of view, since it was the system used in the SAFE FOODS project. However, via the use of translation tables these codes can be simply replaced by another classification system (e.g. FoodEx) if useful. Processing information will be coded using the codes as listed in Appendix A. When an ingredient, e-RAC or processing code is not available, a new code can be generated using the following format:

- For processing: PROC_country code_increasing number
- For ingredient: INGR_country code_increasing number
- For e-RAC: ERAC-country code_increasing number

So for example for the Netherlands: PROC_NL_01, PROC_NL_02, etc. After the exercise an inventory will be made of the extra codes used and a proposal for new standardised codes that can replace these national codes. This can be done by a simple update. We propose to work in Excel or Access and to make a table (or worksheet) containing the information on the conversion to ingredients (section 3.1) and one on the conversion of ingredients to e-RAC (section 3.2). For an example of the format of such tables (worksheets), see Tables 4 and 5 respectively.

4.2 Use of the collected information for dietary exposure modelling

To perform exposure assessments to chemicals analysed (predominantly) at RAC level, food consumption data need to be converted to the same level. In this way, food consumption data and concentration data can be linked directly. With the use of the information in Table 4 and 5, the consumption of FoodEx codes used in the Comprehensive database can be converted to e-RAC consumption estimates at the national level. First, FoodEx consumption estimates are converted to those at ingredient level using the percentages of an ingredient in the relevant food (Table 4), and subsequently the information present on the conversion to e-RAC (Table 5) can be used to calculate the amount of e-RAC consumed. For example, food ‘wheat bread, brown’ contains about 55 % wheat flour (white + wholemeal). When someone consumes 150 g of this food, the amount of wheat flour consumed equals 82.5 g. Since the conversion factor of wheat flour to wheat is 1, this is also the amount of e-RAC wheat consumed.

By converting FoodEx consumption estimates only to those at ingredient level, this database can also be used to perform exposure assessments to chemicals analysed in ingredients. In the FoodEx classification system there are codes that represent single ingredients (e.g. wheat flour, dried apricots, etc), but by using

***Table** 4. Ingredient composition of FoodEx codes, including processing type*

Food		Ingredient			Processing type		
FoodEx code	FoodEx name[1]	FoodEx code[2]	FoodEx name[1]	Proportion (%)	Code[3]	Name[1]	Cereal type
A.01.04.001.002	Bread with raisins	A.01.03.001.003	Wheat flour, white	55	4	Baking of bread	Flour
A.01.04.001.002	Bread with raisins	A.05.07.001	Dried vine fruits	20	7	Drying	-
A.01.04.001.001	Wheat bread, white	A.01.03.001.003	Wheat flour, white	65	4	Baking of bread	Flour
A.01.06.002.004	Muesli with fruit	A.01.06.001.020	Wheat flakes	50	1	None	Wholemeal
A.01.06.002.004	Muesli with fruit	A.01.06.001.018	Oat flakes	35	1	None	Wholemeal
A.01.06.002.004	Muesli with fruit	A.05.07.001	Dried vine fruits	15	7	Drying	-
A.05.01.002	Oranges	A.05.01.002	Oranges	100	2	Peeling	-
A.12.01.001	Juice, apple	A.12.01.001	Juice, apple	100	9	Juicing	-

[1] These columns are not compulsory
[2] When no FoodEx code is available to identify an ingredient a country specific code can be used as explained in section 4.1.
[3] Use the processing codes as listed in Appendix A. When no processing code is available for a certain processing type, use a country specific code as explained in section 4.1.

***Table 5.** Conversion of ingredients to e-RAC ingredient*

Ingredient		e-RAC		Processing code[3]	Conversion factor	Cereal type
FoodEx code	FoodEx name[1]	CODEX code[2]	CODEX name[1]			
A.01.03.001.003	Wheat flour, white	GC0654	Wheat	4	1.0	Flour
A.05.07.001	Dried vine fruits	FB0269	Grape	7	3.5	-
A.01.06.001.020	Wheat flakes	GC0654	Wheat	1	1	Wholemeal
A.01.06.001.018	Oat flakes	GC0647	Oat	1	1	Wholemeal
A.05.01.002	Oranges	FC0206	Orange	2	1	-
A.12.01.001	Juice, apple	FP0226	Apple	9	1.31	-

[1] These columns are not compulsory
[2] When no CODEX code is available to identify an e-RAC, a country specific code can be used as explained in section 4.1.
[3] Processing code belonging to the ingredient and as defined in Table 4.

the information on the composition of FoodEx codes representing composite foods also ingredients 'hidden' in these foods are included in the assessment. In this way all possible dietary sources of exposure can be addressed in the exposure assessment.

