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Environmental impact of meat industry – current status and future perspectives

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Abstract

This paper gives an overview of the environmental impact of the meat chain. This industry has a significant impact on the environment and current scientific research outlines three main perspectives – product-based using life cycle assessment as a tool; process-based exploring the main environmental aspects and; systems–based, analyzing the rationale for environmental management. Environmental impacts influence three dimensions – climate change, consumption of natural resources and environmental pollution. Future research should focus on environmental impacts of the meat chain expressed in terms of existing and newly developed environmental indicators and identifying solutions for decreasing the overall environmental impact.

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Keywords: meat chain; environmental impact; environmental indicators

1. Introduction

The livestock sector's need for natural resources, such as land, water and energy, is increasing and this sector has a severe environmental impact on air, water and soil[1]. These impacts arise from various emissions into the environment as well as from the consumption of resources associated with production processes[2]. Meat is one of the food products with the greatest environmental impact due to the inefficiency of animals in converting feed to meat. It is assumed that 75-90% of the energy consumed by livestock is needed for body maintenance or lost in manure and by-products such as skin and bones[3]. Depending on the perspective of research, environmental performance

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may be analyzed in terms of the meat product, the manufacturing processes and the system in which the meat companies operate, Fig. 1.

The product-based perspective is mainly performed by calculating various environmental indicators and presenting them in relation to the product, expressed as a functional unit. Depending on the role of the company in the meat chain (farming house, slaughter house and meat processing plant), the most commonly used functional units are one kg of livestock[4,5]; one kg of carcass[6,7] and one kg of meat[8].

The process-based perspective is related to analyzing specific environmental aspects connected with the core and supporting processes in the meat chain. Major environmental aspects are discharge of waste water and solid waste and consumption of water and energy[9,10]. According to European and UN documents, the main environmental performance indicators in meat production are meat yield (share of lean meat in live animal and/or in carcass), solid output (in farming, this is mostly manure; in slaughtering/deboning, this is the percentage of by-product such as offal, bones, fat and skin), energy consumption (electric and thermal) and energy-to-meat ratio, water consumption, waste water discharge and waste water load (mostly chemical oxygen demand) and chemical usage[9,11].

The system-based perspective analyzes existing environmental management systems (EMS) in meat companies. EMS research dimensions are drivers and motivation in implementing EMS; costs and financial issues in implementing EMS and benefits and effects of implemented / certified EMS[12]. Depending on the time dimension, research covers: *ex ante* (prior to implementation of the EMS), ongoing/mid-term (during implementation) and *ex post* (upon implementation).

The main objective of this paper is to present the main research streams for analyzing environmental performance in the meat industry.

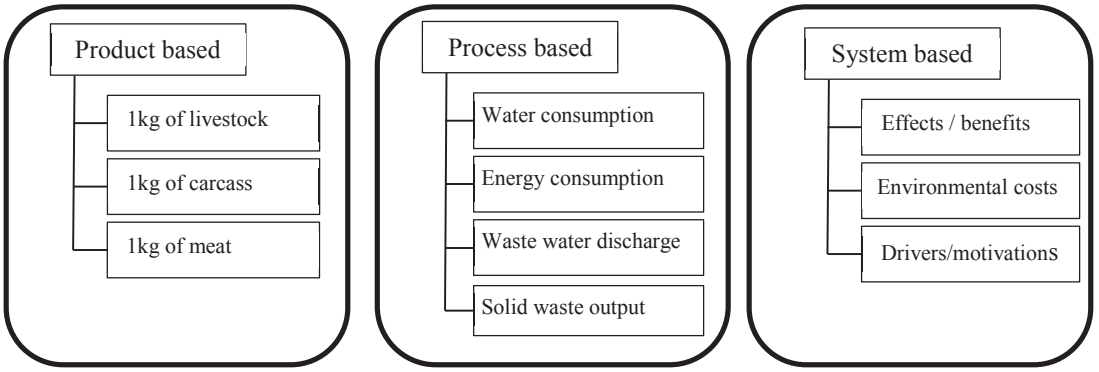

Fig. 1. Environmental research perspectives in the meat chain.

