Environmental life-cycle assessment in production of pork products

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ABSTRACT

The objective of this paper was to assess the environmental performance of the production of pork products in Serbia. Life cycle assessment calculations have been performed to identify and quantify the environmental impacts from a cradle-to-grave perspective covering four subsystems: 'pig housing farm', 'slaughterhouse', 'meat processing plant' and 'waste and waste water treatment'. Structured survey has been conducted in order to collect life cycle inventory input data. Six environmental impact potentials were calculated in this study: global warming potential, acidification potential, eutrophication potential, ozone layer depletion, photochemical smog and human toxicity.

The global warming potential associated with the production of 1 kg of pork products is 9.04 kg CO2eq. Acidification potential within the pork meat chain is 9.874 x 10-3 kg SO2eq while the eutrophication potential is 0.0151 kg PO4eq. The largest contributor to the environmental profile of meat production within the pork meat chain is the production of feed and manure management. Contributions of the processing plants are mainly due to water and energy requirement and use of refrigerants in the cold chain.

Keywords: *life-cycle assessment, pork products, environment, indicators, footprint*

INTRODUCTION

The pig sector is the biggest contributor to global meat production, with over 37 percent and it is expected that global demand for pig meat will grow by over 35 percent until 2030 (MacLeod et al., 2013). Understanding the global warming impacts of meat production on the environment is very important. The predominant greenhouse gases (GHG) emitted from agriculture are methane (CH4) and nitrous oxide (N2O), which respectively possess 21 and 310 times the global warming potential (GWP) of carbon dioxide (CO2) (IPPC, 2006; MacLeod et al., 2013).

Environmental performance indicators in the pig meat production are meat yield (share of lean meat in live pig and/or in carcass), solid output (in farming mostly manure, in slaughtering/deboning 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. Indicators are mostly calculated per 1 kg of meat (final product) as outlined in European Integrated Pollution Prevention and Control document for the food, drink and milk industries, (IPPC, 2006) and in the United Nations Environment Program document (UNEP, 2000).

Life cycle assessment (LCA) is a useful tool as it considers all the GHG 's emitted from all stages of agricultural and food production. It can assist in determining the overall material and energy efficiency of an agricultural system and can assist in the identification of 'hotspots' or polluting stages in production systems (Biswas et al., 2010). As a result, mitigation strategies can focus on the primary sources of the GHG emissions within the food chain. This paper gives a contribution to LCA of meat production within the meat production chain.

According to the global LCA Study on the pig supply chain from the Food and Agriculture Organization, feed production contributes around 60 percent of the emissions arising from global pig supply chains, and manure storage/processing 27 percent. The remaining 13 percent arises from a combination of postfarm proce-

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ssing and transport of meat (6 percent), direct and indirect energy use in livestock production (3 percent) and enteric fermentation (3 percent) (MacLeod et al., 2013).

The main climate change categories related to pork production are global warming potential (GWP), namely emission of methane, nitrous oxide and carbon dioxide; acidification and eutrophication potential as well as the use of natural resources, namely water and energy (Reckmann et al., 2012). From an environmental perspective, 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) (Dalgaard et al., 2007). Although meat processing contributes less to the overall environmental issues, process improvements and decrease of environmental impacts are very desirable.

The meat production sector is among the leading food sectors in Serbia. According to official data for 2011, total pork production in Serbia was around 270 thousand tones (Yearbook, 2012). Environmental impacts of the Serbian meat chain, have not been studied yet. To the best of our knowledge and available data, this paper presents the first life cycle inventory and environmental consequences identification of meat supply chain in this part of Europe.

Due to importance of studying environmental impacts, the objective of this paper was to assess the environmental performance of the production of fresh pork and pork products in its life-cycle from the pig farm, via slaughterhouse to meat processing plant following the same products thought the supply chain during year 2013.

MATERIALS AND METHODS

LCA methodology used in this research was based on the ISO 14040:2006 standard published by the International Organization for Standardization. It included the following steps: mapping the process (setting the goal), setting scope and boundaries, collecting inventory data, and interpretation of the results (ISO, 2006).

