Product Expansion for the *Superwijzer*

Report
Delft, February 2012

Author(s):
Marieke Head
Maartje Sevenster

Publication Data

Bibliographical data:
Marieke Head, Maartje Sevenster
Product Expansion for the *Superwijzer*
Delft, CE Delft, February 2012

Protein / Food / LCA / Impacts

Publication number: 12.2681.25

CE-publications are available from www.cedelft.eu

Commissioned by: Stichting Varkens in Nood
Further information on this study can be obtained from the contact person Marieke Head.

CE Delft
Committed to the Environment

CE Delft is an independent research and consultancy organisation specialised in developing structural and innovative solutions to environmental problems.
CE Delft's solutions are characterised in being politically feasible, technologically sound, economically prudent and socially equitable.

Contents

1 Introduction

1.1 Background

The *Vleeswijzer* (Meat Index) was launched at the end of 2009. Developed by the Varkens in Nood foundation, the *Vleeswijzer* offers consumers information about the environmental and animal welfare impacts of the most common meat and meat alternative products. In 2011 CE Delft collaborated on an update to the Vleeswijzer, known as the Superwijzer. CE Delft's contribution included determining the environmental effects of 98 meat, eggs, meat alternatives, dairy and dairy alternatives product types over the entire product life cycle up to the point of sale to the consumer. These impacts per kilogram of product (excluding packaging) are input to yet to be released *Superwijzer* smartphone App.

In order to cover a wide range of products available in the supermarket, Varkens in Nood has asked CE Delft to conduct a life cycle assessment study on 13 additional product variants.

1.2 This report

This report is to be treated as an addendum to 'Life Cycle Impacts of Protein-rich Foods for *Superwijzer*', a report detailing the life cycle assessments of the first 98 products studied. As such, this report will only include a very brief section on system definition and methodology. Instead, the focus will be on presenting the results of the new 13 product variations as well as a discussion of these results.

In addition, this study will assess how readily the new products can be extrapolated in order determine the environmental impacts of similar products.

2 System definition

2.1 Goal and scope

The end goal of this study is to add to the existing product data that will be used in the Superwijzer. Further details of the goal and scope of this study are found in the main report.

Also, the possibility of extrapolating new products from old products will be evaluated. For those products that can be extrapolated, instructions for conducting the calculations will be provided.

2.2 Product inventory

This product expansion includes 13 new product variants. These are listed in Table 1.

Table 1 Product types included in the study expansion

Product
Dairy products
Butter (82% milk fat)
Coffee creamer (8.5% milk fat)
Cooking cream (20% milk fat)
Quark (fresh cheese)
Vla (Dutch pudding)
Goat cheese, soft
Sugar and sweeteners
Beet sugar, conventional
Beet sugar, organic
Cane sugar, conventional
Cane sugar, organic
Glucose-fructose
Fruit and concentrates
Fruit (average)*
Fruit concentrates (average)*

* Average of apple, grape, orange and strawberry.

2.3 Product extrapolation

As described in the introduction, Varkens in Nood would like to extrapolate data from both the main study (CE, 2011a) and this study expansion to model similar products and product variants, independently from CE Delft. As part of this study expansion, CE Delft will indicate whether or not certain product extrapolations are possible. Varkens in Nood has provided a list of possible products for which they wish to extrapolate results (see Table 2).

Table 2 **Possible product for extrapolation**

Extrapolated Product
Other coffee creamers
Whipped Cream
Sour cream
Organic variants of dairy products
Soya yoghurt
Soya single cream
Biogarde
Vanilla or chocolate vla
Ready-made quark desserts
Dairy beverages (i.e. breakfast drinks)
Light dairy beverages (milk drinks and chocolate milk)
Fruit in products

2.4 Impact categories

As with the main study, the new products were also assessment using a customised version of ReCiPe (hierarchic endpoint) method. The impact categories have been clustered into four main categories:
- Nature and Environment (species.year);
- Human Health (DALY);
- Climate Change (kg CO_2-eq.);
- Land Use (m^2).

For more details about the methodology, please refer to the main report (CE, 2011a).

3 Data Sources

3.1 Dairy products

The additional dairy products were based upon the same basis as the dairy products analysed in the main study. Details regarding the following data can be found in CE (2011a):
- animal feed;
- land use;
- animal emissions;
- farm systems;
- slaughter and processing;
- transportation, distribution, storage and retail.

The new individual dairy products were modelled with the allocation of milk solids content of the raw milk, as described in CE (2011a). The milk solids content of the new products were obtained from Voedingswaardetabel (2011), by totalling fat, protein and carbohydrate mass percentages.

As for the specific processing required for each new product, IPCC (2006), COWI (2000) and IDF (2010) were used. Hybrid products such as vla (pudding) were modelled using a milk base and the addition of sugar, thickeners and flavouring agents. These additional ingredients were previously modelled in CE (2011a).

