Available online at www.sciencedirect.com
ScienceDirect
Procedia Food Science 5 (2015) 258 – 261
Procedia Food Science

International 58th Meat Industry Conference "Meat Safety and Quality: Where it goes?"

Environmental performance of the poultry meat chain – LCA approach

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Abstract

This review aims to give an overview of published environmental assessments using the life cycle assessment (LCA) approach. LCA was deployed in terms of five main subsystems in the poultry meat chain: poultry farm, slaughterhouse, meat processing plant, retail and household use. This review revealed that 15 different environmental potentials are used as environmental indicators for estimating environmental performance of the poultry meat chain. General finding is that further research should use the LCA approach to assess the environmental performance of an overall poultry meat chain, focusing on the global warming potential, acidification potential, eutrophication potential and ozone layer depletion.

Keywords: life-cycle assessment; poultry meat chain; environmental potentials

1. Introduction

The environmental impact of livestock production has a major impact on the environment, since meat contributes between 4.6 and 7.1 gigatonnes of greenhouse gases (GHG) each year to the atmosphere and production processes for meat account for between 15% and 24% GHG emissions[1]. The environmental impact of poultry chain is estimated to emit 0.6 gigatonnes CO_2-equivalent[2].

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Peer-review under responsibility of scientific committee of The 58th International Meat Industry Conference (MeatCon2015)
doi:10.1016/j.profoo.2015.09.074

According to ISO 14040, life-cycle assessment (LCA) represents the compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle and it is a tool for the analysis of the environmental burden of products at all stages in their life cycle[3]. A limited number of studies have researched environmental performance in the meat chain, especially the poultry chain. There are papers targeting different aspects of the poultry meat chain, but there is an evident lack of studies concerning life-cycle assessment (LCA) approach for the environmental performance of an overall poultry meat chain. Table 1 gives an overview of the poultry chain LCA manuscripts emphasizing system boundaries and environmental impacts.

Table 1. Summary of studies linking environmental impacts of the poultry chain.

Authors	**Sample**	**Research focus**	**System boundaries**[a]					**Environmental impact**[b]
			1	**2**	**3**	**4**	**5**	
[4]	3 main broiler production systems in the UK	LCA of broiler production systems			✓			GWP, EP, AP, EC, LC, ADP
[5]	Two production scenarios of chickens	Comparison of production of chickens consumed in France	✓	✓	✓			GWP, CED, AP, EP, TEP, EC, LC
[6]	Chicken product	Environmental improvement through LCA methodology	✓	✓	✓	✓	✓	GWP, OLD, AP, EP, WC, CED
[7]	Chicken meat production systems in Switzerland	Environment impacts and selected import sources	✓			✓		CED, GWP, OLD, LC, AP, EP, TEP, HT, WC, FEP
[8]	Poultry slaughterhouse in Brazil	A case study of cleaner production		✓				WC, EP, FD
[9]	Two chicken meals	Life cycle assessment of integrated food chains – Sweden					✓	GWP, AP, EP, POFP
[10]	The US broiler poultry sector	Life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions	✓	✓	✓			GWP, OLD, AP, EP, EC
[11]	Two differing Brazilian poultry production systems	Cradle to gate study	✓	✓	✓	✓		GWP, OLD, AP, EP
[12]	Finnish broiler chicken fillet product	Supply chain integrated LCA method	✓	✓	✓	✓		GWP, AP, EP, OLD, PS, FEP
[13]	Meat production	An estimation of potential future greenhouse gas emissions			✓			GWP

[a]: Subsystem 1 — Poultry farm; Subsystem 2 – Slaughterhouse; Subsystem 3 – Meat processing plant; Subsystem 4 - Retail; Subsystem 5 - House hold use;

[b]: Global warming potential (GWP); acidification potential (AP); eutrophication potential (EP), ozone layer depletion (OLD), photochemical smog (PS) and human toxicity (HT); abiotic depletion potential (ADP); land competition / use (LC); photochemical oxidants formation (POFP); energy consumption (EC); water consumption (WC); cumulative non-renewable fossil and nuclear energy demand (CED), terrestrial ecotoxicity (TEP), Freshwater depletion (FD), fresh water aquatic ecotoxicity (FEP)

2. Life-cycle assessment

LCA is a tool used for identifying hot spots in the production chain which may give opportunities for lowering environmental impacts while improving efficiency and profitability[14,15]. Analysis of Table 1 shows that common potentials analyzed by all authors for subsystem 1 are GWP, AP and EP, for subsystem 2 is EP, for subsystem 3 is GWP, for subsystem 4 are GWP, AP, EP and OLD and for subsystem 5 are GWP, AP and EP.

The system boundaries cover five main subsystems 'poultry farm', 'slaughterhouse', 'meat processing plant', 'retail' and 'household use'. The 'waste and waste water' subsystem is present in each of the five subsystems, which includes all activities related to waste management of solid waste and treatment of waste water.

