BIOENG

Brazilian Journal of Biosystems Engineering (2024), 18 1239

REGULAR ARTICLE

A proposal to implement circular economy practices in the milk production chain in the municipality of Wenceslau Braz

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V INTERNATIONAL SYMPOSIUM ON AGRIBUSINESS AND DEVELOPMENT: TECHNOLOGY AND SUSTAINABILITY

Academic Editor: Celso Antonio Goulart

Statements and Declarations

Data availability
All data will be shared upon request.

Institutional Review Board Statement
Not applicable.

Conflicts of interest
The authors declare no conflict of interest.

Funding
This research was funded by Minas Gerais State Research Support Foundation (FAPEMIG) grant number 5.16/2022.

Autor contribution
APRF: Experimental data collection, Data storage, Data analysis, Literature review, Manuscript writing, Manuscript revision, Funding acquisition; JDN: Conceptualization, Literature review, Manuscript writing, Manuscript revision, Supervision, Funding acquisition; JAGS: Literature review, Manuscript writing, Manuscript revision, Supervision.

Abstract

The dairy industry has experienced significant changes since 2021, characterized by increased milk production and a concurrent exodus of producers as the sector becomes more professionalized and modernized. A pressing concern within this chain is the management of whey, a byproduct of cheesemaking. While whey is nutritionally rich, its improper disposal poses a significant environmental threat. A shift towards a Circular Economy (CE) is imperative to foster sustainable growth in the dairy sector. The CE can create new markets, generate income, and mitigate environmental impacts by revaluing whey as a potential raw material. This paper proposes implementing circular practices in the milk production chain. Using the case study methodology, it evaluates their implications for sustainable rural development in a small town in Minas Gerais. The case study was conducted in a dairy located in the municipality of Wenceslau Braz, in the state of Minas Gerais, Brazil. The rural dairy industry in Wenceslau Braz significantly impacts the local economy, providing jobs, promoting local products, and sustaining rural life. However, implementing circular economy practices faces challenges due to inadequate technology for recycling whey in small-scale operations. To address this problem, it is necessary to support micro and small businesses through financial services and research investments. The dairy industry discussed in this paper is already engaged in circular practices, such as donating whey for animal feed and producing cheese bread.

Keywords

Rural development; Bioeconomy; Dairy industry; Production chain; Circular economy.

Introduction

The milk production chain is one of Brazil's main economic activities, present in almost every Brazilian municipality, involving more than one million producers in the countryside, as well as generating millions of new jobs in other segments of the industry (EMBRAPA, 2020). Since 2021, the production scenario has undergone significant changes, with many producers abandoning the activity. On the other hand, there has been a significant increase in milk production as a result of the professionalization and modernization of the entire production chain (EMBRAPA 2020; SILVA, 2023).

According to Almeida et al. (2023), it is estimated that milk production will grow by 1.6 per cent per year and by 2029 it will increase by 14 per cent, due to the rapid growth of the global population. In addition, dairy products are an essential source of nutrients in human diets (STANCHEV et al., 2020) growing in line with the increase in population (USMANI et al., 2022). However, the growth of the dairy industry results in the generation of large quantities of waste which, despite its nutritional value, can cause negative impacts on different ecological systems (MARTINEZ - BURGOS et al., 2021).

With the growing concern about the conscious consumption of natural resources, interest has arisen in a more sustainable dairy industry that embraces the principles of the Circular Economy (CE), whose main objective is to maximize the potential of the resources used in a given production process, which contributes to reducing pollution, the need for virgin raw materials and a reduction in waste generation (ELLEN MACARTHUR FOUNDATION, 2015). This concern led to the development of the 2030 Agenda in September 2015, which sets out a commitment to the health of humanity in social, environmental and economic terms, based on 17 Sustainable Development Goals (SDGs). In which the circular economy collaborates to achieve SDGs 12, 13, 14, 15 and 1, which act respectively on sustainable consumption and production, against global climate change, conservation of marine and terrestrial resources, as well as helping to eradicate poverty through the creation of cooperatives and their inclusion in the circular economy structure (MENDES et al., 2020).

