Questionmark

Environmental impact study of juice

For the sustainability database of Questionmark

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1 Contents

2 Introduction

2.1 Background

Questionmark rates thousands of consumer products based on their impact on health, environment, human rights and animal welfare throughout the production chain. In order to measure these impacts, Questionmark uses robust methods that adhere to widely accepted scientific theories and can be applied at product level.
To investigate the environmental impacts of products Questionmark uses the Life Cycle Assessment (LCA) methodology. LCA models the complex interaction between a product and the environment from cradle to grave. It is also known as life cycle analysis.

The main phases of an LCA are:

1. Goal & Scope definition, the product or service to be assessed is defined, a functional basis for comparison is chosen and the required level of detail is defined.
2. Inventory analysis of extractions and emissions. An inventory list of all the inputs and outputs of a product or service.
3. Impact assessment the effects of the resource use and emissions generated are grouped and quantified into a limited number of impact categories, which may then be weighted for importance.
4. Interpretation, the results are reported in the most informative way possible.

2.2 This study

This document describes the way in which LCA is applied to investigate the environmental impact of juice. The goal of this study is to produce a database of environmental impacts of these products, which will be used to compare the different products.

This report does not include the cultivation phase of the juice production as this is already described in the report of potatoes, vegetables and fruit

[reference]. The report refers to this reference for the methodology and data concerning the cultivation.

2.3 Product scoring

The scoring of products is done on two levels: product level and ingredient level.

Product level

Pictures are taken of a selection of products from different supermarkets, in this case of products related to potatoes, vegetables and fruit. The products are analysed on at least ingredients, country of origin, labels, packaging and type of storage in the supermarket (ambient temperature, cooling and freezer).

The environmental impact of the different packaging, freezer, cooling and ingredients is analysed using the life cycle assessment (LCA) methodology. The environmental impact of these elements is determined using a LCA. The ecopoints as calculated using the LCA impact assessment methodology ReCiPe are added together and scaled as described on the site of Questionmark: http://www.thequestionmark.org/methode/milieu

The products are compared based on the environmental impact of 1 kg of the edible part of the products.

The product scoring on a scale from 1-10 is done by giving the 1% best scoring products a 9.5 or higher. The 5% lowest scoring products get a score of 1.

Ingredients

The environmental impact of the ingredients is determined using the LCA methodology. The details of the LCA are described in the next chapters. The LCA of the packaging is described in a separate report.

2.4 Input of stakeholders

Questionmark invites stakeholders to provide feedback on each study performed to obtain useful critique on methodological choices and outcomes and thus to conduct studies in a robust and proficient manner. A panel of experts and stakeholders is consulted in the study about the cultivation of Potatoes, vegetables and fruit[1]. The stakeholders that have been consulted in that study are requested to provide feedback on this study again for their input. Stakeholders that are specific for he juice sector are requested to provide feedback as well.

3 Goal and scope definition

3.1 Goal

The goal of the study is to develop a life cycle assessment ingredient database of juices. This database will be used as input to compare the environmental aspects of different juices and juice related products.

3.2 Scope

The scope of this study comprises of the following fruit juices, processing type, labels and countries.

