Iranian Journal of Applied Animal Science

Evaluation of Environmental Impacts in Turkey Production System in Iran

Research Article

K. Kheiralipour[1*], Z. Payandeh[1] and B. Khoshnevisan[2]

[1] Department of Mechanical Engineering Biosystems, Ilam University, Ilam, Iran
[2] Department of Agricultural Machinery, University of Tehran, Karaj, Iran

Received on: 8 Dec 2016
Revised on: 24 Mar 2017
Accepted on: 15 Apr 2017
Online Published on: Sep 2017

*Correspondence E-mail: k.kheiralipour@ilam.ac.ir

Online version is available on: www.ijas.ir

ABSTRACT

Poultry industry is an important production system due to providing remarkable portion of the human food and protein needs. Considering the necessity of environmental protection, the amount of environmental impacts of a turkey production unit in Iran was determined using life cycle assessment method. The required information were collected through questionnaires and interviews with farm owners. In this research, the system boundary was poultry farm gate and functional unit was considered as onetonne of turkey meat. The amount of indicators including abiotic depletion, abiotic depletion (fossil fuels), global warming, ozone layer depletion, human toxicity, fresh water aquatic ecotoxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity, photochemical oxidation, acidification potential and eutrophication potential were found to be 1.61 kg Sb eq, 20.19 MJ, 3.63 kg CO_2 eq, 1.90 kg CFC -11 eq, 67.60 kg 1.4 DB eq, 4.55 kg 1.4 DB eq, 1.04 kg 1.4 DB eq, 1.17 kg 1.4 DB eq, 0.0005 kg C_2H_4 eq, 0.024 kg SO_2 eq and 0.0094 kg PO4 eq, respectively. The results showed that the feed input has the highest emissions in comparison with other inputs.

KEY WORDS emission, environment, life cycle assessment, turkey production.

INTRODUCTION

Awareness about environment protection and demand for environmentally friendly products in recent decades has led agricultural researchers to pay more attention to clean production (Khoshnevisan *et al.* 2015). Now, the environment is one of the main elements in the global macro policies. For this reason, the most important factor and prerequisite for many activities at the macro level are compatibility with environment (OECD, 1999). In this regard, some appropriate indexes have been introduced in order to assess the sustainability of agricultural production methods from the point of environmental aspects (Brentrup *et al.* 2004). In the recent decade, life cycle assessment (LCA) is one of the main tools for assessing environmental impacts. In fact, LCA is an environmental management tool via environmental performance evaluation (Guinée, 2002). In addition, the method is suitable for comparison of different agricultural production or processing systems (Bojacá *et al.* 2014; Khoshnevisan *et al.* 2014). Livestock and poultry industries have high importance in terms of providing human required food and protein. Due to the appropriate growing characteristics such as weight gain and high growth rate, low feed conversion ratio and high nutritional value, industrial production of turkey is expanding around the world (Anonymous, 2008). In 2007, the United States, Europe, Brazil and Canada were ranked from first to fourth turkey meat production contries in the world, respedtively. In breeding poultry in Iran, turkey production has the highest economic aspect after chicken production.

Industrial turkey production in Iran was began since 1976. Turkey meat production in 1996 was 25 tonne and in 1997 was increased to 350 tonne per year. In 2014, it was increased to 1700 tonnes per year (Anonymous, 2012; Anonymous, 2013).

Some studies have been conducted in the context of the application of LCA method in agriculture for crop and food production (Rebolledo-Leiva *et al.* 2017; Benis and Ferrão, 2017; Llorach-Massana *et al.* 2017). In livestock and animal production, LCA methodwas used to study the milk production (Cederberg and Mattsson, 2000; Thomassen *et al.* 2008), pig production (Basset-Mens and Vanderwrf, 2005; Nielsen *et al.* 2013) and egg production (Sefeedpari *et al.* 2012; Leinonen *et al.* 2014). Some researches were reported in different countries using LCA method in chicken production, such as: Pelletier *et al.* (2008) in the US, Nielsen *et al.* (2011) in Denmark, Bengtsson and Seddon (2013) in Australia, Ewemoje *et al.* (2013) in Niger, Da Silva *et al.* (2013) in Brazil and French and Gonzalez-Garcia *et al.* (2014) in Portogate. However, there wasn't reported a study about application of life cycle assessment method in turkey production system.

