Journal of Cleaner Production 179 (2018) 160–168

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Environmental assesment of intensive egg production: A Spanish case study

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ARTICLE INFO

Article history:

Keywords:
LCA
Laying hen farm
Egg production
Environmental impact
Carbon footprint

ABSTRACT

Food production in intensive farming systems can be unsustainable in several ways. Although hen egg is consumed worldwide as a very valuable and cheap source of protein, there is an evident lack of studies concerning the environmental performance of egg production. The European Union produces approximately 7 million tonnes of useable eggs per annum and Spain is one of the largest egg producers.

In this work, Life Cycle Assessment (LCA) methodology was applied to analyse the environmental impacts of intensive egg production using as a model a Spanish farm with 55,000 laying hens, producing about 13 million eggs per year. High quality inventory data was obtained directly from this facility. The main factors involved in egg production were included (hen feed, water, electricity, transport, cleaning elements, packaging material, replacement of exhausted laying hens, wastes and gas emissions). Inventory data were analysed using the ReCiPe Midpoint (H) V1.12/Europe Recipe H, the ReCiPe Endpoint (H) V1.12/Europe Recipe H methods and the Greenhouse Gas Protocol V1.01/C02 eq (kg) by means of the LCA software package SimaPro v8.

LCA results showed that, according to normalization results, natural land transformation was the most prominent category, followed by terrestrial ecotoxicity and freshwater ecotoxicity. The most important source of harmful environmental impacts in all the categories under assessment was the production of the hen feed and, to a lesser extent, the purchase of new laying hens to replace the old ones. On the contrary, water consumption and the employment of chemicals for cleaning barely influenced the impact. One aspect that was noteworthy was the beneficial effect on environmental impact produced by the sale of old laying hens for meat production, especially on the urban land occupation and metal depletion categories. Additionally, the carbon footprint of egg production was calculated and a value of 2.66 kgCO_2eq per dozen eggs was obtained. Environmental improvement actions should be directed mainly towards optimizing the hen feed formulation, not only from an economic perspective, but also considering the environmental aspects involved.

1. Introduction

The production of eggs worldwide has been increasing during recent decades. According to the FAO, in 2013 the global production of eggs had reached a volume of about 68 million tonnes (FAO, 2016). The European Union produces approximately 7 million tonnes of useable eggs per annum. Specifically, France and Spain are the largest egg producers (accounting for approximately a quarter of European production) (MAPAMA, 2017).

Food production requires large amounts of energy, which implies several negative environmental impacts such as greenhouse gas (GHG) emissions. In addition, since consumers in developed countries have started to demand high-quality food, produced under more environmentally friendly conditions (González-García et al., 2014), producers confront the contradictory demands of the need to increase food production while having to reduce the ecological impact of intensive production methods (Darnhofer et al., 2016). So, as occurs with other food industries, commercial egg production faces the challenge of producing high quality products in a way that meets consumer expectations, satisfies environmental regulations and maximizes profitability (Freeman et al., 2009). Moreover, egg producing farms are included in the Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry and Pigs contained in the Industrial

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https://doi.org/10.1016/j.jclepro.2018.01.067

Emissions Directive (IED, 2010/75/EU) issued by the European IPPC Bureau. Nevertheless, it was not until the 1980s that the environmental impact of intensive livestock farming was considered a problem. Awareness of the implications of farming activities such as the contamination of soil due to excess manure application and its impact on soil and water quality have increased over the years. Hence, the environmental impacts of agriculture and animal production have been increasingly acknowledged (Paolotti et al., 2016).

The poultry industry is one of the largest and most developed of the existing industries in the agriculture sector (Ghasempour and Ahmadi, 2016). In Spain in 2017 there were 1260 egg producing farms and the average number of hens per egg production facility was 67,700. During the last few years, the tendency in Spain has been to increase the number of hens housed in cages, which now represent 93% of total laying hens (MAPAMA, 2017). Considering all EU countries, in contrast, this percentage is much lower (40%), since free range production facilities are becoming more widespread due to public concern for animal welfare (Leenstra et al., 2014).

Life cycle assessment (LCA) is defined as a method for assessing environmental aspects and potential impacts associated with a product (Calderón et al., 2010, 2017; Iglesias et al., 2012). It has been demonstrated to be a worthwhile tool for quantifying resource use and emissions in a wide range of primary sectors such as meat production (Cederberg, 2014; Velarde et al., 2015) and dairy farms (Hospido et al., 2003) and also in industrial sectors (Tecco et al., 2016; Vázquez-Rowe et al., 2012). In addition, the food system produces a large amount of GHG, specifically 33% of anthropogenic carbon emissions (Zhou et al., 2017). Furthermore, recently, the carbon footprint has been employed as a global measure of the production performance of different foodstuffs (Casolani et al., 2016).