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https://doi.org/10.18011/bioeng.2024.v18.1239
Received: 30 October 2024 / Accepted: 13 November 2024 / Available online: 23 December 2024

In view of the above, methodological reductionism is not appropriate for resolving the emerging problems of post-modernity, since these discussions are located on the periphery and beyond the boundaries set by each discipline (PAUL, 2011). Thus, this project is interdisciplinary in nature, incorporating elements from Veterinary Medicine, Engineering and Applied Social Sciences to analyze circular practices in the milk production chain and their implications for sustainable rural development in the town of Wenceslau Braz, in the state of Minas Gerais.

With the growing emphasis on sustainability, researchers and industry leaders recognize the potential to develop innovative approaches to valorizing whey. This involves transforming it into value-added products while minimizing environmental impact and waste (SOUMATI et al., 2023). Proposals to valorize whey include: biofertilizer and energy production (CECCONET et al., 2018), bioplastic production (REDDY et al., 2019), lactic acid production (COSTA et al., 2020), food production (SCHOINA et al., 2019), animal feed (SCHOINA et al., 2019) and soil amendment (BONDI et al., 2021).

Although the most rational and economical way to treat dairy waste is to combine it with the production of energy and bioproducts with high commercial value, through the application of circular economy concepts (MARTINEZ-BURGOS et al., 2021), conventional treatments still predominate. Although these are costly and at odds with the prospects of the circular economy, given the potential to use effluent as a raw material to generate bioproducts with significant economic value. In addition, there are still potential gaps in work involving the production of food and pharmaceutical ingredients from whey (MARTINEZ - BURGOS et al., 2021), and comparative studies to assess the efficiency, cost-effectiveness, environmental impacts of different techniques and practical case studies of circular economies are still scarce (SOUMATI et al., 2023; HERBSTRITT et al., 2023).

This study aims to propose the implementation of circular economy practices within the dairy production chain and to assess their implications for sustainable rural development in the municipality of Wenceslau Braz. The motivation for this research is the lack of appropriate disposal for whey, a byproduct generated in large quantities by the dairy industry. Moreover, considering the significant number of rural dairies and small-scale producers that could benefit from this residue, it represents an alternative to reduce environmental impacts and foster the development and growth of small and medium-sized rural enterprises.

Materials and methods

The study was conducted in March 2024 in the municipality of Wenceslau Braz, located in Serra da Mantiqueira at an altitude of 1.174 meters, with a mild climate and easy access via Presidente Dutra Highway, BR 459, bordering the municipality of Campos do Jordão, in the state of São Paulo and the municipalities of Delfim Moreira, Itajubá and Piranguçu, in the state of Minas Gerais (SECRETARY OF CULTURE AND TOURISM OF THE MUNICIPALITY OF WENCESLAU BRAZ, 2024). The methodological approach chosen for this work consists of a case study, based on the stages suggested by Forza (2002), Croom (2005) and Souza (2005 apud Miguel, 2012), as shown in Figure 1. The methodology chosen is empirical in nature, as the researcher needs to go into the field, talk to people and witness social relationships. Case studies are increasingly being used by social researchers because they serve different purposes, such as: exploring real-life situations whose boundaries are not clearly defined, describing the context in which a given investigation is being carried out, as well as explaining the variables of a given phenomenon in complex situations that do not allow the use of surveys and experiments (GIL, 2010). In addition, case studies allow examining a specific phenomenon within a real-world setting, where the lines between the phenomenon and its context are frequently blurred (MIGUEL, 2012). This is particularly evident in the case of the Circular Economy within the dairy production chain, as Herbstritt et al. (2023) highlight a dominance of theoretical analyses in the relevant literature, with a dearth of practical case studies.

