Experiences and Improvement Possibilities – LCA Case Study of Broiler Chicken Production

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ABSTRACT

The environmental impacts of a typical Finnish broiler fillet product were studied using production network integrated life cycle assessment method. The results of the study clearly demonstrated the significance of the environmental releases caused by the primary (incl. broiler chicken houses) production, which was in this magnitude an unexpected result for the industrial broiler chicken manufacturer as well as other project partners. According to the results, the majority of the environmental impacts caused by the production network originated from the housing of the broilers and the crop cultivation for fodders. Broiler farming had the most impact on eutrophication and acidification due to the nutrient run-off and leaching and ammonia evaporated from broiler manure. The most important outcome of this case study was the reliable and inclusive information produced, which can be used to develop the production network, especially in the chicken contract farms. The broiler chicken manufacturer is now considering different ways to react for the improvement challenges related to the contract producers.

Introduction

As a part of the Finnish Foodchain LCA project MTT and Finnish Environment Institute carried out a life cycle assessment (LCA) study on Finnish broiler production. The product chosen for the LCA was a honey-marinated and sliced broiler fillet which is a volume product on the Finnish broiler chicken markets. LCA was based on the actual production processes in Finland within the years 2004 and 2005. The main objectives of the study were to compile reliable environmental impact data for all process stages involved in the systems considered, to identify and assess the significance of the impact sources, and to draw and evaluate possibilities to improve the environmental performance of the production network.

The project was the first LCA study implemented by the industrial broiler chicken manufacturer. Also the suppliers of the broiler chicken manufacturer and a retailer joined the execution of the study. Hence, both the upstream and the down stream processes of the production network were covered by real bodies for the data collection of the study. This also made it possible to carry out the study as a production network integrated LCA to achieve continuous development due to joint efforts of the network.

In the LCA it was taken account of all stages of the product and distribution systems essential for the final consumer product, beginning with the production of farm inputs e.g. fertilisers, followed by the cultivation of crops for feeding, broiler housing, raw material deliveries to food processing, processing and packing in industry, the production of the packaging, distribution to the retail stores, and finally refrigeration in retail stores. Consumer activities were not included in the study. The data used in the study were based on empirical investigation of the real processes of the current production network. One important aim behind this was to get the different parties involved in the production network to learn more about product integrated environmental management, respective assessment of environmental impacts, and related benefits, i.e. learning by doing. This approach gives a real possibility to seek continuous and effective improvements in the production network. Principles and benefits of production network (supply web) management based LCA are more widely presented and discussed by Virtanen and Poikkimäki [see e.g. 1,2].

After the finalisation of the LCA project some interviews were done among company representatives to collect and analyse views of the companies of the networked and product-based environmental management of products. Special interest of the interviews was on how the results and experiences gained in the project have been utilised.

Materials and methods

The method used for assessing environmental impacts of broiler chicken chain was life cycle assessment. The functional unit (FU) was 1000 kg honey marinated and sliced broiler filler bought by consumers from retail shops. The central data were based on empirical investigation of the real processes. The parties of the supply chains conducted the main fieldwork for the data acquisition. Hence, data on the industrial processes came from Finnish plants producing and processing raw materials and products needed in the chain. Altogether almost 20 broiler farms (both for parent stock and chick production) were involved in data collection on energy, water and fodder use and related outputs. Average Finnish grid electricity data was used for electricity. Local energy production, like steam, was taken as it currently appeared. Consumer products were assumed to be distributed and sold in Finland according to the current regional market shares. The emissions from the delivery web were modelled using realistic delivery routes with initial loading, retail stops, collection of and final discharge of return load each. Logistics was modelled in collaboration with Finnish logistic and retail company, including retail product losses. The data for retail cooling was drawn using nominal electricity consumptions of the cooling devices and assessed average product throughputs of the cold stores. Consumer activities, like shopping trips, refrigeration and cooking were not included.

The impact categories were climate change, tropospheric ozone formation, aquatic eutrophication and acidification. In characterization the site-dependent characterization factors were used for the two latter impact categories [3,4]. For climate change the IPCC 2001 characterization factors [5] and for the formation of tropospheric ozone factors by Hauschild et al [6] were used. Unit process data acquisition methods and sources as well as detailed system boundaries, scoping and assumptions are described in detail in the project report as well as other issues (e.g. land use, eco-toxicity, solid wastes, utilization of side streams) included in the interpretation phase of the results [7].