3.2 Sugar and sweeteners

Sugar was modelled using a combination of sources. The sugar crops (cane and beet) were previously modelled in CE (2011a). The sugar beet production was modelled using CE (2004), which details beet sugar processing in the Netherlands. In the case of cane sugar processing, Ecoinvent (2007) was used.

Glucose-fructose was modelled according to a study conducted by CE Delft (CE, 2004). The basis for this model was wheat, which was modelled for use in animal feed and as an ingredient in the main study.

3.3 Fruit and fruit concentrates

Fruit and fruit concentrates[1] were modelled as described in CE (2011b). Four types of fruit were calculated, including average fruit and concentrate. These were based upon the following fruits: apple, grape, orange and strawberry. In addition, an average fruit process and an average fruit juice process were modelled. The background data for the cultivation of fruit were purchased from ESU-Services, a Swiss-based consultancy that conducts life cycle assessments and has developed an extensive LCI database of various products and processes. Crops yields, as well as the inputs required for concentrate manufacturing and transportation of fruit were applied to the data as described in CE (2011b).

[1] Fruit concentrate is used as a base ingredient for producing juice from concentrate, but is also commonly used prepared foods such as desserts and sauces.

4 Environmental scores and analysis

4.1 Comparison of dairy products

In order to test its validity, the new data was benchmarked against the other dairy products modelled in the CE study (2011a) (see Table 3).

Table 3 Comparison of dairy products, all made with average Dutch raw milk, based on four environmental impact measures (species.yr, kg CO_2, DALY, m^2), percentages are relative to the highest scores in each category

Product	Nature and Environment		Climate Change		Human Health		Land Use	
	species.yr	% species.yr	kg CO_2	% kg CO_2	DALY	% DALY	m^2	$\%m^2$
Product Expansion								
Butter, average	2.81E-07	100%	8.54	100%	5.12E-06	100%	6.32	100%
Milk, coffee creamer, light	6.40E-08	23%	2.04	24%	1.19E-06	23%	1.44	23%
Milk, coffee creamer, full cream	8.90E-08	32%	2.83	33%	1.65E-06	32%	2.00	32%
Milk, cream, 20% fat	9.16E-08	33%	2.85	33%	1.72E-06	34%	2.06	33%
Quark, skim	5.70E-08	20%	2.60	30%	1.33E-06	26%	1.29	20%
Quark, semi-skim	6.53E-08	23%	2.98	35%	1.52E-06	30%	1.48	23%
Vla, vanilla	3.54E-08	13%	1.24	15%	7.68E-07	15%	0.87	14%
Goat cheese, soft	9.70E-08	34%	4.00	47%	2.67E-06	52%	3.33	53%
CE, 2011a								
Milk, buttermilk, average	3.00E-08	11%	1.04	12%	6.03E-07	12%	0.68	11%
Milk, semi skim, average	3.67E-08	13%	1.21	14%	7.17E-07	14%	0.83	13%
Mozzarella, cow	1.51E-07	54%	6.89	81%	3.51E-06	69%	3.41	54%
Yoghurt, full cream, average	4.02E-08	14%	1.80	21%	9.18E-07	18%	0.91	14%
Milk, raw, Dutch herd, average	4.33E-08	15%	1.24	14%	7.68E-07	15%	0.97	15%
Cheese, old, average	2.11E-07	75%	8.80	103%	4.67E-06	91%	4.76	75%
Cheese, young, average	1.94E-07	69%	7.57	89%	4.13E-06	81%	4.38	69%
Cheese, goat, young	1.85E-07	66%	7.27	85%	4.95E-06	97%	6.35	100%

As shown in Table 3, the butter has the highest environmental scores of the new products, while vla has the lowest impacts. The difference between these two products is approximately ten-fold, largely due to the amount of raw milk required for each kilogram of product. Butter requires 6.49 kg of raw milk per kg, while vla only requires 0.76 kg of raw milk. The difference lies in the total milk solids required to manufacture each product type. In addition, vla has other added ingredients, which reduces the amount of milk required per kg of product.

Also of note is the fact that products have the same relative scores across impact categories. The reason for this is due to the fact that production has by far the largest contribution to the environmental scores of the products.

Although processing techniques may have somewhat different energy requirements, the impacts pale in comparison to the production of milk itself.

In terms of how the product expansion results compare with the dairy products from the main study, butter has a similar environmental impact to that of old cheese. The reason for the fluctuation between the two products is that butter requires more raw milk than the cheese, however the cheese production is more energy intensive than the butter production.

