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Circular Economy Diagnosis of the Agro-Food Chain of Cheese from Chone, Manabí Province

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Abstract---*The Chone cheese agri-food chain faces challenges in terms of sustainability and resource efficiency. The production process generates waste and byproducts that, in many cases, are not properly utilized. Economically, although the activity is fundamental to the local economy, an adequate structure for incorporating circular economy practices that improve competitiveness and reduce the environmental footprint of production is still lacking. This circular economy assessment of the Chone cheese agri-food chain in the province of Manabí seeks to evaluate the practices and processes involved in the production, distribution, and consumption of cheese, and to identify opportunities to improve the sustainability and efficiency of resource use, from both environmental and socioeconomic perspectives. The milk produced by local farmers is a key input for cheese making. The quality of this milk depends on the agricultural practices employed in pasture production and livestock feeding. A key factor for the success of the circular economy is the level of awareness and knowledge about sustainable practices among producers, cooperatives, and consumers. The results showed that a lack of awareness and training on sustainable models is also a barrier to implementing these approaches. This diagnosis allows us to identify critical areas where the circular economy could be implemented to promote greater resource efficiency, reduce environmental impact, and generate economic benefits for both producers and the Chone community.*
Keywords---*benefits, circular economy, impact, Production, resources*

Introduction

The circular economy assessment of the Chone cheese agri-food chain in the province of Manabí aims to analyze current practices in cheese production, distribution, and consumption in order to identify opportunities for more sustainable and efficient resource use within this sector. Currently, cheese production in the region is deeply intertwined with local livestock farming, which relies on agricultural and resource management practices that, in many cases, are not entirely sustainable. This generates not only economic challenges but also environmental impacts that affect both local biodiversity and product quality.

This diagnostic study aims to evaluate the different stages of the cheese value chain, from milk production to marketing, seeking to integrate the principles of the circular economy. These principles propose improved resource utilization, waste reduction, and the reuse of byproducts such as whey, all with a focus on environmental sustainability and strengthening the local economy (Wamba & Queiroz, 2020).

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Furthermore, this analysis seeks to identify the level of awareness and understanding among producers and consumers regarding the importance of implementing circular models in agri-food production, as well as the potential barriers and opportunities for adopting these practices. Ultimately, the assessment aims to offer practical solutions that contribute to a more efficient, sustainable, and competitive agri-food system for cheese producers in Chone, benefiting both the local economy and the environment.

The research aims to improve the overall utilization of cheese during its production, as it tends to generate waste that could be used in other byproducts. Therefore, the circular economy is being implemented, since it determines the use or reduction of waste and allows for the development of new product ideas made from the waste generated during cheese production, thus ensuring the full utilization of resources (Patwa et al., 2021).

In Ecuador, the province of Manabí has historically been recognized for its agricultural activity, particularly in the production of dairy products such as cheese. Chone, as one of the cantons with the highest livestock activity, faces challenges in terms of the sustainability of its agri-food chain, especially in cheese production. Currently, cheese producers in this region follow traditional practices that, although effective in terms of production, are not always environmentally and economically sustainable. Furthermore, waste management and the efficient use of natural resources such as water and energy remain critical areas that require attention. (Suarez, 2023).

The circular economy represents a key alternative to the traditional linear "take, make, and dispose" model by promoting waste reduction, material reuse, and resource optimization throughout the entire production chain. In this context, the agri-food sector, and specifically the cheese value chain in Chone, Manabí province, faces significant environmental, economic, and social challenges that require a transition to more sustainable and circular models. (Prieto-Sandoval et al., 2017)

The dairy sector, particularly cheese production in Chone, generates a considerable amount of waste and byproducts, such as whey, solid packaging waste, and wastewater from manufacturing processes. When not properly managed, this waste can contribute to environmental pollution and the waste of valuable resources. Applying circular economy principles, such as reusing whey in other industries or using recyclable packaging, can drastically reduce the negative environmental impact of this activity. (Arteaga Solórzano et al., 2021).