After the finalisation of the study, three semi-structured interviews of company representatives were made to collect and analyse the views of the industry. The main target of the interview survey was to study how the results and experiences gained in the project had been utilised or could be utilised in different activities (production, R&D, management etc.) by the participant companies, especially in broiler chicken manufacturer. Two of the interviewed company representatives represented broiler chicken manufacturer, and the third one industrial fodder producer. Two of the persons were deeply involved in the making of the study, while one representative was the leading manager of the chicken business, and in this interview the special focus was on the diffusion of the project results as well as learning due to the project in the organisation. In addition to interviews, the personal observations and notes about the company participants and their thoughts, reactions and statements were made by the author during the two-year (2005-2006) process along dozens of project meetings. Those notes served as a very valuable source of information also to the outcomes of this paper.

Results

According to the LCA results, broiler chicken housing and related fodder production created the majority of the environmental impacts in each impact category studied. The results for primary energy demand, climate change, acidification and eutrophication are presented in figures 1 and 2. Fodder production, especially crop cultivation phases, for broiler chickens accounted for 25% of the primary energy consumed in the production network, followed by the refrigeration in retail stores (20%) and broiler chicken housing (16%), respectively. In terms of global warming potential, production of fodder accounted for 36% of the total impact, and broiler housing 29%. This result was not only influenced by the emissions from energy consumption but also by the nitrous oxide emissions from the fertiliser production and use, as well as in nitrous oxide and methane that are evaporated in broiler chicken manure handling. Nevertheless, carbon dioxide was still the most influencing gas in the climate change potential creating 59% of all the impacts of the category. Carbon dioxide emissions were evenly distributed throughout the production network correlating with the energy consumption. The contribution of retail for climate change was 9% (figure 1).

Broiler chicken housing and corresponding fodder production accounted for over 80% of all eutrophication and acidification impacts created by the entire production network. This was especially due to the crop cultivation

needed for broiler chicken fodders, which had the biggest contribution to the nutrient run-off and leaching, as well as ammonia evaporation from manure (Figure 2). The contribution of the parent stock, including the growth of the parent stock, chick production and related fodder production and hatching, was in all impact categories from 8 to 9 per cent. The share of the marinade in the final product is much higher than its corresponding environmental impacts. Relatively largest contribution of the marinade (rape seed oil) was in eutrophication, with 4% of the total impact in the category.

The non-point releases from the agriculture are much more difficult to control than e.g. the point sources of the industry due to the field and climate conditions of agriculture. However, there are measures to control emissions from field cultivation. These measures include activities such as decreasing the high concentrations of easily soluble phosphorus in soils, maintaining good soil structure and drainage, preventing erosion by favouring no-tillage methods and withdrawing the most unproductive and high erosion risk field parcels from agricultural use, and turning them into, for instance, buffer zones.

