J. Dairy Sci. 94:5833–5841
doi:10.3168/jds.2011-4545

Potential for improving the carbon footprint of butter and blend products

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ABSTRACT

To reduce the environmental impact of a product efficiently, it is crucial to consider the entire value chain of the product; that is, to apply life cycle thinking, to avoid suboptimization and identify the areas where the largest potential improvements can be made. This study analyzed the carbon footprint (CF) of butter and dairy blend products, with the focus on fat content and size and type of packaging (including product waste at the consumer level). The products analyzed were butter with 80% fat in 250-g wrap, 250-g tub, and 10-g mini tub, and blends with 80% and 60% fat in 250-g tubs. Life cycle assessment was used to account for all greenhouse gas emissions from cow to consumer. A critical aspect when calculating the CF is how emissions are allocated between different products. Here, allocation of raw milk between products was based on a weighted fat and protein content (1:1.7), based on the price paid for raw milk to dairy farmers. The CF (expressed as carbon dioxide equivalents, CO_2e) for 1 kg of butter or blend (assuming no product waste at consumer) ranged from 5.2 kg (blend with 60% fat content) to 9.3 kg of CO_2e (butter in 250-g tub). When including product waste at the consumer level, the CF ranged from 5.5 kg of CO_2e (blend with 60% fat content) to 14.7 kg of CO_2e (butter in mini tub). Fat content and the proportion of vegetable oil in products had the greatest effect on CF of the products, with lower fat content and a higher proportion of vegetable oil resulting in lower CF. Hence, if the same functionality as butter could be retained while shifting to lower fat and higher proportions of vegetable oil, the CF of the product would be decreased. Size and type of packaging were less important, but it is crucial to have the correct size and type of packaging to avoid product losses at the consumer. The greatest share of greenhouse gas emissions associated with butter production occurred at the farm level; thus, minimizing product losses in the whole value chain—from cow to consumer—is essential for efficient production.
Key words: butter, dairy production, life cycle assessment, carbon footprint

INTRODUCTION

Climate change is one of the greatest concerns facing our society (Steffen et al., 2007). The food sector represents up to about one-third of global anthropogenic greenhouse gas (**GHG**) emissions, if also including emissions from deforestation (Barker et al., 2007), and the Food and Agricultural Organization of the United Nations has estimated that the livestock sector is responsible for 18% of GHG emissions (Steinfeld et al., 2006). The dairy sector represents 4.0% of anthropogenic GHG emissions, including those relating to meat production from dairy-related culled and fattened animals (Gerber et al., 2010). Emissions associated solely with milk production, processing, and transportation of milk and dairy products comprise an estimated 2.7% of global anthropogenic GHG emissions (Gerber et al., 2010).

With a growing population and limited land resources for cultivation, it is evident that the food sector, and not least the dairy sector, faces a major challenge. Furthermore, with a predicted increase in demand for animal products (FAO, 2006), efficient production is crucial. The most efficient way to reduce emissions is to consider the whole value chain of a product; that is, to apply life cycle thinking. In recent years, efforts to quantify the contribution of food products to climate change have increased dramatically, resulting in several standards and guidelines on how to calculate the carbon footprint (**CF**). Studies analyzing the CF (and other environmental impacts); for example, on milk and dairy products, have already been carried out in different countries (Berlin, 2002; de Vries and de Boer, 2010; Nilsson et al., 2010). Many companies, such as Arla Foods (Viby, Denmark), Fonterra (Auckland, New Zealand), Unilever (Rotterdam, the Netherlands), and Nestlé (Vevey, Switzerland), are all engaged in efforts to map the CF of their products. Retailers are also placing high emphasis on CF; for example, Walmart (Benton-

Received May 18, 2011.
Accepted August 16, 2011.
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ville, AR) has initiated the Sustainability Consortium, where the food industry meets to develop guidelines on how to assess the environmental impact of products, and Tesco (UK) and Casino (France) have begun to label dairy products with CF values. In addition to calculating a product's CF, and thereby knowing which products have a lower contribution to climate change, life cycle assessment (**LCA**) is primary used to analyze "hot spots" in the value chain and thus identify where to reduce emissions most efficiently.

