

The Lombard Dairy Industry in the Perspective of Circular Economy: Degree of Application and Improvement Potentials

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Abstract Circular Economy is an economic concept, aiming at increasing resource efficiency, recirculating resource streams and minimizing waste of an industrial process. Thereby, ideally, environmental impacts can be decreased while the profitability of the considered process is improved. This concept is growing increasingly popular among the scientific community. Yet, due to the immense variety of potential applications, it can be difficult to assess the degree of application in a particular industrial sector at a given time. For this contribution, a survey is conducted among producers of dairy products, in Lombardy, Italy. The aim of the survey is to investigate the current degree of application of Circular Economy among these producers considering waste recovery, by-product valorization, and renewable energy production. Furthermore, the producers' perception of Circular Economy is tested, and their interest in an intensified implementation inquired. Considering the most relevant resource streams (i.e., by-products, water, energy, and solid waste), more detailed questions are added, focusing on internal management and recovery strategies.

Keywords: cheese production, sustainability, resource efficiency, by-product valorization, waste recovery

1. Introduction

The EU has identified Circular Economy as a key component to be achieved (European Commission, 2015) in the pursue of higher sustainability with regard to ecology, economy and society. In recent years, many contributions have explored new applications for circular technologies and strategies to measure circularity from single production processes to national scales (Saidani et al., 2019). However, little can be found on the degree of application of said technologies. Additionally, agriculture takes a unique role in Circular Economy, as it poses particular conditions to the production processes and the ability to recirculate materials (Koppelmäki et al., 2021).

Therefore, this contribution explores the application of the Circular Economy concept in the Lombard dairy sector to expand the knowledge on this aspect. Circular strategies as well as common technologies are included in the assessment, focusing on the main resource streams.

2. Methods

A survey was conducted among the members of a dairy cooperative in Lombardy, Northern Italy, and 48 companies were contacted. The survey had a scoping character, trying to identify general flows and trends, aiming to create an overview on the current situation to be able to prepare more detailed follow-up investigations. The questionnaire consisted of three main sections with a total of 31 questions. The first part focused on resource input and consumption, the second one on by-products and waste flows, and the third one on current and future activities. The aim of the first two sections of the questionnaire was to draw a picture of the size of resource streams and their economic relevance for the annual production. Especially the second part was focusing on the aspect of circularity by including the major by-product and waste streams of cheese production and their use or treatment. In the last part, the current and planned circularity activities regarding the different streams as well as the companies' motivation to (or not to) extend their efforts were investigated.

Due to the complexity of the questionnaire, the response rate was low. Therefore, the dairies were contacted again telephonically to remind them to complete the survey. This activity is ongoing for which reason more answers are expected to be collected. To this moment, fifteen companies have filled in the survey. Fourteen of these were dairies producing cheese, while one was a consortium that collected cream from other dairies to produce butter.

3. Results

The main findings of the survey are shown in *Figure 1*. Ten companies relied on fossil energy production, all using fossil gas and four additionally liquid fuels. For each of the companies, the fossil energy production represented 1% - 3.5% of the annual production costs. Renewable energy production was applied by six companies that had installed photovoltaic elements, representing 0% - 2.8% of the annual production costs. Three companies were using both, fossil and photovoltaic energy production. Two companies collected manure from dairy farms to produce biogas.

Water consumption was costing none of the companies more than 0.5% of the annual production costs and only

one companies had installed cooling towers to be able to replace well water for cooling purposes during the production. Another company recovered rainwater and water from cleaning activities to be reused. These measures saved thirty and twenty percent of the water input, respectively. Four companies applied energy efficiency measure of which three were focusing on refrigeration efficiency and one on heat recovery.

Only some of the companies packed their own products. Most delivered them, e.g., as whole cheese wheels. Of the eight companies claiming to pack at least part of their products, three companies recycled packaging, one referred to the waste collection and four used eco-materials. Since companies packed only a portion of their own products, the cost of packaging varied a lot, reaching up to a maximum of 11% of the annual production costs.

