Life Cycle Assessment of Miyoko's Kitchen Non-Dairy Cheese

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Summary

Life Cycle Associates examined the greenhouse gas (GHG) emissions associated with the production of Miyoko's Kitchen non-diary milk and cheese products. Emissions on a life cycle basis were compared to comparable dairy products. The life cycle of cheese includes the production of inputs, transport, and cheese processing. Life cycle GHG emissions for Miyoko's Kitchen non-dairy cheese are over 10 time lower than those from dairy cheese. The cashew milk has one-third of the GHG emissions per liter of milk. The lower GHG emissions are due to several factors. First, the contribution of methane from enteric fermentation and manure management in cows results in a high GHG intensity for milk production. Since methane has a greater warming effect than CO_2, the dairy pathway has intrinsically high GHG emissions. Secondly, cashews are organically grown with low farming inputs. These primary factors result in the milk and cheese products with much lower GHG emissions than the dairy alterative.

1. Introduction

Miyoko's Kitchen produces non-dairy milk and cheese products that contains protein and nutrients from cashew nuts. There are many reasons to expect that milk and cheese made from cashew nuts should be highly sustainable. The cashew nuts used in the process of producing cheese and milk are grown organically and rainfed, which means no synthetic fertilizers or chemicals are used and there is no irrigation. Several life cycle assessment (LCA) studies have shown that synthetic fertilizers have the highest contribution in overall GHG emissions of crops (Vinyes et al., 2018). Moreover, cashew is a perennial crop and Perennials are expected to provide greater protection against soil erosion, retain more water and nutrients, store more carbon in biomass, and be more resilient to pests compared to annual crops (Cox et al., 2006).

In order to scientifically assess the relative environmental impacts of cashew milk and cheese and other substitute products, Miyoko's Kitchen embarked on a life cycle assessment study to quantify the greenhouse gas emissions of production and use of cashew cheese and milk.

2. Goal and Scope

The goals of this study are to examine the greatest contributing factors to cashew milk and cheese greenhouse gas (GHG) emissions throughout its life cycle, compare cashew milk and cheese to the most popular dairy and non-dairy products available in the U.S. market. The scope of the GHG study covers from the farming to retail steps of dairy and non-dairy milk and cheese production, with the added step of packaging production and disposal.

System Boundary

The system boundary defines the scope of activities and emissions associated with a life cycle analysis. General classes of inputs and outputs are identified for key processing steps. The system boundary for the substitute products is the same to ensure that the analysis is performed on a consistent basis. Transport emissions of finished products are excluded from this study because they are the same in all cases, and therefore cancel out. However, since cashew is imported from Vietnam, the transportation of cashew nuts is included in the LCA. The system boundary diagram in Figure 1 shows the life cycle steps that are included in the cashew milk and cheese life cycle assessment. The life cycle steps for dairy milk are slightly different, as shown in Figure 2.

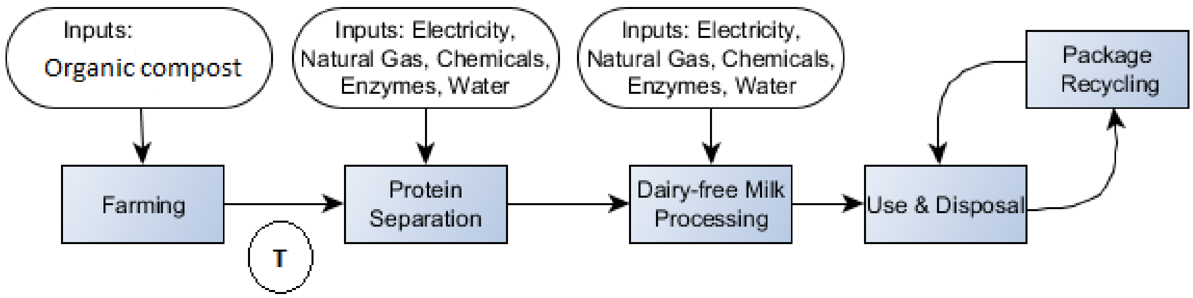

Figure 1. Non-Dairy Milk and Cheese System Boundary Diagram.