The environmental impacts of the other products are primarily affected by their relative amounts of milk solids. The higher the proportion of milk solids relative to raw milk, the more raw milk is required to produce a given amount of product. As such, products having very different fat contents, such as the case of cooking cream (20% milk fat) and regular coffee creamer (8.5%), can have similar environmental impact scores. The same holds true for light coffee cream, as although the fat content is greatly reduced, the total milk solid content is not proportionally lower. This results in environmental impact scores which are higher than expected.

Further details regarding milk, buttermilk, yoghurt and cheese, as well as various milk production practices (grazing, organic, etc.) can be found in CE (2011a).

4.2 Comparison of sugar and sweetener types

The results of four types of sugar as well as results for Ecoinvent data are shown in Table 4.

Table 4 Comparison of sugar types, based on four environmental impact measures (species.yr, kg CO_2, DALY, m^2), percentages are relative to the highest scores in each category

Product	Nature and Environment		Climate Change		Human Health		Land Use	
	species.yr	% species.yr	kg CO_2	% kg CO_2	DALY	% DALY	m^2	$\%m^2$
Product Expansion								
Cane sugar, conventional	1.80E-08	24%	0.23	16%	6.30E-07	47%	0.96	24%
Cane sugar, organic	1.73E-08	23%	0.18	12%	7.25E-07	54%	0.96	24%
Sugar beet, conventional	1.82E-08	24%	0.75	52%	5.64E-07	42%	0.98	25%
Sugar beet, organic	1.69E-08	22%	0.69	47%	8.40E-07	62%	0.94	24%
Glucose-fructose	7.55E-08	100%	1.53	100%	1.37E-06	100%	3.95	100%
Ecoinvent								
Sugar, from sugarcane, at sugar refinery/BR U (Ecoinvent database)	1.86E-08	25%	0.20	13%	6.27E-07	46%	0.97	24%
Sugar, from sugar beet, at sugar refinery/CH U NL (Ecoinvent database)*	1.64E-08	22%	0.58	38%	2.1E-07	15%	0.89	22%

* Ecoinvent data supplemented with Dutch carbon footprint study data from Suiker Unie (2011).

As shown in Table 4, glucose-fructose has by far the highest environmental impact. The main difference relates to the cultivation of the base crop, wheat. Wheat has a much lower crop yield than sugar beet (about 4 ton/ha[2] vs. 64 ton/ha) and therefore more land and more fertilisers are required per ton of wheat than per ton of sugar beet.

The ranking of the sugars is different dependant upon the environmental impact category. In terms of the effects on biodiversity (nature and environment), the impacts of cane sugar and beet sugar are approximately the same. The difference is that organic variants have slightly lower scores than their conventional counterparts.

In terms of the carbon footprint of the sugar, cane sugar scores better than the beet sugar. This follows as the trend as the carbon footprints of the Ecoinvent data. In terms of human health impacts, the sugar beet data has a higher impact than the Ecoinvent data as a higher fertiliser use (as modelled in Blonk, 2008) results in a higher emissions of ammonia and nitrogen oxides. This is especially the case with organic sugar beets, as natural fertiliser (manure) releases a larger amount nitrogen compounds upon application.

In terms of land use, the difference between the organic and conventional and cane sugar and beet sugar are too small to be able to draw definitive conclusions.

4.3 Fruit and fruit concentrate

Table 5 Comparison of fruit and fruit concentrate types, based on four environmental impact measures (species.yr, kg CO_2, DALY, m^2), percentages are relative to the highest scores in each category

Product	Nature and Environment		Climate Change		Human Health		Land Use	
	species.yr	% species.yr	kg CO_2	% kg CO_2	DALY	% DALY	m^2	$\%m^2$
Fruit								
Fruit, average	1.21E-08	74%	0.274	74%	3.22E-07	71%	0.688	57%
Apple	1.26E-08	77%	0.302	82%	3.50E-07	78%	0.750	63%
Grape	1.64E-08	100%	0.369	100%	4.51E-07	100%	1.20	100%
Orange	5.46E-09	33%	0.139	38%	1.56E-07	35%	0.325	27%
Strawberry	1.39E-08	85%	0.287	78%	3.32E-07	74%	0.478	40%
Fruit concentrate								
Fruit, average	9.25E-08	66%	2.30	73%	2.62E-06	74%	4.88	83%
Apple	9.85E-08	71%	2.61	83%	2.87E-06	82%	5.86	100%
Grape	7.45E-08	53%	1.88	59%	2.20E-06	63%	5.46	93%
Orange	5.77E-08	41%	1.73	55%	1.96E-06	56%	3.42	58%
Strawberry	1.39E-07	100%	3.16	100%	3.52E-06	100%	4.79	82%

As shown in Table 6 the cultivation of grapes has the highest impact of all the fruit types for all environmental impact categories. The reason for this has to do with the fact that grapes have the lowest crop yield of the fruit types (8 ton/ha as opposed to 20-30 ton/ha yields). A low crop yield is associated with relatively higher energy, pesticide and fertiliser requirements per ton, than crops with higher crop yields. Conversely, the lowest environmental scores are for orange cultivation which have the highest crop yields.

