LIFE THE TOUGH GET GOING PROJECT: IMPROVING THE EFFICIENCY OF THE PDO CHEESE PRODUCTION CHAINS BY A DEDICATED SOFTWARE

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ABSTRACT

The paper describes the state of progress of the LIFE The Tough Get Going (LIFE TTGG) project (funded by the European Union). The authors aim to improve the entire life cycle efficiency of European Protected Designation of Origin (PDO) cheeses by designing and developing software, that will work as Environmental Decision Support System for the environmental footprint assessment (in compliance with PEF methodology promoted by European Commission) and its reduction. The software has been calibrating and validating on the companies of the Grana Padano and Comté cheese supply chains (100 farms, 34 dairies, and 19 packers).

In this article, the environmental impact of 10g dry matter of Grana Padano PDO cheese was evaluated, through 3 different impact categories: Climate Change, Acidification, and Mineral Fossil & Ren Resource Depletion. Two emission mitigation scenarios were considered: reduction of energy consumption in the dairy processing phase and environmental packaging optimization.

Key Words: Life Cycle Assessment, Dairy Products, Software, PDO

1.INTRODUCTION

Farming activities are considered to play an important role in depleting the Earth's resources and contributing significantly to Greenhouse Gas (GHG) emissions, to soil fertility, to water scarcity and to the release of pollutants that affect ecosystem quality (McMichael et al., 2007)but its acquisition requires energy expenditure. In post-hunter-gatherer societies, extra-somatic energy has greatly expanded and intensified the catching, gathering, and production of food. Modern relations between energy, food, and health are very complex, raising serious, high-level policy challenges. Together with persistent widespread under-nutrition, over-nutrition (and sedentarism.

Life cycle assessment (LCA) represents a reference method that helps in analyzing supply chains with the aim of achieving environmental sustainability objectives (Sala et al., 2017) The LCA methodology, integrated with the Life Cycle Design (LCD) methodology, allows the development of products with a low environmental impact (Vezzoli, 2018). Previous works have been already done in developing operational methods for the assessment of the environmental impacts of dairy activities: EDEN-E tool (van der Werf et al., 2009)an operational method for the environmental evaluation of dairy farms based on the life cycle assessment (LCA, the LatteGHG tool (Pirlo and Carè, 2013), PMT_01 tool (Famiglietti et al., 2019). Based on our knowledge, a model for assessing and reducing the environmental impacts of dairy products in a full life-cycle perspective has not yet been developed. The present study reported the application of the LIFE TTGG in the assessment of the environmental impacts of 10 g of dry matter of Grana Padano PDO cheese. Two "Scenario analyses" were performed to compare different energy management practices for dairy plants and for packaging solutions.

2.MATERIAL AND METHODS

2.1.Goal

The objective of this study was to present the LIFE TTGG software prototype, a comprehensive LCA instrument that aims to: a) analyze the environmental impacts of EU PDO hard and semi-hard cheeses according to PEF methodology; b) assess three different impact categories and determine the contribution of each production stage; c) support technicians and researchers in the evaluation of an environmental load of EU PDO cheeses.

The software has been developing by the LIFE Programme found by the European Commission. The project duration is from July 2017 to June 2021.

2.2.Scope

2.2.1.System boundaries

The entire life cycle is assessed, including the following life cycle stages: raw milk supply, dairy processing, non-dairy ingredients supply, packaging, distribution, use, end-of-life. Company-specific data are required for raw milk supply, dairy processing, and packaging. While secondary datasets are used for the other stages. A specific average database has been implementing for Grana Padano and Comté PDO cheeses. This database will be used to reduce data collection effort and will increase the reliability of European PDO LCA analyses.

The temporal coverage for data collection is one year. The model of LCA analysis is descriptive (attributional) (European Commission, 2013).

2.2.2.Allocation

The environmental impacts of processes that involve multiple co-products, were allocated following the IDF rules (IDF, 2015; The European Dairy Association, 2018): biophysical allocation was used for the production of raw milk and meat at the farm gate and dry mass content allocation was used for the processing of the finished dairy products and by-products.

