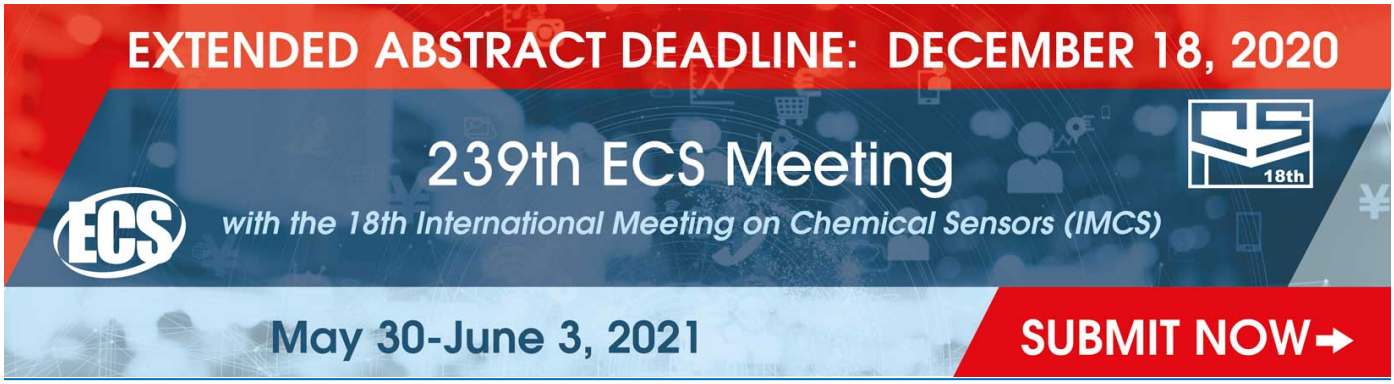
Environmental footprints in the meat chain



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Environmental footprints in the meat chain

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Abstract. The objective of this paper was to present environmental performance of the meat chain and highlight main environmental footprints. The meat sector is recognized as one of the leading polluting sectors in the food industry. The meat chain was analyzed from a five-link perspective introducing the following actors: farm(er)s, slaughterhouses, meat processors, customers and consumers. Meat production needs natural resources (water and energy) resulting in waste and waste water discharge. As an outcome it has a high influence on climate change in respect to global warming, acidification and eutrophication potentials and ozone depletion substances.

1. Introduction

Meat production is increasing as a result of world's population growth and consumption of meat per capita [1]. However, meat is considered as a food product with the greatest environmental impact [2]. Regardless of the role in the meat chain, this type of production seeks for natural resources (land, water and energy) and emits various pollutants into the environment [air, water, land] [3, 4]. Steinfeld et al. assume that all livestock systems occupy up to 30 per cent of the planet's ice-free terrestrial surface area [5]. The future will bring us differences in livestock production between countries [developed vs. developing] and production systems (highly intensive production systems vs. smallholder systems) [6]. Livestock production is characterized with the inefficiency of animals in converting feed to meat since over 75% of the energy consumed is lost in body maintenance, manure and by-products such as skin and bones [2]. At the farm level, manure management is mostly responsible for polluting the environment. Main environmental impacts in slaughterhouses and meat processing plants are usage of energy, usage of water, waste handling and wastewater discharge [7]. The availability of environmental indicators allows comparing the environmental performance over time and against other food companies, highlighting optimization potentials [8].

The meat chain has five main links – farm(er)s, slaughterhouses, meat processors, customers [supermarkets, butcheries, retailers] and consumers [9, 10]. 'Farming' includes all livestock activities which take place in a farm, covering also contribution of feed production and waste/manure management [11]. 'Slaughterhouse' covers reception of live animals, livestock handling, animal welfare, slaughtering and chilling [12]. 'Meat processing plant' starts with reception of carcasses and ends up with the storage of final meat products [12]. 'Customers' are points of sale and cover supermarkets and grocery shops or specialized shops selling meat [10]. 'Consumers' cover refrigeration of food [13], meat preparation and cooking [14]. Meat is consumed for a number of reasons such as nutritional needs and dietary patterns [15] sensory attributes and cultural habits, religion beliefs and wealth [16, 17]. This clarifies why the discussion on the nutritional benefits versus the environmental effects of meat consumption is opposed [18].

