Greenhouse-Gas Emissions from the Production and Processing of Food

- Working paper –

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1 Introduction and Key Issues

Public and political discussion on global climate change, which has been intensified by publication of the World Climate Report (IPCC 2007), has raised the issue of agriculture[1], and especially the **climate footprint of food**, in addition to the 'classic' issues of energy supply[2] and mobility[3].

Within the scope of the joint project **Food Change**[4] supported by the German Federal Ministry of Education and Research, Öko-Institut carried out a so-called material flow analysis, in the course of which the climate footprints for the cultivation, processing and transport of food were determined.

To reflect the whole spectrum of the food discussion – from the cultivation of food and animal feed along with their environmental and social consequences, through dietary habits to questions of logistics and food preparation – would exceed the scope of this article.

Its focus thus lies on a quantitative analysis of the **greenhouse gas emissions of selected food** and a comparison of the supply of these products from **conventional and organic** farming. In addition, issues which concern the role played by the freight transport of food are discussed.

For broad food-based issues, the results of the Food Change project (Eberle et al. 2006) can be referred to as well as discussion papers and reference materials connected to the Food Change project, which are available on the project website.

The data used in this working paper are based on studies by Öko-Institut, which was supported by a number of institutions, including the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry for Education and Research as well as the Federal Environment Agency.

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Note: The data used in this working paper were updated in July 2009.

[1] For the role of agriculture in climate change, see FAO (2006).

[2] See Fritsche, Uwe R. et al. 2007: Greenhouse-gas emissions and mitigation costs of nuclear, fossil and renewable electricity generation, a working paper by Öko-Institut, Darmstadt (www.oeko.de).

[3] See www.renewbility.de.

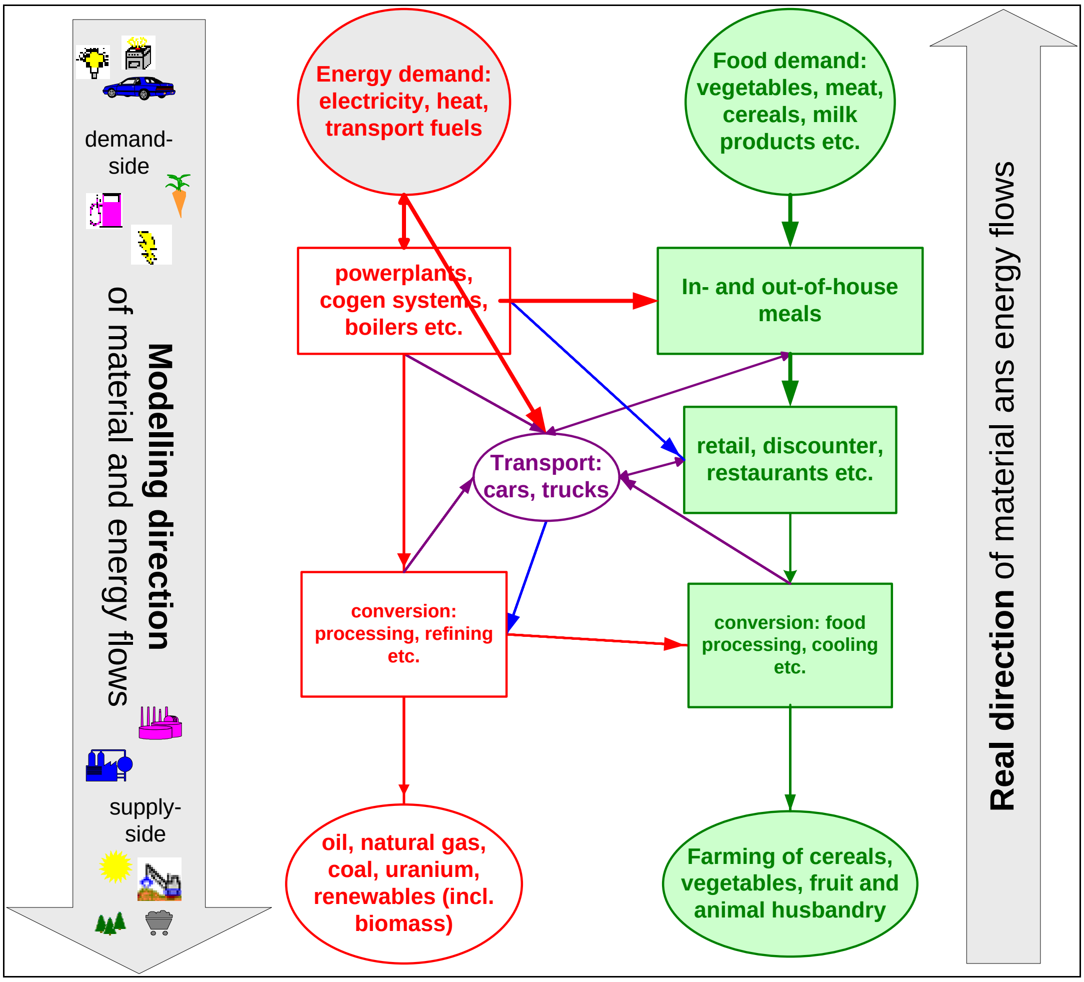
[4] See Eberle et al. (2006); Wiegmann et al. (2005a); www.ernaehrungswende.de.