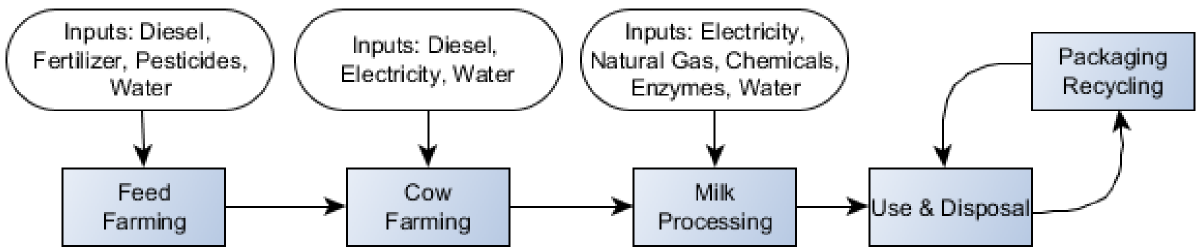

Figure 2. Dairy Milk System Boundary Diagram.

Functional Unit

The functional units correspond to the units used to sell food products - the mass or volume of the products, in case of milk, the functional unit is 1 L of product and for cheese is 1 kg. The results would be different for different sizes of containers since the amount of packaging required to contain different volumes does not scale linearly; however, the results would not vary significantly among the alternatives to Miyoko's cheese and mild.

3. LCA Modeling Approach and Data Inventory

Life cycle assessment (LCA) is a methodology for studying the potential environmental impacts incurred throughout the entire life of a product system. This LCA examines potential emissions from the production, use, and disposal of cashew milk and cheese in terms of GHG emissions and fresh water consumption.

Every product has its own life cycle, composed of many different steps. The life cycle of cashew milk includes the farming of cashew, processing of cashew nuts, transportation of cashew to the US, cashew milk production, retail, and production and disposal of its PET beverage container. It also includes the production of all upstream inputs, such as organic compost, electricity, and transport of intermediate and finished products. This analysis includes all pathway process steps, including milk processing, packaging, and disposal of packaging. Upstream emissions are also included. This refers to the embedded GHG burden associated with process inputs such as electricity. The same process is considered for cashew cheese. Emission factors for the modeling of process GHG impacts were taken from the GREET_1 2018 model. Retail and transport to retail are excluded from this analysis since they are assumed to be identical for all products.

Cashew and Cashew Milks

Data was collected from the supplier for farming stage, processing and transportation of cashew. Since cashew is grown organically, in the farming phase, the only input is organic compost (Table 1). Moreover, according to cashew supplier, the energy for processing is provided through burning the cashew shells which is biogenic emissions and is not included in the LCA. The cashew was transported from Vietnam by ship to the port of the US and then by truck to Miyoko's Kitchen. The data regarding the process of making products and recipes were provided by Miyoko's Kitchen.

Table 1. Data Inventory for Cashew Production.

Item	Unit	Value
Farming		
Organic Compost	kg/ha	700
Cashew Nut Yield	kg/ha	1,600
Cashew Kernel Yield	kg/ha	350
Transportation		
Ship	mile	8125
Truck	mile	438

Dairy Milk

The life cycle of dairy milk involves the production of corn and other feed for cows, manure management and enteric emissions, and the allocation of emissions between milk and meat production. An in-depth analysis of dairy farming was outside the scope of this study. Instead, the carbon intensity of dairy milk was taken from two 2013 studies that examined the cradle to farm gate and the farm gate to end of life emissions of American produced dairy milk (Thoma et al., 2013a, 2013b). These studies used a biophysical approach to allocation as described in their 2012 publication (Thoma et al., 2012).

Dairy milk is assumed to be packaged in a high-density polyethylene (HDPE) container with 29% recycled content. The greenhouse gas emissions for dairy packaging are taken from the Thoma et. al (2013b) life cycle assessment of dairy production (Thoma et al., 2013a).

