Greenhouse Gas Emissions of Organic and Conventional Foodstuffs in Austria

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ABSTRACT

The aim of this study was to analyse greenhouse gas emissions (GHGE) of more than 100 foodstuffs from two organic production methods in agriculture as compared to conventional farming in Austria. The system boundaries of the life-cycle study range from agriculture and its upstream supply chain to the retailer, including changes in soil organic carbon (humus) and land use change. In conclusion, all organic products showed lower GHGE per hectare but also per kg of foodstuff than comparable, conventional products. Organic dairy products resulted in 10 to 21 % lower CO_2-eq per kg of product than conventional foodstuffs, organic wheat bread 25 showed % and organic vegetables showed 10 to 35 % lower CO_2-eq per kg of product.

Keywords: organic farming, dairy, vegetables, bread, retailer, LCA, GHG

1. Introduction

The consumer's choice in quality of foodstuffs can influence greenhouse gas emissions (GHGE) from the food sector (Burdick and Waskow 2009). Organic agriculture is contradictorily discussed as a possible way to reduce GHGE (e.g. Hirschfeld *et al*. 2008). However, the mitigating effect on GHGE per kg of organic products is unclear especially under supermarket conditions. The primary goal of the present study was to compare GHGE of organic foodstuffs with conventionally grown ones. All balanced foodstuffs are retail products, processed and marketed by nationwide supermarket companies in Austria.

2. Materials & Methods

To date, 102 foodstuffs from organic and conventional agriculture, respectively, have been subject to comprehensive CO_2-balancing (product carbon footprint, PCF). The PCF includes all relevant greenhouse gases (Carbon Dioxide, CO_2; Methane, CH_4; Nitrous Oxide, N_2O) in CO_2-equivalents (CO_2-eq) according to IPCC (2006) and IPCC (2007) guidelines and is closely based upon the eco-balance guidelines ISO 14040, ISO 14044 and PAS 2050 standard. The system boundaries range from agricultural production to retailers, including the upstream supply chain (e.g., production of fertilizer, pesticides or seeds) as well as processing, packaging, storage and all transports up to and including retail (Figure 1).

Generally, GHGE from dairy products, bread and vegetable products were calculated for three different methods of agricultural production and further processing:

- Organic premium brand „Zurück zum Ursprung" (Bio-ZZU)
- Organic EU-standard, according to regulation (EC) 834/2007 (Bio-EU)

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- Conventional (Conv.)