Adopting a circular economy model could allow cheese producers to generate additional income by valorizing byproducts, such as whey, which is currently considered waste. Likewise, circular practices in cheese marketing, such as the use of returnable or recyclable packaging, can open new market opportunities, especially in a context where consumers are increasingly interested in sustainable and responsible products. (Negrón-Ríos, 2020).

The dairy sector in Chone is based on small and medium-sized producers operating within local cooperatives. These actors face challenges related to market access and the implementation of sustainable practices due to a lack of resources, training, and technical support. A comprehensive assessment of the circular economy can identify ways to train producers in best practices, improve value chain efficiency, and strengthen the local economy, thereby promoting a circular economy in the dairy sector of Manabí province. This would contribute to a regulatory framework that incentivizes the adoption of sustainable practices, enhances the sector's competitiveness, and fosters value creation through the efficient management of resources and waste (Salameh & Jaber, 2000).

Materials and Methods

The methodology for diagnosing the circular economy in the agri-food chain of Chone cheese must be structured and adapted to the region's specific characteristics, the production chain, and the principles of the circular economy. For the study, surveys and interviews with key stakeholders were conducted.

A qualitative approach was used, employing interviews with cheese producers, distributors, and local authorities in the province of Manabí, who provided information on current circular economy practices in the Chone cheese agri-food chain. The interviews were conducted in person with the participants' consent. Participant observation was also carried out at cheese factories and local markets to supplement the data obtained. Vasilachis et al. (2019) argue that the flexibility of the qualitative research process leads researchers to return to the field, to the situation, to encounters with social actors, to the corpus, and to field notes repeatedly.

At the same time, the quantitative approach, according to Arellano (2013), aims to measure and weigh reality, evaluating it in terms of its behaviors and trends. This is necessary if one wants to know precisely what has happened or what is happening, what its performance has been, and what consequences it has in the immediate, but also in the long term.

The data collection method employed was carried out through interviews with a total of 20 cheese producers and distributors, as well as with representatives of local authorities, in addition to the quantitative approach through the implementation of a structured questionnaire with closed questions, based on key indicators of the circular economy such as recycling, resource efficiency, and waste management in the agri-food chain (Trang, 2023).

The questionnaire was specifically designed for cheese producers, distributors, and other key stakeholders in the Chone cheese agri-food chain. A mixed-methods approach was used, combining semi-structured interviews (qualitative approach) with a structured questionnaire (quantitative approach). The interviews focused on obtaining detailed information about the practices and challenges in implementing a circular economy in cheese production in Chone. Equation 1 was used to calculate the sample size

$$n = \frac{WITH_{\alpha}^{2} * p * q}{and^{2}} \quad (1)$$

Where:
n→Desired sample size
WITH→Statistical parameter that depends on the Confidence Level (CL)
and→Maximum acceptable estimation error
p→Probability of the studied event occurring (success)
q (1-p)→Probability that the studied event will not occur

Analysis and Discussion of the Results

The Chone cheese agri-food chain was identified by characterizing all the actors involved, from primary production (livestock farmers) to marketing and final consumption. Figure 1 shows the actors who participated in the research.