2 Life Cycle Analysis: From the Field to the Plate

To examine the role played by food in climate change, the method of *material flow analysis* is used in the following[5]. In purely physical terms, materials flow from the extraction of resources (e.g. cultivation of food) through further processing, to the products acquired, used and finally disposed of by consumers.

In comparison, the analytical focus of a material flow analysis goes in the opposite direction: it begins with the demand and follows the material flow back to the extraction of resources. In the case of food, it proceeds from food consumption and tracks all associated uses of energy, materials and transport through the different stages of transformation back to the production of primary energy or extraction of raw materials (see figure below).

Figure 1 Principle of the material flow analysis for food



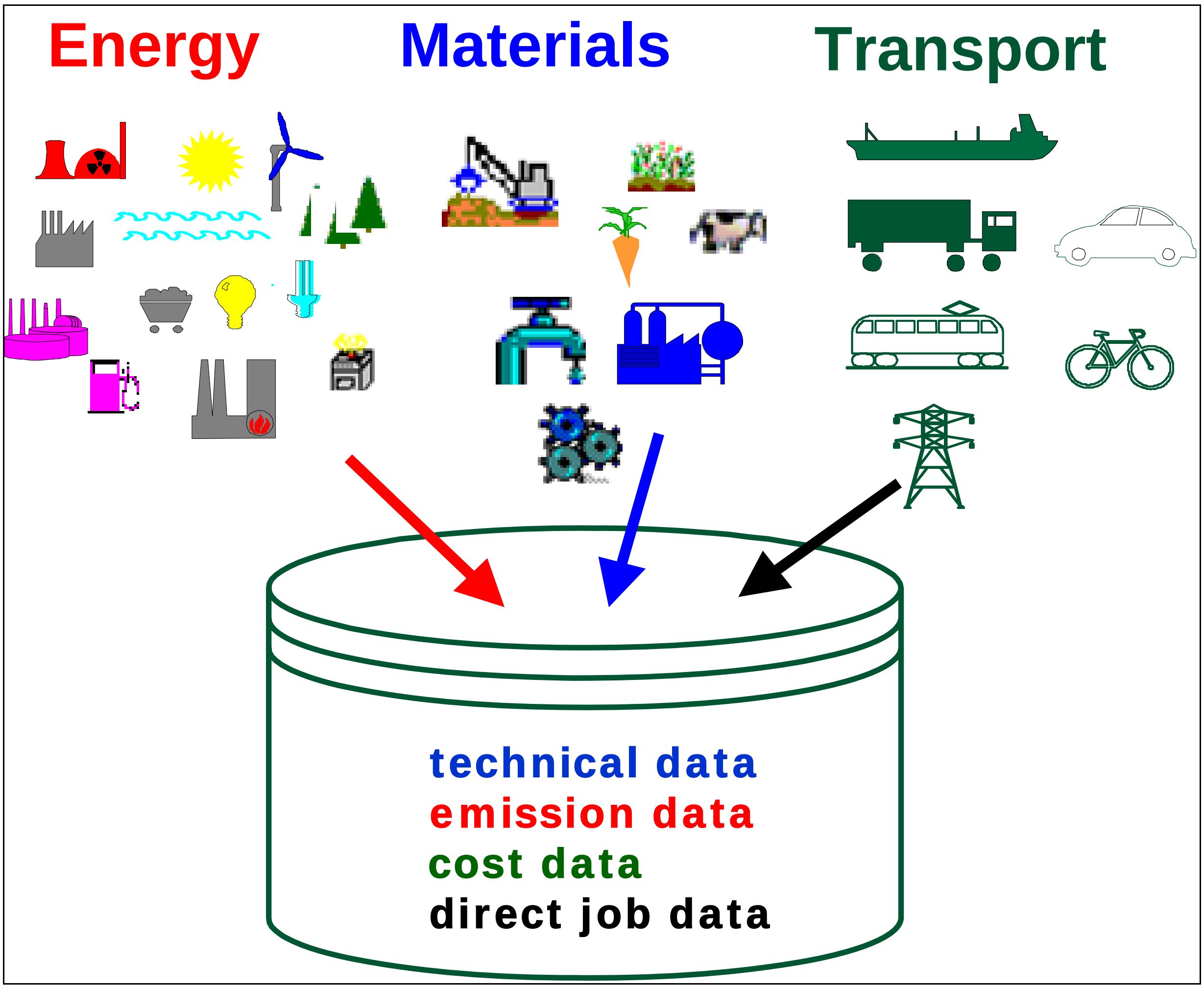
Source: Öko-Institut e.V.

