



Environmental impact of cheese production: A case study of a small-scale factory in southern Europe and global overview of carbon footprint

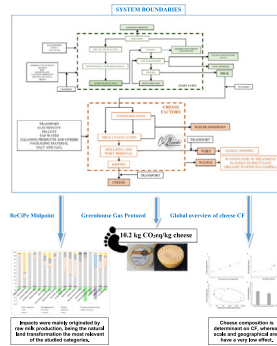
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HIGHLIGHTS

- LCA of a small-scale cheese factory located in Southern Europe was carried out.
- LCA results were determined by milk production impact (cow feeding).
- The use of whey to feed pigs decreases the global impact.
- The carbon footprint was 10.2 kg CO₂ eq kg⁻¹, similar to other full-fat cheeses.
- Cheese composition determines carbon footprint and scale effect is negligible.

GRAPHICAL ABSTRACT



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ABSTRACT

The environmental performance of a small-scale cheese factory sited in a NW Spanish region has been analysed by Life Cycle Assessment (LCA) as representative of numerous cheese traditional factories that are scattered through the European Union, especially in the southern countries. Inventory data were directly obtained from this facility corresponding to one-year operation, and the main subsystems involved in cheese production were included, i.e. raw materials, water, electricity, energy, cleaning products, packaging materials, transports, solid and liquid wastes and gas emissions. Results indicated that the environmental impacts derived from cheese making were mainly originated from raw milk production and the natural land transformation was the most affected of the considered categories. On the contrary, the manufacturing of packaging material and other non-dairy ingredients barely influenced on the total impact. Additionally, an average carbon footprint of the cheeses produced in the analysed facility has also been calculated, resulting milk production and pellet boiler emissions the most contributing subsystems. Furthermore, it was notable the positive environmental effect that entailed the direct use of whey as animal feed, which was considered in this study as avoided fodder. Finally, a revision of published works regarding the environmental performance of cheese production worldwide was provided and compared to results found in the present work. According to the analysed data, it is clear that the content of fat and dry extract are determinant factors for the carbon footprint of cheeses, whereas the cheesemaking scale and the geographical area have a very low effect.

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1. Introduction

The food sector is one of the most important manufacturing and economic sectors in Europe, however, it is also an important source of

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environmental impacts (González-García et al., 2013a). Certainly, the food and beverages sector is responsible for 20–30% of the household environmental impacts in Europe (van Middelaar et al., 2011; Palmieri et al., 2017). The types of foods with the greatest burdens are meat products (beef, pork and poultry) and dairy products (cheese, milk and butter) (Notarnicola et al., 2017). Dairy products constitute a significant source of daily nutrients for human consumption, and are highly recommended as part of a healthy and balanced diet. Nevertheless, their production has been associated with a great environmental impact (Palmieri et al., 2017). Within dairy products, nowadays cheese is experiencing an increasing demand and is the most consumed dairy product after drinking milk (González-García et al., 2013b; Rööß et al., 2016; FAO, 2017). Concretely, the per-capita apparent consumption of cheese represents about 3% of the overall basket in the European Union (Notarnicola et al., 2017). Since fresh milk is a highly perishable product with high transport cost associated, it is commonly processed in the region where it is produced (González-García et al., 2013a). In Europe, after local fresh-milk requirements have been met, cheese has traditionally been considered the preferred outlet for milk, being the European Union the largest producer of cheese in the world (Finnegan et al., 2017). In addition, every year, approximately 10 million tons of cheese are consumed in the EU. This means that, on average, each European yearly eats about 14 kg and it is expected that cheese consumption per capita in the European Union will increase to 16 kg by 2025 (Statista, 2018).

Current patterns of food production and consumption are increasingly considered to be unsustainable in several ways. Lifecycle thinking and assessment, and their analytical power in assessing supply chains, have been recommended as reference methodologies for assessing the impacts derived from food production (Notarnicola et al., 2017). In fact, it has been demonstrated that life cycle assessment (LCA) is a convenient method for quantifying resource use and emissions in a wide range of primary and industrial sectors (Calderón et al., 2010; Laca et al., 2011; Iglesias et al., 2012; Vázquez-Rowe et al., 2012; Calderón et al., 2018; Abín et al., 2018). Particularly, this environmental methodology has been widely applied for the evaluation of the environmental performance of different agro-food products, such as, fish, eggs and meat, paying special attention to the dairy sector (González-García et al., 2013a). In addition, lately carbon footprint has been used as a global measure of the production performance of different foodstuffs regarding the different domains of sustainability. Therefore, carbon footprint is a very effective tool from a communication point of view, although, as reported by Casolani et al. (2016), it is only part of the whole.