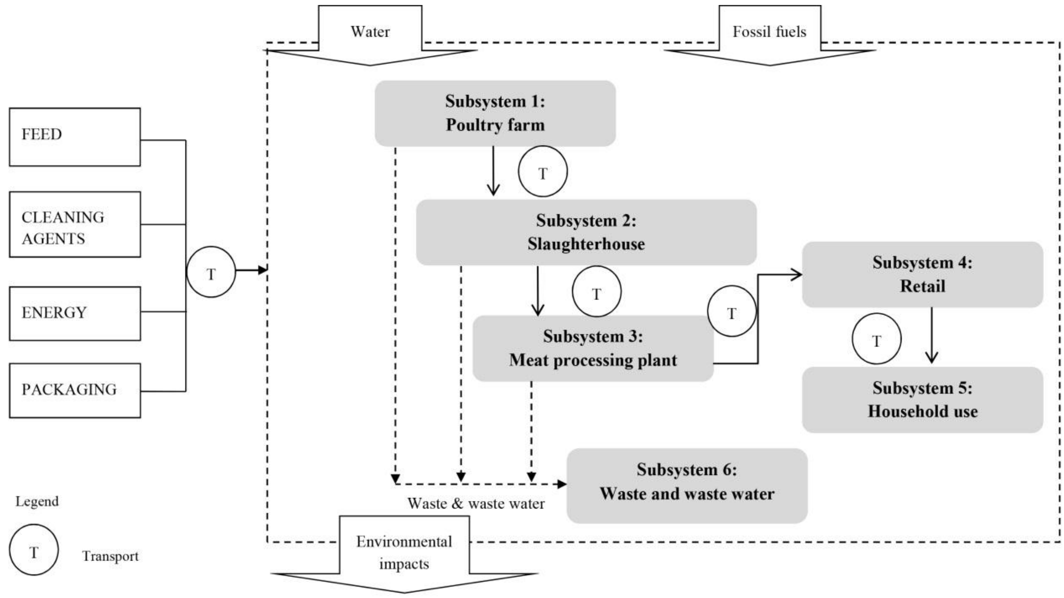

Fig. 1. Generic model of system boundaries of the poultry meat production life cycle.

3. Discussion

Nine out of ten selected studies in Table 1 examined global warming potential (GWP) as important part of poultry meat chain. Research of prediction of environmental impacts of broiler production systems using LCA has found that processing and transport have large environmental impacts, especially in terms of the GWP[4]. Broiler chicken housing and related fodder production was responsible for most of the GWP, as production of fodder accounted for 36% of the total impact, and broiler housing 29% and this result was not only influenced by the emissions from energy consumption, but also by the nitrous oxide emissions from fertiliser production and use, as well as in nitrous oxide and methane emissions from handling broiler chicken manure[12]. In the study concerning estimation of potential future GHG emissions from meat production it was found that meat production (beef, chicken and pig meat) will stay a large producer of greenhouse gases and it will account for up to 6.3% of current greenhouse gas emissions in 2030[13].

In eight examined studies, acidification potential (AP) was regarded as an important environmental impact. As ammonia is an acidifying substance emitted from livestock production, the chicken farm is a large contributor to AP and the reduction in waste lowers acidifying emissions the most[9]. Pardo et al. concluded that up to 20% of GHG emissions connected to packaging were avoided by using biodegradable materials instead of plastic tray and film and that there was reduction in terrestrial acidification (-0.5%), as well as in ozone depletion (-1.5%)[6]. While researching the chicken meat supply chain and environmental impacts for its improvement, Katajajuuri et al. concluded that broiler housing had a large influence on acidification and eutrophication, because of nutrient run-off and leaching and ammonia emissions from broiler chicken manure[12].

Nine selected studies researched eutrophication potential (EP). Study of management of water use at a poultry slaughterhouse showed that dry cleaning procedures, control over the amount of water used on a sector-by-sector basis, better collection of exsanguination residues, automation of the water system and change in the configuration of the wastewater treatment plant through the use of an anaerobic reactor and a sequential oxic/anoxic system for reduction of the eutrophication effect of the final wastewater product should be adopted[8].

Ozone layer depletion (OLD) has been examined in five studies. Production of fertilizers, and especially nitrogen fertilizer, was crucial for ozone depleting emissions[10]. By applying poultry litter to agricultural fields, litter management offsets 1% of global warming emissions, 25% of ozone depleting emissions, 7% of acidifying emissions and 2,5% of eutrofying emissions[10]. Katajajuuri at al. concluded that broiler housing is the most important phase regarding tropospheric ozone formation because of the methane emissions from broiler manure. By using alternative fuels 70% of greenhouse gas emissions from broiler houses could be cut, but it would result in a 7% increase in tropospheric ozone formation because of increased air emissions[12].

4. Conclusion

Implementation of a LCA approach may lead to improvements of sustainability of the poultry meat chain. Further research should use the LCA approach for the environmental performance of an overall poultry meat chain including all the subsystems and focusing on the global warming potential (GWP), acidification potential (AP), eutrophication potential (EP) and ozone layer depletion (OLD). These four environmental potentials have been recognized as the most important in the poultry meat chain, but other environmental potentials should also be further investigated.

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