LCA METHOD - TOOL FOR FOOD PRODUCTION EVALUATION

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Abstract

Food is one of the basic human physiological needs which cannot be substitute in any way or by anything. Like every human activity, also the food production has impact on the environment. In particular, people from developed countries begin to be interested in the environmental impacts caused by satisfying their needs. For the environmentally friendly selection, they need to know about these impacts. One of the methodological tools providing such information is the Life Cycle Assessment - LCA. LCA is a method for assessment of product environmental impacts during its entire life cycle. The results can be used to identify hot spots during the cycle and thus, to define possibilities for improving product environmental profile, to inform key persons and to find the related marketing mark. In addition to other benefits, we can use the LCA to carry out comparative studies that means comparing alternative products that serve the same purpose. Food production is composed of an agricultural phase, a processing phase and a trade phase. In our studies within the SUKI - Sustainable Kitchen project, the aim was to compare approximately 20 kinds of most commonly used foods aiming to the public catering facilities in terms of GHG emission load. Alternatives were cultivation methods - organic/conventional in the agricultural phase, processed/unprocessed in the processing phase and imported/regional and storage/fresh in the trade phase. Project results confirm the general assumption about the less emission load of unprocessed, fresh and regional products. For example, production of one kilogram of chips produces 11 times more emissions than the production of one kilogram of raw potatoes. Storage of tomatoes in cooling boxes for 7 days causes up to 40% of total emissions. Remaining 60% go to agriculture and transport. Regarding the agricultural phase evaluation, we cannot clearly state that products from organic farming produce less emissions. Among 11 evaluated agricultural products, 8 organic products go better as compared to only 3 conventional ones. Regarding the total sum, the situation is more complicated. Among 22 evaluated foods, organic food goes better in 11 cases as well as the conventional food. This situation is mainly caused by a lack of processing capacity for organic products resulting into too long transport distances.

Key words: comparative LCA, food, organic/conventional production

Food is one of the basic human physiological needs, it will always be a necessity for humans (Andersson, K., 2000) which cannot be substitute in any way or by anything (Carlsson-Kanyama, A., 1998). Like every human activity, also the food production has impact on the environment. These impacts naturally grow with the increasing human population and increasing demand for food production. Current food production systems require more inputs and food consumption patterns in rich parts of the world are not sustainable (Andersson, K., 2000). The system is designed to satisfy the economic and nutritional requirements of the rapidly growing population and the environmental aspect remains aloof (Andersson, K., 1998). Within the European consumption, the food sector covers 20-30 % of impacts (Cellura, 2012). This makes food an important sphere to optimize (Wallen, A., 2004). Growing interest in the environment is reflected in the interest of consumers in more environmentally friendly products, including food. The food selection change is a step towards the sustainable development (Carlsson-Kanyama, A., 1998). The consumer can thus affect the environment through his choice, but he needs to know the information (Wallen, A., 2004). At the political level, food is one of the priority sectors of Sustainable Consumption Policy which requires environmental assessment of the food production chain, tries to identify problems and their improvement and to deliver environmental information to consumers (Cellura, 2012). One of the methodological tools providing such information is the Life Cycle Assessment - LCA. LCA is a method for assessment of product environmental impacts during its entire life cycle. Detailed description is specified in the ISO 140 standards. This method had been originally developed to analyse industrial processes but in the last 15 years, it has been adapted for assessment of the environmental impacts of agriculture (Harris, S., 2009). The results can be used to identify hot spots during the cycle and thus, to define possibilities for improving product environmental profile, to inform key persons and to find the related marketing mark. In addition to other benefits, we can use the LCA to carry out comparative studies that means comparing alternative products that serve the same purpose (Kočí, V., 1999). In agricultural practice, the LCA draws attention as a tool for measuring of environmental impacts in different production system types (Koga, N., 2006, Hayase, K., 2007). Unlike the industrial one, the agricultural system is complicated and it is necessary to pay attention to different methodological requirements (Haas, G., 2000). The agricultural life cycle assessment is becoming more important as it assesses the product environmental design from the beginning and defines differences between systems with equivalent functions. For this reason, it can be used as a crucial tool for producers, consumers and policy makers (Cellura, 2012).