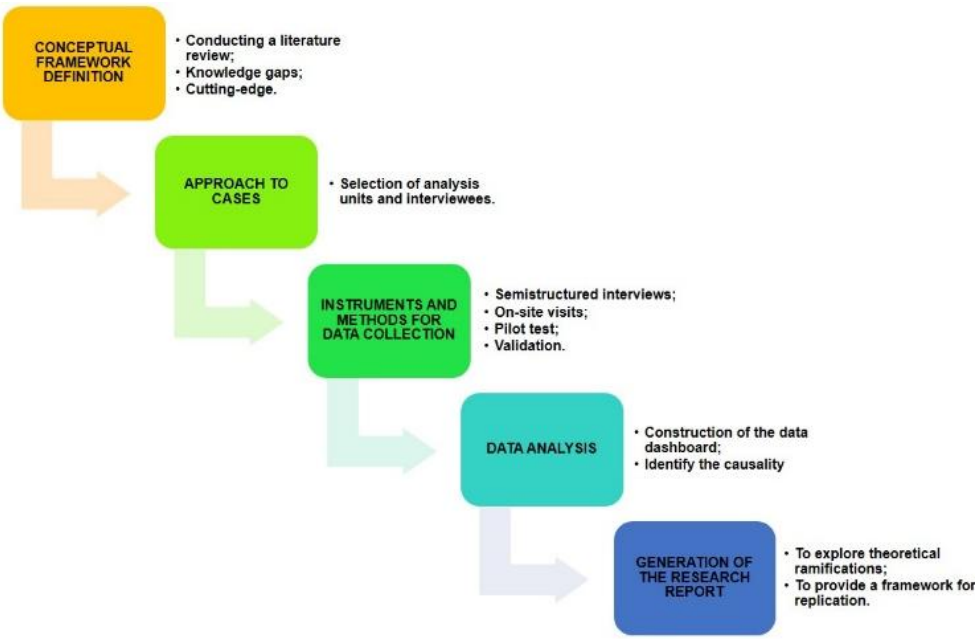

Figure 1. Conducting a case study (Adapted from Miguel, 2012, p. 134).

Results and discussion

Agroindustry A, as described in Figure 2, the agro-industry, with an annual turnover of approximately 3 million, is classified as a small business, according to SEBRAE (2022), small businesses are those with sales revenue in the domestic market of more than R$360,000 and less than or equal to R$ 4.8 million. Still according to SEBRAE (2022), another form of classification is by the number of staff employed, with small companies being those with 20 to 99 people employed, validating their small size, given that they have 27 employees.

The workers' ages vary widely, as illustrated in Figure 3. Notably, one employee is a teenager working as a young apprentice, the son of a dairy operator. Out of the 27 employees, 20 live in Wenceslau Braz, near the dairy, and 7 live in nearby municipalities. This corroborates Damke et al., (2021) assertion that establishing rural industries is crucial for retaining people in rural areas.

For young people to remain in rural areas, Silva and Botelho (2016) highlight the need for access to material and symbolic resources, such as improved infrastructure, expanded access to energy, water, telephony, and internet, as well as increased access to and importance of social policies. According to Macedo (2006, apud SILVA; BOTELHO, 2016), young people seek opportunities to stay in rural areas.

Another aspect addressed is the investment in the knowledge of its employees, which is done at dairy A through lectures and training with the technical consultant, when there are changes to the inspection process, for example. This coincides with one of the pillars of sustainability, social justice, which is aimed at generating jobs and income, training employees and suppliers, as well as substantially improving the rights and conditions of large sections of the population (DAMKE et al., 2021).

Regarding milk suppliers, the dairy has a total of 75 producers, 16% of whom live in the municipality of Wenceslau Braz, compared to 84% in the neighboring towns of Delfim Moreira, Itajubá and Maria da Fé. These producers supply between 6.000 and 10.000 liters of milk a day during the off-season and the harvest. However, the profile of the producers is versatile: "We have producers from 1000 to 5 liters, someone wants to sell milk to us and they're on the route, it's ok" (Interviewee A, 2024). Interviewee A estimates that 50% of suppliers have access to technology, such as mechanized milking, refrigerators, rapid tests to detect mastitis and the internet itself.