Almond and Soy Milk

The sources of data for the life cycle inputs for each product were selected to be as recent and geographically relevant as possible. A range of published literature and national data sources were used in this LCA. Data regarding the soy and almond milk were gathered from Kendall (2015), Ecoinvent (2016), USDA (2016), and Scipioni (2012) (Table 2).

Table 2. LCA Modeling Inputs

Parameter	Almond Milk	Soy Milk	Dairy Milk[1]
Farming Inputs			
Nitrogen (lb/lb)	0.1070	0.006	
P_2O_5 (lb/lb)	0	0.017	
K_2O (lb/lb)	0.1070	0.028	
Diesel (Btu/tonne)	519,149	519,149	
Pesticides (g/tonne)	42.9	42.9	
Herbicide (g/tonne)	300	300	
CA Water Transport Energy (kWh/tonne)	531.8		
Processing			
Electricity (kWh/kg milk)	0.218[2]	0.218	
Natural Gas (MJ/kg milk)	2.043[2]	2.043	
Additives			
Sunflower oil (% by mass)			
Cane Sugar (% by mass)	2.88%	2.84%	
Additional Parameters			
Protein content of finished milk	0.41%	3.29%	3.38%
Plant content of finished milk (kg/kg)	0.026	0.123	

1. Dairy milk inputs are not shown since dairy milk life cycle emissions are based on literature sources only.
2. Almond milk processing inputs are assumed to be the same as soy milk.

4. Life Cycle Inventory

Life cycle inventory (LCI) data reflects the emissions associated with farming inputs, process fuels, transport segments, and any process or input relevant to production. Emissions can occur directly, as in the case of fertilizer off-gassing or natural gas combustion, or indirectly, as in the case of inputs to farming such as fertilizer or pesticides, which reflect the emissions required for production.

In this LCA, emissions that were calculated from process inventory data use the emission factors in the GREET1_2018 model. LCI data in GREET are organized as a column (or array) of energy use and emissions values. An LCI array can represent a single process fuel or feedstock, such as natural gas used for fuel production, or it can represent aggregated fuel cycle results, such as ethanol transport and distribution.

Life Cycle Impact Assessment

The GREET model is configured to determine energy inputs, GHG emissions, and criteria pollutant impacts. This analysis focuses on GHG emissions. GHG emissions are expressed as grams of carbon dioxide equivalent per liter of milk (g CO_2e/L), and are referred to as the carbon intensity (CI). The GHG emissions constituents considered in this analysis are CO_2, N_2O, CH_4, CO, and volatile organic compounds (VOCs).

Global warming potentials (GWP) (g CO_2e/g constituent) for CH_4 and N_2O are taken from the Intergovernmental Panel on Climate Change (IPCC) global warming potential (GWP) values (IPCC 2007) for a 100-year time horizon. CO and VOC are oxidized to CO_2 in the atmosphere, and thus have a GWP of 1 when expressed as CO_2 (fully oxidized form). The analysis excludes the climate impact of secondary and higher order atmospheric species that arise from direct emissions, including ozone, oxides of nitrogen (NO_x), and secondary aerosols.

5. Greenhouse Gas LCA Results

Cashew LCA

In order to calculate the LCA of cashew milk and cheese, first the GHG emission of cashew nut should be calculated. Based on the data provided by the supplier, the GHG emissions of cashew were calculated as 214.66 kg CO_2e/tonne. The CI of cashew is lower compared to almond and soybean due mainly to the fact that cashew was grown organically and aside from organic compost, no other inputs are used in the farming stage (Table 2, 3). It can be seen from Table 2, that high amount of nitrogen fertilizer is used in almond farming and nitrogen fertilizer is the most important factor in N_2O emissions from agricultural soils. It should be noted that the global warming potential (GWP) of N_2O is 298 times the GWP of CO_2.

Table 3. GHG emissions of different crops (gCO_2e/tonne).