According to importance of preserving environment natural resources in livestock production, the aim of this study was to investigate environmental impacts in turkey production in terms of resource use and environmental impact loads using LCA method.

MATERIALS AND METHODS

Data collection

This research was conducted in 2015. The required data was collected from a turkey production unit with capacity of 16000 chicks and 120 day production period in Najafabad Township, Isfahan, Iran. The township is 26 km far from Isfahan city at 32 degrees and 38 minutes north latitude along the equator and 51 degrees and 21 minutes east of Greenwich meridian. Najafabad is one of the main poultry production townships in Iran.

Life cycle assessment

International Organization for Standardization (ISO) has introduced the life cycle assessment (LCA) as a method for collection and evaluation of inputs, process, outputs and potential environmental impacts of a system over its life cycle. According to ISO, each LCA project includes four stages: 1) goal and scope definition, 2) inventory analysis, 3) impact assessment and 4) interpretation (ISO, 2006a). In this study, LCA method was used to analyze the environmental impacts of turkey. The LCA was carried out based on ISO standard (ISO, 2006b).

Emissions related to inputs and outputs of the turkey production unit were considered to be determined. The emissions were those emitted into water, soil and air be determined were. In this study, inputs were feed, fuel and electricity and outputs were chicken meat and manure. To determine the environmental impacts of the turkey production system, SimaPro Software was used. The collected data were interred to the software and analyzed by CML-IA baseline V3.01 / EU25 model. LCA method was conducted in four stages as follows. The first stage in LCA study is defining the purpose and scope. Defining the goal and scope should be clear and in compatible with the purpose of the study. This stage describes the studied product, goal and scope through its boundaries.

Selecting functional unit in this stage is an important phase. Functional unit is a reference unit that connects the input and output of a system (Sonesson *et al.* 2010). In this study, the functional unit was considered as one tonne of turkey meat in the production unit, i.e. all emissions due to consumed inputs for production of one tonne turkey meat was calculated. Also, the boundary of the studied system was gate of the turkey production unit.

Inventory analysis stage is most laborious and sensitive stage of the LCA study and should be conducted very carefully because further stages are highly dependent on the results of this stage (Leap, 2014). Inventory is actually a set of data that includes the creation of methods to calculate the inputs and outputs resources or materials in the process. Inventory data should be in compatible with the functional unit that it was created in the previous stage. At this stage, basically a collection of data is gathered to be obtained a quantitative analysis of the environmental impacts. To achieve this goal in the presented research, the calculations were done based on the data related to electricity, fuel and feed consumption and producing the manure which the information was provided by the farm owners.

Electricity was used for providing water, lighting, ventilation and powering the feeding system in the production unit. Electricity is supplied from the Isfahan power plant. The environmental impacts of electricity supply depend on used fuel in the power plant to generate electricity. In the power plant 99% of the electricity supply was generated from natural gas and 1% from rresidual fuel (mazut).

The studyed turkey production unit consumes diesel fuel and natural gas for heating and transportation. Therefore, the environmental impacts of diesel fuel and natural gas were calculated in this study.

To calculate the environmental impacts of feed materials, amounts of consumed feeds by birds were calculated based on the information provided by the farm owners.

Turkey manure is used as a fertilizer for growing plants. Because of the low rate of nitrogen in turkey manure, it is an alternative to artificial fertilizers. Greenhouse gas emissions of livestock systems are due to enteric fermentation and manure and that of poultry is from manure only. Poultry manure produces direct and indirect nitrous oxide (N_2O) and methane emissions (Nielsen *et al.* 2011). Methane is emitted through manure storing. The nnitrous oxidedirectly is released from manure surface in unit floor whereas indirect emission of nitrous oxide is result of nitrogen leaching and evaporation (IPCC, 2006).

The environmental impacts of input and output materials in previous stage were determined in impact assessment stage. Impact categories should be established according to objective criteria. There are different methods; some methods state the impacts on human health. For example, Eco Indicator 99 is a method that focuses on global effects such as ecosystems (acidification, eutrophication, land use and toxicity), resources (minerals and fossil fuels) and health (carcinogenic, climate change and ozone layer). Another method evaluates the environmental strategies in terms of life expectancy, morbidity, potential growth of crops, meat or fish production potential, the growth potential of tree and so on.