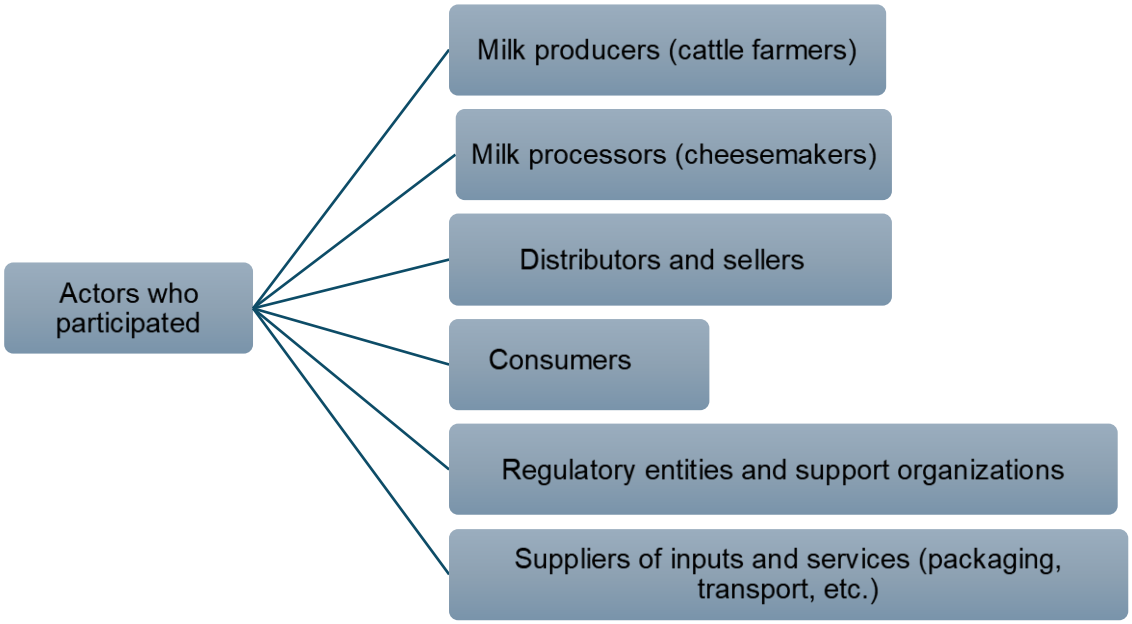

Figure 1. Actors who participated in the research

Analysis of production processes

Studies of agricultural and livestock practices in Chone were carried out, focusing on milk production, including the management of natural resources (soil, water, pasture) and inputs (fertilizers, livestock feed). Research was conducted on the transformation and production of cheese. In this context, an evaluation of the cheese production processes was carried out, from the reception of the milk to the maturation, packaging, and storage processes. In the case of distribution and marketing, an assessment was made of how the cheese is distributed in the local, regional, and national markets, and how the waste generated during transport and sale is managed. Figure 2 shows the role of the agri-food chain for Chone cheese

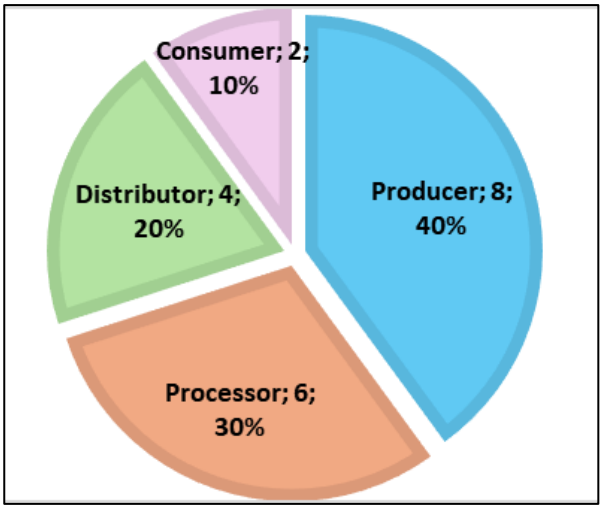

Figure 2. *Role of Chone cheese in the agri-food chain*

The participants in the value chain can be observed, noting that producers are the largest participants at 40%. One of the aspects considered in the survey was related to the length of time they have been involved in the agri-food activity, with the most recently identified participants. Additionally, their familiarity with the concept of a circular economy was assessed, yielding the results shown in Figure 3.

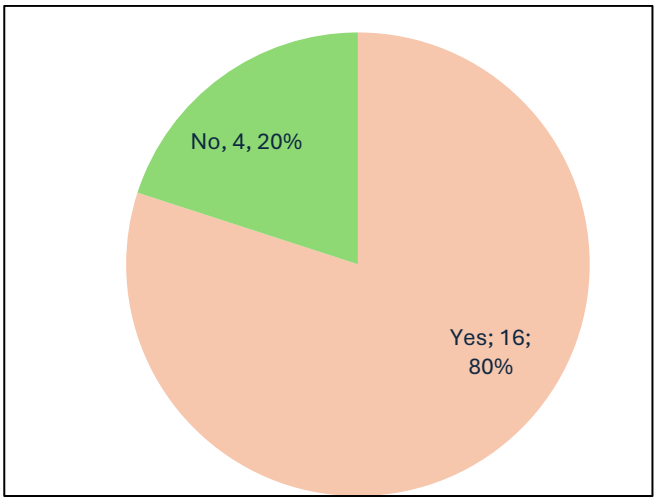

Figure 3. *Familiarization with the circular economy*

When asked about the possibility of applying the circular economy to cheese production in Chone, positive responses were obtained from those surveyed. They were aware of the quantity of inputs used in cheese production, such as milk (80%), rennet (10%), salt, and containers (5%).