The first LCA studies focused on cheese production appeared in 2000 and, since then to now, the number of them has been increasing. However, several authors claim that there is still a lack of information regarding different aspects of the environmental performance of cheese factories (Finnegan et al., 2017). In this context, it should be remark that very little information about the production of small-scale artisanal cheese has been reported. Indeed, to the best of our knowledge, only a few works has been published regarding this issue. Specifically, Vagnoni et al. (2017) analysed the production of Sardinian sheep milk cheese at industrial and semi-artisanal scale in Italy and found that the scale has no effect on GHG emissions in the studied case. In Brazil, Santos Jr. et al. (2017) analysed a small-sized dairy industry and Nigri et al. (2014) assessed the artisanal manufacturing processes of “Minas” cheese. The former author concluded that the artisanal production of “Minas” cheese exerted lower environmental impacts than the industrial process and highlighted the need of further studies on the analysis of the environmental impact of cheese production at different scales.

Moreover, a considerable amount of cheese is produced in Europe, on both artisanal and factory scale, especially in southern Europe (Fox et al., 2017). Concretely, the quantity of artisan cheese producer has grown significantly (Bouma et al., 2014; Maye et al., 2016). Since

2012, FACE (Farmhouse and Artisan Cheese & Dairy Producers European Network) has been working to represent and defend the interests of European farmhouse and artisan cheesemakers. Actually, many cheese producers in Europe, are organized in small, family-owned and operated cheese factories. Spain occupies the seventh position in EU-28 in terms of the volume of cheese produced (EUROSTAT, 2015). There are few dairy multinational companies that account for the main production of industrial cheeses, however, in terms of the number of dairy factories, more than 85% have less than ten workers in Spain. Approximately, 70% of Spanish raw milk is produced in the North of Spain and, concretely Asturias is one of the regions with most tradition in manufacturing cheese, producing more than one hundred varieties, many of them included in the Protected Designation of Origin (PDO) (MAPAMA, 2017).

Cheese has been reported as one of the dairy products with higher environmental impacts and, although the dairy sector has been thoroughly analysed from a LCA perspective, and, as commented above, few environmental information is available about the manufacturing of artisanal cheeses. Indeed, still today, there is a lack of data regarding the environmental impacts associated with small- or large-scale cheese production. In addition, this is difficult to establish predictions since, it is expected that, on one hand, a larger scale entails saving on resources and, on the other hand, a smaller scale with less mechanised processes involves less requirements of energy (Iglesias et al., 2012; Santos Jr. et al., 2017). Consequently, the objective of this work has been to analyse the environmental performances of a small-scale cheese factory, which has been selected as representative of traditional cheese production in southern Europe. This factory is located in a Spanish region (Asturias), where the artisanal production of cheese has a strong traditional character. With this work it is expected to increase the knowledge about the environmental performance of small sized artisanal factories in southern Europe. Particularly, the results obtained here have been analysed and compared to other LCA-studies found in literature with the main aim to determine the possible effects of scale and degree of mechanisation, as well as cheese composition and geographical area, on the impacts derived from cheese production. Besides, the identification of the subsystems with major environmental impacts in the specific factory here analysed would permit to establish improvement actions, which could be extrapolated to other artisanal cheese factories with similar size and organization.

2. Materials and methods

2.1. LCA

2.1.1. Objectives and functional unit definition

LCA methodology was employed with the aim to determine the environmental impact of a small-scale cheese factory sited in southern Europe. The functional unit chosen was 4770 kg of cheese, which is the amount of cheese produced in 2016.

2.1.2. System description and boundaries

The environmental assessment was carried out considering a “cradle to retail stores” perspective including the production of the main raw material and the management of wastes. The small factory selected as a case study for this work is located in northern Spain (Piloña, Asturias) and it produces mainly two different types of artisanal cheeses: “Franxón” Cheese (around 70% of production) and PDO “Casín” Cheese (approximately 30% of production). “Franxón” is a white mould cheese (similar to Camembert), which is made from pasteurized cow milk and matured for 15–20 days. “Casín” is a hard cheese obtained from raw cow milk and matured during 2 months, its texture is crumbly and dry and it possesses a characteristic odour and strong taste. “Franxón” and “Casín” are commercialised as whole cheese with weights of 270 g and 250 g, respectively. They are wrapped in paper and, due to its soft texture, “Franxón” is also packaged inside a poplar wood box. Both types of

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