[2] Calculated as a weighted average of the top 90% wheat producing countries.

The environmental scores for fruit concentrate are both a function of crop yields as well as the amount of fruit required to produce a ton of concentrate. In this case, strawberry has by the highest score for every environmental impact category. This has to do with a high fruit input requirement (10 ton) per ton of concentrate, in addition to a relatively low crop yield (21 ton/ha[3]).

4.4 Extrapolation of product results

In terms of product extrapolation, this is best done on case by case basis as many of the products are different from one another and require changes to be made to the database in order to derive robust results. Table 6 provides some of the products that Varkens in Nood wishes to extrapolate. Beside each product, the basis for the extrapolation as well as a brief description of what would need to be altered in the model is described. Finally, a conclusion of whether or not extrapolation would result in reliable environmental impact scores is given.

Table 6 Conclusions about the possibility of extrapolating other products from existing data

Extrapolated Product	Base	What Needs to be Altered	Conclusion
Other coffee creamers	Coffee creamer	The ratio of milk solids needs to be adjusted, depending on milk solids content of the creamer.	Extrapolations can be made without further literature review, however adjustments do need to be made from the base process. See Annex C.
Whipping cream	Cream	The ratio of milk solids needs to be adjusted, to take into consideration a higher fat content.	Extrapolations can be made, without further literature review, see Annex C. This process refers to the unprepared whipping cream. Prepared whipping cream would require taking into consideration the sugar as well as the pressurised packaging process. This is in not included in the extrapolation.
Sour cream	Cream	The ratio of milk solids needs to be adjusted, depending on the fat content of the sour cream.	Extrapolations can be made, without further literature review, see Annex C.
Organic variants of dairy products	Conventional versions and organic raw milk	The organic raw milk needs to substituted in for the conventional raw milk.	Extrapolations can be made, without further literature review, however adjustments do need to be made from the base process. See Annex C.

3 A weighed average yield was taken for the top 90% of EU strawberry cultivating countries. If a higher yield (Spain = 37 ton/ha) or lower yield (Poland = 4 ton/ha) were to be used, the results could change. This represents the average across Europe.

Extrapolated Product	Base	What Needs to be Altered	Conclusion
Soya yoghurt	Soya milk, cow's milk yoghurt processing	The ratio of solids needs to be adjusted, depending on the fat content of the soya yoghurt.	Extrapolations can be made, without further literature review, however adjustments do need to be made from the base process. See Annex C.
Soya single cream	Soya milk, cooking cream (20% milk fat)	The ratio of solids needs to be adjusted, depending on the fat content of the soya cream.	Extrapolations can be made, without further literature review, however adjustments do need to be made from the base process. See Annex C.
Biogarde	Yoghurt	The ratio of solids needs to be adjusted, depending on the fat content of the yoghurt.	Extrapolations can be made, without further literature review, however adjustments do need to be made from the base process. See Annex C.
Vanilla vla	Vla	The ratio of ingredients due to the change in flavour.	Vla (pudding). See Annex C.
Chocolate vla	Vla	The ratio of ingredients due to the change in flavour.	Vla (pudding). See Annex C.
Ready-made quark desserts	Quark	Other ingredients (sugar, fruit, etc.) need to be added.	Extrapolation can be made, but ensure that the quark in the dessert has the same amount of milk solids as the base process. Adjust the proportions of the ingredients depending on the product.
Dairy beverages (regular milk)		Other ingredients (sugar, fruit, etc.) need to be added.	Use the processes Milk/yoghurt/soya milk (CE, 2011a), ensure that proportion of ingredients are correct.
Light dairy beverages		Other ingredients (sugar, fruit, etc.) need to be added.	Use skim milk (from CE, 2011a) and add the correct proportions of ingredients.
Fruit in products		This would need to be provided by CE Delft as separate fruit results (the following fruit types are available: apple, orange, strawberry, grapes).	Add these processes to another prepared foods, in the correct proportions.