5 For a closer analysis of this method in the context of the 'food' demand category, see Wiegmann et al. (2005a).

With the help of the material flow analysis, the material flows and environmental burdens which arise from the **demand** for products and services can be determined. To this end, all essential manufacture and distribution activities up to the source (extraction of resources) are quantitatively re-traced. In the process, effects from abroad (imports) and regional characteristics can also be taken into account.

Information relevant to material flow and the environment such as cost and employment data are integrated in the GEMIS computer model. This software, which was developed by Öko Institut and is publicly accessible, contains information on numerous process chains, including those for food as well as those for the energy industry and transport.

Figure 2 GEMIS as database for the material flow analysis



Source: Öko-Institut e.V.

With this database and an integrated tool, GEMIS can carry out life cycle analyses quickly and transparently, and can, in this way, provide an integrated footprint of environmental effects (see OEKO 2009).

3 Life Cycle Analysis: Results for Food

Overall, the demand category of food leads annually to around 4.4 tonnes of greenhouse-gas (GHG) emissions per average household, corresponding to 16 percent of the GHG emissions arising from total private consumption. It is thereby of the same magnitude as the 'mobility' demand category. The production of food (including freight transport) constitues a share of 45 percent of this total; the rest is due to energy consumption for the storage and preparation of food as well as partial space heating (kitchen) and shopping trips (see Wiegmann et al. 2005a).

In the Food Change project, an analysis of the life-cycles of selected food was undertaken, concerning the **conditions in Germany** at the beginning of the 21st century (Wiegmann et al. 2005a). The volume of food bought commercially and consumed by the average German household per person per year formed the basis of the calculations (see the following table)[6].

Table 1 Specific consumption of food in Germany in 2000

Consumption of	**kg/capita/year**	**Share**
Meat incl. sausage meats	48.4	9.9%
Potatoes incl. potato products	42.8	8.8%
Vegetables	101.2	20.7%
Fruit	73	15.0%
Oils, fats, margarine	11	2.3%
Sugar	6.1	1.2%
Cereals (flour and cereal products)	7.2	1.5%
Bread and baked products	54.6	11.2%
Pasta products	5.5	1.1%
Milk products	130.5	26.7%
Eggs	7.8	1.6%
Total	**488.1**	

Source: Wiegmann et al. (2005a); data for food consumption inside and outside of the home

In the year 2000, the food consumption in Germany was made up in total of approx. 27% milk products, 21% vegetables, 15% fruit, 11% bread and pastries as well as 10% meat and almost 9% potatoes.

6 The following food was not included in the analysis: citrus fruits (33 kg/cap), bananas (10 kg/cap) and remaining southern fruits (8 kg/cap). Data on cultivation and processing for the food are currently not sufficient in order to calculate sound carbon footprints. Moreover, drinks are also not incorporated.

In part, the role played by individual food in GHG emissions within the above-mentioned group differs. The following table shows the carbon footprint results[7] with regard to the supply of selected food.

Table 2 Climate footprints of food from conventional and organic agriculture bought in a retail shop

	CO_2 equivalents in kg/kg product according to cultivation method	
Food	**conventional**	**organic**
poultry	3.46	3.01
poultry DF	4.46	4.02
beef	13.28	11.36
beef DF	14.28	12.36
pork	3.21	2.99
pork DF	4.21	4.00
vegetables fresh	0.15	0.12
vegetables canned	0.50	0.47
vegetables DF	0.40	0.37
potatoes fresh	0.19	0.13
potatoes dried	3.72	3.29
pommes frites DF	5.62	5.46
tomatoes fresh	0.33	0.22
bread rolls, white bread	0.65	0.54
bread - mixed wheat and rye	0.73	0.61
noodles	0.90	0.75
butter	23.74	22.07
yoghurt	1.22	1.15
cheese	8.48	7.92
milk	0.93	0.88
eggs	1.91	1.53

Source: GEMIS 4.5 (OEKO 2009); for specifications of the process chains: Wiegmann et al. (2005a); DF = deep-frozen

The processing, cooling and transport of food were included in these carbon footprints as far as they represent relevant process steps.

Furthermore, the origin of the food was differentiated according to conventional and organic agriculture.

In the following, the differences in the climate footprints of different groups of food are shown, including the differences between food from organic and those from conventional agriculture.

