Grana Padano and Parmigiano Reggiano cheeses: preliminar results towards an environmental eco-label with Life DOP project

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Abstract

Grana Padano and Parmigiano Reggiano are two of the most important Italian PDO cheeses. To improve the environmental impact performances of their production, the Life Cycle Assessment (LCA) method has been used. In the Life DOP Project, LCA of milk production at farm will be completed on about 120 dairy farms of the province of Mantova (Northern Italy). Mitigation strategies to improve both environmental and economic production sides will be suggested, focusing on forage crop production (yield increase), milk production (dairy efficiency increase), herd management (animals' health and welfare) and off-farm purchased feed. From the preliminary results, shown on 4 farms, there is evidence that improvements are needed. In particular, the most efficient farm (farm C) has the best environmental sustainability, while the others have worse outcomes, mainly due to poor dairy efficiency and related issues.

1. Introduction

Grana Padano and Parmigiano Reggiano cheeses are two of the most important dairy products of Protected Designation of Origin (PDO) in the Italian agri-food context. Their production has a huge market impact because they are among the most exported Italian agri-food products worldwide (Bava et al., 2018). The production chains of Grana Padano (GP) and Parmigiano Reggiano (PR) are quite complex, thus involving several stakeholders and producers that contribute to the environmental sustainability of these cheeses. More in detail, to produce GP and PR, the environmental impacts related to the cheese factory phase as well as to the milk production phase, including production of animals' feed and slurry management must be taken into account. In addition, the dairy farming context is quite complex and several farms must be investigated to get statistically relevant information about the local milk production system. This complexity supports the need of detailed primary data for agricultural production systems when reliable environmental analyses are searched (Lovarelli and Bacenetti, 2017).

In order to promote, among others, (i) mitigation strategies for milk production and for manure/slurry management and the related emissions to the environment and (ii) a manure-slurry exchange system among farmers, the project Life DOP (LIFE15 ENV/IT/000585) has started since 2016 (www.lifedop.eu/en/). In particular, in order to make available to farmers an organic fertiliser characterised by an adequate nitrogen content and a higher solid matter respect to slurry, an exchange system for manure and slurry has been promoted. It permits to farmers to sell slurry and manure that are mixed in a dedicated implement and digested in two anaerobic digestion plants. After, the digestate fraction is returned to farmers according to the exchange system, and is spread on fields. This allows introducing the concept of circular economy on livestock farms, exploiting the capabilities of slurry and manure and bringing environmental benefits. Since policy makers must promote strategies for a sustainable consumption and production, this project is in line with the European goals and challenges for low environmental impact productions.

In this context, efficiency improvements for dairy farms, animal management and animal feeding are key aspects. Thus, about 120 dairy farms in the province of Mantova in Northern Italy were investigated to carry out a Life Cycle Assessment (LCA) analysis of each farm and promote mitigation strategies for a sustainable milk production pathway. On about 10% of the farms investigated, the suggested improvements will be re-analysed by means of LCA and the reduction in environmental impact due to the efficiency increase will be quantified and suggested for future mitigation strategies. Moreover, an environmental sustainability label will be developed to certify the commitment of GP and PR producers towards sustainable productions and resource use efficiency. In particular, improvements in resource use efficiency and animal care, balanced feed intake and feed self-sufficiency allow a better use of resources and an increase in milk productivity. As a result, this will provide both environmental and economic benefits.

The aim of this study, being part of the project, is firstly to improve the dairy efficiency of cows, their productivity and the on-farm feed production in qualitative and quantitative terms to reduce the environmental impact of off-farm feed and, especially, of its transport from other countries. Secondly, to get information and the best mitigation strategies for cheese production. The development of an environmental label will allow policy makers to understand:

- the importance of circular economy and of the value of environmental assessment studies to make valid decisions,
- how environmental assessments can support business strategies,
- the environmental consequences of mitigation strategies by evaluating their effective applicability on farms.

2. Materials and methods

2.1. Goal and scope

In this study, LCA (ISO 14040 series, 2006) is applied to quantify the environmental impact of milk production on the analysed farms and to investigate the possible improvements for producing milk more efficiently.