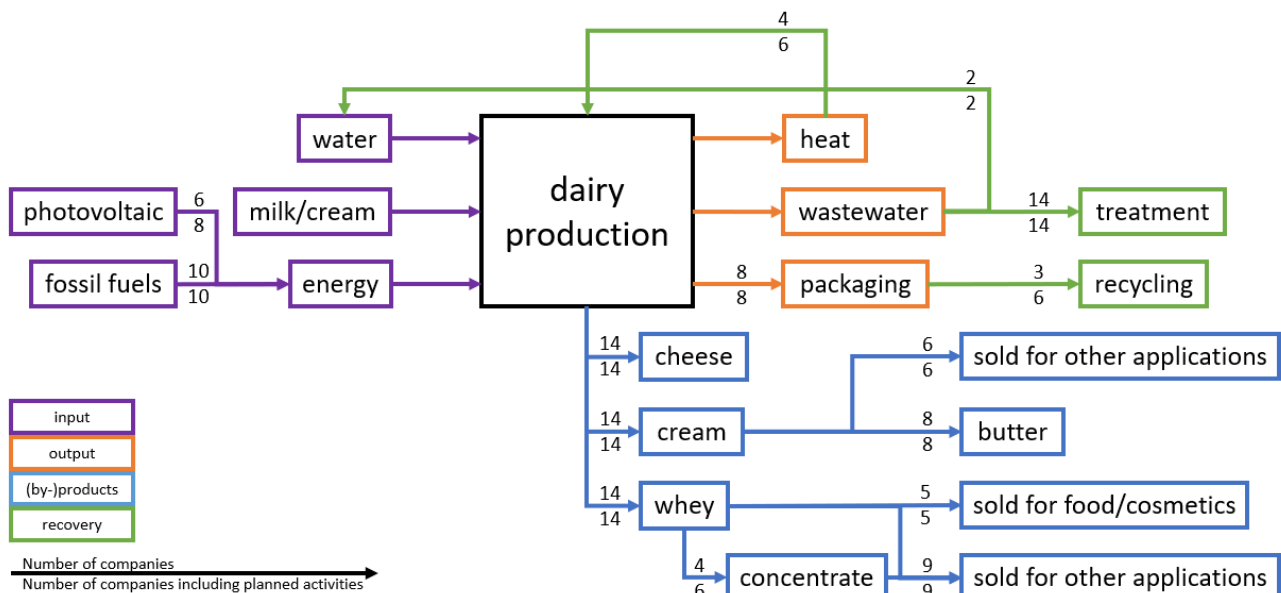


Figure 1. Scheme of the main resource streams investigated in the survey. Arrows without numbers indicate that all companies required or produced the resource. A total of fifteen answers were collected, of which fourteen were of cheese producers and one a consortium that produced butter from cream collected from other dairies. Non-circular disposal strategies and minor resource streams are not considered.

For the surveyed companies, between 60% and 80% of the milk input was turned into by-products with fourteen companies producing whey and thirteen cream. The earlier mentioned consortium had cream as an input and produced butter as the main product. Five of the companies sold their whey for high quality applications such as food or cosmetics, while the rest sold them for zootechnical or other/undefined purposes. Four companies concentrated the whey before selling. Eight companies sold their cream to butter production (mainly to the consortium) or made butter themselves while six companies sold it as it is for undefined purposes. Fourteen companies treated their wastewater through aerobic biological systems. Seven companies listed additional waste streams of which only two listed more than one type. One differentiated between mixed waste and packaging and the other one between 15 different categories.

In the last part of the questionnaire, companies were asked for their current or planned activities to increase the circularity of their production. Two companies are working on improving their whey valorization by concentration and pulverization, respectively, while one company that already concentrates whey wants to produce pure whey proteins. Meanwhile, four companies are improving or planning on improving their wastewater treatment, while four claim to have an efficient purification in place. Nine companies have activities set to improve the energy efficiency with seven focusing on light and electricity and two on heat recovery. Two companies are planning on installing photovoltaic elements and four companies want to improve their handling of packaging materials.