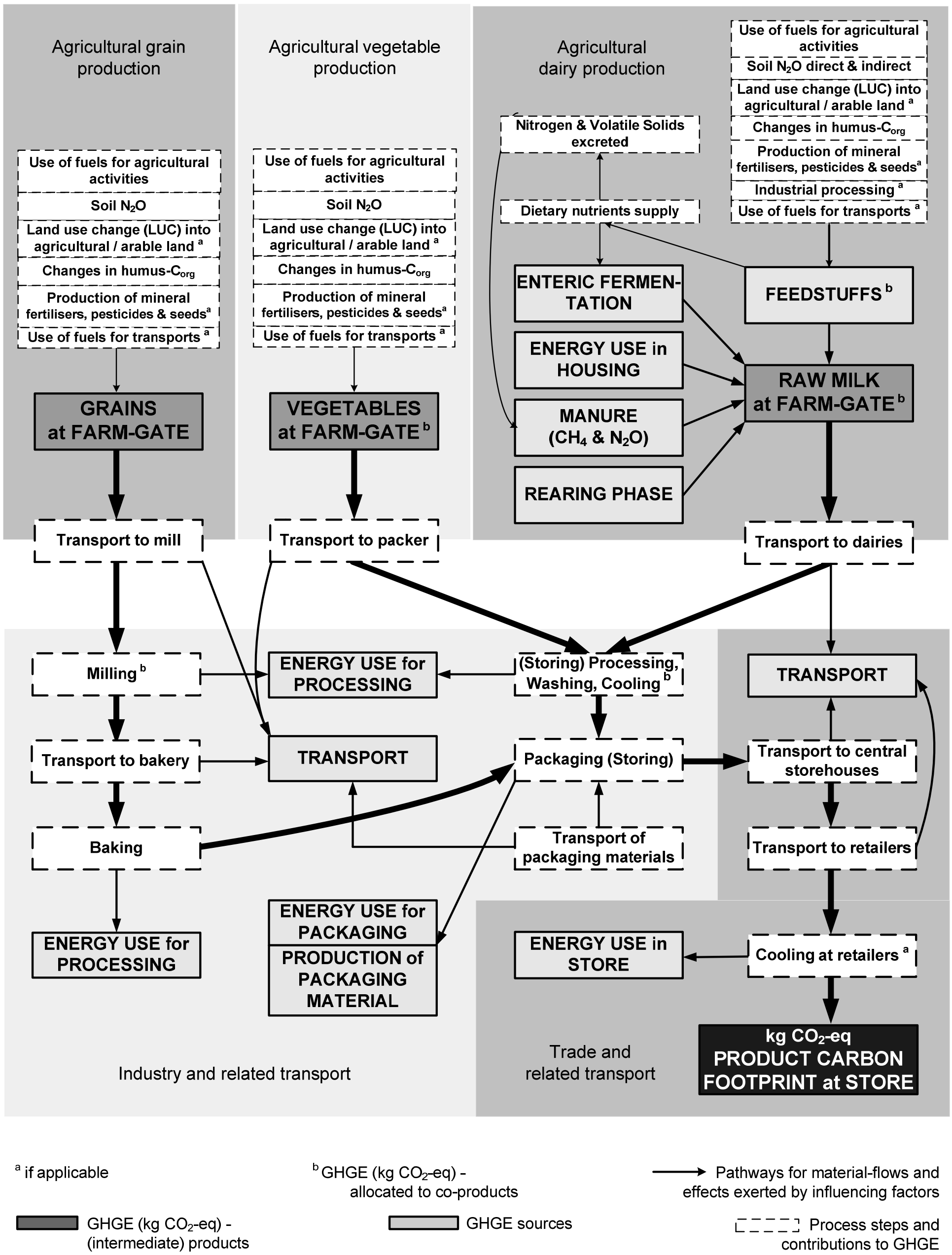

Figure 1: System boundaries for calculation of GHGE for breads vegetables and dairy products .

Modelled farms were assumed to come from the same region as the Bio-ZZU farms considered. As a result, climatic and geographical conditions for production are similar among the production systems. The conventional method of production was modelled with regard to the Austrian agrarian environmental programme.

The organic brand „Zurück zum Ursprung“ belonging to the supermarket chain Hofer/Aldi Süd provided primary data, which was the basis for an Austrian-specific „supermarket standard”. This includes transport, processing, packaging and distribution being used in the same manner for all three methods of production except the use/technique of partly baked frozen pastries, which is not practiced in Bio-ZZU.

Furthermore, secondary data from GEMIS (2007; v4.42 and v4.5), Ecoinvent v2.0 (Ecoinvent Centre 2007) and approximately 200 relevant national and international publications and statistics were consulted (important statistics and data bases, not further considered/described in this publication, were: BMLFUW 2005, BMLFUW 2006a, BMLFUW 2006b, BMLFUW 2007, BMLFUW 2008a, BMLFUW 2008b, Bokisch 2000, Carlsson-Kanyama and Faist 2000, Hülsbergen 2002, LCA Food DK 2002, LFI 2007, Mäder *et al*. 2002, Niggli *et al*. 2008, ÖPUL 2007, PAS2050 2008, Statistics Austria 2008).

This detailed database enabled the study to take the specific production conditions in Austria into consideration, as well as the current level of knowledge about GHGE. Unlike most PCF found in the literature, two further items land use change (LUC; GHGE-source) and changes in humus (GHGE-source or -sink) were included in the analysis based on Hörtenhuber *et al*. (2010) with minor modifications.