2. Materials and methods

A literature review was performed by analyzing scientific manuscripts in the domains of environmental impacts in the meat chain published in databases such as Web of Science, EBSCO, ScienceDirect and GoogleScholar. No geographical restrictions were applied.

2.1. Environmental footprints

Depending on the approach, there are different methods on how to evaluate environmental impacts [19]. The basic approach is in calculating environmental performance indicators [EPIs]. As referred to the latest ISO 14001 standard, EPI is a measurable representation of the status of operations, management or conditions related to environmental aspects [20]. Reasons for calculating reliable numeric indicators are for organization's legal responsibility on environmental issues and for ensuring achievement of certain environmental objectives [21]. Guidance on the design and use of EPIs within an organization on both continual improvement and prevention of pollution is outlined in ISO 14031 [22]. Environmental practices in meat companies show two performance dimensions – environmental and economic [7]. Financial indicators are perceived as backward looking, lacking predictive ability to explain future [environmental] performance, being too summarized to guide managerial action and providing no guidance to evaluate intangible assets [21]. Rule of the thumb for all EPIs are that they should be (i) measurable; (ii) objective; (iii) verifiable; (iv) repeatable and (v) technically feasible [23]. In general there are three levels of EPIs that are related to the maturity of implemented environmental practices, Figure 1.

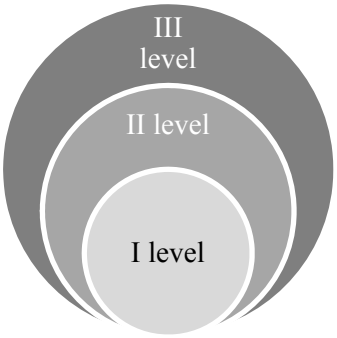

Figure 1. Levels o EPIs

First level of EPIs are elementary indicators showing only figures such as energy and water consumption, waste water discharge or annual food production with no connection between them. Second level introduces functional units such as one kg of livestock [24, 25]; one kg of carcass [26, 27] and one kg of meat [28] and enables correlation between first level EPIs. Most common used second level EPIs are water consumption per functional unit (m^3 of water/kg of food), energy consumption per functional unit (MJ of energy/kg of food), etc. This approach to environmental performance shows the relationship between the organization and the environment, including environmental effects of resources consumed and the environmental impacts of the organizational processes [29]. Third level of EPIs provide information on different footprints on the environment such as ecological footprint, water footprint and carbon footprint as the three most recognized members of the so-called footprint family [30]. The ecological footprint refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social, cultural and economic environment for present and future generations [31]. This footprint is not commonly used in the meat sector. The water footprint is built on the concept of 'virtual' water at a [meat] company level, and the indicator can be estimated for a business or a product by calculating the total water used during the production of goods and services in the entire supply chain [30]. Carbon footprint measures the total set of greenhouse gas emissions caused directly and indirectly by an individual, event, organization or product and is expressed in CO_2 equivalent since the

largest single contributor to climate change is CO_2 [30]. This footprint is very often used in presenting the environmental impact of meat production.

2.2. Meat chain framework

There are three main environmental research perspectives recognized in the meat chain. The first analyzes the meat product perspective through life cycle assessment. This technique calculates environmental indicators in relation to the meat product to assess the potential environmental impacts and consumption of resources [4]. The second focuses on manufacturing processes recognized in the meat industry. This perspective analyzes specific environmental impacts connected with recognized processes that occur on site during meat production / processing [32]. Finally, the third explores the environmental systems in which the meat companies operate [32].

Most common second level of EPIs in the meat production are meat yield (share of lean meat in live animals and/or in carcass), solid output [in farming mostly manure, in slaughtering/deboning percentage of by-product such as offal, bones, fat and skin] and energy consumption [electric and thermal]. Besides these EPIs, meat companies calculate various consumptions and discharges per functional unit such as energy-to-meat ratio, water consumption, waste water discharge and waste water load [chemical oxygen demand] and chemical usage [12, 33, 34]. Simplified generic model of the environmental impact of the meat chain is presented in Figure 2.