References

Blonk et al., 2008
H. Blonk, A. Kool and B. Luske
Milieueffecten van Nederlandse consumptie van eiwitrijke producten : Gevolgen van vervanging van dierlijke eiwitten anno 2008
Gouda : Blonk Milieuadvies, 2008

CE Delft, 2004
H.J. (Harry) Croezen, J.T.W. (Jan) Vroonhof
Bietsuiker en isoglucose vergeleken
Delft : CE Delft, 2004

CE Delft, 2011a
M.E. (Marieke) Head, M.N. (Maartje) Sevenster, H. (Harry) Croezen
Life Cycle Impacts of Protein- rich Foods for Superwijzer
Delft : CE Delft, 2011

CE Delft, 2011b
M.E. (Marieke) Head, B.T.J.M. (Bart) Krutwagen
LCA-studie siropen
Delft : CE Delft, 2011

COWI, 2000
COWI Consulting Engineers and Planners AS
Cleaner Production Assessment in Dairy Processing
Copenhagen: UNEP/Earthprint, 2000

Ecoinvent, 2007
Ecoinvent database, version 2.2
S.l. : Swiss Centre for Life Cycle Inventories, 2007

IDF, 2010
A common carbon footprint approach for dairy : the IDF guide to standard lifecycle assessment methodology for the dairy sector
In: Bulletin of the International Dairy Federation no.445, 2010

IPPC, 2006
Reference Document on Best Available Techniques in the Food, Drink and Milk Industries
Sevilla : European Commission, Joint Research Centre, Institute for Prospective Technological Studies, 2006

Suiker Unie, 2011
A. Backx
Carbon footprint van suiker en bijproducten. Memo.

Voedingswaardetabel (2011)
Voedingswaardetabel
http://www.voedingswaardetabel.nl

WUR, 2010
Kwantitatieve Informatie Veehouderij
Wageningen : Animal Sciences Group Wageningen UR (WUR), 2010

Annex A Environmental impact results per product

Table 7 Environmental impact results per kg product type

Product	Nature and Environment	Climate	Human Health	Land Use
	species.yr	kg CO_2	DALY	m^2
Dairy Products				
Butter, average	2.81E-07	8.54	5.12E-06	6.32
Milk, coffee creamer, light	6.40E-08	2.04	1.19E-06	1.44
Milk, coffee creamer, full cream	8.90E-08	2.83	1.65E-06	2.00
Milk, cream, 20% fat	9.16E-08	2.85	1.72E-06	2.06
Quark, skim	5.70E-08	2.60	1.33E-06	1.29
Quark, semi-skim	6.53E-08	2.98	1.52E-06	1.48
Vla, vanilla	3.55E-08	1.25	7.66E-07	0.87
Goat cheese, soft	9.70E-08	4.00	2.67E-06	3.33
Sugar				
Cane sugar, conventional	1.80E-08	0.23	6.30E-07	0.96
Cane sugar, organic	1.73E-08	0.18	7.25E-07	0.96
Sugar beet, conventional	1.82E-08	0.75	5.64E-07	0.98
Sugar beet, organic	1.69E-08	0.69	8.40E-07	0.94
Glucose-fructose	7.55E-08	1.45	1.35E-06	3.95
Fruit				
Fruit, average	1.21E-08	0.274	3.22E-07	0.688
Apple	1.26E-08	0.302	3.50E-07	0.750
Grape	1.64E-08	0.369	4.51E-07	1.20
Orange	5.46E-09	0.139	1.56E-07	0.325
Strawberry	1.39E-08	0.287	3.32E-07	0.478
Fruit concentrate				
Fruit, average	9.25E-08	2.30	2.62E-06	4.88
Apple	9.85E-08	2.61	2.87E-06	5.86
Grape	7.45E-08	1.88	2.20E-06	5.46
Orange	5.77E-08	1.73	1.96E-06	3.42
Strawberry	1.39E-07	3.16	3.52E-06	4.79

Annex B Detailed explanation of systems and outcomes

Table 8 Explanation of the outcomes and the systems for each product type

Product	Remarks
Dairy Products	Milk is produced with dairy cows, which emit greater amounts of greenhouse gases both from enteric fermentation and in manure. All milk is from Dutch production systems. Milk is assumed to come from a mix of systems: zero grazing (21%), unlimited grazing (38%) and day grazing (41%). In addition to grass and roughage, dairy cows are also fed concentrates, which contain several ingredients, including those that grow in tropical regions.
Butter (82% milk fat)	Butter is produced from cream that is separated from pasteurised milk. The process involves the following steps: – cream is chilled and churned; – liquid phase (buttermilk) is removed; – butter grains are washed; – salt can be added; – butter grains are agitated and folded to create butter.
Coffee creamer	Coffee creamer or koffiemelk, is condensed milk which is used in coffee. Milk is evaporated, homogenised and sterilised, without any other additives. Coffee creamer in the Netherlands is available as a UHT product in glass bottles, cartons and single use capsules.
Cooking cream (20% milk fat)	Cream is separated centrifugally from pasteurised milk. The cream is then sterilised and packaged in UHT cartons or plastic bottles.
Quark (fresh cheese)	Quark is a type of fresh cheese that is made by warming soured milk and then straining out the milk solids. The cheese is not aged, has no salt added and it has a similar fat content to yoghurt. In the Netherlands, quark is typically sold in plastic containers and is kept refrigerated.
Vla (Dutch pudding)	Vla is a pudding, primarily made of pasteurised milk, with the addition of whey, sugar, thickeners, flavouring and salt. It is typically sold in cartons in the refrigerator section of the supermarket.
Sugar	Sugar is used as a sweetener in various products. Sugar consumed in the Netherlands is either in the form of beet sugar or cane sugar.
Beet sugar, conventional	Beet sugar is produced from sugar beets, which are grown throughout Northern Europe. The sugar beets are processed, resulting in sugar, molasses and pulps. The conventional sugar beet is grown with the use of artificial fertilisers and pesticides.