Why consider changes of soil organic carbon (humus)? – The sequestration of CO_2 in soils due to humus increase in organic farmland has been scientifically documented in many cases (i.e. Niggli *et al*. 2009, Fließbach *et al*. 2007) and has been incorporated in the PCF of this study in detail. A study from Bavaria (Küstermann *et al*. 2007) outlined a – for Austria relevant – point of reference: On average 400 kg CO_2 per ha and year were found to be sequestrated in organic farmland. In contrast, conventional farming leaded to a humus decrease of 202 kg CO_2 per ha and year per year (Küstermann *et al*. 2007). In both cases, CO_2 sequestration and release were assumed to proceed only a few decades but were actually related to a 100 year time-scale.

Why consider land use change (LUC)? – Austria imports large quantities of soy, used in conventional animal feed, primarily from Brazil (partially also from Argentina, AGES 2005). On the other hand, the quantity of organic soy imported from South America for organic agriculture is assumed to be small. The organic brand Bio-ZZU does not import any soy from South America. Soy cultivation in tropical regions, particularly in Brazil, contributes to the continued destruction of tropical forests. This causes, inter alia, huge CO_2-emissions, much higher than those caused by the transportation of soy from Brazil to Austria. The GHGE of this ecologically threatening land use change (LUC), contribute to 15-20% of global CO_2-emissions, more than the total emissions of global agriculture (Smith *et al*. 2007/IPCC).

3. Results

All organic products (Bio-ZZU as well as Bio-EU) display lower GHGE per hectare but also per kg of foodstuff than comparable, conventional products:

- Dairy products: 10-21 % lower CO_2-eq per kg of dairy products
- Wheat bread: 25 % lower CO_2-eq per kg of bread
- Vegetables: 10- 35 % lower CO_2-eq per kg of fresh vegetables

3.1 Dairy

Despite the lower milk output of organic cows, 15.7 % lower GHGE (CO_2-eq) per kg of fresh milk are emitted compared to conventional production (Figure 2). The lack or low proportion of soy from South America in organic feed is the main reason for the lower GHGE of organic milk. Transportation causes only a small proportion, ranging from 5 to 8 % of total GHGE in all three considered methods of production.

3.2 Wheat bread

The production of 1 kg of organic wheat bread from Bio-ZZU results in 433 g CO_2-eq and thus in around 25 % lower GHGE than comparable, conventional wheat bread (Figure 2). One kg of organic wheat bread produced following the organic EU regulation also displays 22% lower GHGE. However, the emissions caused by agriculture and baking account for the largest proportion of GHGE. The proportion of GHGE from transport is under 10 %.

Although the yield of cereals and vegetables in organic agriculture is generally one third to one half smaller than in conventional agriculture, GHGE per kg of organic products are still 10-35 % lower. An important reason for this is the lack of nitrogen (N)-mineral fertilizer, as this requires high amounts of natural gas and crude oil during the production processes. Additionally, N-mineral fertilizer use causes considerably higher N_2O-emissions than compared to the mix of organic fertilizing methods with compost and biologically fixed nitrogen by legumes. According to IPCC (2006), the latter does not emit any N_2O.

3.3 Onions

One kg of Bio-ZZU onions causes 139 g CO_2-eq per kg along the entire supply chain and results in a mitigation of 13.7 % of GHGE compared to the conventional product (Figure 2). The example of onions demonstrates the low absolute CO_2-eq-amount of most open land fresh vegetables in contrast to dairy products (see also Fritsche *et al*. 2007).

In the area of agriculture, both organic production methods for onions result in about 40% fewer GHGE than conventional production. Again, the main reason is the lack of N-mineral fertilizer and its consequences on soil-N_2O-emissions.

GHGE from transports show 57 g CO_2-eq per kg and thus exceed the small absolute GHGE from agriculture. GHGE from packaging are relatively high for vegetables (one fourth of total GHGE). The total mitigating effect of both organic production methods across the whole supply chain are 13% (Figure 2).