Many authors considered limitations in LCA studies related to meat production due to the use of various functional units (FU) (Reckmann et al., 2012). The purpose of FU is to provide a reference unit to which the inventory data are normalized. However, depending on the system boundaries, three most often used functional units were 1 kg of pig produced (Basset-Mens and van der Werf, 2005; Dalgaard et al., 2007); 1 kg of pig carcass (Nguyen et al., 2011; Williams et al., 2006) and 1 kg of bone- and fat-free meat (final product), (Cederberg and Flysjö, 2004). The selected FU, which confers a reference to which inputs and outputs are referred to, was set as 1 kg of pork (fresh pork and pork products) as final product to the customer.

Inputs for the LCA calculations included feed for the pigs, fresh water, packaging materials and cleaning agents, while outputs covered final products, waste and waste water discharge. Energy consumption analyzed in this study covered electrical and thermal energy used in production facilities. Activities taken into consideration were processing activities within the facilities.

The system boundaries covered four subsystems 'Pig housing farm', 'Slaughterhouse', 'Meat processing plant' and 'Waste and waste water treatment'.

Table 1. Physical performance of analyzed pork products chain

Pig housing farm	Number of heads	[kg]
Total production at farm	**3.245**	**313,296.00**
Sold to third parties[1]		
Fatteners	753.00	83,940.00
Breeding gilts	9.00	1,440.00
Weaned piglets	6.00	133.00
Total	**768.00**	**85,513.00**
Sent to slaughterhouse		
Fatteners	1,855.00	199,103.00
Pigs	551,00	14,372.00
Sows and boars	71,00	14,938.00
Total	**2,477.00**	**228,413.00**
Output from slaughterhouse	**[%]**	**[kg]**
Carcass side	75.87%	98,028.00
Trimmed carcass side	2.30%	2,966.00
Sow carcass side	1.88%	2,424.00
Pig carcass main cuts	12.98%	16,767.00
Piglet meat I and II category and young pig	6.98%	9,023.00
Total	**100.00%**	**129.208,00**
Output from meat processing plant	**[%]**	**[kg]**
Fresh Pork	74.37%	96,085.83
Smoked pork	5.69%	7,356.56
Cooked sausages	5.36%	6,921.89
Bacon	2.72%	3,520.33
Fermented sausages	1.14%	1,472.87
Other	10.72%	13,850.53
Total	**100.00%**	**129,208.00**

[1] Part of pig production was sold to third parties (showed in italic).

Subsystem 1 – Pig housing farm included all activities which take place in a farm. Farming of pigs considered feeding sucking piglets, weaned piglets, fatteners, breeding gilts, boars and sows. Subsystem 2 – Slaughterhouse included all activities which take place in a slaughterhouse, from reception of live pigs, covering livestock handling and animal welfare, slaughtering (stunning, bleeding, scalding and dehairing, evisceration, splitting the carcass) and chilling. For the production of 1 kg consumable meat, more than 1 kg of animal must be raised and transported to the slaughtering house. As a result, only parts of the animal that fit for human consumption are kept and the inedible parts are removed in the slaughtering process (Roy et al., 2012). Use of waste and cleaning agents were included in this subsystem and used in the calculations.

Subsystem 3 – Meat processing plant included all activities which take place in a processing plant, from reception of carcasses, covering preparation activities, thermal processing, waste handling and storage of final products. Use of waste and cleaning agents were included in this subsystem and used in the calculations. Subsystem 4 - Waste treatment included issues related to management of manure, solid waste (confiscates and offal) and treatment of waste water. Manure was managed at uncovered anaerobic lagoon (on-site), drained twice a year.

Figure 1 presents a generic model of system boundaries of the pork production life cycle used in this research.