Product	Remarks
Beet sugar, organic	Beet sugar is produced from sugar beets, which for Dutch sugar, are grown throughout Northern Europe. The sugar beets are processed, resulting in sugar, molasses and pulps. The organic sugar beet is grown without artificial fertilisers and pesticides.
Cane sugar, conventional	Cane sugar is produced from sugar cane, which is grown in tropical areas throughout the world. The three largest producers of sugar cane are Brazil, India and China. Conventional sugar cane is grown using artificial fertilisers and pesticides.
Cane sugar, organic	Cane sugar is produced from sugar cane, which is grown in tropical areas throughout the world. The three largest producers of sugar cane are Brazil, India and China. Organic sugar cane is grown using only natural fertilisers and no pesticides.
Glucose-fructose	Glucose-fructose can be made using various different crops, including corn and wheat. In this study the glucose-fructose is produced with wheat. The wheat is milled to make starch and then it is processed to produce glucose-fructose syrup.
Fruit and fruit concentrates	Fruit and fruit concentrates can be used to flavour various products, such as dairy products.
Fruit	An average fruit type has been modelled to take into consideration the various types of fruit that may be used to flavour prepared foods. Average fruit includes apple, grape, orange and strawberry. The fruits can be left whole but can also be pureed to be used in products such as sorbet.
Fruit concentrates	Fruit concentrates are produced by juicing or pressing the fruit. The juice is then further concentrated to certain sugar specifications (known as degrees of Brix) by evaporating a proportion of the water content. Fruit concentrates can be used in the juice or soft drink manufacturing industries but also by manufacturers of prepared products. An average fruit type has been modelled to take into consideration the various types of fruit that may be used to flavour prepared foods. As with the average fruit, the average concentrate includes apple, grape, orange and strawberry.

Annex C Instructions for extrapolation

C.1 Foreword

Results for base processes have been provided in order to be able to extrapolate the results of other variants within product groups. Since the data is being extrapolated, a degree of uncertainty may exist in the calculated results. Most importantly, the products being extrapolated need to fit within the product categories outlined in Section 4.4.

C.2 Base data for various dairy products

The base data is based upon a fictitious product within a product category, containing 100% milk solids. That is to say, the product contains no water and the mass percentages of fats, proteins and carbohydrates total 100%. Table 9 contains the data required for calculating the extrapolated products. The procedure for calculation is given in Section C.3.

Table 9 Base data for calculating the given extrapolated products

Process	Specific	Unit	Nature and Environment (species.yr)	Climate Change (kg CO_2)	Human Health (DALY)	Land Use (m^2)
Coffee creamer						
Milk production, transport, processing	Condensation	1 kg coffee cream with 100% milk solids	3.33E-07	10.5	6.14E-06	7.49
Post factory (distribution and storage)	UHT	1 kg coffee cream	1.52E-11	0.0158	1.19E-08	0.000311
Sour cream						
Milk production, transport, processing	Pasteurisation, incubation, heating	1 kg sour cream with 100% milk solids	3.34E-07	14.1	7.23E-06	7.55
Post factory (distribution and storage)	Refrigerated	1 kg sour cream	5.38E-11	0.114	5.06E-08	0.00211
Whipping cream*						
Milk production, transport, processing	Centrifuging	1 kg whipping cream with 100% milk solids	3.33E-07	9.96	6.06E-06	7.49
Post factory (distribution and storage)	Refrigerated	1 kg sour cream	5.38E-11	0.114	5.06E-08	0.00211

* Non-whipped cream which can be combined with sugar to make whipped cream.