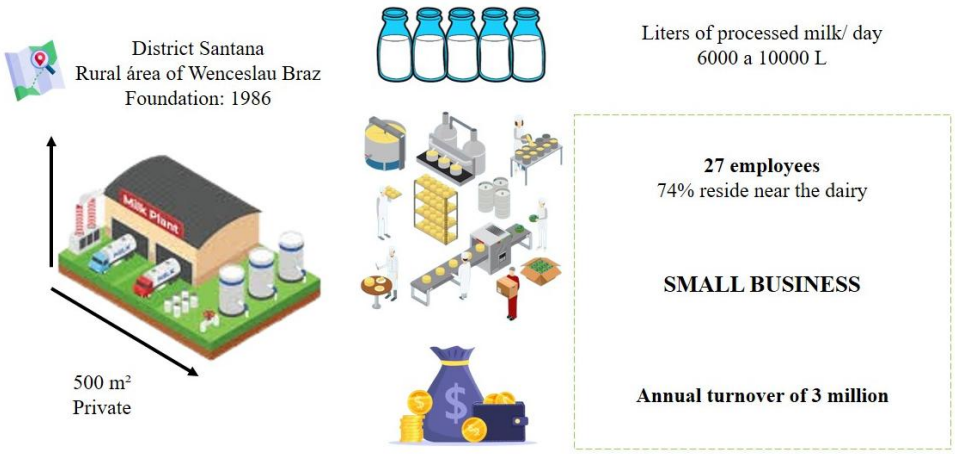

Figure 2. Profile of Dairy A.

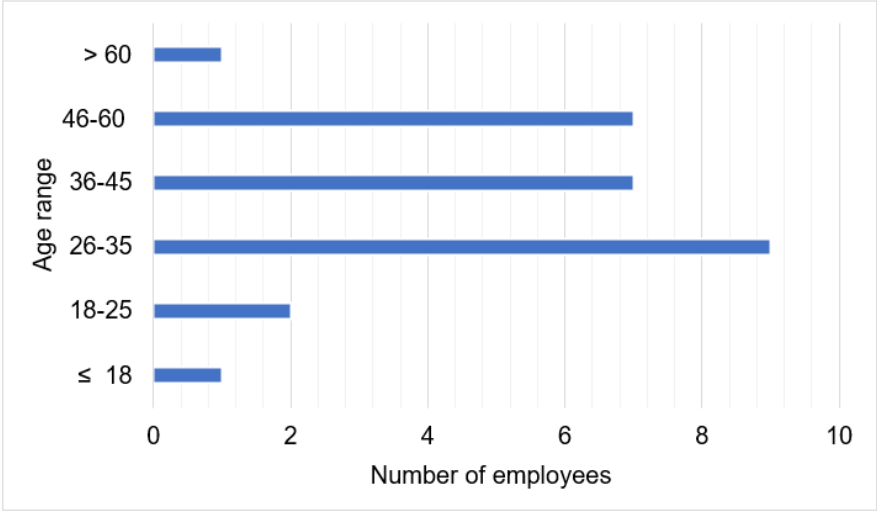

Figure 3. Age range of employees at dairy A.

The dairy also invests in the knowledge of its producers, through lectures, information leaflets such as milking hygiene, visits to producers, among others. In 2023, a series of lectures was even held in partnership with the Itajubá Teaching and Research Foundation (FEPI), a neighboring university, the Cooperative Credit System (SICREDI) and dairy A.

Dairy A has a wide variety of dairy products, producing the following types of cheese: mozzarella, nozinho and palito, standard and fresh minas, montanhês and provolone. As well as yoghurt, butter and dulce de leche. Their criteria for selecting buyers are "loyal clients, who pay the bills on time" (Interviewee A, 2024). These products are sold in local supermarkets, local businesses such as bakeries and grocery stores, inter-municipal businesses that are members of CIMASP, as well as three wholesale buyers who resell.

On average, 6,000 liters of milk are processed per day at dairy A, although there are variations over the course of the year, up to 10,000 liters per day. The milk is collected by a tanker lorry, two covered body lorries, a covered pick-up truck and, in some cases, the producer himself brings the milk in his private vehicle. All transporters measure the milk on the property and, especially in the case of the tanker truck, when collecting the milk, the transporter carries out the alizarol test. When the milk arrives at the dairy, the volume of milk and the temperature are measured, and the titratable acidity, cryoscopic index and antibiotic test are analyzed.