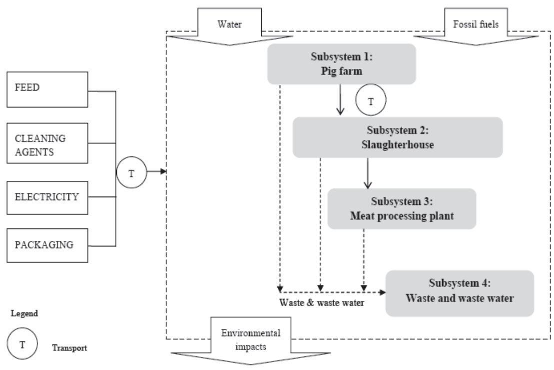

Figure 1. Generic system boundaries of the pork production life cycle. Dark gray subsystem boxes are based on collected real data. Light gray subsystem boxes are based on database

Pig feed included the major ingredients (maize, wheat, soybean, sunflower, yeast, sugar and vegetable oil). The production of additional ingredients (such as vitamins, etc.) which are used in the production of feed was considered as out of the system boundaries due to their small quantities.

Since three subsystems (pig farm, slaughterhouse and meat processing plant) are located at one location, internal transport of livestock to slaughterhouse and carcasses to meat processing plant have not been included since the results do not affect final results. Transportation of feed to the farm, transport of products to retail and final consumption of meat products (i.e. consumer purchasing, food storage and preparation at home, food waste and waste handling of packaging) were not included in this assessment since these data were not available.

In order to collect data necessary for the calculations, a structured questionnaire was developed. It was sent to the selected meat producer in advance giving them time to gather data. The company was requested to provide data for the year 2013, on a 'whole of factory basis' for the three subsystems – pig housing farm, slaughterhouse and meat processing plant. During on-site visits that took place in the period May – September 2014, presented information were discussed with the responsible personnel in order to check uniformity of metric units of the data.

Raw data obtained from the three production facilities, were the main constituents of the foreground life cycle inventory data for the four subsystems. For the purpose of processing data from 'whole of factory basis' to a 'product basis', mass allocation of inputs and outputs (water consumption, waste and waste water discharge, use of acid and alkaline cleaners, and consumption of electric and thermal energy) were used. Average monthly temperatures were collected from official meteorological data in order to calculate environmental impact of manure (Yearbook, 2014). Since part of the production at pig housing farm was sold to third parties (Table 1) allocation was considered as percentage of weight of pigs sent to slaughterhouse divided by the total weight of pigs (86.56%). This ratio was considered for further calculation of inputs of feed and water and output of manure.

Environmental indicators (consumption of water, cleaning agents, energy, disposal / discharge of waste and waste water) were calculated on an annual basis and divided by the total annual quantity of produced final products. All energy units were converted to MJ (MIT Energy Club, 2007). Calculation of CO2 emissions per kWh of used electricity was based on data given for the Republic of Serbia (IEA, 2013). Inventory data for the production of pig meat products expressed per 1 kg of final product are presented in Table 2.

Table 2. Global inventory for the production of 1 kg of pork meat (all subsystems)

	Unit	Pig housing	Slaughter-house	Meat processing	[kg]
Input - Materials					313,296.00
Water	L / kg f.u.	94.61	7.89	5.26	
Cleaning agents (alkaline)	g / kg f.u.		0.40	0.60	83,940.00
Cleaning agents (acid)	g / kg f.u.		0.17	0.26	1,440.00
Feed	kg / kg f.u.	6.625			133.00
Input – energy					85,513.00
Electric energy	MJ / kg f.u.	12.38	2.78	4.18	
Thermal energy	MJ / kg f.u.			0.67	199,103.00
Packaging materials					14,372.00
HDPE bags	g / kg f.u.			0.047	14,938.00
PVC bags	g / kg f.u.			1.528	228,413.00
Output					[kg]
Waste – confiscate	kg / kg f.u.	0.056	0.244		98,028.00
Waste - manure / slurry	m3 / kg f.u.	0.073			2,966.00
Waste water	L / kg f.u.	24.64	7.89	5.26	2,424.00

Acronyms: HDPE - High-Density Polyethylene, PVC - polyvinyl chloride

Carbon Calculations over the life cycle of industrial activities (©CCaLC) database and Ecoinvest database were used (CCaLC, 2013). Summary of data sources considered in this study are presented in Table 3.