Table 10 Dutch raw cow's milk variants. Used in Section C.4

Ingredient	Nature and Environment (species.yr)	Climate Change (kg CO_2)	Human Health (DALY)	Land Use (m^2)
Raw cow's milk, average	4.33E-08	1.24	7.68E-07	0.973
Raw cow's milk, organic	3.27E-08	1.52	1.00E-06	1.57
Raw cow's milk, pasture	4.22E-08	1.23	7.55E-07	0.966
Raw cow's milk, zero grazing	4.70E-08	1.27	8.16E-07	1.00

Table 11 Other raw milk variants. Used in Section C.4

Ingredient	Nature and Environment (species.yr)	Climate Change (kg CO_2)	Human Health (DALY)	Land Use (m^2)
Raw goat's milk, average	4.13E-08	1.17	9.51E-07	1.42
Raw goat's milk, organic	3.18E-08	1.51	1.73E-06	1.80
Raw buffalo's milk, average	3.04E-07	3.18	1.80E-06	3.56
Soymilk, certified soy	9.31E-09	0.607	2.09E-07	0.495
Soymilk, certified soy, organic	8.37E-09	0.722	2.70E-07	0.460
Soymilk, uncertified soy	1.54E-07	0.887	2.09E-07	0.495
Soymilk, uncertified soy, organic	9.35E-08	0.778	2.38E-07	0.588

Table 12 Subdivision of 1 kg vla, total and by ingredient. This table is to be used if changing the ingredient proportions

Ingredient	% in product	Expression of results	Nature and Environment (species.yr)	Climate Change (kg CO_2)	Human Health (DALY)	Land Use (m^2)
Vla (total)	**100%**	**Per kg vla**	**3.54E-08**	**1.24**	**7.68E-07**	**0.869**
Milk	80%	Per kg milk	3.84E-08	1.26	7.47E-07	0.864
Whey	6%	Per kg whey	4.09E-08	1.87	9.53E-07	0.925
Sugar	5%	Per kg sugar	1.82E-08	0.752	5.64E-07	0.985
Cornstarch	7%	Per kg cornstarch	1.97E-08	1.19	1.16E-06	1.04
Salt	2%	Per kg salt	2.62E-10	0.180	2.13E-07	0.0156

Data in Table 13 and Table 14 can be used in the extrapolations in Section C.4.

Table 13 Subdivision of coffee creamer. This table can be used if changing the milk out for other cow's milk variants and other types of milk, such as soy milk

Ingredient	Expression of results	Nature and Environment (species.yr)	Climate Change (kg CO_2)	Human Health (DALY)	Land Use (m^2)
Coffee creamer (total)	**Per kg coffee creamer**	**3.33E-07**	**10.1**	**6.11E-06**	**7.49**
Milk, raw, Dutch herd, average	Per kg coffee creamer	3.33E-07	9.51	5.91E-06	7.49
Processing	Per kg coffee creamer	1.49E-10	0.408	1.22E-07	0.00517
RMO transport	Per kg coffee creamer	3.12E-11	0.0358	2.70E-08	0.000539
Post factory (UHT)	Per kg coffee creamer	5.38E-11	0.114	5.06E-08	0.00211

Table 14 Subdivision of yoghurt. This table can be used if changing the milk out for other cow's milk variants and other types of milk, such as soy milk

Process	Specific	Unit	Nature and Environment (species.yr)	Climate Change (kg CO_2)	Human Health (DALY)	Land Use (m^2)
Yogurt (total)		**1 kg yoghurt with 100% milk solids**	**3.35E-07**	**14.2**	**7.28E-06**	**7.55**
Milk production	Average Dutch herd	1 kg yoghurt with 100% milk solids	3.33E-07	9.51	5.91E-06	7.49
RMO transport		1 kg yoghurt with 100% milk solids	3.12E-11	0.0358	2.70E-08	0.000539
Processing	Pasteurisation, incubation, heating	1 kg yoghurt with 100% milk solids	1.58E-09	4.52	1.30E-06	0.0641
Post factory (distribution and storage)	Refrigerated	1 kg yoghurt	5.38E-11	0.114	5.06E-08	0.00211

C.3 General Instructions for dairy product extrapolations

These instructions are relevant if making a small adjustment to the proportion of milk solids to an existing product. If changing out base ingredients or modifying other parameters, proceed to Section C.4

1. Determine which product group your chosen product belongs to.
2. Acquire the LCIA results[4] for that product group:
   a Find the product group in Table 9.
   b Take the LCIA data for the milk production, transport and processing.
3. Determine the % milk solids in your chosen product:
   a Look up the nutritional data for that product (www.voedingswaardetabel.nl is a good place to start).
   b For a 100 g portion of that product, add up the number of grams of fat, protein and carbohydrate.

4 In this case, this would be the climate, biodiversity, land use and human health scores.

c This total number of grams out of 100 g will be your percentage of milk solids.
4. Multiply the milk production, transport and processing LCIA results of each impact category with the percentage of milk solids in you chosen product.
5. Add the transport to the base processes.
   a Locate the post factory LCIA for your product.
   b Add the post factory LCIA to the results from step 4 for each of the impact categories.