This stage is automatically done by LCA software. In this study 11 environmental indicators were evaluated including: abiotic depletion, abiotic depletion (fossil fuels), global warming, ozone layer depletion, human toxicity, fresh water aquatic eco toxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity, photochemical oxidation, acidification potential and eutrophication potential. Environmental impacts were assessed based on CML-IA baseline V3.02 / EU25 / Characterization.

In interpretation stage LCA results are scrutinized according to the goals of study, for example, analyzing the results and codificating some conclusions and recommendations in order to minimize the environmental impacts of the studied system (Weiler, 2013). In this section, the results were discussed in order to draw conclusions and provide solution.

RESULTS AND DISCUSSION

The amount of each input and output for the studied turkey production unit has been listed in Table 1. These values were considered to calculate the environmental impacts of the turkey production in the farm. According to Table 1, 457000 kg feed, 20000 l diesel fuel and 41322 kWh electricity was used in the studied turkey production unit. On the other hand, production of turkey meat and manure were 201600 and 180000 kg, respectively. Payandeh (2016) reported the average feed consumption, diesel fuel, gas and electricity to produce chicken in poultry production as 5104 kg, 6021, 1084 m^3 and 1433 kWh, respectively. Output of the poultry was chicken meat and manure with amount of 2400 and 1691 kg, respectively. Based on the above data, the ratio of meat production to feed consumption in turkey production was 0.44 kg meat/kg feed that was lower than that of chicken production (0.47 kg meat/kg feed). These results show that by consuming 1 kg feed, 0.44 kg turkey meat is produced but in poultry production 0.47 kg meet is obtained. Although the difference between the ratio of meat production to feed consumption in turkey and poultry units is low (0.03), but to produce more turkey meat form the consumed feed, the management level of input consumption in the turkey production unit must be improved.

The ratio of meat production to fuel and electricity consumption in turkey production unit were 10.08 kg meet/L diesel and 4.88 kg meet/kWh electricity, respectively, whereas these amounts in poultry production were 3.98 kg meet/L diesel, 2.21 kg meet/m^3 gas and 1.66 kg meet/kWh electricity, respectively. These results show that the consumption of fuel and electricity in turkey production was lower than that of poultry production unit.

In this research, the amount of abiotic depletion, abiotic depletion (fossil fuels), global warming, ozone layer depletion, human toxicity, fresh water aquatic ecotoxicity, marine aquatic ecotoxicity, terrestrial ecotoxicity, photochemical oxidation, acidification potential and eutrophication potential indicators were calculated. The obtained values of the environmental indicators for producing one tonne of turkey meat have been listed in Table 2. As can be seen in Table 2, the amounts of above indicators were 1.61 kg Sbeq, 20.19 MJ, 3.63 kg CO2 eq, 1.90 kg CFC -11 eq, 67.60 kg 1.4 DB eq, 4.55 kg 1.4 DB eq, 1.04 kg 1.4 DB eq, 1.17 kg 1.4 DB eq, 0.0005 kg C_2H_4 eq, 0.024 kg SO_2 eq and 0.0094 kg PO_4 eq, respectively. Payandeh (2016) investigated the environmental impacts of poultry production systems in Isfahan, Iran. The amounts of the mentioned indicators in producing 1000 kg meat were0.0022 kg Sbeq, 40924.976 MJ, 5782.380 kg CO2 eq, 4.225 kg CFC -11 eq, 41447.050 kg 1.4 DB eq, 5866.113 kg 1.4 DB eq, 32057072.3 kg 1.4 DB eq, 1952.126 kg 1.4 DB eq, 1.237 kg C_2H_4 eq, 35.755 kg SO2 eq and 9.881 kg PO4 eq, respectively. Although the amounts of the environmental impacts of turkey were lower than those of the poultry production system, but some inputs were not studied in turkey production such as one-day chick and feeding equipment. This result is due to lower consumption of electricity and fuel in turkey compare to poultry production unit. The role of effective factors in environmental indicators was determined and has been shown in Figure 1. The contribution of feed input in all environmental indicators is higher than those other factors.