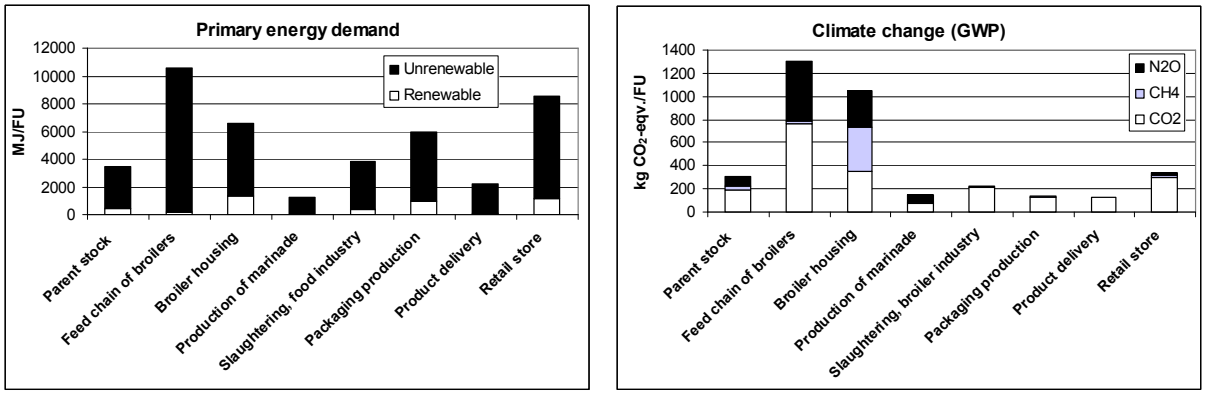

Figure 1. Primary energy demand and climate change impact by life cycle phases in the broiler chicken production network (1000 kg product as FU).

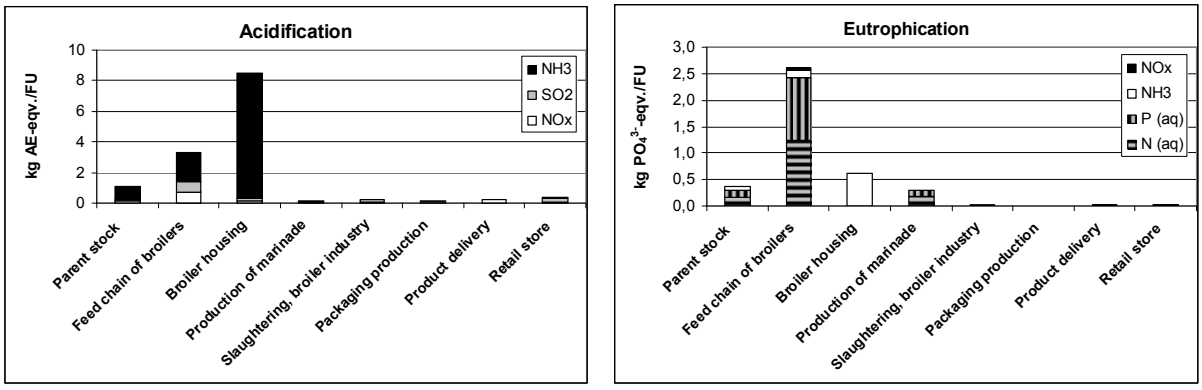

Figure 2. Acidification and eutrophication impact by life cycle phases in the broiler chicken production network (1000 kg product as FU).

Good production circumstances in broiler chicken houses call for maintaining suitable growth temperature and good air quality free from harmful gases, excess humidity and dust. Removing ammonia from the housing air is one of the most concrete and effective ways of improving the environmental performance. The removal of ammonia has also a decreasing effect on the amount of dust in the outlet, which in turn significantly improves the operational preconditions of heat exchangers. The use of heat exchangers enabled intensified ventilation in the broiler chicken houses, which in turn keeps the litter drier, decreases ammonia releases, and has a beneficial impact on the health of the broiler chicken flock.

When considering the energy consumption of the whole production network, broiler housing was the most energy consuming part. This consumption was mainly due to the heating of the broiler houses. Therefore, if investments targeted to this area could be made, already a modest heat recovery of 10 per cent would reduce 30

per cent the heating energy required. From the entire production network point of view, this reduction would equal to a decrease of 4 per cent in the total primary energy consumption.

In addition to that, motivating contracted primary producers and other local farmers to apply chicken manure more evenly along the agricultural soil parcels would have a beneficial impact on the nutrient loads of local and regional areas. Nutrient loads could also be reduced if broiler chicken farmers would transfer broiler chicken manure to neighbouring crop farmers to replace mineral fertilisers rather than using it all on their own crop fields.

The environmental impacts caused by the broiler chicken production network were also illustrated with the Finnish Eco-Benchmark. The Eco-Benchmark describes the environmental impacts related to average Finnish consumption and daily consumption amounts. The scale used in the benchmark weights the environmental impacts according to their importance allowing the comparison of the environmental impacts for various daily consumption patterns. According to the Finnish Eco-Benchmark, the environmental impacts created by the broiler chicken production network are for almost 50% due to eutrophication and for 25% due to acidification.