Table 3. Summary of data sources considered in this study

Input / output		Source
Energy	Electricity (Serbian profile)	CCaLC database (CCaLC, 2014) International Energy Agency (IEA, 2013)
	Liquefied petroleum gas (LPG)	CCaLC database (CCaLC, 2014)
	Coal	CCaLC database (CCaLC, 2014)
Feed	Maize silage	CCaLC database (CCaLC, 2014)
	Maize for feed	CCaLC database (CCaLC, 2014)
	Wheat for feed	CCaLC database (CCaLC, 2014)
	Soybean for feed	CCaLC database (CCaLC, 2014)
	Sunflower conventional	Ecoinvest database from CCaLC database (CCaLC, 2014)
	Yeast	CCaLC database (CCaLC, 2014)
	Sugar from sugar beet	Ecoinvest database from CCaLC database (CCaLC, 2014)
	Vegetable oil	CCaLC database (CCaLC, 2014)
Packaging materials	Polyethylene bags (HDPE)	CCaLC database (CCaLC, 2014)
	Polyvinyl chloride (PVC) bags	CCaLC database (CCaLC, 2014)
Cleaning agents	Acid chemicals	CCaLC database (CCaLC, 2014)
	Alkaline chemicals	CCaLC database (CCaLC, 2014)
Refrigerant	R-22	(EPA, 2010)
Water	Tap water at user (Europe)	Ecoinvest database from CCaLC database (CCaLC, 2014)
Waste	Biodegradable waste (confiscate / offal)	CCaLC database (CCaLC, 2014)
	Manure	Reserve Livestock Calculation Tool (RLCT, 2012)
	Waste water – industrial treatment	CCaLC database (CCaLC, 2014)

Acronyms: HDPE - High-Density Polyethylene, PVC - polyvinyl chloride

Calculation of refrigerant environmental parameter for R-22 was used from (EPA, 2010). Manure climate impact was calculated using Climate Action Reserve Livestock Calculation Tool (RLCT, 2012) as one of tools recommended by the US Environmental Protection Agency (EPA, 2012). All data processing was performed using © Microsoft Office Pack 2007.

RESULTS AND DISCUSSION

Environmental impact potentials calculated in this study were as follows: global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), ozone layer depletion (ODP), photochemical smog (PS) and human toxicity (HT). Results of the environmental impact assessment calculated per 1 kg of pork are shown in Table 4.

The results show that for GWP, subsystems 1 and 4 dominate with their impact on the environment, due to the impact of feed (subsystem 1) and manure at farm (subsystem 4). The processes contributing to major GHG emissions on livestock farms are: production of feed, enteric fermentation from feed digestion by animals, manure handling and energy use in farms (Röös et al., 2013).

Similar results were presented in the Japanese study, showing that The GHG emission of pork (farm gate, including manure) in Japan were considered to be 5.57 CO2 eq/kg-meat (Roy et al., 2012). On the other side, subsystems 2 and 3 had considerably lower GWP. In Japan GHG emission from slaughtering process of pork was estimated to be 0.12 kg CO2 eq/kg-meat (Roy et al., 2012).

Based on the analysis of over 20 LCA studies, the range of GWP per kg of bone-free meat (subsystems 1 and 2) is from 3.6 to 8.9 kg CO2 eq. (Cherubini et al., 2014; Röös et al., 2013). Studies covered developed countries and different production systems (organic, conventional, high and low profit). Our results show that overall GWP throughout the life-cycle is over 9 kg CO2eq per kg of FU while several European LCA studies showed that an average global warming potential of pork production is 3.6 kg CO2- eq per kg pork, ranging from 2.6 to 6.3 kg CO2- eq per kg pork (Reckmann et al., 2012).

Röös et.al. presented that AP results are in the range from 0.026 – 0.156 (kg SO2e) covering subsystems 1 and 2 (kg of bone-free meat) (Röös et al., 2013). On the other side, de Vries analyzed nine LCA studies on pork production and states that the AP of pork, varied from 43 to 741 g SO2 /kg (de Vries and de Boer, 2010). In our results, Subsystem 4 has the highest contribution to AP (Table 4).