Table 1 Amount of input/outputmaterial for onetonne turkey production

Input/output	Unit	Amount
Input		
Food	kg	457000
Fuel	l	20000
Electricity	kWh	41322
Output		
Meat	kg	201600
Manure	kg	180000

Table 2 Amount of emissions in turkey production unit

Impact category	Unit	Amount
Abiotic depletion	kg Sbeq	1.61
Abiotic depletion (fossil fuels)	MJ	20.19
Global warming (GWP 100a)	kg CO_2 eq	3.63
Ozone layer depletion (ODP)	kg CFC-11 eq	1.90
Human toxicity	kg 1,4-DB eq	67.60
Fresh water aquatic ecotoxicity	kg 1,4-DB eq	4.55
Marine aquatic ecotoxicity	kg 1,4-DB eq	1.04
Terrestrial ecotoxicity	kg 1,4-DB eq	1.17
Photochemical oxidation	kg C_2H_4 eq	0.0005
Acidification potential	kg SO_2eq	0.024
Eutrophication	kg PO_4 eq	0.0094

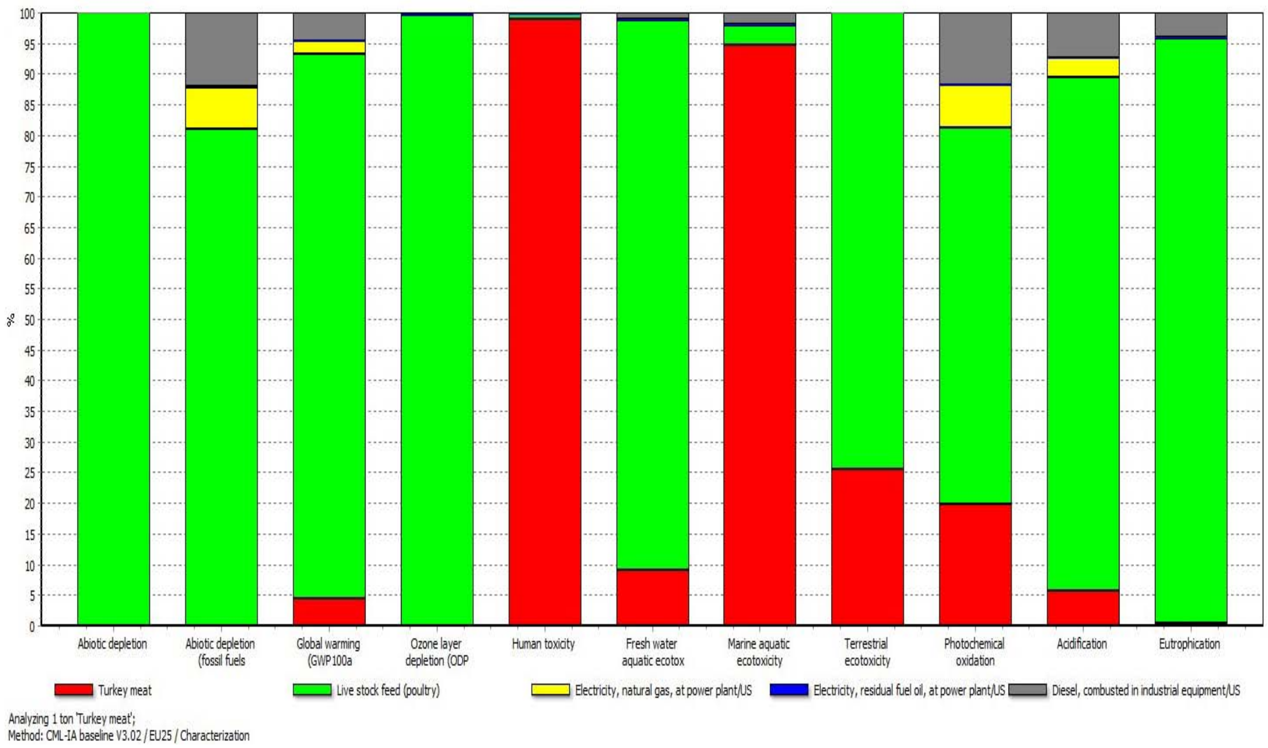

Figure 1 Contribution of resources to environmental impact categories for one tonne turkey produced

This result is in agreement with the results of previous studies by Payandeh (2016), Da Silva *et al.* (2013), Nielsen *et al.* (2011) and Bengtsson and Seddon (2013). The reason of this result is due to use fossil fuels in production of agricultural products that causes increasing of greenhouse gases in feed production process.