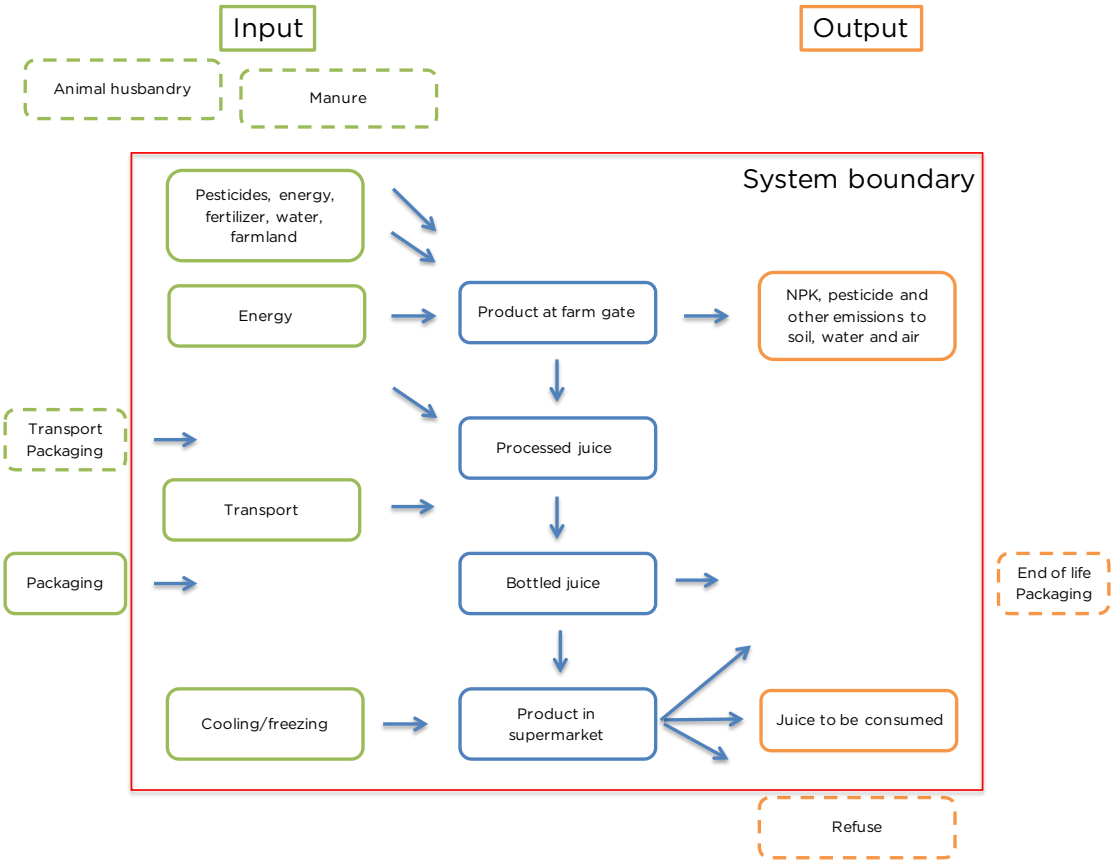
Fruit	Processing type	Label	Countries
Pineapple	Not from concentrate, from concentrate, concentrate	No label, organic	Thailand, Kenia, Indonesia, Costa Rica
Apple	Not from concentrate, from concentrate, concentrate	No label, organic	Netherlands, Poland, Germany, China, Turkey
Grape	Not from concentrate, from concentrate, concentrate	No label, organic	Italy, Spain, France
Orange	Not from concentrate, from concentrate, concentrate	No label, organic	Spain, Brazil

More fruit types will be added at a later stage. The same methodology as described in this report is used to obtain the environmental profile of these other fruit types. This report will not be updated, only the inventory data of these fruit juices will be added as Annex.

3.3 System boundaries

3.3.1 PRODUCT SYSTEM

The product system is shown in the figure below.



The packaging is put outside the product system. The reason is that this is separately analysed. See document [reference].

3.3.2 EXCLUSIONS

While efforts were made to include all relevant aspects of the life cycles of the various products, not everything could be included. The reason for this exclusion has to do with the relative low impacts of some aspects as well as the high degree of uncertainty in these data. The excluded aspects of the life cycles were as follows:

- Farm infrastructure:
- Equipment
- Storage rooms
- Employee commuting
- Office activities

Materials and waste at the production facilities:

- General materials used
- Transport packaging
- Wastewater
- Production waste
- Refuse from consumer

Transport packaging is not included in the scope of the project as it is not expected that the transport packaging has a high impact and would influence the results much.

