Life Cycle Assessment of Cheese in Terms of Climate Change

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Abstract. Milk products are important sources of nutrients in the human diet; however, they have a significant impact on the environment, particularly because of the greenhouse gases that are generated during the production of these products. Therefore, this study aims to analyze the impact of life cycle of Cagliata cheese on climate change. In this study, the selected functional unit is 1t of Cagliata cheese produced in Lithuania and exported to Italy. The environmental impact evaluation of the product in terms of CO_2 eq. covered four stages: milk production, cheese production, packaging, and transportation. Emission factors for each stage was recalculated based on data from the cheese producer and the literature review. Results show a total carbon footprint of 2.109 t CO_2 eq./1t of Cagliata cheese throughout the life cycle. The primary production stage of milk contributed the most - some 1.058 t CO_2 eq./1t (50% of the total life cycle carbon footprint), cheese production phase - 0.65 t CO_2 eq./1t of cheese. Based on the results improvement options are suggested for producer to minimize cheese contribution to the climate change.

Keywords: life cycle assessment, cheese, climate change, Lithuania

1. Introduction

Global food production uses more than a third of the world's land surface, accounting for about 30% of all anthropogenic greenhouse gas (GHG) emissions (Garnett, 2011). The food industry is therefore a major contributor to climate change, eutrophication and biodiversity loss. The increasing environmental impact is because current patterns of food production and consumption are considered unsustainable (Natarnicola et al, 2017). Climate change, eutrophication, biodiversity loss, and other negative impacts are associated with problems arising from population growth and growing food demand (Godfray, Garnett, 2014).

Dairy products are an important source of nutrients and an integral part of the human diet (Kim et al., 2014), but they are also associated with significant environmental impacts, especially due to greenhouse gases generated during the production of these products (Milani et al., 2011, Gonzalez-Garcia et al., 2013). The dairy industry generates wastewater that can have a strong impact on the environment due to its pollutant properties (Mirabella et al., 2014; Prazeres et al., 2012). Climate change is also affecting milk production itself, with direct and indirect effects on agriculture. Direct effects include effects on crops; indirect effects include increased numbers of pests and pathogens (Gauly et al., 2013). It is therefore essential to find the most effective ways to reduce the impact of food production on the environment, as well as ways to adapt to climate change and meet the challenges posed by a growing human population.

The first life-cycle studies for cheese production appeared a couple decades ago. Since then, the number of life cycle analysis (LCA) for cheese production has grown. However, there is still a lack of information on environmental performance aspects that could be used in the cheese-making industry (Finnegan et al., 2017). In Lithuania, life cycle analysis for a specific food product is still rarely applied. Therefore, this study aims to apply LCA for *Cagliata* cheese produced in one of the biggest milk industries in Lithuania.

2. Methods

The object of the research was the semi-hard cheese Cagliata, which was chosen taking into account the fact that its production volumes in the company are one of the largest in comparison with other products. This cheese is made without any additives or preservatives. Salt is used in small amounts, but not included into LCA analysis.

The functional unit is 1 tonne of Cagliata cheese exported to the Italian market. The results are presented in t CO_2 equivalent of 1 t Cagliata cheese. The boundaries of the system cover four stages: 1 - milk production, 2 - cheese production, 3 - packaging, 4 - transportation. Data received from the company: consumption of electricity, packaging materials, fuel, heat, raw milk and amount of cheese produced in 2017.

Based on literature review (Basset-Mens et al. 2009, Capper et al. 2009, Cederberg et al. 2009, Guignard et al. 2009, Thoma et al. 2013), an average of 1,058 CO_2 eq/t was used to calculate the greenhouse gas emissions from the production of milk for Cagliata cheese.

The main factor determining greenhouse gas emissions at the cheese-making stage is energy consumption. In this study, the emissions from the production of 1 tonne of

Cagliata cheese were calculated on the basis of A. Flysjö (2012) CO_2 equivalent for milk processing, which was selected according to the type of cheese and is equal to 0.65 CO_2 eq./t of cheese production.

Cagliata cheese is packaged in two types of packaging - blocks of 14-16 kg and spherical packaging of 10 kg. Cagliata cheese packaging emissions were calculated using the CO_2 equivalent values of different packaging materials provided by the James (2010) and the data on materials used for packaging Cagliata cheese in 2017 from the enterprise.

Greenhouse gas emissions during the transportation stage of Cagliata cheese were calculated using the average distance traveled, transporting raw milk and the final cheese product from the enterprise location, and taking into account the return of trucks. Milk is being transported from Lithuania, Latvia and Estonia. The 90% of cheese goes to Italy. Formula and emission factors by vehicle fuel type were used to assess the impact of the transport phase on climate change according to the Breisinger (2012).