As can be seen in Figure 1 the portion of feed contribution to most of indicators was higher that other inputs and outputs. The portion of feed contribution to abiotic depletion, abiotic depletion (fossil fuels), global warming, ozone layer depletion, marine aquatic ecotoxicity, photochemical oxidation, acidification potential and eutrophication potential indicators were 100, 81, 89, 99.8, 89, 61, 84 and 95% respectively. This result shows that the management of input consumption in feed production step (i.e. in crop production farms) must be improved to reduce input materials and environmental impacts.

CONCLUSION

In this study the amounts of inputs and outputs and environmental impacts of turkey production system in Iran were determined. Also influenced of fuel, electricity, enteric fermentation and feed on environmental indicators were evaluated. There was concluded that feed input had the highest effect on the determined environmental indicators. The farmers can apply better input use management, improve the feed productivity and use efficient equipment to increase efficiency, decrease losses and finally decrease environmental impacts. As the emissions related to feed input were higher than others, applying appropriate methods of feed consumption is recommended. The farmers are recommended to use renewable energy such as solar, wind and biomass to reduce environmental emissions in turkey production units and feed production farms. Using intelligent systems to control temperature, humidity and ventilation can reduce fuel consumption.Relevant agencies can help turkey production owners to conduct practical programs to promote emission reduction skills of farmers.

ACKNOWLEDGEMENT

The authors acknowledge the farmers, Najafabad Township, Isfahan, Iran, who provided the useful information for this research. Also Ilam University is appreciated for financial supports of the research.

REFERENCES

Anonymous. (2008). Energy balance sheet. Iranian Energy Productivity Organization. Available at: http://www.saba.org.ir.

Anonymous. (2012). Agricultural statistics. Center of Statistics and Information Technology, Ministry of Agriculture.

Anonymous. (2014). Agricultural statistics. Poultry Information Institute. Available at: http://www.infopoultry.net.

Asheri E. and Karimzadeh Y. (2010). Calculation of production factors productivity in broiler units of West Azerbaijan. *Anim. Sci. J. (Pajouhesh and Sazandegi)*. **86,** 2-7.

Basset-Mens C. and Vanderwrf H.M.G. (2005). Scenario-based environmental assessment of farming systems: the case of pig production in France. *Agric. Ecosyst. Environ*. **105,** 127-144.

Bengtsson J. and Seddon J. (2013). Cradle to retailer or quick service restaurant gate life cycle assessment of chicken products in Australia. *J. Clean. Prod*. **41,** 291-300.

Benis K. and Ferrão P. (2017). Potential mitigation of the environmental impacts of food systems through urban andperi-urban agriculture (UPA)-a life cycle assessment approach. *J. Clean. Prod*. **140,** 784-795.

Bojacá C.R., Wyckhuys K.A.G. and Schrevens E. (2014). Life cycle assessment of Colombian greenhouse tomato production based on farmer-level survey data. *J. Clean. Prod*. **69,** 26-33.

Brentrup F., Küsters J., Kuhlmann H. andLammel J. (2004). Environmental impact assessment of agricultural production systems using the life cycle assessment methodology: I. Theoretical concept of a LCA method tailored to crop production. *European J. Agron*. **20(3),** 247-264.

Cederberg C. and Mattsson B. (2000). Life cycle assessment of milk production-a comparison of conventional and organic farming. *J. Clean. Prod*. **8,** 49-60.

Da Silva V., Wander Werf H., Soareso S. and Corson M. (2013). Environmental impacts of French and Brazilian broiler chicken production scenarios: a LCA approach. *J. Environ. Manage*. **133,** 222-231.

Ewemoje T.A., Omotosho O. and Abimbola O.P. (2013).Cradle-to-gate LCA of poultry production system in a developing country-the case of Nigeria. *Int. J. Agric. Sci*. **3,** 323-332.