The ingredients are modelled from cultivation to supermarket, including all production processes and transport phases. A graphic representation of the general life cycle of and the processes taken into account is shown in

3.3.3 FUNCTIONAL UNIT

The functional unit follows the definition of the functional unit as described in the general description of the environmental analysis[a]. This document describes the functional unit as follows: the consumption of 1 kg juice as consumed by the consumer.

3.3.4 MULTIFUNCTIONAL PROCESSES

In the gate-to-gate analysis (processing and transport to the Netherlands) of juices one multifunctional process has been identified: Juice production. The products of the juice production process depend on the fruit but often the following products are identified: juice, essential oils, pulp and scrap.

Economic allocation is used to divide the inventory between the different products. This is done because mass allocation does not reflect the drivers of the production well. Essential oils are only a fraction of the mass of the products but the price per kg is high: 13 €/kg for essential oil and 0.2 €/kg for juice[2]. Allocation is based on these product prices.

[a] Zie: http://www.thequestionmark.org/methode/milieu

4 Data inventory

4.1 Juice production

The energy use of juice from fruit is based on three reports: Beccali (2009)[2], Knudsen (2011)[3], a Sense (2013) project[4] and a mass balance as reported by FAO. See Annex 1 for an overview.

4.2 Country mixes

Products often don't mention the country of origin of the ingredients. The country of origin of the juices is based on reports of AIJN from 2012 or from CBS if not present in the AIJN reports. Se Annex 2 for more details.

4.3 Orange juice

Orange juice is mainly produced in Spain, Brazil and the United States. Orange juice is most often concentrated to about one sixth of the volume at the country of orange cultivation. The origin of both types of juice is different.

The mass balance of juice from fruit is based on three reports: Beccali (2009)[2], Knudsen (2011)[3], a Sense (2013)[4] project and a mass balance as reported by FAO.

The energy use of the juice production is described in Annex I.

4.4 Pineapple juice

Pineapple juice is mostly imported from Thailand and Costa Rica as concentrate. Juice is extracted from the pineapple and is often the co-product in the production of canned pineapple[5]. The non-fruit parts can be used as feed[6]. We do not have information concerning the prices of juice, canned pineapple and the remains. Therefore it is assumed that the price of

juice and canned pineapple is similar and much higher than the remains. This results in an allocation of 100% to juice and canned fruit. The edible part of a pineapple is about 64% according to FAO[7]. The energy use of the juice production and concentration processes is based on the data of frozen concentrated orange juice production.

4.5 Apple juice

Apple juice is both available as pure juice and juice from concentrate. The pure juice originates from mainly Germany and Poland. Also pure juice from the Netherlands is available in Dutch stores. Apple juice concentrate is mainly from China, Poland and Turkey.
The juice yield of apples used in this study, 73%, is based on an average of five sources, see table below. The energy use of the juice production and concentration processes is based on the data of frozen concentrated orange juice production.

4.6 Grape juice

Grape juice in Europe is produced mainly in Italy, Spain and France. The juice is often from vineyards for wine production and not intentionally produced for juice. The juice is assumed to be the only product of value and the whole inventory of grape and juice production is allocated to the juice. The amount of juice extracted from the grape, 82%, is based on a report of the FAO[8]. The energy use of the juice production and concentration processes is based on the data of frozen concentrated orange juice production.

4.7 Juice production

The yield of the juice production is based on different reports. The yield percentage is shown in the table below. The table shows the percentage juice that is obtained when fruit is processed.