MATERIAL AND METHOD

SUKI (Sustainable Kitchen), the Czech Austrian project, dealt generally with emissions produced by catering facilities and possibilities for their reduction. Subaims of the project were to answer the following questions regarding the assessment of greenhouse gas emissions: What is the influence of production systems (organic, conventional), what is the influence of the origin (regional, imported), what is the influence of the seasonality (fresh, stored) and what is the influence of the processing degree (raw, processed). To determine the emissions, the LCA method was selected while the results came only from the climate change impact category. The authors are aware that there is a certain simplification and results cannot be presented as a complete LCA study. On the basis of wide data collecting and evaluation of consumption of involved catering facilities, 11 most commonly used agricultural products were selected. Through their processing into partial components, the results are extended to the 22 final products. For each of them, there have been several comparative studies carried out according to the mentioned project subaims. The cradle to gate approach was used. The studies were processed in accordance with standards ISO 140 (ČNI, 2006a, ČNI, 2006b). A general framework for crop and livestock products is shown (*Figure 1*). As a functional unit, 1 kg of the products heading to the catering facility has been chosen. The product system was divided into sub-processes: agriculture, processing and trade. For agriculture, inputs relating to the consumption of seeds, fertilizers, pesticides and fuel within agricultural operations for crop production, feed consumption, energy and fuel within the livestock sector were surveyed. Emissions from nitrogen fertilizer application within crop production and emissions from manure management in the livestock production, calculated according to the IPCC methodology (de Klein, C., 2006, Dong, H., 2006), were integrated into agriculture. For processing, the data on energy consumption were collected, within the trade, it was travel distance, information on cargo and storage time of various foods. All data was obtained primarily from farmers, processors and traders, absent sufficient data, it was supplemented by data from available databases. To obtain the necessary results, the ReCiPe Midpoint (H) method has been chosen as a characterization model. Results come from the climate change impact category and they are expressed in kg of a carbon dioxide equivalent (CO_2e).