4. Discussion

Due to environmentally friendly cultivation and the low use of readily soluble mineral fertilizers, GHGE can be considerably reduced in/via organic agriculture. Moreover, through humus accumulation, CO_2 can be sequestrated in soil. This is also apparent in the lower GHGE per kg of product. In terms of dairy, the practice in organic agriculture of (general) disuse of soy from South America results in lower GHGE per kg of organic milk (particularly due to the absence of GHGE caused by land use change in Brazil). Hence the lower output of dairy in organic farms is more than compensated for. The results demonstrate that as a consequence of production and consumption of organic products, GHGE per capita can be reduced considerably. In Austria, these GHGE mitigation effects are presented to consumers through a packaging label on the entire organic product line of Bio-ZZU.

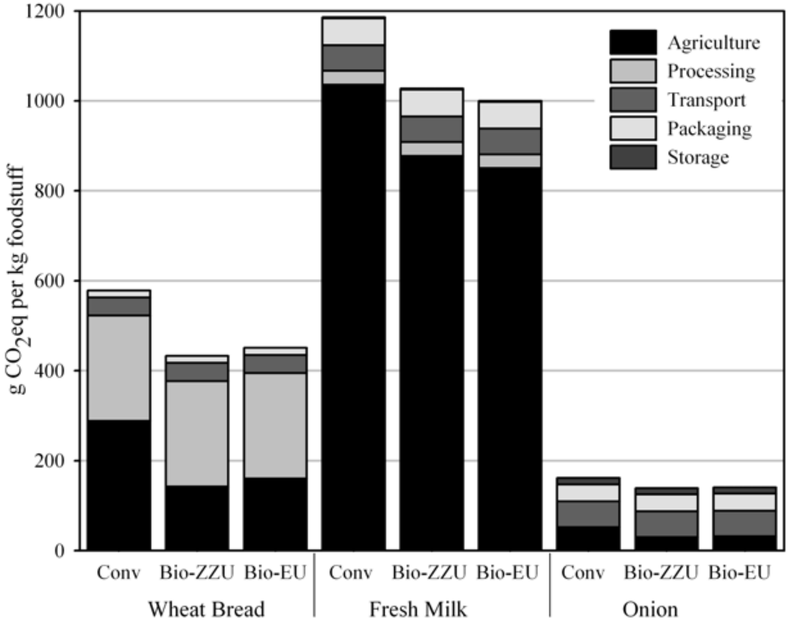

Figure 2: GHGE of each 1 kg wheat bread, fresh milk and onions for the three considered methods of production.

5. References

AGES (Austrian Agency for Health and Food Safety, 2005): Machbarkeitsstudie für Auslobung "gentechnikfrei" und Vermeidung von GVO bei Lebensmittel aus tierischer Erzeugung. Vienna, Austria.

BMLFUW (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2005, 2006a, 2007, 2008a): Grüner Bericht. http://www.gruenerbericht.at

BMLFUW (2006b): Richtlinien für die Sachgerechte Düngung - Anleitung zur Interpretation von Bodenuntersuchungsergebnissen in der Landwirtschaft.

BMLFUW (2008b): Deckungsbeiträge und Daten für die Betriebsplanung 2008.

Bokisch F.-J. (2000): Bewertung von Verfahren der ökologischen Produktion im Hinblick auf den Energieeinsatz und bestimmte Schadgasemissionen, Landbauforschung Völkenrode, FAL Sonderheft 211.

Burdick B., Waskow F. (2009): Ernährung und Klimaschutz: Orientierung für Verbraucher. *Journal für Verbraucherschutz und Lebensmittelsicherheit*, 4, pp. 164-173.

Carlsson-Kanyama A., Faist M (2000): Energy Use in the Food Sector: A data survey Department of Civil and Environmental Engineering, Swiss Federal Institute of Technology, Zürich, Switzerland.

Eurobarometer (2009): Europeans' attitudes towards the issue of sustainable consumption and production. Analytical report. Flash EB Series #256.

Ecoinvent Centre (2007): Ecoinvent data v2.0 final reports Ecoinvent 2000 No. 1-25, Swiss centre for Life Cycle Inventories, Dübendorf.