Table 4. Environmental impact assessment results associated with the production of 1 kg of pork products

Impact category	Unit	Sub-system 1	Sub-system 2	Sub-system 3	Sub-system 4	Total
Global warming potential	kg CO_2eq	4.2688	0.4323	0.7247	3.6134	9.0392
Acidification potential	kg SO_2eq x 10^{-3}	1.915	0.148	0.234	7.577	9.874
Eutrophication potential	kg PO_4eq	0.0119	0.0000189	0.0000245	0.00314	0.0151
Ozone layer depletion potential	kg R11 x 10^{-5}	0.0595	1.112	1.669	0.00017	2.839
Photochemical smog potential	kg C_2H_4 x 10^{-4}	0.797	0.0996	0.162	4.33	5.388
Human toxicity potential	kg DCB	0.2196	0.00547	0.0169	0.1299	0.3719

The dominant source of acidifying emissions during animal production is ammonia emissions. Ammonia is released from manure in farms and during manure handling (Röös et al., 2013). The ammonia losses from manure depend on several factors, including temperature and pH. Liquid manure handling systems emit less Ammonia than solid manure handling but liquid/slurry storage stimulates CH4 production, due to anaerobe conditions (IPCC, 2006; Röös et al., 2013). Manure handling in our research was at uncovered anaerobic lagoon.

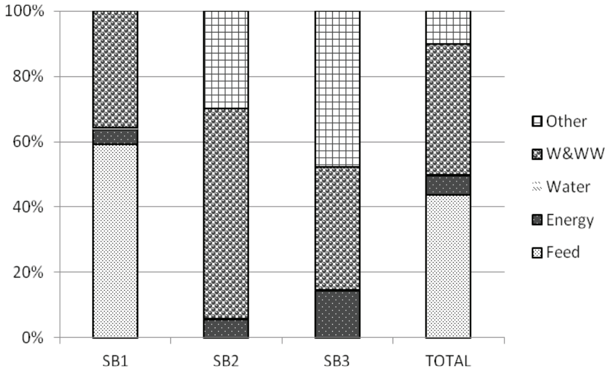

Figure 2. Relative contributions (in %) of Global Warming Potential for three subsystems and overall life-cycle. Acronyms: SB1 – subsystem 1, SB 2 – subsystem 2, SB3 – subsystem 3

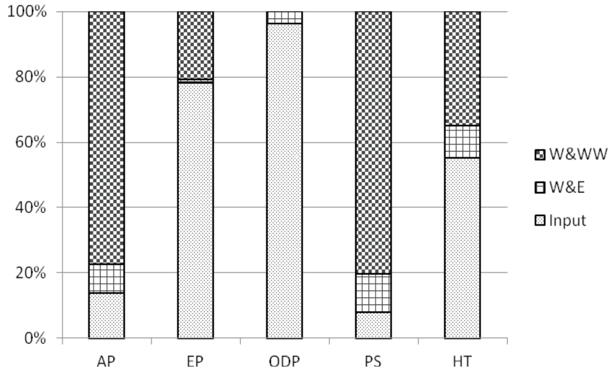

Figure 3. Result (in %) for each environmental impact and category involved in the pork production. Environmental impact acronyms: acidification potential (AP), eutrophication potential (EP), ozone layer depletion (ODP), photochemical smog (PS) and human toxicity (HT).Category acronyms: waste and waste water (W&WW), water and energy (W&E), input: refers to all inputs (feed, water, packaging, cleaning agents)

The main contributor to eutrophication in meat production is the nitrate leaching from fields during feed production and ammonia release from manure handling dominate the emissions of eutrophying substances (Röös et al., 2013). This is confirmed in our results, where subsystem 1 has the highest contribution to EP. Röös et al. showed that EP results are in the range from 0.015 – 0.102 (kg PO4eq) (Röös et al., 2013).

Subsystems 3 and 2 dominate with their impact on ODP due to use of refrigerants in the process of chilling / freezing of meat. Temperature regime in meat production and processing facilities is important since maintain of the cold chain by keeping products under low temperature inhibit growth of potentially harmful microorganisms (Sofos, 2014).