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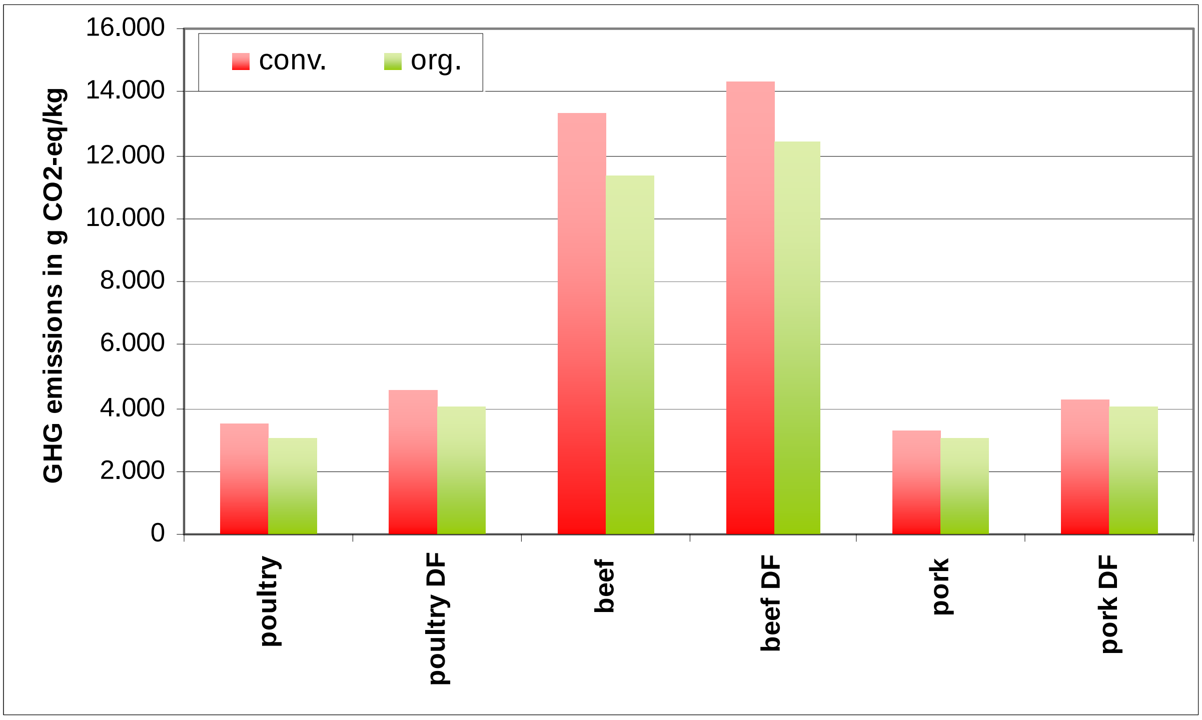
[7] In order to take into account other GHG emissions (predominantly CH_4 and N_2O) beyond CO_2, the overall impact of all GHG is given as *CO_2 equivalents.* The individual GHG are converted into the equivalent CO_2 mass using their relative, weight-based global warming potential (CO_2 = 1), taking into account the varying atmospheric residence times involved. The data refer to a time horizon of 100 years, according to IPCC (2007).

3.1 Comparison of different types of meat

The comparison of poultry, pork and beef clearly shows that value chain of beef is associated with significantly higher levels of greenhouse- gas emissions than those of poultry and pork, which are very similar. This is above all a result of methane release in cattle husbandry and the provision of animal feed. The value chain for deep frozen meat induces higher greenhouse-gas emissions for all types of meat. However, meat from organic agriculture performs consistently better. The savings are between 5% (pork) and 15% (beef) compared to the conventional value chain.

Figure 3 GGH emissions for different types of meat (from agriculture to retail)