Cashew	Almond	Soybean
214.66	1020.40	247.47

While the farming stage of cashew has low CI, the transportation of cashew has a high contribution in overall CI of cashew because the cashew is imported from Vietnam (Figure 3).

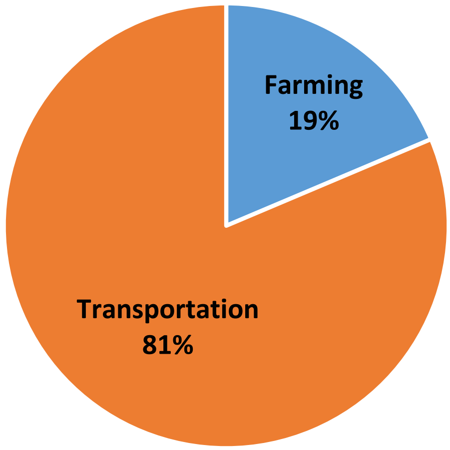

Figure 3. Share of each step from total CI of cashew.

Cashew Milk

The GHG emissions of cashew milk along with other non-dairy milk such as soy milk and almond milk as well as dairy milk were estimated and shown in Figure 4. As can be seen from Figure 4, the GHG emissions were presented based on two functional units, volume basis and protein content basis. The GHG emissions of non-dairy milk is much lower than dairy milk. Among non-dairy milk, cashew milk has the higher GHG emissions due to high consumption rate of cashew nut compared to almond and soybean. As a matter of fact, for each kg of cashew milk, 0.34 kg of cashew is used while for almond and soybean, 0.03 kg and 0.12 kg of crop were used, respectively.

Scenario 1: Baseline				
1a. Volume Basis				
Results (g CO_2e/L milk)	**Almond**	**Soy**	**Dairy**	**Cashew**
Farming	26.7	31.2	1,273	74.01
Processing	259	262	112	259
Electricity	107.5	107.5		107.5
NG	141.0	141.0		141.0
Additives	6.4	6.3		6.4
Packaging & EOL	104.4	104.4	82.3	104
Co-Product Credit	(16.1)			
Total (g CO_2e/L milk)	390	397	1,467	437

Figure 4. GHG emission of non-dairy and dairy milk.

The share of each step from total CI of dairy and non-dairy milk are shown in Figure 5. The energy required for processing of non-dairy milk was assumed to be the same.