The water used at dairy A comes from a spring and the amount of wastewater produced each day is monitored by the environmental company providing the service. The dairy does not have a waste treatment plant, but it does receive guidance on waste management from the contracted company and has a particle filtration and decantation system.

When asked in which cases the milk is discarded at the dairy, interviewee A reports cases of antibiotics, acidity above 18 D and the addition of water, and the destination given to condemned milk is to return it to the producer. Returning to the topic of whey waste, on average around 5.600 liters are produced daily by dairy A. This figure follows the variation in milk during the harvest and off-season. The whey is offered to producers and suppliers of the dairy for animal feed and is in high demand, as shown in some of interviewee A's statements "[...] and the whey, there are days when there's even a fight over the whey, because it's for pigs, cows, they consume a lot", "we have an outlet for 100% of the whey produced, we have a high demand for animal feed". This corroborates Nunes et al (2018), who point to the use of whey for animal feed.

However, the authors also mention whey for making fresh cheeses, such as ricotta and cottage cheese, but the final residue (whey with caustic soda) is at odds with the prospects for the development of the circular economy, as it will consume more energy and financial resources.

When asked about his knowledge of initiatives aimed at reusing whey, the interviewee had already taken part in a project between a local university, the dairy and Itajubá City Hall, a municipality neighboring Wenceslau Braz, to include whey in school meals.

Although the concept of the circular economy is not new and is based on others used since the 1960s, the concept has gained greater relevance on the international agenda since the actions of the Ellen MacArthur Foundation around 2010. It is therefore necessary to get to grips with the interviewee's understanding of the topic, to recognize what this economy means, which aims to make the most of the potential resources used in a given production process, which contributes to reducing pollution, the need for virgin raw materials, as well as reducing waste generation (ELLEN MACARTHUR FOUNDATION, 2015). The circular economy is responsible for developing innovative techniques for valorizing waste, such as whey. Transforming it into products with added value, minimizing pollution and waste (SOUMATI et al., 2023). Some of the applications of the circular economy in the milk production chain: production of biofertilizer and energy, production of bioplastics, production of lactic acid, soil improver, production of cheese, dairy drinks and animal feed (FORTES; NADAE; SANCHÉZ, 2023).Finally, when asked about the likelihood of the dairy adhering to a circular practice, the interviewee was highly receptive, but said that the greatest difficulty would be investment and cooperativism between the interested parties.

This corroborates Almeida et al (2023) who mention that to overcome limited access to expensive technologies, it is necessary to implement economic support programs for small producers to collect, dispose of, treat and, above all, value whey.

Conclusions

The rural dairy industry has an influence on both the economic and social aspects of the town of Wenceslau Braz. It generates decent jobs close to home, promotes the culture of local products, guarantees a safe working environment and keeps people in the countryside. However, one difficulty in implementing the circular economy in the milk production chain in remote communities is the fact that the technologies for reusing and recycling whey are not adapted to these small producers and consumers with low economic power. It is therefore necessary to encourage the formalization and growth of micro and small businesses through access to financial services and investment in research and development.

However, although the term circular economy is not widely used in the milk production chain, dairy A already has some circular economy practices, such as donating whey for animal feed, which reduces the cost of animal production, as well as commercializing whey as a raw material for producing cheese bread. In social terms, the dairy invests in the professionalization of its employees and producers through partnerships with universities and local financial institutions. On the social front, the dairy invests in professionalizing its employees and producers through partnerships with universities and local financial institutions.

The guiding problem of this study is: How can circular practices be implemented in the milk production chain in the town of Wenceslau Braz, in the state of Minas Gerais? The answer to this question lies in the development of solutions adapted to the local geography, economy and politics, as well as cooperativism between the stakeholders (the state, companies and universities). Through action plans, investments in research, legislative updates and, above all, government incentives to promote a more sustainable agri-food system. Future topics for the authors of this project include family succession and social technologies in the milk production chain.

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