2.2.3.Functional unit and reference flow

The functional unit (FU) and reference flow used in the software was: 10 g dry matter of cheese, consumed at home as a final product without cooking or further transformation.

2.3.Inventory analysis

The average inventory included in the software was developed based on information collected directly on farms and dairy plants with dedicated check-lists.

The information needed for raw milk production phase are: a)herd management (n° of lactating cows, dry cows and replacing animals); b)feed composition; c) livestock management (housing and bedding system); d)manure management (storage systems including anaerobic digestion); e) crops yield and fields management; f) energy consumption (electricity and fuel).

Direct emissions in air, water, and soil are estimated following EEA (2016) and IPCC (2006). The information needed for the dairy and packaging phase are listed in Table 21. The secondary dataset used in the software are: Ecoinvent 3.4, Agri-footprint, ELCD, Swiss Input-Output database, Industry data 2.0, and USLCI.

2.4.Emission estimation and impact assessment

The final environmental impact is expressed on 16 impact categories, following the ILCD 2011 Midpoint + (version 1.0.9, May 2016) – normalization/ weighting set EU27 2010 per person, equal weighting (European Commission and Joint Research Centre, 2012).

2.5.Scenario analyses

Two scenario analyses were performed to test software taking into account some technical options on the dairy processing and packaging phases. In this specific case, we focused on heat recovery from whey and packaging optimization. Inputs and outputs of the analyzed supply chain are reported in Table 21.

Table 21. Data refer to 1 kg Grana Padano PDO

Group	Characteristic		Units	Dairy
Main ingredients	Raw milk		kg per kg of cheese	13.83
	Salt		kg per kg of cheese	0.05
	Rennet		g per kg of cheese	0.28
	Lysozyme		g per kg of cheese	0.10
Cleaning agents	Cleaning agents		kg per kg of cheese	0.02
Packaging	Electricity – portioning and packaging		MJ per kg of cheese	0.54
	Primary packaging – polymer bag		g per kg of cheese	37.00
	Secondary packaging – Corrugated board		g per kg of cheese	51.00
	Tertiary packaging – LDPE film		g per kg of cheese	3.00
	Tertiary packaging – EUR flat pallet		g per kg of cheese	5.00
Energy consumption	Electricity		MJ per kg of cheese	2.40
	Heat from boiler (natural gas)		MJ per kg of cheese	6.72
	Transport inputs materials		tkm per kg of cheese	0.07
Refrigerant gases	Refrigerant gas		g per kg of cheese	0.02
Other inputs/outputs	Underground water		kg per kg of cheese	30.30
	Wastewater		m^3 per kg of cheese	0.02
Dairy outputs	Grana Padano PDO	DM 67.5%	kg per kg of cheese	1.00
	Whey	DM 6.4%	kg per kg of cheese	11.64
	Cream	DM 26.0%	kg per kg of cheese	0.99
Distribution	Transport to the logistics center		tkm per kg of cheese	0.32
	Electricity for distribution center and retail		MJ per kg of cheese	0.02
	Food loss		%	5.00
Use phase	Electricity for domestic refrigeration		MJ per kg of cheese	0.36
	Food waste		%	7.00
End-of-life of packaging	Recycling paper		g per kg of cheese	29.75
	Recycling plastic		g per kg of cheese	17.09
	Incineration		g per kg of cheese	7.08
	Landfill		g per kg of cheese	42.08

3.RESULTS AND DISCUSSION

3.1.Environmental impacts

Characterization, normalization and weighting results of 10 g of DM of Grana Padano PDO are shown in Table 22. Three different impact categories out of sixteen: Climate Change (CC), Acidification (A), and Mineral Fossil & Ren Resource Depletion (MF&RRD) were reported.

The main contribution to CC and A impact categories was related to raw milk production (81% and 87% respectively). Dairy processing is the most significant phase for MF&RRD (42%).

In Figure 1 are reported the characterization results of the different compartments for the selected functional unit.