Fließbach A., Oberholzer H.-R., Gunst L., Mäder P. (2007): Soil organic matter and biological soil quality indicators after 21 years of organic and conventional farming. *Agriculture, Ecosystems & Environment*, 118, pp. 273-284.

Fritsche U.R., Eberle U., Wiegmann K., Schmidt K. (2007): Treibhausgasemissionen durch Erzeugung und Verarbeitung von Lebensmitteln. Arbeitspapier Öko-Institut e.V. - Institut für angewandte Ökologie, Darmstadt, Hamburg und Freiburg. http://www.oekoinstitut.de/publikationen/forschungsberichte/.

GEMIS 4.42 (2007): Globales Emissions-Modell Integrierter Systeme, Version 4.42.

GEMIS 4.5 (2007): Globales Emissions-Modell Integrierter Systeme, Version 4.5.

Hirschfeld J., Weiß J., Preidl M., Korbun T. (2008): Klimawirkungen der Landwirtschaft in Deutschland. http://www.ioew.de/.

Hörtenhuber S., Lindenthal T., Amon B., Markut T., Kirner L., Zollitsch W. (2010, in press): Greenhouse gas emissions from selected Austrian dairy production systems—model calculations considering the effects of land use change. *Renewable Agriculture and Food Systems*, doi:10.1017/S1742170510000025.

Hülsbergen K.-J. (2002): Entwicklung und Anwendung eines Bilanzierungsmodells zur Bewertung der Nachhaltigkeit landwirtschaftlicher Systeme. Habilschrift. Halle/Saale, 2002. Shaker-Verlag, Aachen 2003.

IPCC (Intergovernmental Panel on Climate Change, 2006): Guidelines for National Greenhouse Gas Inventories. In H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara, K. Tanabe (eds) National Greenhouse Gas Inventories Programme. IGES, Japan.

IPCC (2007): Climate Change 2007. IPCC Fourth Assessment Report. The Physical Science Basis. www. Ipcc.ch/ipccreports/ar4-wg1.htm.

ISO 14040 (2006): International Standard: Environmental management – Life cycle assessment – Principles and framework. Second edition 2006-07-01.

ISO 14044 (2006): International Standard. Environmental management – Life cycle assessment – Requirements and guidelines. First edition 2006-07-01.

Küstermann B., Kainz M., Hülsbergen K.-J., (2007): Modeling carbon cycles and estimation of greenhouse gas emissions from organic and conventional farming systems. *Renewable Agriculture and Food Systems*, 23, pp. 1-16.

LCA Food DK (2002): http://www.lcafood.dk/ [Download: 2008-11-14].

LFI (Ländliches Fortbildungsinstitut Österreich, 2007): Düngung im ÖPUL.

Mäder P., Fließbach A., Dubois D., Gunst L., Fried P., Niggli U. (2002): Soil Fertility and Biodiversity in Organic Farming. *Science*, 296, pp. 1694-1697.

Niggli U., Fließbach A., Hepperly P., Scialabba N. (2009): Low Greenhouse Gas Agriculture: Mitigation and Adaptation Potential of Sustainable Farming Systems. FAO, April 2009, Rev. 2 – Rome.

Niggli U., Schmid H. und Fliessbach A. (2008): Organic Farming and Climate Change. International Trade Centre (ITC) UNCTAD/WTO, Geneva.http://orgprints.org/13414/.

ÖPUL (Austrian agri-environmental programme, 2007): Das aktuelle Agrar-Umweltprogramm in der ländlichen Entwicklung 2007 bis 2013. http://www.landnet.at/article/archive/5128.

PAS2050 (Publicly Available Specification, 2008): Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. BSI British Standards. ISBN 978 0 580 50978 0.

Smith P., Martino D., Cai Z., Gwary D., Janzen H., Kumar P., McCarl B., Ogle S., O'Mara F., Rice C., Scholes B., Sirotenko O. (2007): Agriculture. In B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds): Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of IPCC, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Statistics Austria (2008): Statistik der Landwirtschaft 2007. Vienna, Austria.