2. Meat product-based perspective

Life cycle assessment (LCA) is an environmental tool that considers greenhouse gasses (GHG) emitted from all stages of agricultural and food production. This methodology is based on ISO 14040:2006 standard and consists of four steps: (i) mapping the process, (ii) setting scope and boundaries, (iii) collecting inventory data, and (iv) interpreting the results[13]. Mapping the process together with setting the scope and boundaries is to clarify which part of the meat chain is analyzed from the "farm to the fork" perspective. It usually covers farms, slaughter houses and meat processing plants, but it may be expanded to cover retail and household use of meat products. Collecting inventory data is the most important part, since the uncertainty of these data may cause imprecise calculation of various environmental indicators. Interpretation of the results is in direct correlation with the boundaries as well as quality of the data collected. Finally, as a result of the LCA study, mitigation strategies can focus on the primary sources of environmental impact within the meat chain, interpreted in relation to the functional unit.

In respect to more than fifteen different environmental indicators developed in the LCA, the main meat chain impacts are global warming potential, acidification, eutrophication and use of resources[14]. It has been confirmed that

farms have heavier environmental loads compared to slaughter houses and meat processing plants. Emission of methane, nitrous oxide and carbon dioxide from manure are the most significant environmental issues, together with acidification and eutrophication potential, and use of natural resources, namely water and energy[4,15]. The most harmful substances from manure/slurry are nitrous oxide (contributing to global warming), nitrate (contributing to eutrophication) and ammonia (contributing to eutrophication and acidification)[4].

3. Process-based perspective

Water is necessary for all stages in the meat processing chain, which starts with live animals entering the facility and finishes at the last step, where meat products leave the meat processing plant[16]. Machines, equipment and processing areas in the meat industry are designated to work in humid conditions requiring wet cleaning. This affects water consumption as well as discharge of waste water contaminated with the product, raw materials and cleaning chemicals[9].

Throughout the meat chain, energy is used for controlling temperature regimes, i.e. heat treatments such as boiling, cooking, pasteurizing, sterilizing drying and smoking and cooling (mainly chilling and freezing)[9]. Besides this, energy is used for various transportation purposes.

There are two main types of solid waste in the meat industry — inedible products such as bones, fat, heads, legs, skins, hair and offal and packaging materials, mainly paper, plastic and metal[16]. Use of animal by-products is highly regulated in developed countries like the EU as outlined in Regulation 1069/2009[17].

Waste water results from many activities such as washing of livestock, carcasses and offal, cleaning of equipment and work environment, workers' personal hygiene and truck washing[16]. Regarding waste water it is important to emphasize that it contains several types of pollutants such as blood, fat, manure, undigested stomach contents, meat and meat extracts, dirt and cleaning agents. The main waste water indicators are the amounts of waste water discharged and the pollutant load that is generated. Both depend on the type of meat and meat products being manufactured and on the technological environment.

4. System-based perspective

The main intention of implementing an EMS based on ISO 14001 standard is to improve the environmental performance for all environmental aspects, including legal compliance[18]. Commitment to environmental protection is growing within the global market[19]. The growth of the number of EMS certificates world-wide and growing public concern has meant that EMS has become one of companies' priorities[20]. EMS provides benefits to companies in relation to better regulatory compliance, effective use of natural resources, increased sales opportunities and improved image of the company[21].

However, an implemented EMS is not a guarantee of an effective system in place. Environmental awareness is one the most important triggers in implementing an EMS since it corresponds to the environmental practice in place. Depending on the level of environmental awareness, two types of companies are identified[19]. The first type develops only competences to fulfil legal requirements. The second type, however, considers their environmental performance in all decision-making processes, in order to increase their share in markets for environmentally friendly products.

5. Conclusion

Meat sector is one of the leading polluters in the food industry. Regardless of the perspective, environmental impacts of the meat chain influence three dimensions — climate change in respect to the global warming potential, acidification potential and eutrophication potential; consumption of natural resources (mainly water and energy) and; polluting the environment with various types of waste and waste water discharge.

This paper has revealed two main areas of further research. First is the calculation of various generic environmental indicators deployed in the meat chain. This type of research helps in benchmarking and comparing various meat technologies worldwide. The second area of research is analysis of existing environmental practices in meat companies throughout the meat chain and exploration of improvement techniques regarding water and energy

consumption, waste water quality and amount of waste generated. Limitation of this work to date is an omission on the part of environmental studies covering meat consumption and eating habits as well as studies into animal welfare issues. Given the great technological and other differences within the meat chain, promotion of environmentally friendly solutions is the utmost challenge.

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