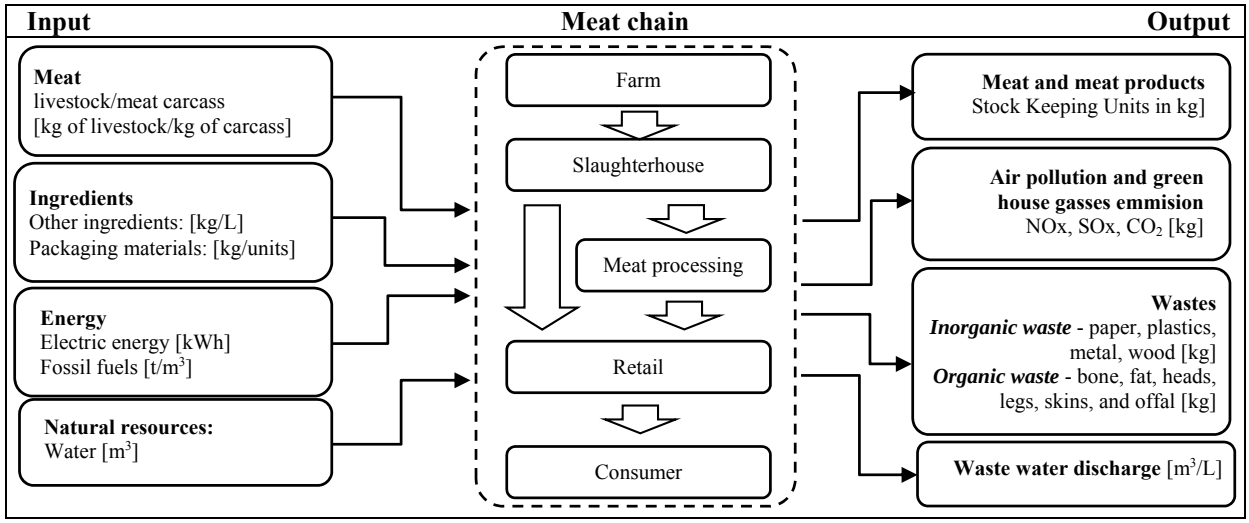

Figure 2: Simplified generic model of the environmental impact of the meat chain

3. Environmental footprints in the meat chain

Although literature review confirms that the greatest environmental impacts arise at farms as a result of livestock production, the entire meat chain has a significant contribution to pollution. The main environmental impacts related to pork production are global warming potential, acidification and eutrophication potential as well as consumption of water and energy [35, 36]. Livestock contributes to global warming potential directly coming from enteric fermentation and manure management and indirectly as a result of feed production [2, 37]. Ammonia is the dominant source of acidifying emissions during animal production [12]. It is released from manure in farms and during manure handling and is dependent on several factor such as physical state, temperature and pH [2]. Liquid manure handling systems emit less ammonia than solid manure handling but liquid/slurry storage stimulates CH_4 production, due to anaerobe conditions [38]. Nitrate leaching from fields during feed production and ammonia release from manure handling dominate the emissions of eutrophying substances as the main contributors to eutrophication in meat production [2]. Two main improvement

streams regarding global warming potential and acidification in meat production are [i] manure management and [ii] feeding strategy [12].

Energy is used throughout the meat chain by the machines and equipment, for controlling temperature regimes (heating / refrigerating) and for transportation purposes [32, 33]. Water is used in all activities in the meat chain. It starts with live animals entering the slaughterhouse, through hygiene and sanitation in slaughterhouses, meat processing plants and retail and finishes at the final – consumption stage [10, 33]. Waste water is a result of various cleaning and sanitation activities such as washing of livestock, carcasses and offal, cleaning and sanitation of equipment and work environment and workers' personal hygiene [39]. At slaughterhouses, water becomes an effluent with high levels of organic load from manure, blood and fat and undigested stomach contents [34].