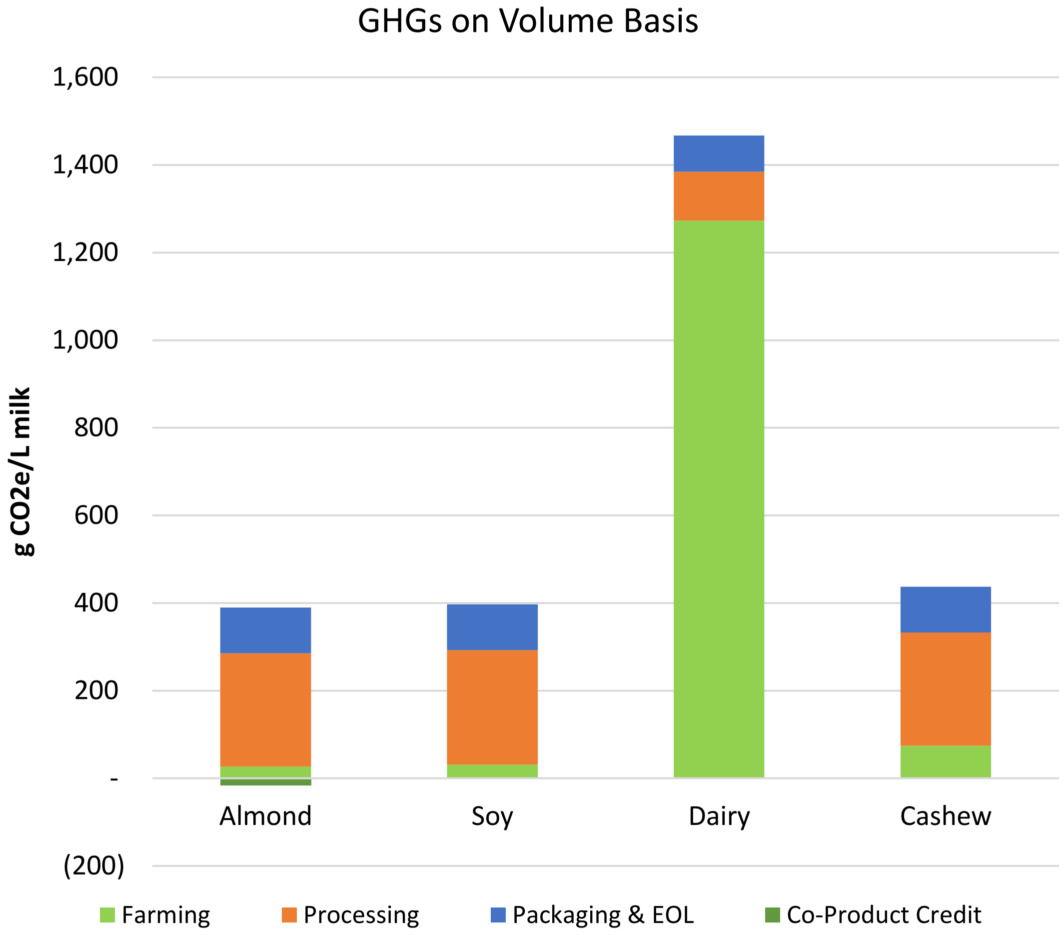

Figure 5. Share of each step in GHG emission of milk.

Cashew Cheese

The GHG emission of cashew cheese were calculated based on the recipe provided by Miyoko's Kitchen staff and compared with dairy cheese (Table 4). Since it was assumed that the production process of non-dairy and dairy cheese is the same, the production process was not included in the LCA.

The GHG emissions for each type of Miyoko's product depends on the ingredients which are primarily cashews and coconut oil. The GHG emissions from dairy products were calculated based on the amount of milk required to produce each type of cheese. The results for Miyoko's Kitchen products were based on their recipe.

Table 4. GHG emissions of non-dairy and dairy cheese.

	Miyoko's Product	Dairy Product
	kg CO_2e/kg	kg CO_2e/kg
Double Cream Chive	0.29	6.18
Mozzarella	0.23	12.22
Butter	0.98	20.54
Cream Cheese	0.38	6.18
Milk	0.43	1.47

6. Discussion

The GHG emissions associated with cashew milk and cheese are much lower than those of dairy milk and dairy cheese. Among non-dairy milk, the GHG emissions associated with growing cashews are much lower than the emissions associated with almond growing on a per kg of nut basis since high levels of fertilizers and associated N_2O emissions correspond to almond production. However, due to the relatively small amount of almonds that end up in almond milk the life cycle GHG emissions of almond milk on a volume basis are lower than those from cashew milk.

While the contribution of farming stage for cashew production is low due to organic farming, the share of transportation in GHG emissions is relatively high since all cashews are imported from Vietnam. The Miyoko's Kitchen is a small non-industrial company and therefore, local truck delivery also contributes more emissions than more efficient large volume rail transport. Nonetheless, the GHG emissions for the cashew products are significantly lower than those from dairy milk. Another factor is scaling up the production of non-dairy milk and cheese. Since cashews can only be cultivated in certain parts of the world, production of high amount of cheese and milk cannot solely depend on cashew and therefore, the use of other crops should be investigated.

A limitation of the study is that most non-dairy cheese have several added ingredients in order to improve the taste profile, nutritional content, and texture of the finished product. The added sugar in non-dairy milk was included both the GHG analysis. Cashew cheese and butter also contains sunflower oil and coconut oil, and the GHG emissions from these were included in the LCA. However, other additives such as emulsifiers, flavor enhancers, and vitamins were excluded from this study.

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