


**CHARACTERIZATION OF ARTISANAL BUTTER CHEESE PRODUCTION:
CONTRIBUTIONS TO THE PROTECTION OF TRADITION AND
GEOGRAPHICAL INDICATION IN THE SERIDÓ SEMI-ARID REGION, BRAZIL**

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ABSTRACT

The aim of this study was to gather information on the production characteristics of non-industrial butter cheeses in the Semi-arid Region of Brazil, and to help identify a standardization pattern in production in order to support further official recognition and protection of the region's traditional cheeses, as has happened in other regions of Brazil and the world. The study was conducted in the Seridó territory in the state of Rio Grande do Norte, Brazil, where there is a tradition of artisanal butter cheese production. A total of 200 cheese producers were interviewed in the Seridó region, and 87 artisanal butter cheese producers were selected from this group. The Seridó region has a tradition of producing butter cheese, but it was found that there is no standardization in the manufacturing stages, such as coagulation and desorption time, nor in the use of inputs (for example: the amount of butter added to the mass). The results of this diagnosis reveal the need to promote technical guidance and training for producers in order to adapt processes and facilities, preserving the traditional way of making butter cheeses in the Seridó region, as well as their quality and safety. Joint implementation of appropriate public policies, investment in technical assistance and training, and dissemination of legislation for artisanal production are fundamental to achieve progress in the protection and geographical indication of butter cheese and to strengthen the traditional way of making it. The results enhance artisanal butter cheese understanding, preserving culture and boosting the region's economy.

Keywords: Food processing. Traditional foods. Raw milk cheese. Artisanal cheese. Territorial valorization.

INTRODUCTION

Traditional and artisanal foods are present all over the world and contribute to cultural and territorial valorization and to preserving people's traditions and identity. Artisanal cheese production values the traditions of the communities and allows small producers to remain in the rural environment on a sustainable basis, because it represents a strong economic activity, with the opportunity to offer unique products, catering for niche markets and with high value-added (Penna; Gigante; Todorov, 2021).

There are more than 30 types of artisan cheese in different regions and biomes of Brazil, demonstrating the country's food and cultural diversity (Kamimura et al., 2019). Brazilian artisan cheeses are found from the north to the south of the country, mainly in the micro-regions of the Southeast (Araxá, Campo das Vertentes, Canastra, Cerrado and Serro), South (Colonial and Serrano), Center (Caipira), North (Marajó) and Northeast (Butter or "Manteiga", and Coalho) (Kamimura et al., 2019; Kothe; Mohellibi; Renault, 2022; Penna; Gigante; Todorov, 2021).

Butter cheese (Queijo de Manteiga or Queijo do Sertão) has a melted paste and very unique characteristics compared to other types of cheese, with a soft texture, and an understated taste and smell reminiscent of butter. The Technical Regulation for the Identity and Quality of Butter Cheese is contained in Normative Instruction No. 30 (Brasil, 2001). The name butter cheese is reserved for products whose dairy base does not contain fat, protein or other products of non-dairy origin. The fat content in the total solids of this cheese varies between 25% and 55%, and its maximum moisture content is 54.9% m/m (Brasil, 2001).

The state of Rio Grande do Norte is the main producer of this cheese in Northeast Brazil, whether in industrial or artisanal form, and protects it by State Law No. 10.230 and Decree No. 31.136 (RN, 2021, 2017), which deals with the production and marketing of artisanal cheeses and butter at the state level. This State Law supports the Federal Law on the production of artisanal cheeses when the producer seeks national marketing ("Selo ARTE") (Brasil, 2022).

The Seridó has a territorial extension of 10,808.615 km², composed of 25 municipalities in the state of Rio Grande do Norte and is divided into the micro-regions of Western Seridó, Eastern Seridó, Serra de Santana and part of the Vale do Açu micro-region (Almeida, 2018). The Seridó region is in the Brazilian semi-arid region. The characteristics of the region are striking semi-arid, hot climate with low humidity, temporary

rivers, sandy, dry and stony soil, Caatinga vegetation adapted to the seasonality of the few rains throughout the year (Morais, 2020).

The Seridó traditionally produces milk and artisanal dairy products, mainly cheeses and butter (Manteiga do Sertão or Manteiga da terra). Dairy farming is an economic activity which has historically ensured the survival and settlement of a large part of the territory's rural families, despite the climatic challenges for farming and feeding cattle (Azevedo; Locatel, 2009). However, these same peculiar environmental conditions guarantee the unique identity and terroir of its food products. The name Seridó or Caicó (Seridó's hub city) is popularly associated with the originality, quality and credibility of the region's products and represents the identity and know-how which set them apart from other regions in Brazil and around the world (Morais, 2020).