Another aspect of particular interest was understanding existing cheese production practices that could be considered part of the circular economy. In this context, it was found that products were being reused. This aspect is fundamental to the circular economy, as it breaks the linear cycle of extracting, manufacturing, and disposing. Its contribution to sustainability is multidimensional, positively impacting the environment, economy, and society by preventing the Extraction of new natural resources, allowing ecosystems to regenerate, mitigating soil and air pollution, and contributing to climate protection by reducing CO_2 emissions to the atmosphere. One of the products that was reused at a rate of 75% was whey at 75%.

The interview asked if they knew of any government or private programs or initiatives that promoted the circular economy in the cheese agro-industry, and it was noted that 60% responded positively. The respondents were aware of some benefits and the implementation of practices in the circular economy; the most relevant for them were job creation (60%), improved sustainability (25%), and cost reduction (15%). This aspect is essential in the economy for

those involved in the production of the product. This study helped to reveal that there is a clear awareness of the circular economy among local producers.

A key finding was that respondents were aware that adopting a circular economy in the cheese value chain could improve the quality of the final product by 95%, thus making it not only an environmental sustainability strategy in the cheese value chain but also directly influencing the organoleptic, nutritional, and commercial quality of the final product. preserving its original essence and extending its shelf life without the need for chemical preservatives, a more authentic flavor, and better fats, higher protein content, among others.

Those surveyed considered it especially important to conduct workshops or training programs on the circular economy for cheese producers and expressed their interest in participating in such programs, as these would help improve results, for example, by transforming sewage waste into organic fertilizers and improving efficiency throughout the entire production cycle. In this context, 95% of respondents were willing to adapt their production methods and incorporate circular economy principles into their final cheese production.

The results obtained above indicate that the producer plays a key role in cheese production, since he not only produces the milk, but also actively participates in the transformation of milk into cheese and in the distribution of the local product. The participation of the producers and their knowledge of the artisanal process add significant value to the identity of Chone cheese.

Many producers have years of experience in this activity. Some may have been involved for generations, reflecting a deep understanding of traditional cheese production and local dairy farming. Some producers may have limited knowledge of the circular economy concept, while others may be partially familiar with practices that encourage resource reuse in their production process.

Producers are generally open to the idea, although they may not have formally implemented the circular economy; however, it is recognized that certain existing practices could align with the principles of the circular economy, such as the reuse of by-products.

The main inputs are fresh milk, rennet, salt, and other specific ingredients depending on the type of cheese. Some producers also use materials for cheese ripening and storage, although these practices may not be formally labeled as "circular economy." Some producers reuse certain materials, such as whey, for other purposes, either in animal feed or as fertilizer.

Many producers reuse whey, either to feed animals or even to manufacture other products such as cream or bread. This reflects a trend toward minimizing waste and making the most of resources. Some producers may have heard about government or private programs or initiatives that promote the circular economy in agribusiness, although these may not yet have been implemented in a meaningful way in the local community.

Adopting circular economy practices could bring benefits such as reduced production costs, improved sustainability, and a stronger positive environmental impact. It could also contribute to the diversification of dairy products. In general, there may be a low level of awareness among local producers about the full benefits of the circular economy. However, there is a willingness to learn about the topic and explore its potential.

Many producers believe that adopting circular economy practices could improve the quality of the final product, as it contributes to more sustainable and efficient processes, which in turn can improve the perception of the product both locally and in wider markets. There is a strong willingness among producers to participate in workshops and training programs on the circular economy. Most believe that this type of training could be very beneficial in improving the efficiency of their processes.