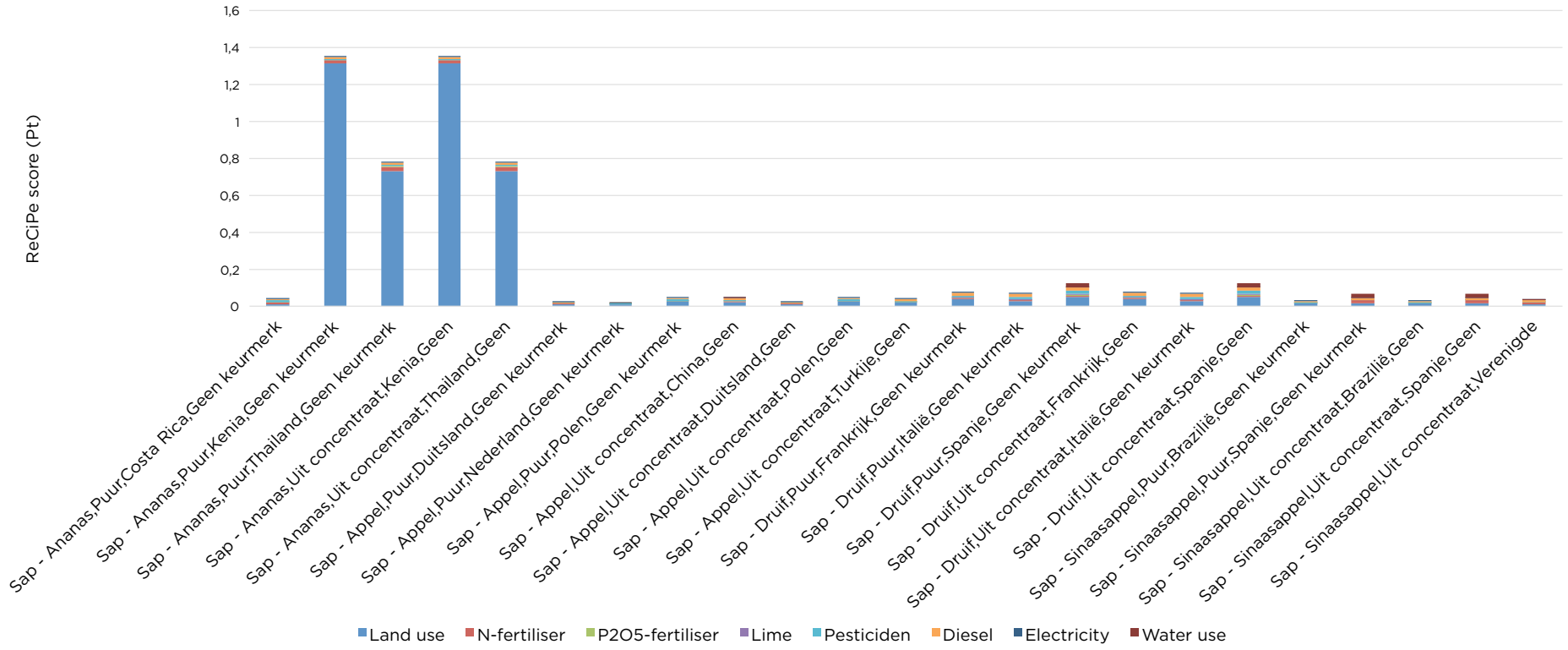
	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
Ananas	69	75	51				67							**65%**
Orang	69									45	71	45	31	**52%**

e														
Apple				65	69	78		80	73					**73%**
Grape									82					**82%**

1: Ndubisi (2013)
2: Nguyen (2012)
3: Farei (2008)[9]
4: Specialty enzymes[10]
5: VICENZI (2001)[11]
6: Shefali (2013)[12]
7: Pal (2011)[13]
8: Engel (2010)[14]
9: Bates (2001)[15]
10: Gonçalves (2013)[16]
11: Knudsen (2011)[17]
12: Jungbluth (2012)[18]
13: Beccali (2009)[19]

5 Results

The results are shown in the two figures below. The figures are the same but the pineapple cultivation in Kenia and Thailand is removed from the results as this allows to see the results of the juices with the lower ReCiPe scores in more detail.