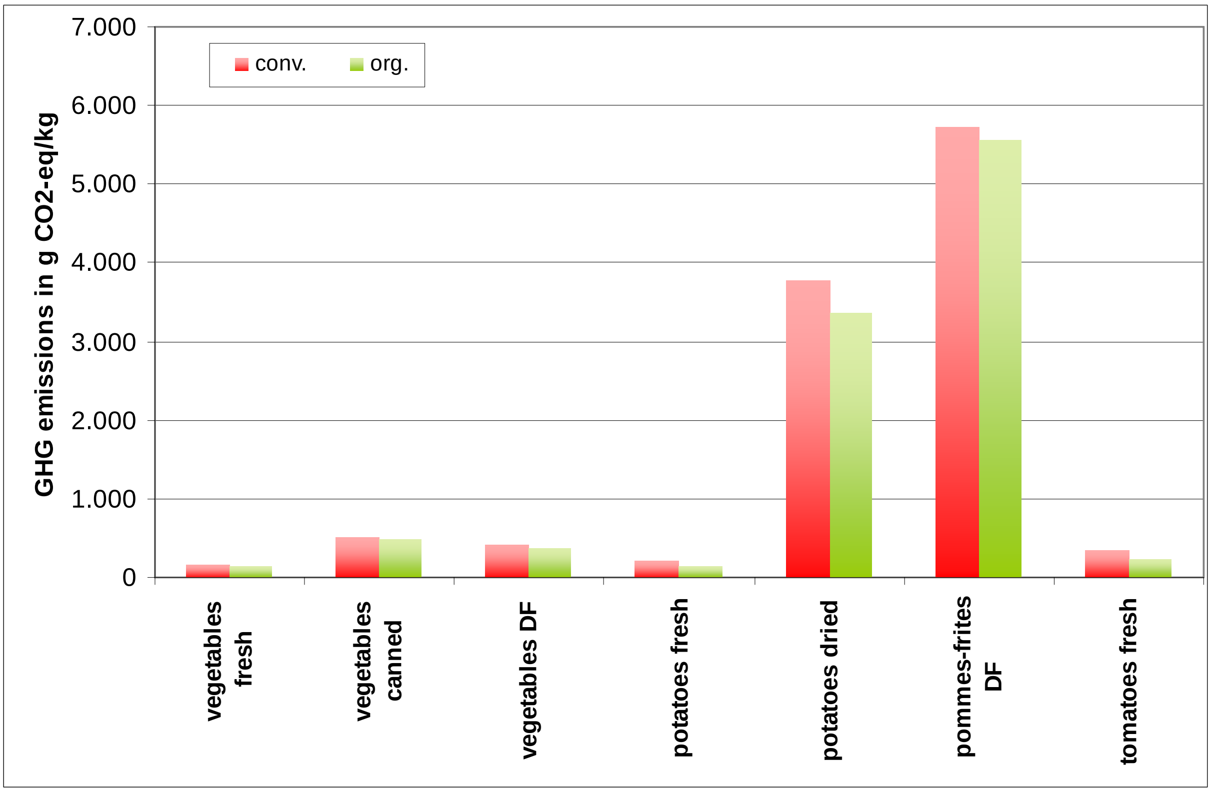


Source: GEMIS 4.5 (OEKO 2009); for specifications of the process chains: Wiegmann et al. (2005a); DF = deep-frozen

3.2 Comparison of different vegetable types

In comparison with meat, the manufacture and processing of vegetables has a significantly lower impact on the climate, as shown in the following figure.

Figure 4 GHG emissions for different types of vegetables (agriculture to retail)



Source: GEMIS 4.5 (OEKO 2009); for specifications of the process chains: Wiegmann et al. (2005a); DF = deep-frozen

Fresh vegetables and potatoes cause approx. 10 % of the emissions caused by meat; in comparison, canned or deep-frozen vegetables induce only slightly more emissions than the fresh products.

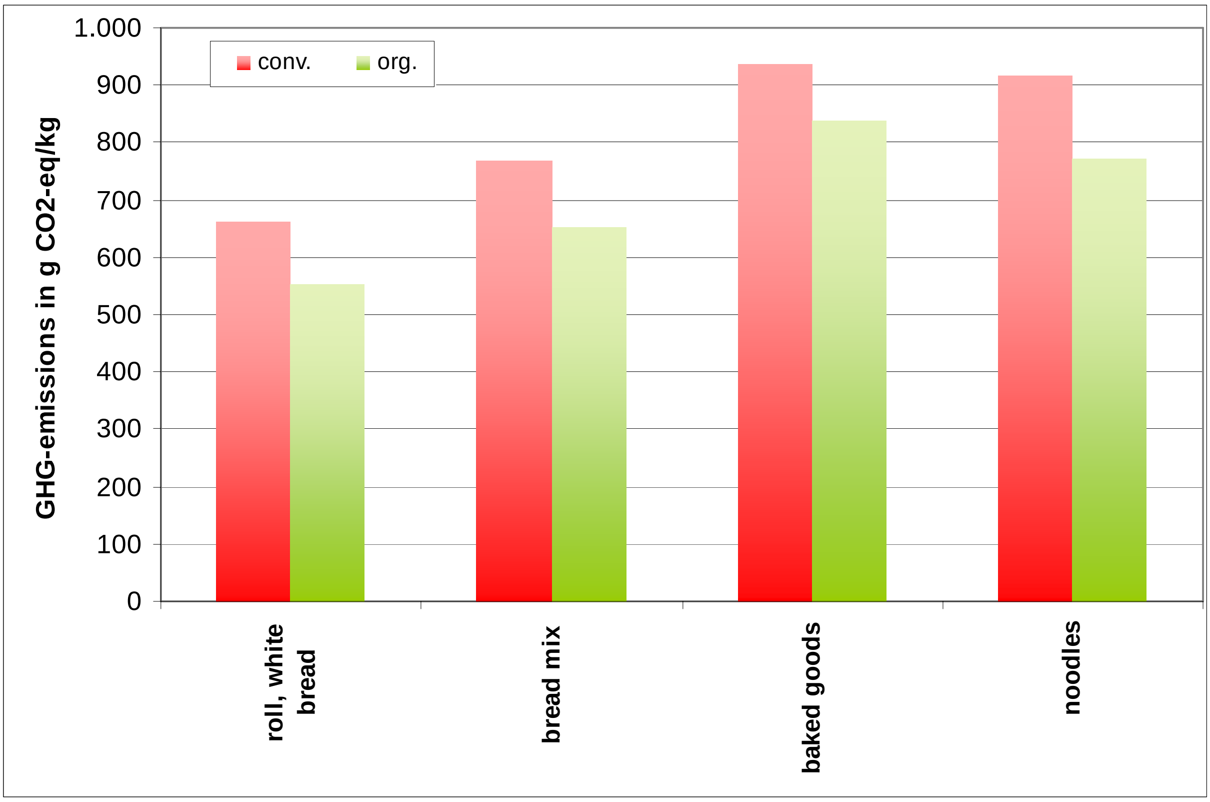
In contrast, dried potato products (e.g. for puree or dumplings) cause per kg about as high a release of greenhouse-gases as for poultry or pork; deep-frozen pommes frites bring about even higher emissions – this is the case even *without* taking into account the actual preparation of the frites in the oven or the deep fryer.