Considering a cradle-to-gate perspective, the results obtained in this study are in accordance with other LCA studies where different meat products were analyzed. Due to the importance of GWP on pork production, relative contributions of each subsystem and major categories were calculated (Figure 2). Major categories were 'feed', 'water', 'energy' (electric and thermal), waste and waste water ('W&WW') and 'other' (potable water, packaging, cleaning agents). The results allowed the identification of inputs with the highest environmental loads. According to these results it is obvious that the production of feed (the main ingredient) for the purpose of feeding pigs significantly contributes to the environmental impacts of Subsystem 1. 'W&WW' is the major contributor to GWP in subsystem 2. Category 'other' contributes the most in subsystem 3. Analyzing the total contribution, categories 'feed' and 'W&WW' play the highest role in GWP. Research in swine carcass production in Brazil also revealed that feed production is a significant contributor to all environmental impact prevailing in GWP, AP and EP, followed by manure management (Cherubini et al., 2014).

Relative contributions of three categories ('Input' – covering all inputs feed, water, packaging, cleaning agents, 'W&WW' referring to waste and waste water and 'W&E' referring to use of natural resources water and energy) to AP, EP, DP, PS and HT as the major environmental impacts in the pork life-cycle, are presented in Figure 3. 'W&WW' is the most dominant categories for AP and PS while 'input' is the most dominant category for EP, ODP and HT.

Limitations in comparing results are due to various factors influencing environmental impact. Cherubini et.al. state some of the reasons for different results in respect to longer period of animal feeding, animal final weight, feed conversion rate, production type (conventional vs. organic), as well as boundaries of the system (Cherubini et al., 2014). Picasso also points out certain limitations such as different metrics with different results that may lead to different recommendations and significant trade-offs exist between carbon foot-print and other relevant environmental variables (Picasso et al., 2014).

There are two main improvement streams regarding GWP and AP in meat production (1) manure management and (2) feeding strategy. Röös found correlations between GWP and AP since feed production is one of the most important sources of GHG for monogastric animals. Use of feed per kg of meat produced gives a higher GWP and has a high correlation to AP (Röös et al., 2013).

Manure improvements can be based on either improving manure management on-site or improving manure quality. Role of manure in overall environmental impact has been highlighted by several authors (Cherubini et al., 2014; de Vries and de Boer, 2010; Steinfeld et al., 2006). There are also high correlations between GWP and EP based on manure handling techniques which reduce nitrogen losses and help reduce both GHG emissions and the most important eutrophying substances (Röös et al., 2013).

Although the price of water in Serbia is lower than in developed countries, water consumption should be emphasized as important. In the pig meat production, water is used for numerous purposes including livestock watering and washing; scalding and carcass washing; production of various meat products; cleaning and sterilizing of knives, equipment and facilities and personal hygiene of employees.

Regarding water saving programs, there are numerous opportunities in minimizing water consumption in the pig supply chain such as optimization of water flow rate, efficient process control, reusing relatively clean wastewaters from cooling systems, vacuum pumps etc. for washing livestock if possible; reusing the final rinse from cleaning operations for the initial rinse on the following day; using high pressure rather than high volume for cleaning surfaces; using automatic control systems to operate the flow of water in hand-wash stations and knife sterilizers (UNEP, 2000).

Improving the quality of wastewater should be considered as a task of high priority. Most water consumed at abattoirs ultimately becomes effluent. Abattoir effluent contains high levels of organic matter due to the presence of manure, blood and fat. Strategies for reducing the pollutant load of abattoir effluent principally focus on excluding blood, fat, manure and scraps of meat from the effluent stream (UNEP, 2000).

Energy is another area where improvement can be made depending on the approach used. Improving simple housekeeping efforts can achieve improvement with limited investments. Additional savings can be made through the use of more energy efficient equipment and heat recovery systems. Finally, recovering methane from the anaerobic digestion of high-strength effluent streams (mostly from manure) to supplement fuel supplies could be a challenge for most pig producers (UNEP, 2000).

CONCLUSION

The meat sector is one of the most important and food manufacturing sectors in Serbia. The study covered the LCA of pig meat production. This study helped in identifying feed production and manure management as main sources of environmental impact. This is in concurrence with previous research of similar LCA studies on meat production. Improvement options need to be supported by and focused on feeding strategy, manure management, water and energy savings and technology improvement.