The Seridó Sustainable Development Agency (ADESE) published the latest census of cheesemakers in the region in technical cooperation with Germany's Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) (ADESE; GTZ, 2008). The researchers mapped 314 artisanal cheese production units in the Seridó and showed that most of them maintained the traditional and rudimentary way of making cheese, making it a centuries-old activity. They found that 51.6% of the cheesemakers used only firewood as a heat source for production and that the region produced 241,328 kg of butter cheese every month, constituting three times more than rennet cheese (74,039 kg) (ADESE; GTZ, 2008). The study estimated that butter cheese accounts for 69% of the total volume of artisanal dairy products in the region, while rennet cheese, bottle butter and cream only account for 21, 6 and 4% of production, respectively (ADESE; GTZ, 2008). This demonstrates the importance of the Seridó region as the traditional home of butter cheese.

The identity and quality references, terroir, and sensory characteristics of the Seridó cheeses have given the region notoriety and recognition as a cheese reference in Brazil. The region's artisan cheeses have been recognized and awarded nationally and internationally in the past five years (Erys, 2019; SEBRAE-RN, 2023). On the other side of this favorable scenario of recognition, producers in the region have to face competition from producers based outside the region, or who adulterate the traditional recipe (Medeiros *et al.*, 2023) unfairly taking part of the authentic cheese market and risking the loss of identity and discrediting of Seridó cheeses over time, even though there are technical regulations, laws and specific decrees for them (Brasil, 2001, 2022; RN, 2021, 2017).

The artisanal nature of butter cheese production gives rise to heterogeneity in its sensory characteristics due to interference from the production environment and knowledge passed down through the generations. However, a minimum standardization level in the production process ensures the identity and safety of artisanal cheese, fostering consumer loyalty and enabling producers to protect their culture and reach a comprehensive, consistent and profitable market (Penna; Gigante; Todorov, 2021). Thus, actions are needed to preserve the characteristics that define authentic butter cheese, guaranteeing its distinction from other cheeses of the same nature.

This study was conceived in view of all the abovementioned productive, social, cultural and economic context of artisan cheese production in the Seridó region and the need to protect the historical and cultural heritage of its people. Our aim was to gather information on the production characteristics of butter cheeses made in a non-industrial way in the Seridó region, and to help identify a standardization pattern in production in order to support subsequent actions to recognize and protect the region's traditional cheeses, as has happened in other regions of Brazil and the world with protected geographical indications and designations of origin. The experience reported in the study can be extrapolated to the context of other traditional products anywhere in the world.

METODOLOGY

CHARACTERIZATION OF THE STUDY SITE

The field research was conducted in the Seridó region, in the center-south of the state of Rio Grande do Norte, in Northeastern Brazil. The Seridó has a tradition of producing artisanal butter cheese. The region is part of the Caatinga, an exclusive biome of the Brazilian semi-arid region, with a predominantly hot and dry climate, with little rainfall throughout the year. The native Caatinga vegetation conditions make it difficult to feed the cattle during the dry months and consequently modify the characteristics of the milk and its derivatives. These environmental conditions are added to the peculiar cultural, social and economic conditions of the people in this region, giving a unique identity to the products obtained and produced there.

SELECTION OF THE PRODUCTION UNITS TAKING PART IN THE STUDY

The study began by identifying the producers who produce artisanal cheese in the Seridó region based on the following sources of information: Latest census performed by

the Seridó Sustainable Development Agency (ADESE; GTZ, 2008); updated producer registers at the Rio Grande do Norte Technical Assistance and Rural Extension Institute (EMATER-RN); the registry of cheese production units registered with the State's Official Veterinary Service (IDIARN); search with public agents, associations, trade unions, cooperatives and other local community organizations; and, a list of producers assisted by the state government's infrastructure financing project with the World Bank. The criteria used to select the Seridó Butter Cheese Production Units (**BCPUs**) to take part in the study was that they produced butter cheese, and they could be units with health registration (non-industrial) or without.

The location of the cheese production units was mapped from the geographic information system using the ESRI® ArcGis (ArcMap) 10.8 program.

DATA COLLECTION

The variables selected for the questionnaires were defined by the researchers and extension technicians. The survey had open and closed questions, divided into four blocks: the owner's profile; the **BCPU'S** profile; the process of producing butter cheese; and management. The **BCPUs** were visited between May and August 2022 to learn about the infrastructure and administer the questionnaires. A total of 200 cheese producers in the Seridó region were identified and interviewed. Next, 87 artisanal butter cheese producers were selected from this group who fit our research object (8 industrial butter cheese producers and 105 Coalho cheese producers were excluded, as they were outside the research objective).

DATA ANALYSIS

The answers to the survey were recorded on Google Forms® and the data was compiled in an Excel® spreadsheet, version 2013. The mean and median of the producers' responses were calculated for the quantitative variables, and the frequency (%) of responses for the categorical variables.