Furthermore, with the information listed in both tables, it can be avoided that the change in chemical concentration due to a weight change is addressed twice when including processing factors in an exposure assessment. This can be done by

a. Using the processing factor to address the effect of weight change and link the resulting concentration to the consumption estimates at the relevant ingredient level (so ignore the conversion to e-RAC).
b. Correcting the processing factor for the weight change, based on the information on conversion factors (Table 5). For example, the conversion factor of raisins is 3.5 (Table 5), meaning that 350 g grape is needed to produce 100 g raisins, and the processing factor is 1.5. The corrected processing factor equals then 1.5/3.5 = 0.43.

Since processing information, by default, already includes weight changes if relevant, a valid approach could be to address the weight change by using processing factors. However, in practice processing information is scarce, due to the large number of chemical – RAC –processing type combinations possible and the fact that processing studies are only performed when it is expected that without processing information a health problem may occur. In those cases in which a weight change is very likely to occur (e.g. drying, cooking), but no processing information is available, you may still want to address a possible change in concentration due to the weight change in a dietary exposure assessment. It is therefore important to have information on weight changes and not to rely solely on the availability of processing factors to address this effect on chemical concentrations.

The result of the whole exercise will thus be the availability of national RAC conversion databases that contain national information on the ingredients present in those FoodEx codes used to code the national food consumption data within the Comprehensive database, as well as national conversion factors to convert ingredients to their e-RAC counterpart. These databases can thus be used to convert the national consumption estimates at FoodEx level to ingredient and e-RAC level for those countries participating in this project. The conversion database generated in this project can however also be used for the conversion of all food consumption databases coded at FoodEx level. For this adjustments of recipes may be needed.

References

Becker W, Pearson M (2002). Riksmaten 1997-98. Kostvanor och näringsintag i Sverige (Dietary habits and nutrient intake in Sweden). Report Uppsala, Livsmedelsverket (National Food Administration). Available online:

Boon PE, Ruprich J, Petersen A, Moussavian S, Debegnach F, van Klaveren JD (2009a). Harmonisation of food consumption data format for dietary exposure assessments of chemicals analysed in raw agricultural commodities. Food and Chemical Toxicology 47: 2883-2889.

Boon PE, Svensson K, Moussavian S, van der Voet H, Petersen A, Ruprich J, Debegnach F, de Boer WJ, van Donkersgoed G, Brera C, van Klaveren JD, Busk L (2009b). Probabilistic acute dietary exposure assessments to captan and tolylfluanid using several European food consumption and pesticide concentration databases. Food and Chemical Toxicology 47: 2890-2898.

Boon PE, Wapperom D, De Maeyer M, Drijvers J, Janssen-van der Vliet M, van Donkersgoed G (2011). Conversion of foods coded according to FoodEx into raw agricultural commodities (RACs). SCIENTIFIC REPORT submitted to EFSA. Report. Available online: To be published on www.efsa.europa.eu.

Codex-Alimentarius (1993). Codex Alimentarius Volume 2, Pesticide Residues in Food. Report Rome, Food and Agriculture Organisation of the United Nations and World Health Organisation. Available online: www.codexalimentarius.net/download/standards/41/CXA_004_1993e.pdf

Donders-Engelen MR, van der Heijden L, Hulshof KFAM (1997). Maten Gewichten en Codenummers 1997. Report Wageningen, Vakgroep Humane Voeding, Landbouwuniversiteit Wageningen en TNO Voeding Zeist.

EFSA (2009). Reasoned opinion of EFSA prepared by the Pesticides Unit (PRAPeR) on the 2007 Annual Report on Pesticide Residues. EFSA Scientific Report 305, 1-106. Report. Available online: www.efsa.europa.eu.

EFSA (2010). 2008 Annual Report on Pesticide Residues according to Article 32 of Regulation (EC) No. 396/2005. EFSA Journal 8(6):1646. [442 pp.]. Available online: www.efsa.europa.eu.

EFSA (2011a). 2009 EU Report on Pesticide Residues. EFSA Journal 9(11):2430. [226 pp.]. Available online: www.efsa.europa.eu.

EFSA (2011b). Evaluation of the FoodEx, the food classification system applied to the development of the EFSA Comprehensive European Food Consumption Database. EFSA Journal 9(3):1970. [27 pp.] doi:10.2903/j.efsa.2011.1970. Available online: www.efsa.europa.eu.

EFSA (2011c). Use of the EFSA Comprehensive European Food Consumption Database in Exposure Assessment. EFSA Journal 9(3):2097. [34 pp.] doi:10.2903/j.efsa.2011.2097. Available online: www.efsa.europa.eu.