2.2. Functional unit and system boundary

The selected Functional Unit (FU) for the analysed farms is 1 kg of Fat and Protein Corrected Milk (FPCM) produced by milking cows. This decision is made according to several studies about milk production (Bacenetti et al., 2016; Bava et al., 2018; Zucali et al., 2017) and to the recommendation by IDF (2015).

This assessment has a cradle-to-farm gate approach. In the system boundary are included all inputs (e.g., machinery, fuel, lubricant, organic and mineral fertilisers, pesticides, water, off farm feed) and outputs (emissions to air, soil and water) as reported in Figure 1.

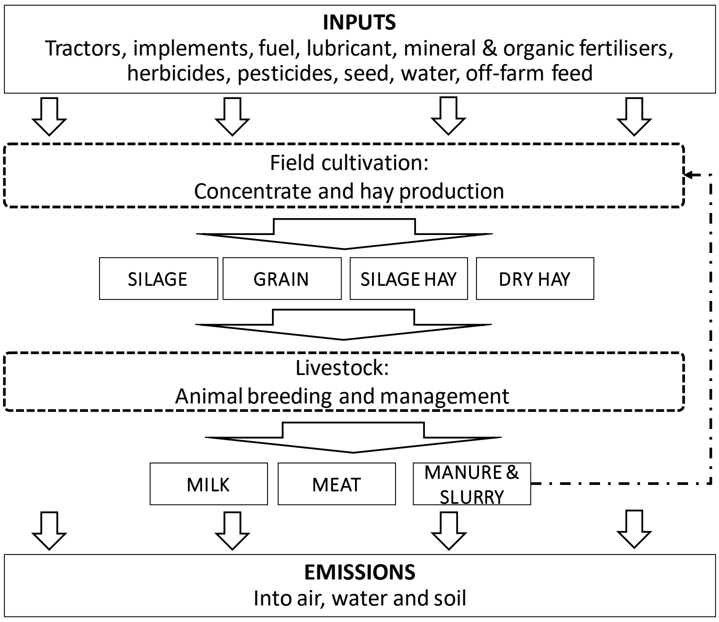


Figure 1: System boundary

2.3. Description of the system and data collection

During the project, about 120 dairy cattle farms have been analysed. They sell milk to 9 dairies, of which 4 produce Grana Padano cheese (GP) and 5 produce Parmigiano Reggiano cheese (PR). The project Life DOP foresees the completion of LCA of the milk production at the farm gate and a second LCA of the cheese production at the dairy factory gate.

In this paper, the attention will be focused on the milk production phase and, in particular, results of 4 dairy farms are reported. In more details, the environmental results related to the first of the three years of analysis will be shown for 2 farms (Farm A and B) selling milk to a dairy for PR production and 2 farms (Farm C and D) selling milk to a dairy for GP production. A

ll data were collected during surveys on farm carried out by experts by asking for information about:

- Field production (e.g., cultivated crops, cultivation practices, inputs such as fertilisers, water, machinery, etc.),

- Herd management (e.g., number and type of animals, purchasing/selling of animals, etc.),
- Milk production (e.g., milk yield and quality, protein and fat content, etc.),
- Feeding (e.g., type and quality of feed, on farm cultivated feed, off farm purchased feed, etc.),
- Manure and slurry management (e.g., availability of manure/slurry, storing system, time and spreading technology adopted, etc.),
- Infrastructure of the dairy farm (e.g., cattle housing, milking parlour, slurry and manure storage, etc.).

Table 1 and Table 2 report the main inventory data about the cultivated crops, herd composition and milk production. Table 3 shows the allocation values adopted for milk (physical allocation between milk and meat considering feed energy by dairy cows and feed requirements for producing milk and meat) calculated in accordance with IDF (2015).