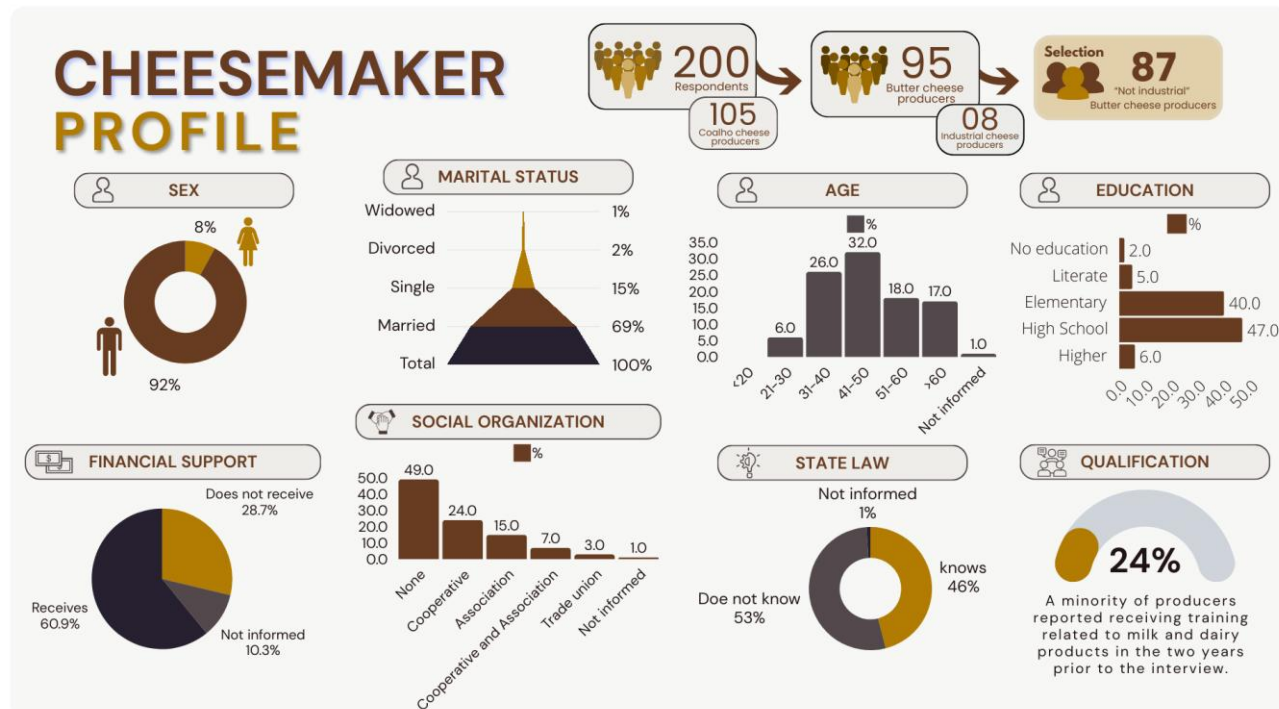
The Chi-squared test was used to verify the existence of a relationship between categorical variables in the study grouped two by two and to assess whether the association between them was significant, applying a 95% confidence interval ($\alpha = 0.05$).

RESULTS AND DISCUSSION

OWNER PROFILE

The results of the variables related to the profile of the owners of butter cheese production units in the Seridó are shown in Figure 1.

Figure 1 - Profile of butter cheese producers in the Seridó region, state of Rio Grande do Norte, Brazil.



Source: Authors 2025

Socio-economic characteristics

The manual process of melting traditional butter cheese requires physical strength and this may be a motivating factor for the higher concentration of men in the process (92%) (Figure 1). Historians have shown that there was already a division of labor by gender on cheese-producing farms in the Seridó in the past, where men were dedicated to making butter cheese and women to preparing rennet cheese (Morais, 2020).

The age groups that accounted for most of the interviewees were 41 to 50 years old (32%) and 31 to 40 years old (26%), with a minority of young people aged up to 30 (6%). This data shows that the future of this centuries-old activity may be threatened by the lack of active participation of young candidates for business succession.

The education level of the owners ranged from no education to complete higher education (Figure 1). Owners with a higher education level are generally more aware of the need to comply with legislation, implement good manufacturing practices and are more

willing to acquire new knowledge (Dos Santos, Clenilson Gonçalves *et al.*, 2017). Therefore, most of the owners interviewed are literate and have a strong potential to deal with issues related to sanitary and hygienic adjustments in the production of traditional cheeses in the region in accordance with official standards (Brasil, 2022; RN, 2017).

Financial support and social organization

Most of the interviewees were beneficiaries of the actions of the National Program for Strengthening Family Farming (PRONAF) (61%) aimed at increasing the productive capacity, generating jobs and raising the income of family farmers (Figure 1). They generally reported that the sale of the cheese produced was the family's only source of income or supplementary income.

Almost half of the owners reported that they did not participate in community organizations such as producers' associations, cooperatives or unions (49%). The Association of Seridó Cheese Producers (Amaqueijo) was recently created with the aim of joining forces to obtain Geographical Indication registration and enhance the value of the Seridó Region's artisanal product (G1, 2022). This initiative was a milestone and planted positive expectations for developing the craft segment in the territory. Participation in this type of social organization is important because it promotes debates and disseminates issues pertinent to the sector, transfers information and strengthens producers; the collective purchase of inputs; greater access to courses, training and scientific research on cheeses and related topics; and the possibility of greater technical support.