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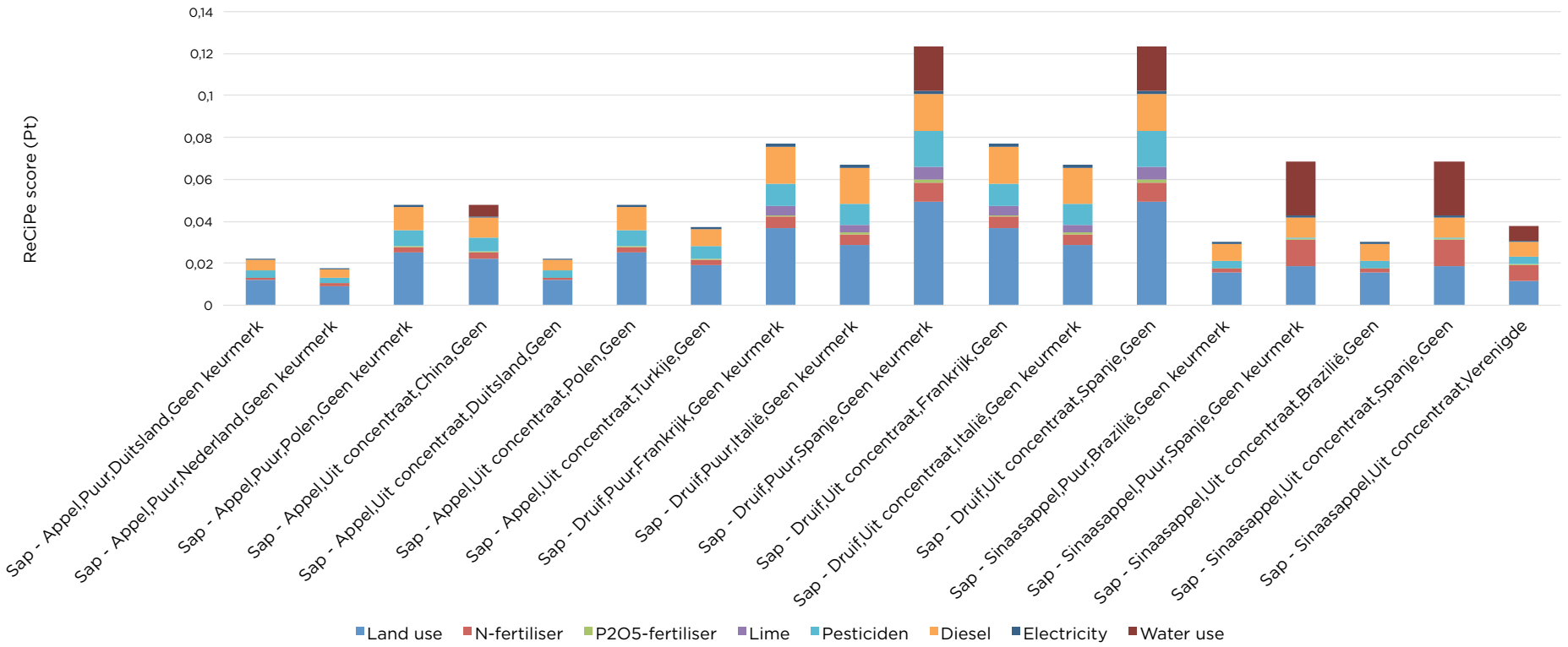

Pineapple juice

Much of the pineapple juice originates from pineapples grown in Thailand and Kenia. Both countries are linked with deforestation for their pineapple plantations. This has a huge impact on the total ReCiPe score. The blue part of the graph consists of the cultivation of the pineapple of which deforestation is the main impact.

Orange juice

Orange juice is often produced from frozen concentrate (FC) originating from Brazil. The concentration energy is besides the cultivation, a substantial part of the impact. More and more orange juice is however consumed from juice that has not been concentrated but directly bottled. Spain is an important production country for this not for concentrate (NFC) juice. The volume to be transported is about a factor six higher for NFC than FC. The transport from Spain is mostly done by truck which is more carbon intensive per kilometre transport. The additional transport this NFC has a similar ReCiPe score as the concentration energy of the FC. This results in similar ReCiPe score.