Table 1: Main inventory data about the on-farm field cultivation. (*) with average self-sufficiency is meant the ratio between the on-farm produced feed and the total feed for cows

Variable	**Unit**	**Farm A**	**Farm B**	**Farm C**	**Farm D**
Total agricultural area	ha	21.3	60.2	92.5	64.9
Alfalfa, area	ha	10.0	50.3	28.2	27.9
Ryegrass, area	ha	8.0	-	4.7	6.9
Winter cereals, area	ha	-	3.3	-	-
Maize for silage, area	ha	3.3	-	59.6	13.2
Maize grain, area	ha	-	-	-	10.0
Soybean, area	ha	-	-	-	6.9
Minor cereals, area	ha	-	3.3	-	-
Mixed cereals, area	ha	-	3.3	-	-
Average self-sufficiency (*)	%	71%	63%	55%	81%

Table 2: Main inventory data about herds and milk production

Variable	**Unit**	**Farm A**	**Farm B**	**Farm C**	**Farm D**
Total number of cows	no.	177	188	285	112
Lactating cows	no.	85	85	52	56
Dry cows	no.	15	15	629	10
Delivered milk	t FPCM/yr	726.0	813.6	3729.9	578.1
Milk per cow	kg FPCM/d	23.3	29.2	35.7	28.1
Dairy Efficiency	kg FPCM/kg feed	1.16	1.19	1.57	1.27
Dry Matter Intake	kg/d	21.2	22.8	23.2	22.6

Table 3: Allocation values for milk (IDF, 2015)

Variable	**Unit**	**Farm A**	**Farm B**	**Farm C**	**Farm D**
Mass allocation	%	84%	82%	84%	88%

2.4. Impact assessment

The following environmental impacts were considered by using the ILCD characterisation method (Wolf et al., 2013):

- Climate Change (CC, kg CO_2 eq),
- Particulate Matter (PM, kg $PM_{2.5}$ eq·10^{-4}),
- Acidification (TA, molc H^+ eq·10^{-1}),
- Freshwater eutrophication (FE, kg P eq·10^{-4}),
- Marine eutrophication (ME, kg N eq·10^{-2}),
- Land Use (LU, kg Carbon deficit·10^{1}),
- Mineral, fossil and renewable resources depletion (MFRD, kg Sbeq·10^{-5}).

3. Results

Table 4 shows the environmental impacts of milk production in the 4 dairy farms analysed. The two farms producing milk for PR cheese have an environmental impact quite close to each other, except for CC (1.58 and 1.17 kg CO_2 eq/kg FPCM, respectively for A and B) that is mostly affected by animal emissions. PM and TA result higher in respect to C and D, mostly because of field emissions in the cultivation practice. In particular, farm A has the lowest milk production, field area and dairy efficiency, which deeply affects the environmental outcomes.

On the contrary, the two farms producing milk for GP cheese (farms C and D) have a different production disciplinary, which allows them introducing energetic animal feeding such as cereal silages characterised by annual cropping cycles. Accordingly, their environmental impact shows bigger variability due to the better and more variable dairy efficiency (1.57 and 1.27, respectively).