Knowledge of sanitary registration

Most of the producers reported that they were unaware of State Law No. 10.230 (Nivardo Mello Law) (RN, 2021, 2017), which deals with the production and marketing of artisanal cheeses and butters in the state (Figure1). With the enactment of this law, the state of Rio Grande do Norte was one of the first federations in the country to have its own legislation for artisanal products, providing for the registration of artisanal establishments without altering the unique way of making the products. Even after five years between the creation of the state legislation and this study, most of the region's non-industrial butter cheese producers were unaware of the law. This demonstrates the need for legislation to be better publicized by the competent bodies and professionals and for health education actions to be carried out in the localities, so that more **BCPUs** seek health registration and

can thus offer safer products to the consumer and expand their operations in markets inside and outside the state with more credibility.

Technical training

The majority of respondents had not undergone any training in the area of milk and dairy products in the two years prior to the interview (76%) (Figure1). This data may be related to the COVID-19 pandemic, which has affected the world since 2020, as many institutions have remained closed for a long period or have carried out training remotely. However, these results are higher than those of Mesquita; Rocha; Carneiro (2009), in which no producer in the Seridó Region had been trained.

The owners who had undergone training cited participation in courses on Good Manufacturing Practices (GMP) and cheese making, promoted by educational institutions and technical assistance (24%). Participation in training can improve producers' awareness of the need for physical adjustments to the **BCPU**, quality control of raw materials and the use of good manufacturing practices, for example, directly reflecting on the quality standards of the products.

Responsibility for production

It is common in the region for the owner to have several roles in the **BCPU**, being responsible for both business administration and production. The survey showed that the owner was solely responsible for making butter cheese in 63.2% of the **BCPU**s (S1 Table).

Someone from the owner's family was involved in 78.2% of the **BCPU**s, such as a spouse, child or other relative. The owner shared responsibility for production with an employee in 8.8% of the units. Only a hired person was responsible for production in 20.7% of **BCPU**s. This shows that **BCPU**s are small, mostly family-run businesses, in which the sale of cheese accounts for all or a large part of the family income. Most family-run production units were also found in Brazilian studies (Minas Gerais regions) by Pinto (2004) in the Serro (55%), Saraiva et al. (2020) in the Serra Geral (57%) and Araújo (2004) in the Araxá (70%).

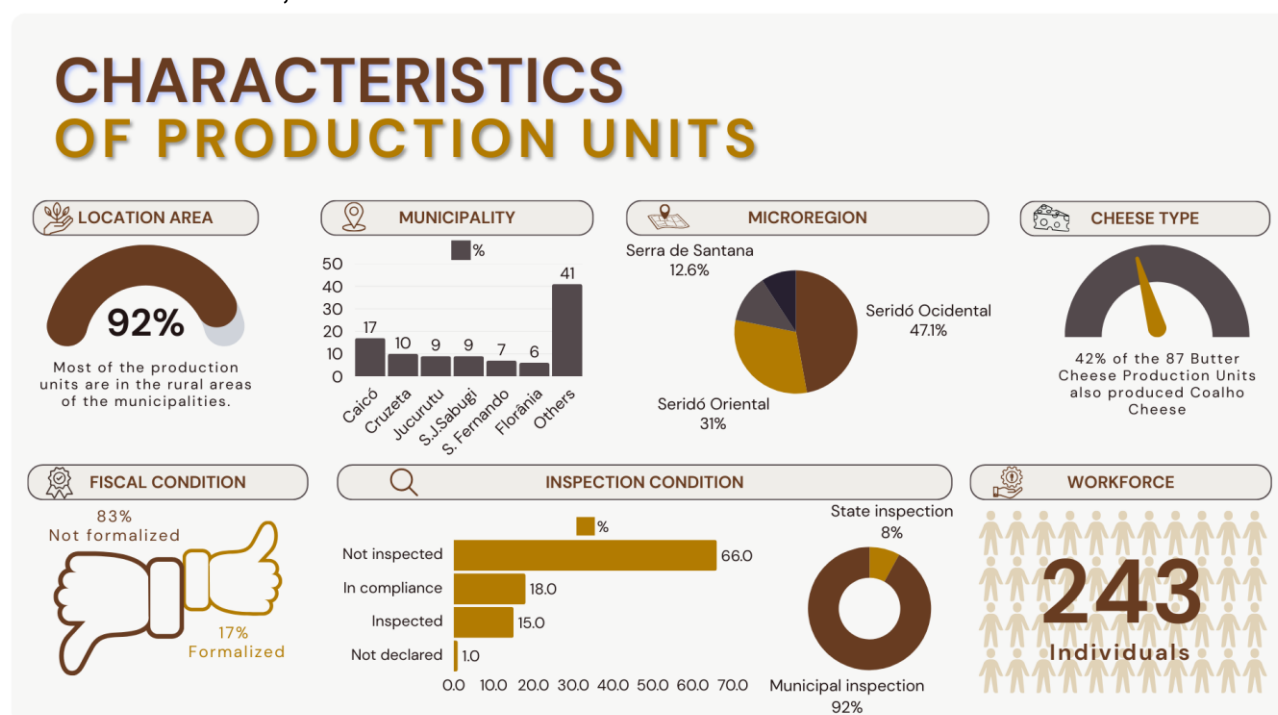
Dairy farming is essential for the social, economic and cultural inclusion of rural families, because most producers occupy small areas of land and employ family labor. These family businesses bring together important aspects: a common purpose in the family, the workforce, production and cultural traditions. However, the activity has been