Gonzalez-Garcia S., Gomez-Fernandez Z., Dias A., Feijoo G., Moreira T. and Arroja l. (2014). Life cycle assessment of broiler chicken production: a Portouguese case study. *J. Clean. Prod*. **71,** 125-134.

Guinée J.B. (2002). Handbook on Life Cycle Assessment Operational Guide to the ISO Standards. Kluwer Academic, New York.

IPCC. (2006). Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. Published by the Institute for Global Environmental Strategies (IGES), Hayama, Japan.

ISO 14040. (2006a). Environmental Management – Life Cycle Assessment – Principles and Framework. International Standards Organization (ISO), Geneva, Switzerland.

ISO 14044. (2006b). Environmental Management – Life Cycle Assessment – Requirements and Guidelines. International Standards Organization (ISO), Geneva, Switzerland.

Khoshnevisan B., Bolandnazar E., Barak S., Shamshirband S., Maghsoudlou H., Altameem T.A. and Gani A. (2014). A clustering model based on an evolutionary algorithm for better energy use in crop production. *Stoch. Environ. Res. Risk. Assess.* **29,** 1921-1935.

Khoshnevisan B., Bolandnazar E., Shamshirband S., Motamed H., Badrul N., Mat L. and Kiah M.L.M. (2015). Decreasing environmental impacts of cropping systems using life cycle assessment (LCA) and multi-objective genetic algorithm. *J. Clean. Prod*. **86,** 67-77.

LEAP. (2014). Greenhouse gas emissions and fossil energy use from poultry supply chains: guidelines for quantification, Livestock Environmental Assessment and Performance Partnership. FAO, Rome, Italy. Available from: http://www.fao.org/3/a-mj752e.pdf.

Leinonen I., Williams A., Wiseman J., Guy J. and Kyriazakis I. (2014). Predicting the environmental impacts of chicken systems in the United Kingdom through a life cycle assessment: egg production systems. *Poult. Sci*. **91(1),** 26-40.

Llorach-Massana P., Muñoz P., Riera M.R., Gabarrell X., Rieradevall J., Ignacio Montero J. and Villalba G. (2017). N_2O emissions from protected soilless crops for more precise food and urban agriculture life cycle assessments. *J. Clean. Prod*. **149,** 1118-1126.

Nielsen N.I., Jqrgensen M. and Bahrndorff S. (2011). Greenhouse gas Emission from the Danish Broiler Production Estimated via LCA Methodology. Knowledge Center for Agriculture, Denmark.

OECD. (1999). Environmental Indicators for Agriculture. Organisation for Economic Co-operation and Development (OECD) Publications Service, Paris, France.

Payandeh Z. (2016). Life cycle assessment of poultry production in Isfahan Provience. MS Thesis. Ilam Univ., Ilam, Iran.

Pelletier N. (2008). Enviromental performance in the US broiler poultry sector: life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emission. *Agric. Syst*. **98,** 67-73.

Rebolledo-Leiva R., Angulo-Meza L., Iriarte A. and González-Araya M.C. (2017). Joint carbon footprint assessment and data envelopment analysis for the reduction of greenhouse gas emissions in agriculture production. *Sci. Total Environ*. **593(1),** 36-46.

Sefeedpari P., Rafiee S.H. and Akram A. (2012). Comparison of energy consumption and greenhouse gas emissions in dairy-cows and egg laying hen farms in Tehran province. Pp. 65-67 in 1st Nat. Conf. Polic. Toward Sustain. Dev. Tehran, Iran.

Sonesson U., Berlin J. and Ziegler F. (2010). Environmental Assessment and Management in the Food Industry. Woodhead Publishing Ltd., Cambridge, United Kingdom.

Thomassen M.A., Van Calker K.J., Smits M.C.J., Iepema G.L. and de Boer I.J.M. (2008).Life cycle assessment of conventional and organic milk production in the Netherlands. *Agric. Syst*. **96,** 95-107.

Weiler V. (2013). Carbon footprint (LCA) of milk production considering multifunctionality in dairy systems: a study on smallholder dairy production in Kaptumo, Kenya. MS Thesis. Wageningen Univ., Wageningen, The Netherlands.