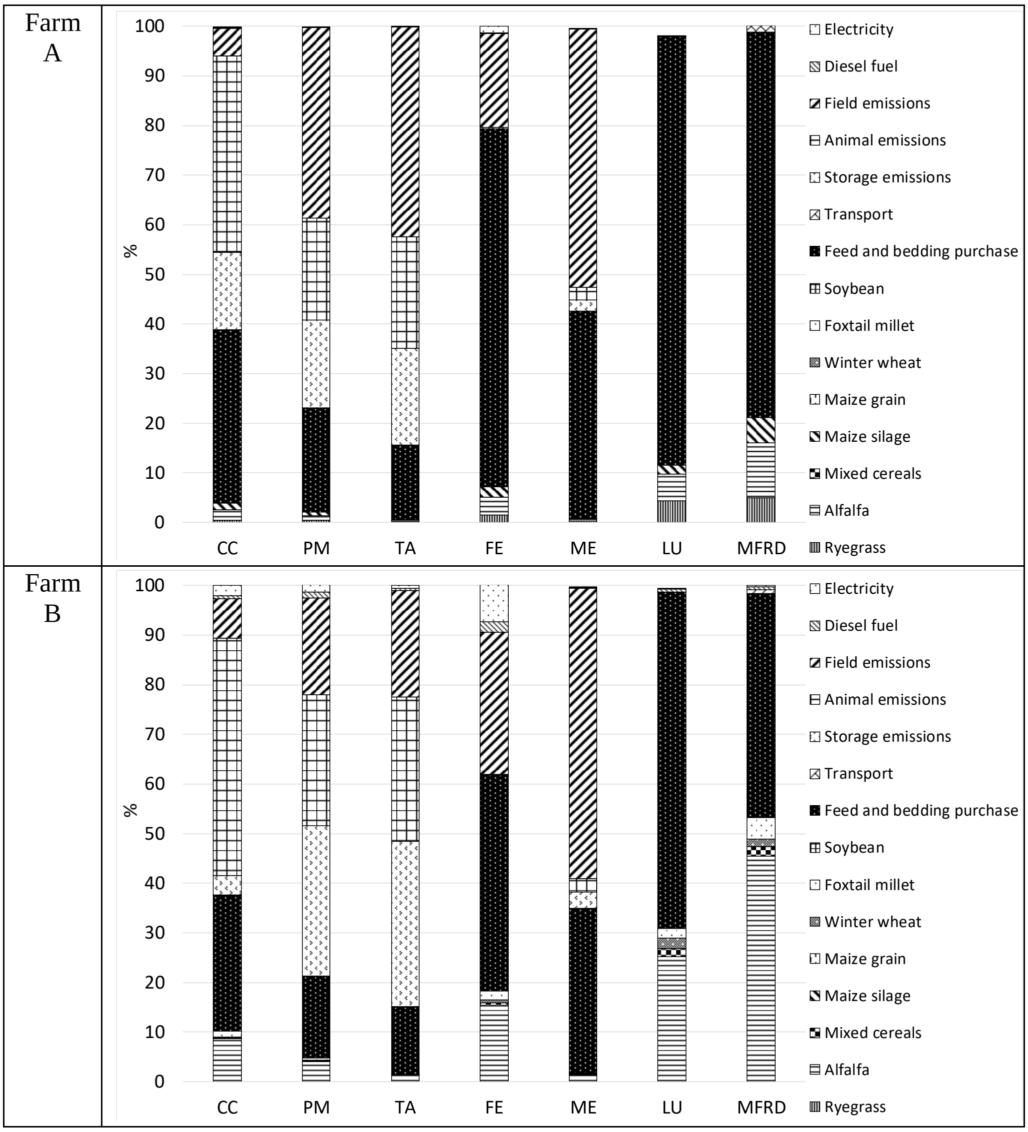
Table 4: Environmental impact of milk production per kg FPCM in the studied farms: A, B (milk for Parmigiano Reggiano cheese) and C, D (milk for Grana Padano cheese)

Impact category	Unit	Farm A (PR)	Farm B (PR)	Farm C (GP)	Farm D (GP)
CC	kg CO_2 eq	1.586	1.173	0.999	1.643
PM	kg $PM_{2.5}$ eq·10^{-3}	0.798	0.579	0.463	0.618
TA	molc H^+ eq·10^{-1}	0.329	0.238	0.185	0.225
FE	kg P eq·10^{-4}	0.835	0.625	0.471	1.127
ME	kg N eq·10^{-2}	0.874	0.763	0.533	0.887
LU	kg carbon deficit·10^{1}	2.651	2.349	1.328	2.785
MFRD	kg Sb eq·10^{-5}	0.550	0.452	0.365	0.990

In particular, for farm C (highest milk production per cow: 35.7 kg FPCM/d) and D (lowest milk production per cow: 28.1 kg FPCM/d), CC is 0.99 and 1.64 kg CO_2 eq/kg FPCM, respectively. Farm D shows the worst performance not only for CC (mainly caused by high methane enteric production) but also for FE and

ME (due to field emissions during cultivation) and for LU and MFRD (due to feed and bedding purchase and the adopted field cultivation practice). Thus, farm D represents the worst performing farm among the four studied ones.

Figure 2 reports the hotspot processes of the four farms.