As is the case with meat, vegetable products from organic agriculture cause between 5% (frozen chips, canned vegetables) and 30% (fresh potatoes and tomatoes) fewer greenhouse-gas emissions than those from conventional farming.

3.3 Comparison of different baked and pasta products

The following figure illustrates the carbon footprint of baked and pasta products.

Figure 5 GHG emissions for baked products and noodles (agriculture to retail)



Source: GEMIS 4.5 (OEKO 2009); for specifications of the process chains: Wiegmann et al. (2005a)

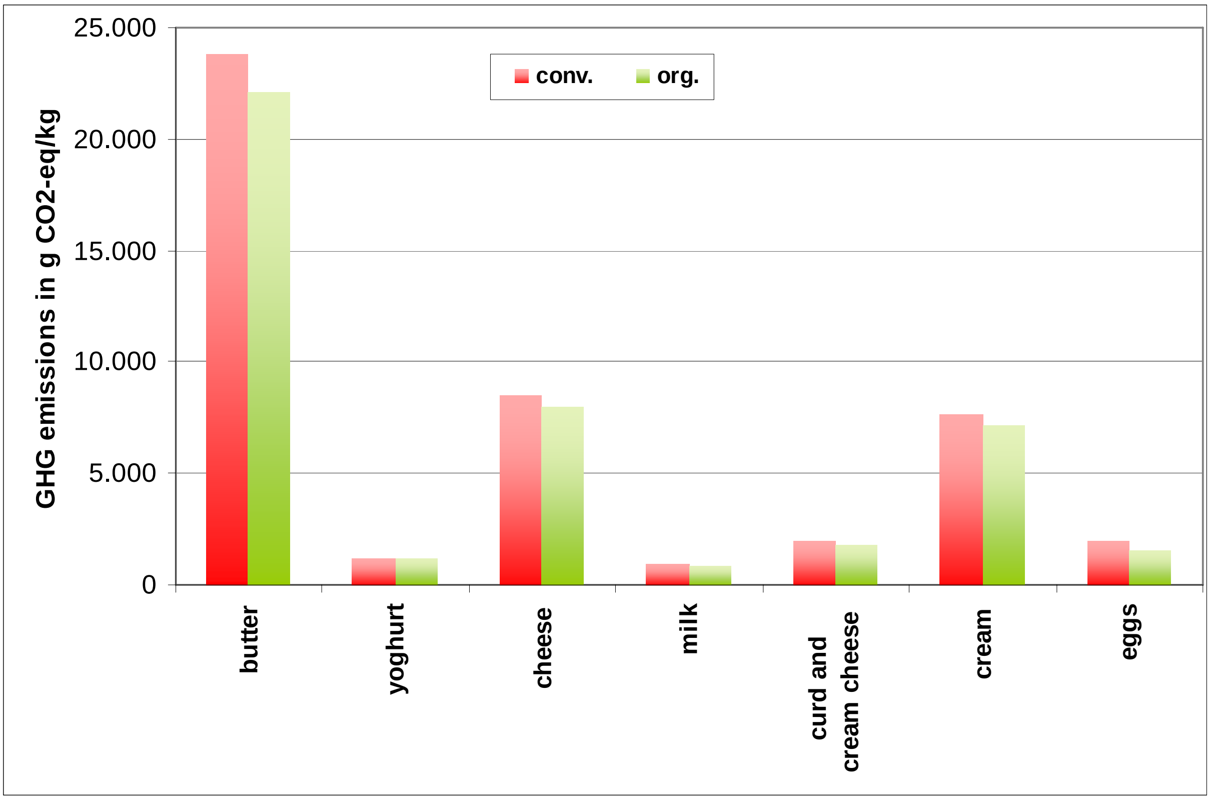
The manufacture of baked and pasta products involves higher emissions of greenhouse gases than that of vegetables. However, these levels are far below those for meat.