Enghardt-Barbieri H, Pearson M, Becker W (2006). Riksmaten. 2003. Livsmedels - och näringsintag bland barn i Sverige (with a summary in English). . Report Uppsala, Livsmedelsverket (National Food Administration).

FAO-Statistics (2000). Technical conversion factors for agricultural commodities. Report Rome, Food and Agricultural Organization of the United Nations. Available online: www.fao.org/fileadmin/templates/ess/documents/methodology/tcf.pdf.

Henderson L, Gregory J, Swan G (2002). The National Diet and Nutrition Survey: adults aged 19 to 64 years. Volume 1: Types and quantities of foods consumed. Report London, TSO.

Leclercq C, Arcella D, Piccinelli R, Sette S, Le Donne C, Turrini A, Group obotI-S-S (2009). The Italian National Food Consumption Survey INRAN-SCAI 2005–06: main results in terms of food consumption. Public Health Nutrition 12(12): 2504-2532.

Müller AK, Bosgra S, Boon PE, Van der Voet H, Nielsen E, Ladefoged O (2009). Probabilistic cumulative risk assessment of anti-androgenic pesticides in food. Food and Chemical Toxicology 47: 2951-2962.

Muri SD, van der Voet H, Boon PE, van Klaveren JD, Brüschweiler BJ (2009). Comparison of human health risks resulting from exposure to fungicides and mycotoxins via food. Food and Chemical Toxicology 47: 2963-2974.

NEVO-Foundation (1996). Dutch Food Composition Table 1996. The Hague, NEVO Foundation.

NEVO-Foundation (2001). Dutch Food Composition Table 2001. The Hague, NEVO Foundation.

NEVO-Foundation (2006). Dutch Food Composition Table 2006. The Hague, NEVO Foundation.

Ocké MC, Hulshof KFAM, van Rossum CTM (2005). The Dutch national food consumption survey 2003. Methodological issues. Archives of Public Health 63: 227-241.

Ocké MC, van Rossum CTM, Fransen HP, Buurma EJM, de Boer EJ, Brants HAM, Niekerk EM, van der Laan JD, Drijvers JJMM, Ghameshlou Z (2008). Dutch National Food Consumption Survey - Young children 2005/2006. Report nr.:350070001/2008. Bilthoven, National Institute for Public Health and the Environment (RIVM). Available online: www.rivm.nl.

Ruprich J, Dofkova M, Rehurkova I, Slamnenikova E, Resova D (2006). Individual food consumption - the national study SISP04. Report Prague, CHFCH NIPH. Available online: http://www.chpr.szu.cz/spotrebapotravin.htm.

Ruprich J, Rehurkova I, Boon PE, Svensson K, Moussavian S, Van der Voet H, Bosgra S, van Klaveren JD, Busk L (2009). Probabilistic modelling of exposure doses and implications for health risk characterization: Glycoalkaloids from potatoes. Food and Chemical Toxicology 47: 2899-2905.

van der Velde-Koerts T, van Donkersgoed G, Koopman N, Ossendorp BC (2010). Revision of Dutch dietary risk assessment models for pesticide authorisation purposes. Report nr.:320005006/2010. Bilthoven, National Institute for Public Health and the Environment (RIVM). Available online: www.rivm.nl.

van Dooren MMH, Boeijen I, van Klaveren JD, van Donkersgoed G (1995). Conversie van consumeerbare voedingsmiddelen naar primaire agrarische produkten (Conversion of consumed foods into raw agricultural commodities). Report nr.:95.17. Wageningen, RIKILT-Instituut voor Voedselveiligheid, Wageningen UR. Available online: www.rikilt.wur.nl.

Appendix A. Processing types and codes used in the conversion

Processing factor	
Code	Type
1	Raw
2	Peeling
3	Cooking in water
5	Canned / conserved
6	Brewing
7	Drying
8	Frying / baking in fat
9	Juicing
10	Milling
11	Marmalade / jam
12	Oil extraction
13	Sauce / puree
16	Wine making[1]
17	Pickling
18	Flakes
19	Grilling
20	Braising
21	Cocoa powder
22	Coffee powder
23	Roasted
24	Roasted and ground
25	Juice concentrated
26	Parboiling
27	Frozen / deep-frozen
28	Dehydrated / powdered
29	Ketchup
99	Unknown

[1] Applicable to both red and white wine

Appendix B. Conversion factors to calculate e-RAC content of fruit and vegetable juices and concentrates.