There are papers targeting different aspects of the poultry meat chain (Cesari et al., 2017; Da Silva et al., 2014; González-García et al., 2014; Kalhor et al., 2016; Skunca et al., 2015; Wiedemann et al., 2017), but there is an evident lack of studies involving a life-cycle assessment approach for the environmental performance of egg production in egg producing farms. In fact, there are very few published studies regarding egg production (Cederberg et al., 2009; Dekker et al., 2011; Ghasempour and Ahmadi, 2016; Leinonen et al., 2012; Mollenhorst et al., 2006; Pelletier et al., 2013; Pelletier, 2017). Thus, the aim of this study was to analyse the environmental performances of egg production in a laying hen farm in Asturias (a region in NW Spain), which has been selected as being representative of intensive European egg production. An LCA has been carried out in order to quantify its environmental impact, and to identify the activities with a major environmental impact, which would permit the establishment of a series of actions aimed at improvement of the situation. Additionally, the carbon footprint of egg production was also calculated.

2. Materials and methods

2.1. LCA

2.1.1. Objectives and functional unit definition

In this study, LCA methodology was used as a tool with the objective of determining the environmental impact of a Spanish-type laying hen farm. The functional unit was the annual egg production in 2015 (13,344,000 eggs).

2.1.2. System description and boundaries

The laying hen farm involved in this research is situated in northern Spain (Asturias). The facility, which houses 55,000 laying hens, consists of two industrial units of 1540 m^2 and 1430 m^2, respectively. One of the units is also used as a storehouse for egg packing materials. In addition, an industrial unit of 500 m^2 accommodates an egg-sorting room, an office and a toilet. The facilities are not connected to the municipal sewage system, so wastewater is stored and removed by an authorized company.

Laying hens employed in this farm are hybrids (Rhode Island Red/Light Sussex cross), medium sized (average weight 2.1 kg), of brown colour with some soft white feathers. Following the ban on conventional cages for laying hens in the EU (Council Directive, 1999/74/EC), hens are housed in suspended wire cages placed in four tiers along the length of each industrial unit (Big Dutchman EUROVENT-EV 1250a - EU - 60®). Sixteen-week-old hens are purchased and they are exploited for 75–80 weeks. After their productive life, exhausted hens are replaced by new laying hens and the old hens are sold for meat production. In 2015 all laying hens were removed and replaced with new ones. Hens are fed with commercial fodder for laying hens (see Table 1 for nutritional data) via automatic feed delivery systems and have continuous access to water supplied from nipple drinkers (6 stainless steel nipples per compartment). Eggs are collected daily by automatic belts, moved to the end of each industrial unit and then to a common egg-sorting room where they are packaged in recycled cardboard boxes and trays.

Polypropylene belts beneath the bottom wires collect the manure that is dried by means of an air duct (dry matter content of up to 60%). The dried manure is removed twice a week and loaded directly onto a truck that carries it to a facility which commercialise it as fertilizer.

The system considered included the whole life cycle involved in the production of the eggs: transportation, consumption of energy and water, waste management and emissions.

2.1.3. Inventory analysis

Data were mainly collected through personal interviews with farmers. Additionally, some information was obtained from bibliographic sources. Inventory data have been organized into the subsystems shown in Fig. 1 and they are summarized in Table 2. The following considerations were taken into account for the inventory analyses:

- With respect to packaging and fodder, only those elements that exceed 5% (w/w) of the total were included, so the polyethylene around the pallets used to transport packaging materials was not considered (<0.05% w/w).
- Regarding cleaning materials, only bleach was included in the inventory, since it was the main cleaning agent employed (>90%).
- Drugs were not taken into consideration since they are only occasionally employed and, in addition, the amounts of these medicinal substances used in the farm were insignificant compared to the total incomes and outcomes.

Table 1
Nutritional composition of the commercial fodder employed in the facility under study.

Component	% (w/w)
Protein	17.3
Lipids	4.0
Fibre	4.5
Ash	14.5
Lysine	0.85
Methionine	0.40
Calcium	4.1
Sodium	0.16
Phosphorus	0.51