going through a process of reducing the number of small family producers in Brazil due to the low price paid for a liter of milk with a reduced profit margin, and consequently low profitability. Therefore, the efforts of this profile of family producers can be directed towards more efficient use of available resources such as land, capital and workforce, together with the rationalization of production costs, increasing income and the ability to meet the family's basic needs (Costa *et al.*, 2015).

ASPECTS OF PRODUCTION UNITS

The results of the variables related to the main characteristics of the butter cheese production units in the Seridó are shown in the Figure 2.

Figure 2 - Characteristics of the Butter Cheese Production Units (BCPUs) of Seridó region, Rio Grande do Norte state, Brasil.



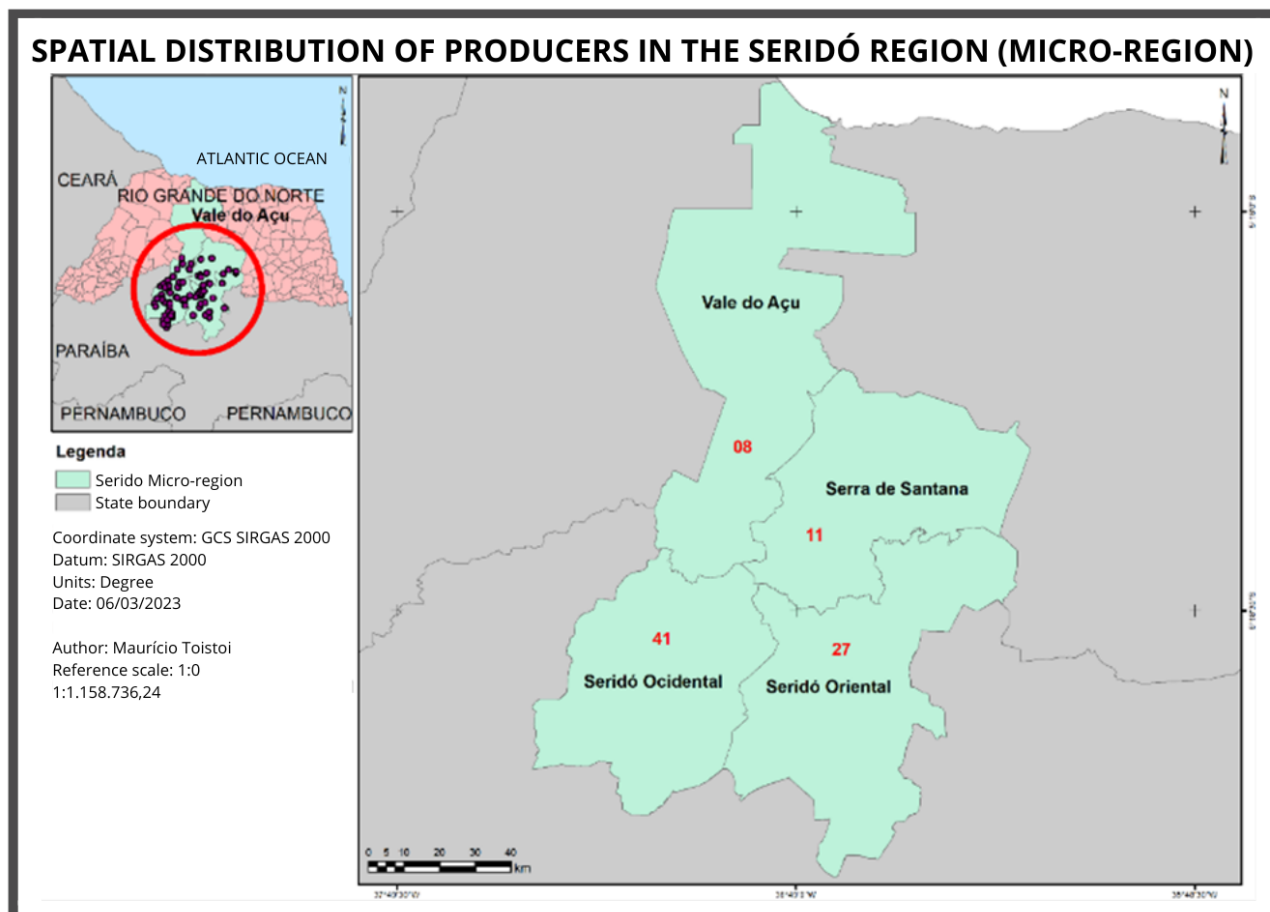
Source: Authors 2025

Location

Butter cheese production is concentrated in the rural areas of the Seridó municipalities (92%), constituting a higher result than found by Azevedo; Locatel (2009) (70%) (Figure 2). The Western Seridó micro-region had the highest **BCPU** concentration in the study (S2 Table; Figure 3). Caicó was the municipality with the highest number of **BCPU**s (15), followed by São João do Sabugi (8), Cruzeta (9), Jucurutu (8) and São