Name product	FAO[1]	EPIC[2]	Conversion factor[3]
Juice, apple	0.65	0.85	1.31
Juice, apple concentrated	0.22	0.85	3.86
Juice, apricot	0.55	0.9	1.64
Juice, apricot concentrated	0.14	0.9	6.43
Juice, banana	0.35	0.65	1.86
Juice, blackberry	0.75	1	1.33
Juice, blackberry concentrated	0.18	1	5.56
Juice, black cherry	0.55	0.9	1.64
Juice, black currant	0.75	0.98	1.31
Juice, cherry	0.55	0.9	1.64
Juice, cherry concentrated	0.14	0.9	6.43
Juice, cranberry	0.75	0.98	1.31
Juice, currant	0.75	0.90	1.20
Juice, currant concentrated	0.18	0.90	5.00
Juice, elderberry	0.75	0.98	1.31
Juice, elderberry concentrated	0.18	0.98	5.44
Juice, grape	0.75	0.95	1.27
Juice, lemon	0.39	0.62	1.59
Juice, lemon concentrated	0.12	0.62	5.17
Juice, lime	0.39	0.7	1.79
Juice, mandarin	0.45	0.67	1.49
Juice, mango	0.1	0.68	6.80
Juice, orange	0.55	0.68	1.24
Juice, orange concentrated	0.125	0.68	5.44
Juice, papaya	0.5	0.5	1.00
Juice, passion fruit	0.31	0.52	1.68
Juice, passion fruit concentrated	0.08	0.52	6.50
Juice, peach	0.55	0.9	1.64
Juice, peach concentrated	0.14	0.9	6.43
Juice, pear	0.55	0.88	1.60
Juice, pear concentrated	0.14	0.88	6.29
Juice, pineapple	0.2	0.6	3.00
Juice, plum concentrated	0.14	0.8	5.71
Juice, raspberry	0.75	1	1.33
Juice, raspberry concentrated	0.18	1	5.56
Juice, strawberry	0.75	0.94	1.25
Juice, tomato	0.8	0.95	1.19
Ketchup, tomato	0.4	0.95	2.38
Puree, tomato	0.3	0.95	3.17
Wine red/white	0.7	0.8	1.14

[1] Conversion factor of RAC (including inedible parts) to juice or concentrate as published by FAO-Statistics (2000).

[2] Conversion factor of RAC to e-RAC

[3] Calculated based on the factors of FAO and EPIC as $(1/Fac_{FAO})*Fac_{EPIC}$.

Appendix C. Conversion factors of fats and oils into e-RAC

Oil / fat	Oil / fat content (%)	Conversion factor[2]	Oil distribution (%) within: Vegetable fats and oils	Oil distribution (%) within: Animal and vegetable fats and oils[3]
Almond	50	2		
Coconut	36	2.8	14.9	14.4
Cotton seed	20	5		
Grape seed	10	10		
Linseed	46	2.2		
Maize (corn)	5	20	0.1	0.1
Olive	50	2	0.3	0.3
Palm fruit	70	1.4	50.3	48.5
Palm kernels	50	2	4.2	4.0
Peanuts	50	2	0.2	0.2
Poppy seed	50	2		
Pumpkin seed	50	2		
Rape seed	42	2.4	17.2	16.6
Safflower	35	2.9	0.3	0.3
Sesame seed	50	2		
Soybean	20	5	1.3	1.3
Sunflower seed	40	2.5	11.2	10.8
Walnut	60	1.7		
Wheat germ[4]	2[4]	50		

[1] Information listed in this table was obtained from van der Velde-Koerts et al (2011).

[2] Was calculated based on the information about the oil / fat content per commodity as 100 divided by this content.

[3] Only the percentages of vegetable oils present are listed here.

[4] Fat content of wheat listed in Dutch food composition table (NEVO-Foundation, 2001).

Appendix D. Drying factors for dried fruits, vegetables and herbs

e-RAC	Moisture percentage fresh RAC[1]	Moisture percentage dry RAC[1]	Conversion factor
Apples	84	20	4.2
Pears	86	25	3.4
Apricots	87	25	3.5
Plums	84	37	2.3
Grapes – raisins	83	27	3.1
Grapes - currants	83	14	5.9
Figs	80	28	2.9
Dates[2]	61	20	3.1
Banana	-	-	3.0
Potato	77	8[3]	9.6
Sweet pepper	91	10[4]	9.1
Chilli pepper	91	8	11.4
Herbs and other vegetables	90[5]	10[5]	9.0

[1] Water content as listed in the Dutch food composition table 1996 (NEVO-Foundation, 2001).
[2] Water content as listed in Dutch food composition table 2001 (NEVO-Foundation, 2001).
[3] Water content of mashed potato powder.
[4] Water content of sweet pepper powder.
[5] Obtained from van der Velde-Koerts et al (2010).