The present study analyzed the CF of butter produced at a dairy in Holstebro, Denmark, with the aim of identifying crucial aspects to consider in CF studies on butter. Nilsson et al. (2010) compared the environmental impact of butter and margarines and showed that the latter (i.e., based on vegetable raw material) gave rise to lower GHG emissions than butter, and that fat content in the product had a significant effect on the outcome. Because the greatest share of emissions occurs before the farm gate, it is important to have good data on raw milk at the farm level. The present study used more recent and detailed data to account for the full life cycle of butter and blends, whereas Nilsson et al. (2010) used published data for butter and did not include the consumer stage. Additionally, the present study analyzed different sizes and types of packaging, comparing the CF of different butter and blends, considering fat content and size and type of packaging, including product waste at the consumer level. The overall aim was to identify the most obvious areas for potential improvement, thus maximizing the reduction in emissions.

MATERIALS AND METHODS

Life cycle assessment is a method to assess the potential environmental impact of products or services in a life cycle perspective; that is, from cradle to grave. Such studies are typically made in accordance with the international standards ISO 14040 and 14044 (ISO, 2006a,b). Life cycle assessment is also used when calculating the CF for products, but in that case, the focus is on a single impact category; namely, the contribution to global warming. More specific recommendations on how to calculate the CF for dairy products are provided in IDF (2010), which was used as the basis for the present study. Analyzing the CF of a product includes all emissions associated with the product's life cycle expressed as carbon dioxide equivalents (**CO_2e**). For dairy products, the most important greenhouse gases are CO_2, CH_4, and N_2O. The characterization factors (in a 100-yr perspective) are as follows: 1 kg of CO_2 = 1 kg of CO_2e; 1 kg of CH_4 = 25 kg of CO_2e; and 1 kg of N_2O = 298 kg of CO_2e (Forster et al., 2007). Calculations in the present study were performed using the LCA software tool SimaPro7 (PRé Consultants bv., Amersfoort, the Netherlands; www.pre.nl).

System Description

Figure 1 shows the flowchart of the system investigated, which includes all activities from cow to consumer, including all farm inputs as well as waste management of consumer packaging. The products analyzed in the present study were produced by Arla Foods at the Holstebro dairy in Denmark, and the production flows are illustrated in Figure 2. Milk produced on Danish dairy farms is collected and transported to the nearest dairy. To maximize efficiency of production, all Arla Foods dairies are specialized and more than 80% of the Arla Foods butter and blends in Denmark are produced at the Holstebro site. Thus, a large amount of cream from other sites is transported to Holstebro and used for butter production. Besides butter, the Holstebro Dairy produces some secondary products (skim milk, cream, and buttermilk), which are primarily used in soft cheese production.

Functional Unit

The functional unit (**FU**) is a quantified performance parameter of a product system under analysis to which all inputs and outputs (or interventions) in that product system are referred. In this study, 2 FU were defined: (1) 1 kg of packaged butter or blend provided at the customer level in Denmark, and (2) 1 kg of packaged butter or blend consumed in Denmark.

The only difference between the 2 FU is that product waste at the consumer stage was included for the second FU. As relatively large uncertainties exist regarding food waste at the consumer level, we chose to show results both excluding and including consumer product waste. The actual products compared were (1) four 250-g packs of wrapped butter (80% fat, 0.60% protein) at a household in Denmark; (2) four 250-g tubs of butter (80% fat and 0.60% protein) at a household in Denmark; (3) one hundred 10-g mini tubs of butter (80% fat and 0.60% protein) at a restaurant in Denmark; (4) four 250-g tubs of blend [80% fat (68.5% butter + 31.5% vegetable oil), 0.50% protein] at a household in Denmark; and (5) four 250-g tubs of blend [60% fat (63% butter + 37% vegetable oil), 0.40% protein] at a household in Denmark.

Allocation

Some activities give rise to more than one product; for example, a dairy cow produces milk but also ap-