Table *22*. Impact assessment results per 10g of DM of Grana Pad*ano* PDO

Potential impact	Units	Characterization	Units	Normalization	Units	Weighted
CC	$kgCO_2eq.$	1.54E-1	-	1.67E-5	µPt	1.12 E+0
A	molc H+-eq.	3.64E-3	-	8.33E-5	µPt	5.56E+0
MF&RRD	kgSb-eq.	3.48E-7	-	3.45E-6	µPt	2.30E-1

3.2.Scenario analysis

Using a heat exchanger to preheat the inlet milk before the curding/cooking phase with hot whey outlet is a common solution that can be implemented in the dairy processing phase. The intervention reduces both thermal (approx. 10% of the energy need) and electrical consumption (linked to the whey cooling system – approx. 5%). For packaging was reduced the weight of primary and secondary packaging (from 37 g to 19 g and from 51 g to 30 g respectively).

The dematerialization of the packaging also corresponds to an optimization of the volumes, that lead to a reduction in the impact of refrigeration and transport in the subsequent phases of the life cycle. Table 23 shows the results achieved after the proposed solution implementation.

Table 2-3. Results concerning the effective solutions proposed (from cradle to grave approach)

Potential impact	Characterization				Weighted			
	Units	Pre-value	Post-value	Delta	Units	Pre-value	Post-value	Delta
CC	kgCO_2eq.	1.55E-1	1.52E-1	1.6%	µPt	1.12E+0	1.10E+0	1.6%
A	molc H+-eq.	3.64E-3	3.63E-3	0.3%	µPt	5.56E+0	5.55E+0	0.3%
MF&RRD	kgSb-eq.	3.56E-7	3.28E-7	7.8%	µPt	2.35E-1	2.17E-1	7.8%
				Total	µPt	6.90E+0	6.86E+0	0.8%

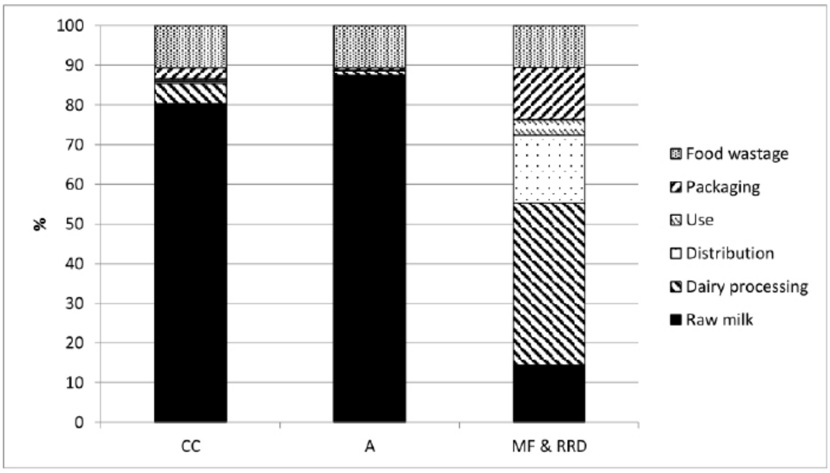

Figure 1. Characterization results of the different compartments per 10 g of DM of Grana Padano PDO

The benefit obtained by the two solutions showed (equal to 0.8%) are split as follows: 0.1% thanks to the heat recovery of whey (approx. 4% considering only the dairy processing phase) and 0.7% thanks to the packaging optimization (approx. 33% considering only the packaging phase: material productions and end-of-life).

4. CONCLUSIONS

The results obtained agree with previous studies (Bava et al., 2018; Famiglietti et al., 2019). The raw milk production represents the main contribution (considering weighted results). The mitigation solutions proposed achieved good reductions in the specific phases (dairy and packer) but have a low benefit (equal to 0.8%) when compared to the life cycle of the product. Further improvements in the LIFE TTGG software development will lead to the involvement of raw milk production phase (approx. 80% of the total impact) and food wastage reduction (approx. 10% of the total impact).

The LIFE TTGG software development has just begun. The target of the software is to compare different mitigation solutions in each production phases. It is a key indicator to improve the EU PDO supply chain, especially for those not shown in this paper (raw milk production and food wastage reduction).

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