Producers are generally willing to participate in training programs if offered practical resources and local examples. This could include the introduction of new technologies and methods that promote sustainability, enabling them to adapt their production methods if clear incentives are provided, such as economic benefits, increased efficiency, and improvements in the quality of their produce.

Dairy and cheese producers in Chone are generally showing increasing interest in circular economy practices, especially those already familiar with some basic concepts, such as reusing byproducts. Many producers see the circular economy as an opportunity to reduce costs and improve efficiency in their operations. However, some still don't fully understand all the principles of the circular economy, although they are willing to explore ways to optimize their resources, such as reusing whey in animal feed or as fertilizer.

Cheese consumers in Chone, especially locals, are not as directly involved in production practices, but they may have a positive perception of the circular economy if it is linked to improved product quality and sustainability. As the market increasingly values sustainable production, consumers may be willing to pay a premium for products that utilize circular economy practices. However, some may be less informed about the concept, so education on the benefits of the circular economy could be helpful in generating greater demand.

Cheese producers in Chone welcome the implementation of the circular economy, as it can contribute to optimizing resources in the production process, improving product quality, and reducing operating costs. Many are already utilizing byproducts, such as whey, to produce other products or even as animal feed. However, some producers may need more information and support to adopt a more formal and systematic integration of circular economy practices. For them, implementing the circular economy could offer added value, both in terms of process efficiency and in satisfying environmentally conscious consumers.

Transporters in the cheese agri-food chain in Chone can also indirectly benefit from the circular economy, especially if waste reduction and resource optimization lead to a decrease in the volume of unused products, such as containers or packaging materials. Although their role focuses on transporting the products, they can reap additional benefits. The circular economy contributes to greater sustainability in the production and distribution of dairy products. Furthermore, if efficiency improves throughout the supply chain, transporters could experience a reduction in operating costs.

Stakeholders in the cheese and dairy agri-food chain in Chone are open to the idea of integrating the circular economy, but their understanding and willingness to embrace it vary. Producers and processors are the most interested in adopting sustainable practices due to the economic and operational benefits, while consumers and transporters are still not fully informed about the potential positive impact of the circular economy. If educational and awareness-raising programs are implemented, all stakeholders are likely to align more closely with the principles of the circular economy, potentially resulting in a more efficient, sustainable, and competitive agri-food chain.

It was found that there is a low level of knowledge and awareness of circular economy principles among producers, cooperatives, and consumers in the region. Education and awareness-raising about the benefits of these practices are essential to promoting their adoption. Specific training and awareness-raising strategies need to be designed, including workshops, information campaigns, and practical demonstrations, so that key stakeholders understand how the circular economy can improve the economic and environmental sustainability of their operations.

To promote the integration of circular economy practices into the Chone cheese agri-food chain, it is necessary to create regulatory frameworks and public policies that incentivize these practices. Furthermore, collaboration among producers, cooperatives, and local authorities must be fostered, and access to innovative technologies and techniques that optimize resource use and minimize waste must be facilitated.

Traditional cheese production methods in Chone are effective in terms of flavor and quality, but they are inefficient in their use of resources such as water and energy, and they generate waste products like whey. These byproducts can be managed in a circular fashion, transforming them into reusable or marketable resources, such as animal feed or valuable fertilizers, which would increase efficiency and reduce environmental impact.

Conclusions

Opportunities were identified to improve the sustainability and efficiency of resources used from both an environmental and socioeconomic perspective, demonstrating that agricultural and livestock practices in the Chone region are closely linked to sustainability. The proper use of natural resources, pasture management, and livestock feeding are vital to ensuring the long-term sustainability of milk production; however, areas for improvement were identified in terms of resource optimization, such as water and animal feed inputs, which must be managed efficiently to avoid resource depletion and environmental degradation.

Implementing circular economy models can significantly improve the competitiveness of the dairy sector in the region. By utilizing waste generated during milk and cheese production, such as whey, and reincorporating it into the production process or other economic activities, producers can generate added value. Furthermore, these models can promote product diversification and open new economic opportunities, benefiting both producers and livestock cooperatives

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