Observations concerning company benefits and improvements

During the project a huge iterative data collection process was conducted meaning hundreds of hours spent with data generation in broiler houses, fodder industry, industrial producers of food and packaging, as well as in logistics and retail companies. Having people from different cross-functions (production, R&D, marketing, environmental experts, logistics, packaging, management, etc.) to work together in a new way has as such been an important feature of the initiative in organisation level as well as between companies. Additionally, the inventory process of this project pointed out direct improvement possibilities, and a separate spin-off project on energy saving measures in the industrial broiler chicken production was launched by the producer. However, these measures do not have big effect on the overall environmental impact of the production network.

In spite of the fact that all the broiler houses are contract farms data collection started quite slowly in broiler chicken farms. Finally, after recalls, 16 broiler chicken farms participated to the study and its detailed data collection which was about half of the farms the inquiry was delivered. Research body organised a feedback discussion workshop for the broiler farms and also detailed feedback was given to the farms. Based on the anonymous survey in feedback workshop and discussions with broiler chicken manufacturer the farms were surprised of the study and satisfied with their efforts, because they could see their position in the farm group in terms of fodder, power and heat consumption. The project strengthened the cooperation between many operators in the chain as well as between industry and research. Most of the involved companies actually joined the new project developing CSR and its criteria with target to utilise product-specific CSZR information of the food products in communication purposes [8]. Results and experiences of this LCA study will be utilised in that context.

The project was probably one of the largest steps for the broiler chicken manufacturer towards environmental awareness as well as responsibility in overall in terms of CSR more as strategic issues in business and product level communication. Other companies involved in the study had longer experience on LCA and experiences moreover strengthened the opinions of companies related to the product integrated environmental management. The detailed LCA results as such were of course a slight surprise up to a point for all the participants due to the fact that any full LCA concerning broiler chicken production has not been published before. From the point of packaging manufacturer and of other chain actors as well the relatively small contribution of logistics and production of packaging to overall environmental impacts were highlighted in the discussions. The role of packaging from the environmental perspective has been discussed more by Katajajuuri and Virtanen [9]. Finally, alternatives concerning treatment and utilising manure has to be analysed more in detail.

Discussion

A well-managed and regionally centred broiler production network has potential and prerequisites to develop the production network less environmentally burdening. Furthermore, the project very clearly indicated that the efforts in the development of the environmental performance should be targeted at the primary (incl. broiler chicken houses) production. Therefore, the importance of the co-operation in-between the industrial chicken producer and their contract broiler chicken farmers needs to be emphasised, as it is the key to significant improvements in the production network.

In terms of magnitude of primary production the results of the study were unexpected by the chain actors, including industrial broiler chicken manufacturer, whose focus in the environmental management efforts had been aimed at the industrial processing. The broiler chicken manufacturing, which includes slaughtering and production of consumer products, for instance, holds quite understandably a significant amount of the energy consumed by the entire network. In relative terms, however, this production site accounts for less than 10% of the total primary energy consumed by the entire network. Nevertheless, the detailed inventory data collection process of this project pointed out direct improvement possibilities, based on which, a separate project on energy saving measures was launched in the premises of the industrial producer. In conclusion, the most important outcome of this case study was the reliable and inclusive information produced, which can be used to develop the production network. This is currently leading broader research and gauging concerning conditions and feeding in broiler houses.

Interviews and observations showed that company-driven joint-effort-studies increased knowledge and learning and supported R&D and innovation activities in these food production networks by identifying the hot spots and improvement options of each network. However, it was pointed out in that the eco-efficiency improvements will evidently be carried out if they are cost-effective as well. If this is not the case the execution of ecological improvements has to be thought much more in detail in companies. Although the farming related processes in the production chain had a significant part of the environmental impacts created, the shared responsibility of the overall environmental performance of the product has to be recognised widely in the production network. The chain is controlled in detail from chick production all the way to the slaughter house operations. Integrated broiler chicken chain has prerequisites to develop the production network into even less environmentally burdening one. There is a need for a common vision and proactive actions in cooperation within the entire production network to find new solutions and to influence on the collaboration in the primary production, especially in grain growing both in broiler and grain farms and in broiler chicken houses. Currently, despite of openness and the good experiences of the study, some companies still see the future prospects and cooperation in different perspective.

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