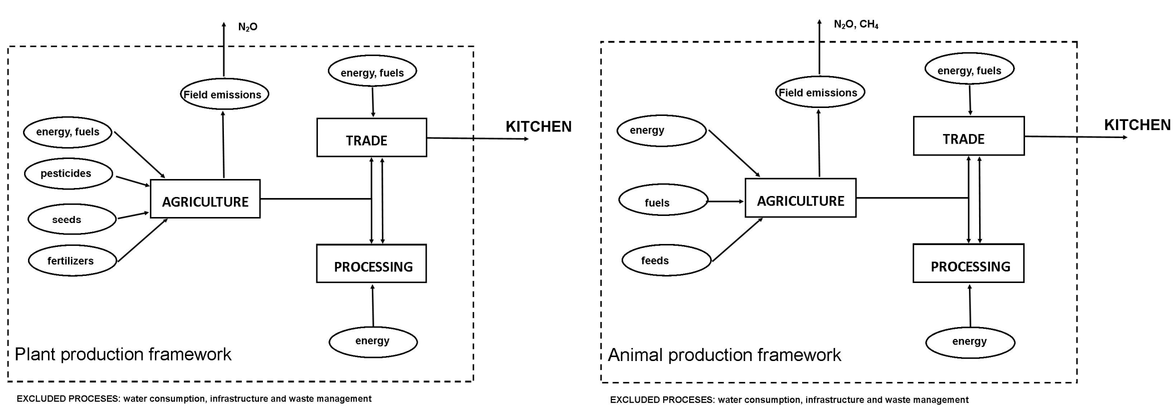

Figure 1 **General LCA framework for plant and animal products**

RESULTS AND DISCUSSIONS

The aim of the study was to perform a comparative study using the LCA method because LCA is a method that can be suitably used to evaluate the environmental impacts of agriculture (Haas, G., 2000). In the study, 22 foods heading to the school canteens were evaluated. From the evaluation of agricultural parts of products of plant origin, we can see that among 9 products, 8 products are less loading in the organic variant (*figure 2*) and only one in the conventional variant. The highest differences were found with cabbage and carrots (about 58% lower emissions from cultivation of organic product variety), minor differences with potatoes (about 13% lower emissions) and wheat (8% lower emissions), the minimum difference with rice growing (about 1 % lower emissions). On the contrary, the only organic product with higher emissions was onion (about 20% higher emissions). Within general evaluation, organic crop production has better results mainly due to the absence of mineral fertilizer usage and the resulting negative emissions within the release of nitrous oxide from nitrogen fertilizers after their application. The same is with the application of banned pesticides. Higher emissions from organic agricultural crop production may be due to a higher frequency of mechanical agricultural operations that are necessary precisely because of the absence of pesticides. Another factor for higher emissions from organic production is the lower yield as compared to conventional production since emissions are related to the yield. This corresponds with the conclusions of the study (Wallen, A., 2004) that state that there can be higher emissions per the functional unit within organic farming. This project evaluated also livestock, namely beef and pork. There the situation is reversed, organic products burden the environment more, it is 26% more with pork and even 112% more with beef. This is primarily due to higher emission load of organic feed. With beef, it is particularly the feeding technology when calves in the organic system are fed with milk and calves in the conventional system with plant feed mixtures. Milk production is more emission-intensive than production of plant feed. From total 11 evaluated agricultural products, 8 organic and 3 conventional products have better results.

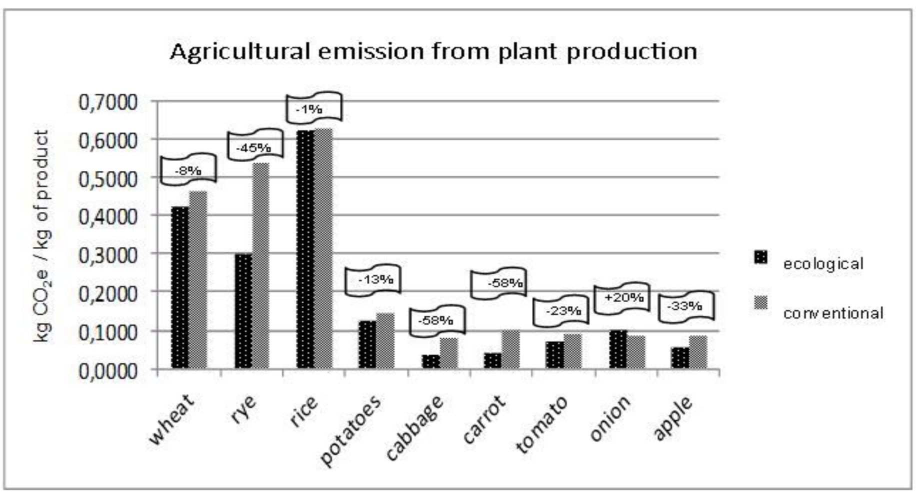

Figure 2 **Agricultural emissions from plant production**

When evaluating all phases, the situation is as follows (*table 1*): among 22 evaluated foods, organic food has better results in 11 cases as well as the conventional food. This fact is mainly due to the lack of processing capacity for organic products in the Czech Republic. As well as due to too long transport distances within the marketing chain of organic products.

Other comparative studies were focused on the degree of product processing, comparison of fresh and stored products, as well as on transport. Another comparison was made in terms of the product processing degree. The extent to which each process contributes to the total emission load is shown in the table (*table 2*). When comparing the degree of processing: for example, the production of 1 kg of chips causes 11x more emissions than the production of 1 kg of potatoes, in case of mashed potatoes, emissions are 16 times higher. Storage of tomatoes for 7 days causes 40% of total emissions. As for the transport, the maximum load is around 20%, especially with organic products. This fact does not correspond with the view that transport does not contribute to GHG emissions to a great degree (Carlsson-Kanyama, A., 1998).

Table 1

Savings of the total greenhouse gas emissions of organic product variants

Food	BIO savings	Food	BIO savings
Wheat	**- 2 %**	Pommes	+ 10 %
Rye	**- 39 %**	Cabbage	**- 26 %**
Wheat flour	+ 10 %	Carrot	**- 24 %**
Rye flour	**- 25 %**	Tomatoes	**- 3 %**
Roll	+ 4 %	Onion	+ 36 %
Bread	**- 2 %**	Peeled onion	+ 36 %
Pasta	+ 5 %	Apple	+ 7 %
Rice	- 1 %	Milk	**- 5 %**
Potatoes	+ 3 %	Yoghurt	**- 4 %**
Peeled potatoes	**- 6 %**	Beef meat	+ 111 %
Pot. Puree	0 %	Pork meat	+ 27 %