This study confirmed previous researches that the largest contributor to the environmental profile is feed production and manure management, both present at pig farms. Contributions of the processing plants (slaughterhouse and processing plant) are mainly due to water and energy requirement in order to keep the high level of good hygiene practice.

For most of the improvement options, the overall uncertainty on the environmental improvement is dominated by the assumption of the degree to which the improvement option can be implemented regarding technology level of the meat sector both on farms and processing plants.

Quality of the results and calculations and limitations of the research are directly linked to raw data obtained from company management. Given the great technological and other differences within the meat sector, as well as specific characteristics of pork products in Serbia, more research is necessary to determine if similar results would be derived across the pork supply chain in Serbia and this part of Europe.

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Procjena utjecaja životnog ciklusa u proizvodnji proizvoda od svinjetine na okoliš

SAŽETAK

Cilj je ovog rada bio procijeniti utjecaj proizvodnje proizvoda od svinjetine u Srbiji na okoliš. Izračuni za procjenu životnog ciklusa provedeni su kako bi identificirali i kvantificirali utjecaj na okoliš po načelu „od kolijevke do groba", koji obuhvaća četiri podsustava: 'farmu za uzgoj svinja', 'klaonicu', pogone za preradu mesa' i 'pogon za zbrinjavanje otpada i otpadnih voda'. U cilju prikupljanja ulaznih podataka inventara životnog ciklusa provedeno je strukturirano istraživanje. Navedenim smo istraživanjem procijenili šest potencijalnih utjecaja na okoliš: potencijal globalnog zatopljenja, potencijal zakiseljavanja, potencijal eutrofikacije, potencijal razaranja ozona, potencijal stvaranja fotokemijskog smoga i toksičnost za čovjeka. Potencijal globalnog zatopljenja povezan s proizvodnjom 1 kg proizvoda od svinjetine iznosi 9,04 kg CO2Eq. Potencijal zakiseljavanja unutar lanca svinjskog mesa iznosi 9,874 x 10-3 kg SO2Eq, a potencijal eutrofikacije 0,0151 kg PO4Eq. Na okoliš u lancu svinjskog mesa tijekom proizvodnje najviše utječu proizvodnja stočne hrane i upravljanje gnojivom. Utjecaj pogona za preradu uglavnom se odnosi na zahtjeve za vodu i energiju te uporabu rashladnih sustava u hladnom lancu.

Ključne riječi: *procjena životnog ciklusa, proizvodi od svinjetine, okoliš, pokazatelji, ekološki otisak*

Bewertung des Einflusses des Lebenszyklus in der Produktion von Schweinefleischprodukten auf die Umwelt

ZUSAMMENFASSUNG

Ziel dieser Arbeit war es, den Einfluss der Herstellung von Schweinefleischprodukten in Serbien auf die Umwelt zu bewerten. Berechungen für die Bewertung des Lebenszyklus wurden vorgenommen, um die Umwelteinflüsse zu identifizieren und quantifizieren, nach dem Grundsatz „von der Wiege bis zum Grabe", der vier Teilsysteme umfasst: 'Schweinezuchtbetrieb', 'Schlachtbetrieb', 'Fleischverarbeitungsbetrieb' und 'Abfall- und Abwasserentsorgungsbetrieb'. Um Eingangsdaten über das Lebenszyklusinventar zu sammeln, wurde eine strukturierte Untersuchung durchgeführt. In der genannten Untersuchung haben wir sechs potentielle Umwelteinflüsse ausgewertet: Potential der globalen Erwärmung, Potential der Versauerung, Potential der Eutrophierung, Potential der Ozonzerstörung, Potential der Entstehung von Sommersmog und Toxizität für den Menschen.

Das Potential der globalen Erwärmung, das mit der Herstellung von 1 kg Schweinefleischprodukten verbunden ist, beträgt 9,04 kg CO2Eq. Das Potential der Versauerung innerhalb der Schweinefleischkette beläuft sich auf 9,874 x 10-3 kg SO2Eq und das Potential der Eutrophierung auf 0,0151 kg PO4Eq. Der größte Einfluss in der Fleischkette während der Herstellung haben die Produktion von Viehfutter und die Verwaltung von Düngemitteln. Die Auswirkung des Verarbeitungsbetriebs bezieht sich größtenteils auf die Wasser- und Energieanforderungen und den Einsatz von Kühlmitteln in der Kühlkette.