Grape juice

Grapes have a relative low yield, this results in a higher ReCiPe score for grape juice as a result of additional use of farming land compared to orange juice or apple juice. The yield in Italy is on average higher than in France, which results in a lower ReCiPe score for Italy than for France.

Concentrate

Fruit concentrates are also used in beverages. We assume that concentrate has a 6 times higher concentration than the original juice. Fruit juice has a Brix value around 10, whereas concentrate often has a Brix value of 60. This concentrate has a 6 times higher concentration.

Pulp and puree

Beverages sometimes contain pulp or purees. The environmental impact is assumed to be the same as juice. This is consistent with the economic

allocation as it is assumed that the price of pulp and purees is the same as for the juice.

Annex 1 - Data juice production

Extraction of 1 kg oranges (averages of 2 publications[2,4]):

0.14 MJ electricity

0,0076 MJ natural gas

Production of 1 kg FJOC (average of two publications[2,3]):

1,81 MJ electricity

0,73 MJ natural gas

0.26 kg steam

Packaging of 1 kg FCOJ[2]:

4.1 MJ electricity

0.0026 LDPE bags

Transport tot the Netherlands

FCOJ and NFC from Brazil is transported in dedicated bulk tanker across the ocean[20] (AIJN 2012). The ships go back empty. The round trip of this ship is therefore required to get one load of orange juice and concentrate in Europe.

Reconstitution and bottling

The energy use of reconstitution is based on a report of Beccali[2] and is assumed to be 0.056 MJ per kg reconstituted juice.

Annex 2 – country mixes

Orange juice

OFJC		NFC	
Brazil	94%	Brazil	70%
USA	6%	Spain	40%

OFJC: Orange juice frozen concentrate

NFC: Not from concentrate

The figures of OFJC are from the AIJN 2012[20] report and the NFC figures are from the AIJN 2014[21] report.

Apple juice

AJC		ANFC	
China	37%	Germany	66%
Poland	46%	Poland	34%
Turkije	17%		

AJC: Apple Juice concentrate

ANFC: Apple Juice not from concentrate

The figures from both the AJC and ANFC are from the AIJN 2012 report[20].

Grape juice

GJC	
France	48%
Spain	28%
Italy	25%

GJC: Grape juice concentrate

The figures from the GJC are from the CBS 2012 and 2013. This is based on the following CBS categories: 20096110, 20096190, 20096911, 20096919, 20096951, 20096959, 20096971, 20096979, 20096990.

Pineapple juice

PJC	
Thailand	46%
Costa Rica	54%

PJC: Pineapple juice concentrate

The figures from PJC are from the AIJN 2012 report[20].

Annex 2 – Other fruit juices

Assumptions fertilizer use

Passionfruit

A book of Paull[22] provides the following fertilizer use with a yield of 1000 kg/ha: fruit fertilizer 10:5:20 formulation at 50% efficiency: 66 kg/1000kg. This is equivalent with 6,6 kg N/1000 kg fruit; 3,3 kg P/1000 kg fruit.

Blueberry

A report of Hayden[23] provides an amount of nitrogen per acre of 60-80 pounds. This is equivalent with 67-90 kg/ha. The average between these two figures is used as the nitrogen input for blueberry in this study.
60-80 pounds of actual nitrogen per acre.

Coconut

The amount of fertilizer use for the growth of coconut is based on a report of Marinussen (2012)[24].

Mango

The fertilizer use of Mango production is based on recommendations of a fertilizer producer[25]. The growth of mango is associated with deforestation according to the Direct Land Use Change Assessment Tool[26].

Other

If no specific fertilizer use is available for a type of fruit, then the fertilizer use is assumed to be the same as a similar type of fruit.
Fertiliser use of citrus fruit (lemon, grapefruit, mandarin) is assumed to be the same as the fertilizer use of oranges. The fertilizer use of the orange cultivation of the country of origin of the specific citrus fruit is used If data is available. The fertilizer use of the orange cultivation in Spain is used if this data is not available.