Speaking about waste in the meat industry, literature recognized two main types - inedible products, mostly bones, heads, legs, hair and offal and various packaging materials [7, 39]. Since consumers prefer lean meat, this causes production of waste in slaughterhouses/meat processing plants [40]. Handling this type of animal by-products is regulated by the law in developed markets, like the EU.

It is known that keeping products at low temperatures inhibits growth of potentially harmful microorganisms [41]. However, the cold chain requirements with their impact on ozone layer depletion due to the use of refrigerants in the processes of chilling / freezing affect the entire meat chain [12]. Development of new refrigerants with low GWP and promotion of natural refrigerants throughout the cold chain is expected [14]. Generic figure of deployed levels of EPIs in meat industry are presented in Figure 3.

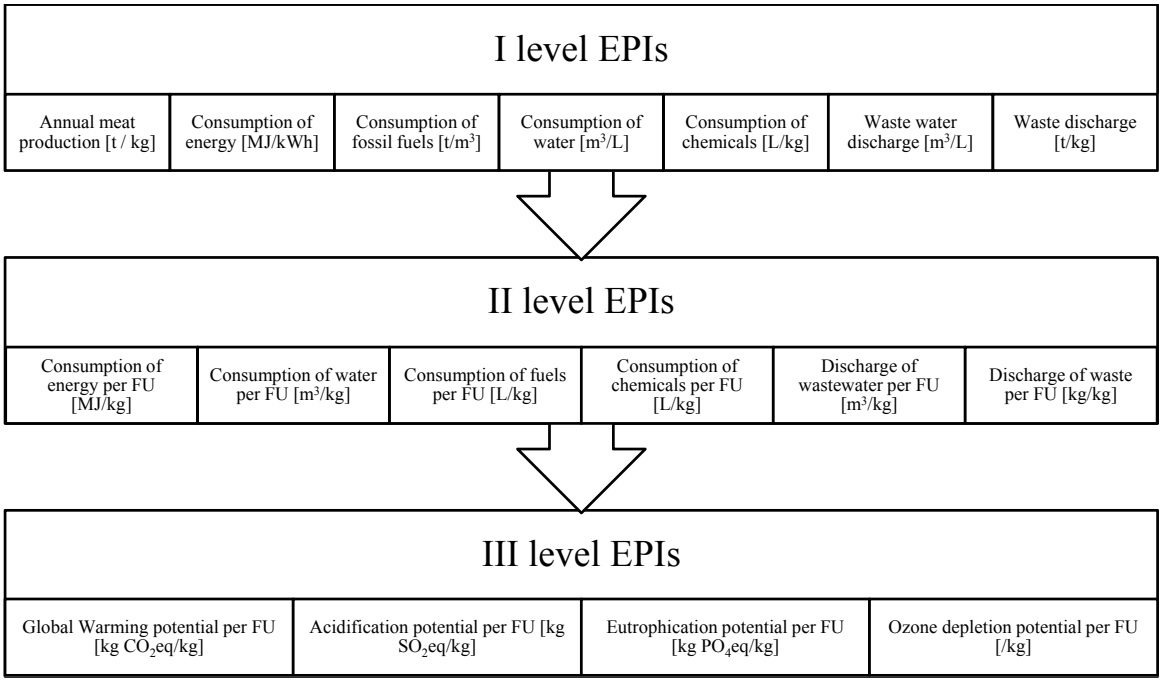

Figure 3: Deployment of three levels of EPIs in the meat chain

Legend: FU – functional unit. In meat industry it is 1 kg of livestock or 1 kg of carcass or 1 kg of meat product [depending on the role in the meat chain].

4. Conclusion

The meat sector is one of the food sectors with global environmental impacts. Regardless of the type of meat produced and technology applied, similar actors in the food chain exist and similar environmental impacts occur. This type of production influences climate change in respect to global warming, acidification and eutrophication potentials and ozone depletion substances and has a high

ratio of consumption of water and energy resulting in waste and waste water discharge. Regardless of differences in meat technology, eating habits and cultural diversity, environmentally sound production is one of the greatest meat chain challenges in 21st century.

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