Example: determine environmental impacts of light coffee creamer

1. *Light coffee creamer belongs to coffee creamer group*
2. *The LCIA of 1 kg of coffee cream for the milk production, transport and processing is:*

3.3E-07 species.year	*10.5 kg CO_2*	*6.14E-6 DALY*	*7.49 m^2*

3. *fat: 0.2 g, protein: 8 g, carbohydrate: 11 g = 19.2 g = 19.2%*
4. $19.2\% \times 3.33E^{-7} = 6.34E^{-8}$species.yr
   $19.2\% \times 10.5 = 2.02$ kg CO_2
   $19.2\% \times 6.14E^{-6} = 1.18E^{-6}$DALY
   $19.2\% \times 7.49 = 1.44$ m^2
5. $6.34E^{-8}$species.yr $+1.52E^{-11} = 6.39E^{-8}$species.yr
   2.02 kg CO_2+0.0158=2.04 kg CO_2
   $1.18E^{-6}$DALY $+1.19E^{-8} = 1.19E^{-6}$DALY
   1.44 m^2+0.000311=1.44 m^2

C.4 Instructions for more complex extrapolations

These instructions are to be used for extrapolations involving changing one of the base ingredients or modifying default processes, such as transportation distance. These extrapolations are complex since both the base data and the amounts need to be changed. In order to conduct these extrapolations, subdivided LCA data is required (see Table 12 to Table 14).

1. Determine the base ingredient required for the product.
   a If the product is cow milk based, proceed to step 2.
   b If the product is based on another type of type, proceed to step 3.
2. Using cow's milk:
   a Locate the LCIA results for the desired variant (organic, pasture fed, etc.) of cow's milk (see Table 10).
   b Determine the % milk solids in your chosen product.
      i. Look up the nutritional data for that product (www.voedingswaardetabel.nl is a good place to start).
      ii. For a 100 g portion of that product, add up the number of grams of fat, protein and carbohydrate.
      iii. This total number of grams out of 100 g will be your percentage of milk solids.
   c Calculate the fraction of milk required to produce 1 kg of a theoretical 100% milk solids product (this should be 1/milk solids content of raw milk or 1/0.13 = 7.69).
   d Multiply the LCIA results by the factor in step c.
   e Add the LCIA results of the milk production, RMO transport and processing.
   f Multiply this total by the % of milk solids (as determined in step b).
   g Add the LCIA results of the post factory process to the results of step e (see Table 9).

3. Using other milk types:
    a Locate the LCIA results for the desired variant (goat, buffalo, soy, etc.) of milk (see Table 10 and Table 11).
    b Determine the % milk solids *both* the base ingredient and your chosen product. For animal-based milks this will be the raw milk and the end product, for plant-based milks this will be the milk ingredient (i.e. soy milk) and the end product.
        i. Look up the nutritional data for that product. (www.voedingswaardetabel.nl is a good place to start).
        ii. For a 100g portion of that product, add up the number of grams of fat, protein and carbohydrate.
        iii. This total number of grams out of 100 g will be your percentage of milk solids.
    c Determine the fraction of milk solids in the product relative to the starting ingredient (i.e. % milk solids product/% milk solids ingredient).
    d Multiply the LCIA results for the new raw ingredient and the milk processing by the fraction calculated in step c.
    e The RMO transport in the base process is over a distance of 35 km. The distance may vary for other products, so the following steps should be taken to adjust the transport:
        i. First, multiply the LCIA results for RMO milk by the factor calculated in c.
        ii. Second, determine the distance from the production of the starting ingredient and the product. Divide the new distance by the old distance to obtain the distance factor. Multiply the LCIA results from step i. by this distance factor.
    f Add the total of step d. and of step e. to the LCIA of the post factory processes (from e.g. Table 9).

Example: determine environmental impacts of organic yoghurt.

1. *Proceed to step 2, organic yoghurt is made of cow's milk.*
2. *Using cow's milk.*
    a. *The LCIA of 1 kg of organic milk:*

W species.year	***X kg CO_2***	***Y DALY***	***Z m^2***

    b. *fat: 0.2 g, protein: 8 g, carbohydrate: 11 g = 19.2 g = 19.2%*
    c. *1/0.13 = 7.69*
    d. $7.69 \times W = 7.69 W species.yr$
    $7.69 \times X = 7.69X\ kg\ CO_2$
    $7.69 \times Y = 7.69 YDALY$
    $7.69 \times Z = 7.69Z\ m^2$
    e. *7.69Wspecies.yr+RMO transport+processing*
    7.69X kg CO_2+RMO transport+processing
    7.69YDALY+RMO transport+processing
    7.69Z m^2+RMO transport+processing
    f. *(19.2% ×total step e) species.yr*
    (19.2% ×total step e) kg CO_2
    (19.2% ×total step e) DALY
    (19.2% ×total step e) m^2
    g. *(total step f +post factory) species.yr*
    (total step f +post factory) kg CO_2
    (total step f +post factory) DALY
    (total step f +post factory) m^2