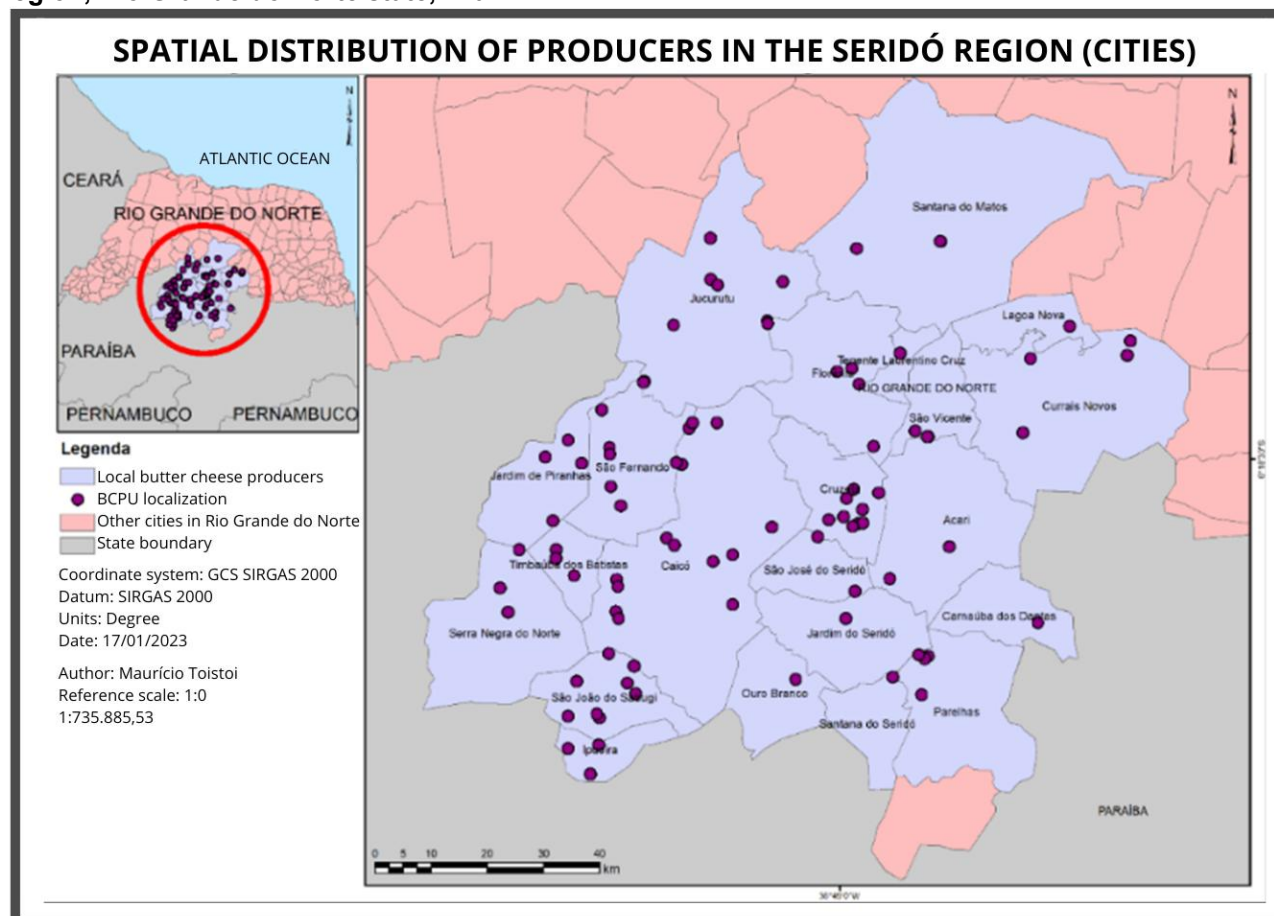
Fernando (6) (S2 Table). No **BCPU**s were found in the municipalities of Bodó, Cerro Corá and Equador (Figure 4; S2 Table).

Figure 3 - Spatial distribution of non-industrial Butter Cheese Production Units (BCPUs) in the micro-regions of the Seridó region, Rio Grande do Norte state, Brazil.



Source: Authors 2025

Figure 4 - Spatial distribution of non-industrial Butter Cheese Production Units (BCPUs) in the Seridó region, Rio Grande do Norte state, Brazil.