As previously, GHG emissions from organically products are 10-15% lower than those from conventional agriculture.

3.4 Comparison of different milk products and eggs

The greatest share of greenhouse gas emissions from food bought commercially is brought about by milk products, followed by meat and meat products. But even here there are large differences between the individual products (see figure 6): butter causes the highest levels of greenhouse gas emissions amongst the individual products, followed by cheese and cream. In this context, organic foods perform slightly better than those produced conventionally.

Figure 6 GHG emissions for milk products and eggs (agriculture to retail)



Source: GEMIS 4.5 (OEKO 2009); for specifications of the process chains: Wiegmann et al. (2005a)

The relatively high carbon footprint of butter, cheese and cream stems from the fact that the fat content of these foods is used as a calculation key for the greenhouse gas emissions – the higher the fat content, the more emissions are added onto the product from the pre-chain (i.e. cows, the animal feed, etc.).

It follows vice versa that 'light' products such as skimmed milk and low-fat cheese cause relatively low levels of greenhouse gas emissions.

For eggs, conventional barn eggs are compared with free-range ones and fodder from ecological agriculture. In this case – as well as with regard to milk products - ecological agriculture performs slightly better in terms of greenhouse gas emissions.

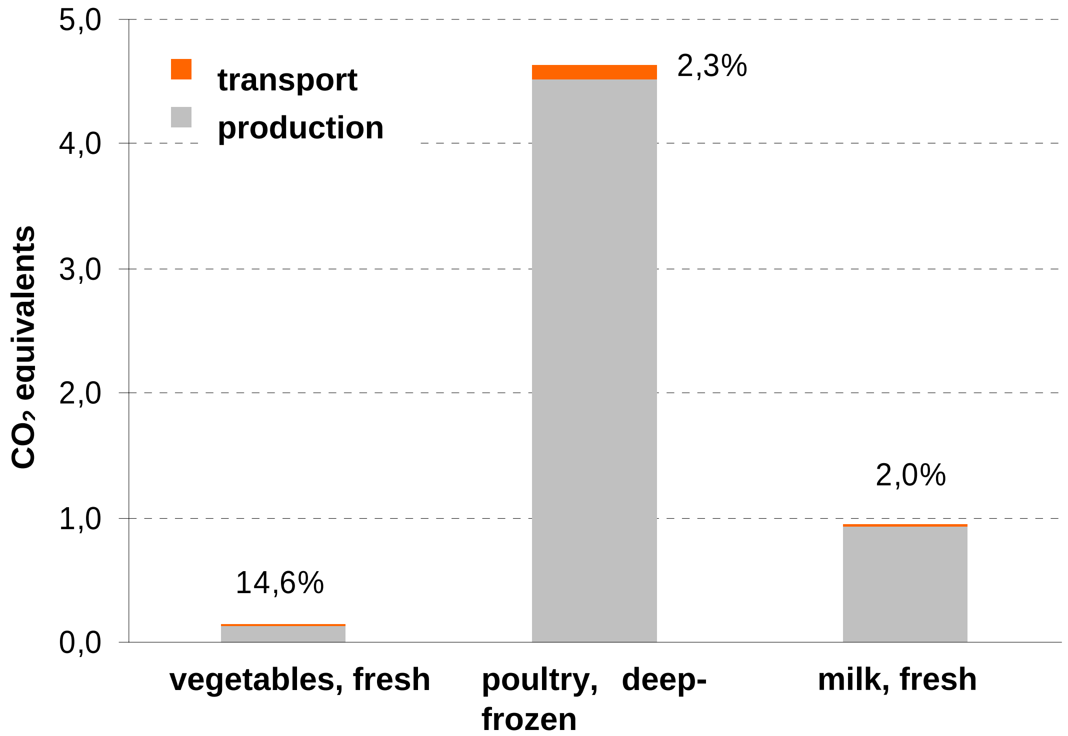
4 Global warming potential of the transport of food

The freight transport of food constitutes a share of around three percent of greenhouse gas emissions arising from the ‘food’ demand category (Wiegmann et al. 2005a). This means that in view of the overall demand category – from agricultural production through the processing, distribution and trade to storage, preparation and household consumption – measures which aim to increase the efficiency of household devices can achieve significantly greater effects in terms of the carbon footprint than measures which aim to reduce freight transport.