Table 2

The percentage of emission load of the particular life cycle parts

Food		agriculture	processing	transport	storage
wheat flour	Organic	72%	8%	20%	0%
	Conventional	86%	10%	4%	0%
pasta	Organic	63%	15%	22%	0%
	Conventional	72%	16%	12%	0%
tomatoes	Organic	38%	0%	24%	38%
	Conventional	48%	0%	16%	36%
potatoes	Organic	65%	0%	23%	12%
	Conventional	77%	0%	10%	13%
pommes	Organic	20%	56%	20%	4%
	Conventional	24%	62%	6%	8%
pork	Organic	98%	1%	0%	1%
	Conventional	97%	1%	1%	1%
milk	Organic	87%	3%	4%	7%
	Conventional	88%	3%	3%	7%

CONCLUSIONS

The consumer needs to know information for environmentally friendly selection. The LCA is a method that can provide it. Within comparative studies of 22 foods used in school meals, fresh, unprocessed and local foods are generally better. When comparing organic and conventional products, we can not make a definite conclusion. Within agricultural process evaluation, 73% of products of organic origin were better evaluated. The dominant positive factor in organic farming is the absence of mineral fertilizers and pesticides. When evaluating the overall product cycle, half of the products is better in the organic form and half in the conventional form. The positive impact of organic food production is eliminated primarily by low-density of processing capacities and long transports within the organic supply chain.

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REFERENCES

ANAndersson, K., Ohlsson, T., Olsson, P., 1998 - Screening life cycle assessment (LCA) of tomato ketchup: a case study. Journal of Cleaner Production, vol. 6, p: 277-288.

Andersson, K., 2000 - *LCA of Food Products and Production Systems*. International Journal of Life Cycle Assessment, vol. 5: 4, p: 239 - 248.

Carlsson-Kanyana, A., 1998 - *Climate change and dietary choices — how can emissions of greenhouse gases from food consumption be reduced?*. Food Policy. vol. 23: 3-4, 277 – 293.

ČSN EN ISO 14 040, 2006 - *Environmentální management - Posuzování životního cyklu - Zásady a osnova*. Český normalizační institut.

ČSN EN ISO 14 044, 2006 - *Environmentální management - Posuzování životního cyklu - Požadavky a směrnice*. Český normalizační institut.

De Klein, C., et al., 2006 - *IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture*, Forestry and Other Land Use. Intergovernmental Panel on Climate Change (IPCC). Geneva.

Dong, H., Mangino, J., McAllister, T. A., Hatfield, J. L., Johnson, D. E., Lassey, K. R., Aparecida de Lima, M., Romanovskaya, A., 2006 - *IPCC Guidelines for National Greenhouse Gas Inventories. Volume 10 - Emissions from livestock and manure management*, Intergovernmental Panel on Climate Change (IPCC). Geneva

Haas, G., Wetterich, F., Geier, H., 2000 - *Life Cycle Assessment Framework in Agriculture on the Farm Level*. International Journal of Life Cycle Assessment. Vol. 5: 6, p: 345 - 348.

Harris, S.t, Narayanaswamy, V., 2009 - *A Literature Review of Life Cycle Assessment in Agriculture*. RIRDC, 2009. Publication No 09/029.

Hayashi, k., Nemecek, T., Gaillard, G., 2007 – *Life cycle assessment of agricultural production systems: current issues and future perspectives*. In: [online]. Food & Fertilizer Technology Center, 2007 [cit. 2013-01-03]. Available:http://www.agnet.org/library.php?func=view&id=20110721140039&type_id=2

Kočí, V., 2009 - *Posuzování životního cyklu Life Cycle Assessment - LCA*. Chrudim: Vodní zdroje Ekomonitor, 263pp.

Koga, N., Sawamoto, T., Tsuruta, H., 2006 - *Life cycle inventory-based analysis of greenhouse gas emissions from arable land farming systems in Hokkaido, northern Japan*. Soil Science and Plant Nutrition. 2006, 52, p: 564-574

Wallen, A., Brant, N., Wennersten, R., 2004 - *Does the Swedish consumer's choice of food influence greenhouse gas emissions?.* Environmental Science & Policy. 2004, vol. 7,: 6, p: 525 – 535.