Source: Authors 2025

Cheese type

Butter cheese was not the only cheese produced in the **BCPU** participating in the study. Rennet cheese was also produced in 42% of the cases, demonstrating that the universe of **BCPU**s in the Seridó is diversified in terms of the type of cheese produced (Figure 2). This variety of products obtained from cheese production units was also identified in the last survey carried out by ADESE; GTZ (2008) in the same region. The agency found that there was a predominance of butter cheese (241,328 kg), followed by Coalho cheese (74,039 kg), butter (22,058 liters), butterfat (12,176 kg) and ricotta cheese (506 kg), demonstrating that these dairy products are also part of the culture of these people and are part of the region's economic activity (ADESE; GTZ, 2008).

Fiscal condition

Only 17% of the **BCPU**s were formalized in the National Register of Legal Entities (CNPJ) (Figure 2). The fiscal formalization of small and medium-sized establishments

guarantees various benefits, from security with regulatory bodies, protection of personal assets, access to social security and more access to credit, as well as strengthening credibility and commercial relations with the possibility of issuing invoices and marketing to public entities (Fameli, 2022).

This informal situation of most artisanal dairy units in the Seridó region has already been identified by Morais (2020), Azevedo; Locatel (2009) and ADESE; GTZ (2008), and seems to exist due to the fear that small family businesses have of the costs of and bureaucratic obstacles to tax compliance. However, we can already see an increase in interest in formalizing **BCPUs** in the region, with greater dissemination of laws that regulate the activity of handicraft products and government policies to stimulate micro and small businesses that have taken place over the last two years throughout the country and in the specific region.

Sanitary inspection

Only 16% of the **BCPUs** said they were inspected, with the majority (92%) being from the Municipal Sanitary Inspection Service (MSI) (Figure 2). The MSI has been growing significantly in Rio Grande do Norte. Some municipalities have created the service, but have not yet implemented it in practice. At the time of the interviews, only one **BCPU** was registered with the State Inspection Service (SEIPOA/IDIARN) in the artisanal category. The municipalities of Parelhas and São João do Sabugi have the highest number of **BCPUs** registered per municipality, both with three.

At the time of the interview, 18% of those interviewed stated that they had contacted the health inspection body and were in the process of adjusting their **BCPU** with the State Inspection Service, 85% of which were artisanal and 15% industrial.

Most of the Seridó Butter Cheese Production Units taking part in the study had no health registration with an official inspection body (66%) (Figure 2). Although the percentage is still not what is expected for the food sector, this was the most positive scenario ever found in the region. The last census carried out in the state (ADESE; GTZ, 2008) identified that 100% of the 314 artisan units in the region at that time operated without health registration. Before that, a study by Nassu, R. T. et al. (2003) had already identified that 90% of the **BCPUs** in the Seridó operated informally, without registration. Later, a study by Vidal (2011) found that 100% of the artisan cheeses sold in the capital Natal/RN were produced in establishments without any health inspection. The improvement

in this scenario was certainly due to the search and professionalization of producers, supported by institutions and policies implemented since 2017, when the State Law on artisanal cheeses was enacted. Since then, more than 25 artisanal units have been registered by the Rio Grande do Norte State Inspection Service (IDIARN, 2025), and others have ceased to operate.

Most of those interviewed participants said they were unaware of the state legislation (53%; Figure 1) and believed that registering a **BCPU** was “very complex”, “difficult”, “bureaucratic” and “costly”. In addition, some small producers reported that they do not have the capital to adapt their facilities to the requirements of the law.

The inspection which goes hand-in-hand with the sanitary registration gives the product greater reliability, hygiene and health guarantees and opens up the market, inserts producers into the formal food market and prevents uninspected products from being seized by the health authorities. For this reason, it is essential that **BCPU**s that are not yet registered voluntarily seek regularization, and that inspection services intensify their work with them.

Health compliance may require minimal changes that are not part of the specific customs of some producers and imply resistance and difficulty in being incorporated into artisanal production, distancing **BCPU**s from health registration. Cruz (2012) followed the traditional practices and knowledge of serrano cheese producers in Minas Gerais, a region with a long history of artisanal cheese production in Brazil, and noted that they carefully analyze the way of making cheese, the utensils used and even possible infrastructural changes. Therefore, rather than requiring producers to comply with legislation, the inspection service needs to apply the law, but in line with ancestral customs and the reality of local production. There is a need to make compliance models more flexible, so that health aspects dialogue with know-how and traditional knowledge, which involve the personalities of artisans and are far removed from a fixed standard, as occurs in the industrial process.