Schlüsselwörter: *Lebenszyklus-Bewertung, Schweinefleischprodukte, Umwelt, Kennzahlen, ökologischer Fußabdruck*

Evaluación de la influencia del ciclo vital en la producción de los productos de carne de cerdo sobre el medio ambiente

RESUMEN

El objetivo de este trabajo fue evaluar la influencia de la producción de los productos de carne de cerdo en Serbia sobre el medio ambiente. Los cálculos para evaluar el ciclo vital fueron hechos para identificar y cuantificar la influencia sobre el medio ambiente según el principio "de la cuna a la tumba", el cual incluye cuatro subsistemas: 'la planta para crianza de cerdos', 'el matadero', la planta para el procesamiento de carne' y 'la planta para deposito de residuos y aguas residuales'. Fue hecha una investigación estructurada el fin de recoger los datos de entrada del inventario del ciclo vital fue hecha una. Con la investigación mencionada evaluamos seis potenciales impactos sobre el medio ambiente: el potencial de calentamiento global, el potencial de acidificación, el potencial de eutrofización, el potencial de destrucción de la capa de ozono, el potencial de formación de esmog fotoquímico y toxicidad para los seres humanos. El potencial de calentamiento global conectado con la producción de 1 kg del producto de carne de cerdo es 9,04 kg CO2Eq. El potencial de acidificación dentro de la cadena de carne de cerdo es 9,874 x 10-3 kg SO2Eq y el potencial de eutrofización es 0,0151 kg PO4Eq. Dentro de la cadena de carne de cerdo los que más influyen sobre el medio ambiente son la producción del pienso y la gestión del estiércol. La influencia de la planta para el procesamiento de carne se refiere principalmente a la demanda de agua y energía, y el uso de los sistemas de enfriamiento en la cadena de frío.

Palabras claves: *evaluación de ciclo vital, productos de carne de cerdo, medio ambiente, indicadores, huella ecológica*

Valutazione dell'incidenza del ciclo vitale nella produzione dei prodotti di carne suina sull'ambiente

SUNTO

Obiettivo di questo studio è quello di valutare l'incidenza della produzione dei prodotti di carne suina sull'ambiente in Serbia. I rilevamenti per la valutazione del ciclo vitale sono stati eseguiti ai fini dell'identificazione e della quantificazione dell'incidenza sull'ambiente in base al principio "dalla culla alla tomba", comprendente quattro sottosistemi: "impianto d'allevamento di suini", "macello/mattatoio", "impianto di lavorazione delle carni" e "impianto per lo smaltimento dei rifiuti e delle acque reflue". Ai fini della raccolta dei dati d'ingresso dell'inventario del ciclo vitale animale, è stata eseguita una ricerca strutturata. Mediante detta ricerca, abbiamo valutato sei potenziali fattori d'incidenza sull'ambiente: il potenziale di riscaldamento globale, il potenziale di acidificazione, il potenziale di eutrofizzazione, il potenziale di degrado dell'ozono, il potenziale di creazione dello smog fotochimico e di tossicità per l'uomo.

Il potenziale di riscaldamento globale legato alla produzione di 1 kg di prodotti di carne suina è pari a 9,04 kg CO2Eq. Il potenziale di acidificazione nell'ambito della catena di produzione della carne suina è pari a 9,874 x 10-3 kg SO2Eq, mentre il potenziale di eutrofizzazione è pari a 0,0151 kg PO4Eq. Sull'ambiente, nel nell'ambito della catena della carne suina, nel corso della produzione, incidono maggiormente la produzione del mangime e la gestione del concime. L'incidenza dell'impianto di lavorazione delle carni si riferisce in prevalenza alle esigenze di acqua ed energia e all'uso di sistemi di raffreddamento nella catena del freddo.

Parole chiave: *valutazione del ciclo vitale, prodotti di carne suina, ambiente, indicatori, impronta ecologica*