Fertilizer use of cranberry cultivation is assumed to be the same as blueberry cultivation.
Fertilizer use of passion fruit is assumed to be the same as another type of tropical fruit: pineapple.
Fertilizer use of plum cultivation is assumed to be similar with fertilizer use of cherries as it is a stone fruit as well. An exception is plum cultivation in South Africa, which is assumed to be the same as apple cultivation in South Africa.

Assumptions pesticide use

Pesticide use of all berries (blueberry, blackberry, raspberry, cranberry) is assumed to be the same as pesticide use in strawberry cultivation.
The pesticide use of all citrus (lemon, grapefruit, mandarin) is assumed to be the same as the pesticide use of orange cultivation.
The pesticide use of the cultivation of cherry and plum is assumed to the same as the pesticide use of apple cultivation.
The pesticide use of the tropical fruit (coconut, mango and passion fruit) is assumed to be the same as the pesticide use of pineapple cultivation.

Assumptions energy use

The assumptions of energy use are based on the growth characteristics, the energy use of fruit where no information is available from is based on types of fruit which have a similar way of growing.
The energy use of all citrus (lemon, grapefruit, mandarin) is assumed to be the energy use of orange cultivation.
The energy use of berries (blueberry, blackberry, raspberry, cranberry) is assumed to be the same as the energy use of strawberry cultivation.
The energy use of the cultivation of cherry and plum is assumed to the same as the energy use of apple cultivation.

Assumptions juice production

The below provides an overview of the juice yield of different reports. The average is used for this study.

	1	2	3	4	5	6	7	8	9	Gemiddeld
Strawberry	49%									49%
Banana										71%
Blueberry										54%
Lemon						42,3 %				42,3%
Mango									52.5 %	52,5%
Passion fruit	39%		32.5 %							36%
Pear										73%
Peach		49%								49%
Coconut							85%			35%
Cranberry		75%								75%
Kiwi				85%						85%
Mandarin					52%					52%
Raspberry	64%									64%
Cherry										69%
Grapefruit								75%		75%
Plum	69%									69%
Zwarte berry	54%									54%

1: http://www.brsquared.org/wine/CalcInfo/FruitDat.htm
2: http://www.fao.org/docrep/005/y2515e/y2515e15.htm
3: Practial action.org - Technical brief, passion fruit juice small-scale manufacture
4: Hai-ning Zhang (2011)[27]
5: FAHAD Y. AL-JUHAIMI AND KASHIF GHAFOOR (2013)[28]
6: F.T. Lynch (2008)[29]
7: Tamil Nadu Agricultural University[30]
8: University of Arizona[31]
9: Juan Buenrostro-Figueroa (2010)[32]

Coconut

A coconut contains about 10% coconut water. The major part of the coconut is has a low economic value and is often discarded. A coconut consists of 50% husk, 15% shell, 25% coconut meat and 10% coconut water. The yield figures apply to husked coconuts. This means that 85% of the yield of cocnuts is edible. The environmental burden of coconut cultivation is allocated to the edible parts based on mass.

Mango

An article of Figueroa reports a by-product percentage of 35-60% of the total fruit weight. The average of these values is 47.5%. We assume that 52.5% of the mango is edible. The environmental burden of the cultivation of mango's is allocated to this part of the fruit.

Banana

The juice yield of bananas is assumed to be the same as the percentage banana pulp in a whole banana. This percentage is set at 71%, based on the potatoes, fruit and vegetable study performed by Questionmark.

Cherry
No data was found concerning the juice yield of cherries. The juice yield of plums is therefore used as approximation.

Pear
No data was found concerning the juice yield of pears. The juice yield of apples is therefore used as approximation.

Blueberry
No data was found concerning the juice yield of blueberries. The juice yield of black berries is therefore used as approximation.

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