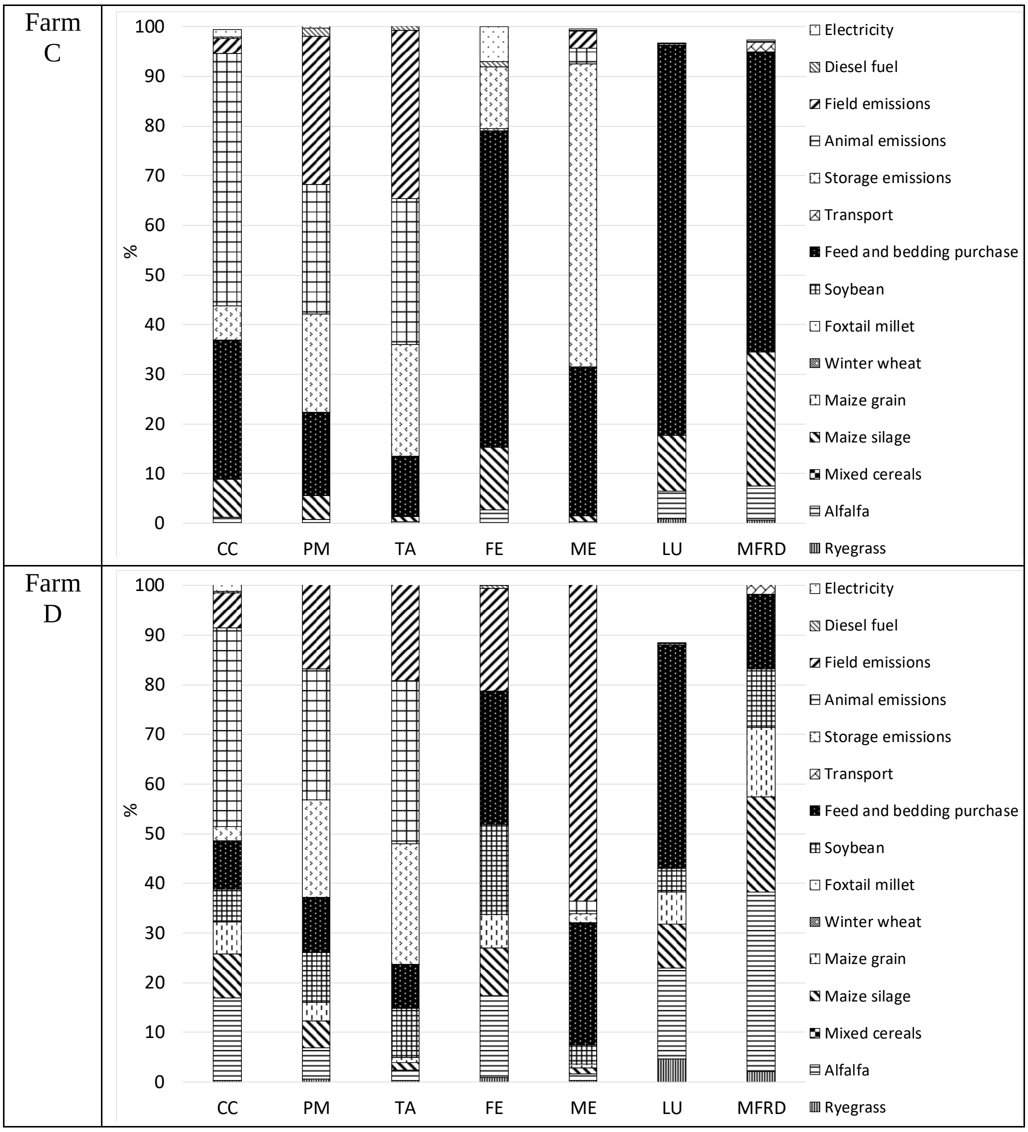


Figure 2: Process hotspots of milk production in the studied farms

4. Conclusions

The outcomes of the present study are referred to just four of all dairy farms taking part in the Life DOP project. Moreover, these results are preliminary ones, and further analyses will be performed along the years. In particular, the improvements suggested to each farm will be studied (e.g., crop yield increase, milk production and dairy efficiency increase, slurry and manure management, animal health and welfare) as well as those at the cheese factories.

From the results, it emerges that the most efficient farm shows also the lowest environmental impact per kg FPCM, pointing out that farms with an efficient farming system have also the best environmental performances. Consequently, it is essential to go towards this direction. An efficient milk production system brings benefits also on the related systems of manure/slurry and cheese transformation, thus it represents an essential step for the circular economy life cycle thinking and for lasting sustainability goals of the agricultural sector. In this context, the introduction of an eco-label for GP and PR will represent a certificate for stakeholders for their commitment, for consumers to understand the role of environmental sustainability and its significance on the production point of view and for other producers to be driven to the same direction.

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