3. Results

Enterprise produced 34,072.63 t of cheese in 2017, 58% (19 658.43 t) of it was Cagliata cheese. During 2017, 196,584.27 t of raw milk was used for Cagliata cheese production. As 10 tons of raw milk are needed to produce 1 ton of cheese, during the production of milk a total of 20798,616 t of CO_2 eq. was released. After recalculating the impact of the agricultural phase on climate change, 1.058 t CO_2 equivalent was determined per 1 tonne of cheese. This corresponds to 50% of all carbon footprint of the cheese (Fig.1).

During the production stage of Cagliata cheese 12777.98 t CO_2 eq. (0.65 t CO_2 eq./1 ton of functional unit) was released into the environment.

The main packaging for Cagliata cheese is tertiary wood (pallet) packaging - 0.016 t of raw material per ton of cheese, which accounted for 73% of all packaging raw materials used for packaging this cheese. The second fraction, according to the packaging weight, was paper (cardboard) packaging - 0.004 t/t (16%), the smallest part of the packaging consisted of plastic bags - 0.002 t of raw material for 1 ton of cheese (11%). However, the contribution to the carbon footprint from plastics was the highest. The total impact of the cheese packaging phase on climate change was 0.017 t CO_2 eq./1 functional unit.

The calculated total greenhouse gas emissions from the transportation stage were 0.384 t CO_2 eq./1 ton of cheese. Cheese transportation accounted for 0.195 t CO_2 eq./1t (51%) of transport emission values, and milk transportation accounted for 0.189 t CO_2 eq./1t. (49%). The mass of milk required for cheese production is 10 times higher than that of exported cheese products, but due to the longer transport distance, the contribution of cheese products and raw milk to climate change differed slightly.

The total life-cycle environmental impact of the cheese was calculated to be 2.109 t CO_2 eq. /1 t of cheese.

4. Conclusions and recommendations

Total contribution to climate change of life cycle of the cheese was 2,109 t CO_2 eq./1t of cheese. Results are similar to those of Clune et al. (2017), but higher than Bava et al. (2018), Vagnoni et al. (2017) and González-Garcia et al. (2013).

The milk production stage had the greatest impact on carbon footprint during the life cycle of Cagliata, amounting to 1,058 t CO_2 eq. /1t of cheese - 50% of the total impact on climate change. Meanwhile, the second most important is the cheese production stage, which amounts to 0.650 t CO_2 eq./1t of cheese (31%) contribution to climate change.

The cheese production phase contributes to climate change due to the high energy consumption of milk processing and cheese production. The transportation phase amounted to 0.384 t CO_2 eq. /1t cheese (18%) and packing stage 0.017 384 t CO_2 eq. /1t of cheese (1%).

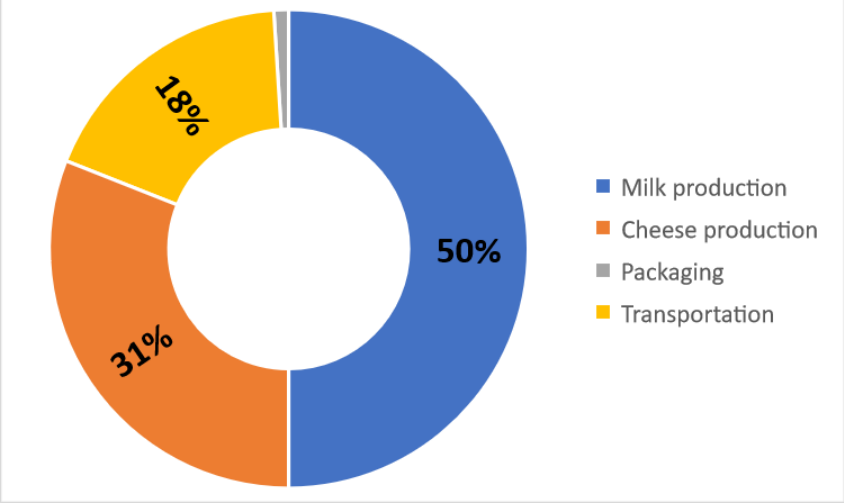

Figure 1. Contribution of life cycle stages to total carbon footprint of the cheese.

Improvement analysis suggests that a total reduction in carbon footprint up to 1,537 t CO_2 eq./t cheese could be achieved. Milk classification (selecting the one suitable for cheese production) at early stages, more efficient energy use and more efficient use of transport contribute to those reductions and were proposed to producer.

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