One company commented on the difficulty of investments for small- to medium-scale enterprises.

4. Discussion

The concept of Circular Economy seemingly has arrived in regional agriculture, especially with regard to energy production and by-product valorization. However, the data suggests that the application is limited to activities that have been subsidized in the past, are required by law or provide an immediate financial benefit.

In 2019, Italy was the second largest European producer of solar energy after Germany (EurObserv'ER, 2021) and production of photovoltaic electricity is continuously subsidized (IEA, 2019) even though the amount of new installations decreased since 2013 due to the end of incentive schemes (IEA, 2017). Meanwhile, the strict requirements for wastewater quality make it necessary to treat streams coming from cheese production before discarding them (Ercoli et al., 2008). In the past two years (2019-2021), whey for industrial use sold at 12€ to 23€ per 1000 kg, while whey for zootechnical use sold at 5€ to 12€ per 1000 kg (Milan Chamber of Commerce, 2021).

Therefore, it is no surprise, that solar energy production, wastewater treatment and selling of by-products are the most common circularity-related practices observed among the dairies, while most of the other activities (such as water reuse, whey concentration and heat recovery) were scarce. Still, the companies seemed open to new technologies and strategies with only three companies not mentioning any plans or activities of improvement, while most of the other companies had at least two activities set.

One issue that became apparent at several points during the survey was the difficulty of communication. Naturally, that is an obstacle any survey has to face, and the present one is no exception. All questions were understood by most of the interviewees, yet there was a considerable number of answers that indicated misunderstandings. For example, did one question inquire on the waste streams leaving the company. Some companies did not fill in any information here, while one company listed fifteen different streams and another company only listed production-related organic waste. On another example, the authors were informed by the cooperative that heat recovery within the cheese production process is a common practice among dairies, yet only one company listed it in the energy efficiency measures. This may be a matter of chance or alternatively may indicate that as a well-established practice it is not considered worth mentioning in the context of circularity. Therefore, better communication is needed to collect more detailed and reliable data. Especially the vocabulary needs to be chosen wisely and questions (if necessary) explained better.

Generally, even though this is only a scoping assessment, indications point at the necessity to improve especially the following aspects as they only occurred sporadically during the survey:

1) Whey concentration or pulverization. Concentrating whey on site has shown to reduce environmental impacts notably (Bacenetti et al., 2018), yet, according to the survey, only four companies are currently concentrating the whey before selling.

- 2) Energy efficiency measures. Heat recovery from water (used for heating and cooling) is applied by one company, while three companies improved their refrigeration efficiency by using modern refrigeration systems.
- 3) Extension of renewable energy production. While six companies had installed photovoltaic elements, other renewable energy sources were scarce. Two companies produced biogas in collaboration with dairy farms.
- 4) Water use efficiency. One company had built cooling towers to be able to reuse cooling water in order to reduce the use of well water and another company was reusing cleaning water and collecting rainwater.
- 5) Waste reduction, recycling and recovery. Three companies stated to be recycling packaging and four apply eco-materials. Meanwhile many companies gave little to no information on their solid waste management, indicating much improvement potential.

Several problems can arise with implementing these points. Firstly, there is the difficulty of large investments for small- and medium sized enterprises, as one company commented in the survey. Furthermore, there can be a lack of financial incentives (water only represents 0.5% of the annual expenses, so the expected financial benefits of water reuse are small). This could be combatted by extending the provision of subsidies connected to environmentally beneficial practices. At the same time, the connection of product quality and sustainability of production in the perception of the consumers and producers should be strengthened. Another measure that could increase the implementation of Circular Economy would be the involvement of producers in the development of new strategies to prove their efficiency and feasibility with real-life evidence.

As the survey is ongoing, more data is expected to be collected over the next months, which will allow a more detailed and representative understanding of the adoption of Circular Economy in the framework considered. Overall, more research is needed to better understand the dynamics of applying Circular Economy in agriculture, to then be able to accelerate its implementation.

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