A differentiated analysis of freight transport also shows that the global transportation of food by plane has a significant impact on the carbon footprint; however, long-distance freight transportation by ship has a lesser effect on the carbon footprint.

In terms of individual food, the share of greenhouse gas emissions caused by freight transport according to each group of food differs considerably in part. In this regard, the share stemming from fresh vegetables is around 15 %; deep-frozen chicken and fresh milk have a share of about 2 % (see figure 7).

Figure 7 GHG emissions for freight transport and manufacturing of food (from farming to retail), in kg per kg of product



Source: Wiegmann et al. (2005a)

The average share of the individual food is around three percent of the total greenhouse gas emissions of the ‘food’ demand category.

The reasons for differences between the individual foods relate to transport-related emissions having an especially high impact on the climate footprint in the case of products which bring about only low levels of emissions in the course of their production, e.g. fruit and vegetables (see chapter 2).

5 Conclusions

Our food makes up a basic share of anthropogenic climate change: the GHG emissions of the food demand are of the same order of magnitude as those of ‘mobility’. Thus, it is without a doubt useful to consider what points of departure there are to achieve a reduction in the greenhouse gas emissions of this category.

The production of food (including the processing and retail) forms 45 percent of the category’s GHG emissions; storage and the preparation of food account, above all, for the remainder.

This demonstrates that the reduction of GHG in the production of food as well as a change in the demand for food are certainly important parameters – they are not, however, the only ones. Measures to reduce energy consumption in the storage and preparation of food are just as important.

With regard to the selection of food, the following can be noted: for climate protection reasons, it makes sense to pay attention to the carbon footprint of products in addition to their healthiness. In terms of vegetables, fruit and pasta products, there are low-emission products. By contrast, very high emissions stem from milk products with a high fat content; beef, as well as products containing dried potatoes, and most deep-frozen products also increase the carbon footprint.

In the case of all of the products considered, those from organic agriculture involve lower emissions than those cultivated conventionally. However, it should be noted that the differences between the individual product groups (e.g. between vegetables and meat) are much greater than the differences between organic and conventional foods within the groups themselves.

By means of a healthy diet, one can make a contribution to climate protection: lower meat consumption, pasta products and potatoes, a high share of fruit and vegetables and not too many milk products (or only low-fat ones) contribute to a lower carbon footprint.

If these foods come, as a next step, from organic farming, the climate footprint is further improved.

If, in a further step, food shopping is also carried out by foot, bicycle or short-distance public transport, and efficient appliances are used in the home for storage and preparation, these people can consider themselves pioneers of climate-friendly behaviour in the context of food.

Literature

Eberle, Ulrike et al. (eds.) 2006: Ernährungswende. Eine Herausforderung für Politik, Unternehmen und Gesellschaft; Oekom-Verlag www.oekom.de/buecher/buchprogramm/landwirtschafternaehrung/archiv/buch/ernahrungswende.html

FAO (United Nations Food and Agriculture Organization) 2006: Livestock's long shadow - environmental issues and options; Rome

IPCC (Intergovernmental Panel on Climate Change) 2007: Climate Change 2007: The Physical Science Basis. Summary for Policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Geneva

OEKO (Öko-Institut) 2009: Global Emissions Model for Integrated Systems (GEMIS) Version 4.5, Darmstadt www.gemis.de

UBA (Umweltbundesamt)/ÖKO (Öko-Institut) 2006: ProBas - Prozessorientierte Basisdaten für Umweltmanagementinstrumente; internet database accessible at www.probas.umweltbundesamt.de

Wiegmann, Kirsten; Eberle, Ulrike; Fritsche, Uwe R.; Hünecke, Katja 2005a: Umweltauswirkungen von Ernährung - Stoffstromanalysen und Szenarien; Ernährungswende-Diskussionspapier Nr. 7 des Öko-Instituts“; Darmstadt/Hamburg www.ernaehrungswende.de/pdf/DP7_Szenarien_2005_final.pdf

Wiegmann, Kirsten; Eberle, Ulrike; Fritsche, Uwe R.; Hünecke, Katja 2005b: Datendokumentation zum Diskussionspapier Nr. 7 ("Umweltauswirkungen von Ernährung - Stoffstromanalysen und Szenarien"); Öko-Institut; Darmstadt/Hamburg www.ernaehrungswende.de/pdf/DP7_Datendoku_2005_final.pdf