Workers

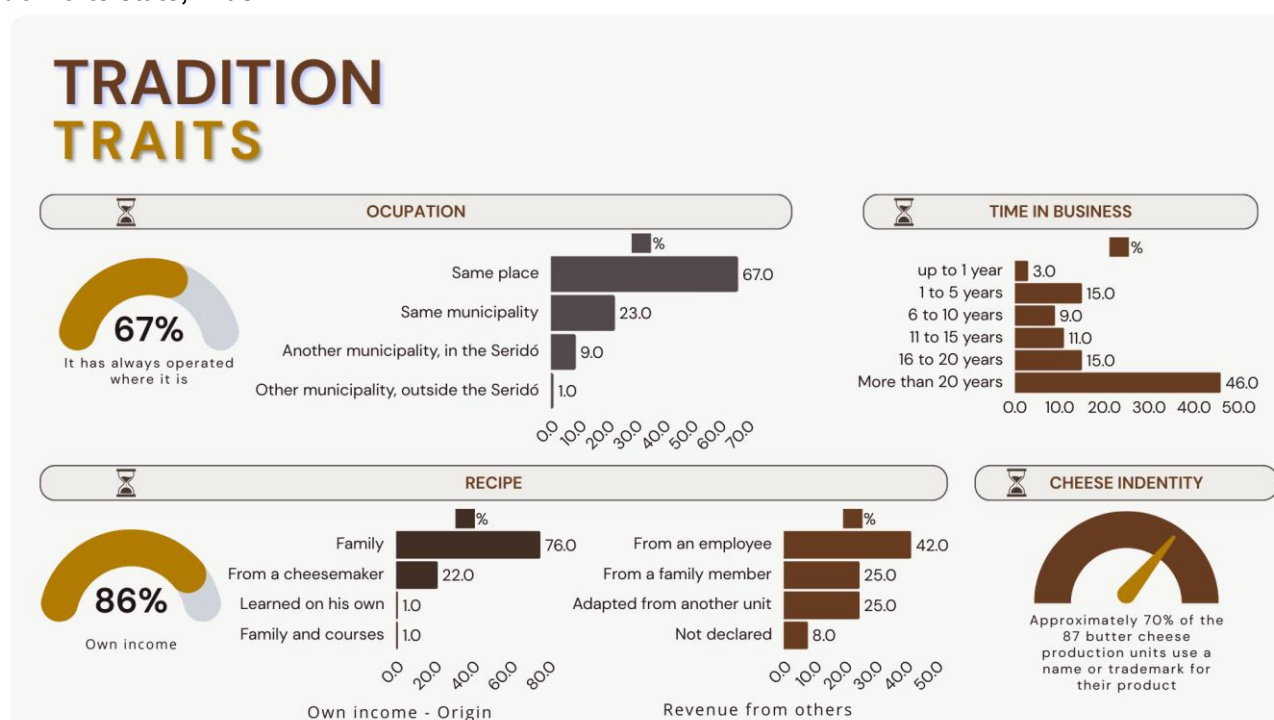
A total of 243 workers are involved in the cheese-making activity (Figure 2). Up to three people were employed in 78% of the **BCPU**s (S3 Table). Caicó, Cruzeta and São João do Sabugi were the municipalities in the region with the highest number of workers per production unit. Caicó and Cruzeta were responsible for having around 17% each of

the total number of **BCPU** workers, followed by São João do Sabugi, with 14%. As for the number of owners, 91% of the **BCPUs** had one owner and 8% had two owners (most often the spouse). These Figs show that the scenario is one of small production units, where family members are involved in production.

Tradition

The results of the variables related to the traditional aspects of the butter cheese production units in the Seridó are shown in Figure 5.

Figure 5 - Tradition traits in the Butter Cheese Production Units (BCPUs) of Seridó region, Rio Grande do Norte state, Brasil.



Source: Authors 2025

Time in business

Most of the **BCPUs** have never operated elsewhere, and even when they moved, they remained in the Seridó region, keeping their roots in the territory (67%) (Figure 5). We found that there is a predominance of old **BCPUs**, 72% of which have been in business for more than 10 years (Figure 5). However, there is also interest from new entrepreneurs in this market, as 18% of **BCPUs** have been in business for less than 5 years. Another interesting fact is that 77% of them have never stopped operating, even in years of severe drought and pasture shortages or even during the COVID-19 pandemic. This shows how

important and well-established traditional cheese production has been in the Seridó region over the years.

Origin of the recipe

Artisanal production is an activity that transforms raw materials into a product by applying manual techniques acquired throughout the artisan's life, whether formally or empirically. One of the main characteristics of this production is traditional knowledge, resulting from social interaction and the socio-cultural context in which the artisans are inserted (Sato Duarte, 2015).

Traditional foods are those that are historically recognized or manufactured according to traditional knowledge, techniques and methods, passed down from generation to generation, or protected as traditional by national or regional legislation, in accordance with Regulation 2074/2005 of the European Parliament (OJEU, 2005).

Traditional production involves values that are not mobilized by big industry, such as personality, care for the product and the natural environment (Santos, Jaqueline Sgarbi; Cruz; Menasche, 2012). The relationship arises with the French term "terroir", used to refer to products with a history, rooted in shared knowledge and local know-how, with elements specific to a specific geographical area where natural and human factors contribute to producing food with unique characteristics and local identity.

The majority of producers reported that they started making butter cheese themselves (63%). The person responsible for making the cheese used their own recipe in 86% of the **BCPUs**, which shows that traditional customs have been preserved in making the cheese (Figure 5). Of these, the majority (76%) received the cheese recipe from family members passed down from generation to generation, highlighting the traditional nature of its production. Less than 2% did not receive the recipe from family members. When the recipe was not their own, it was brought in by the hired cheesemaker in most cases (42%) (Figure 5).

Cheese identification

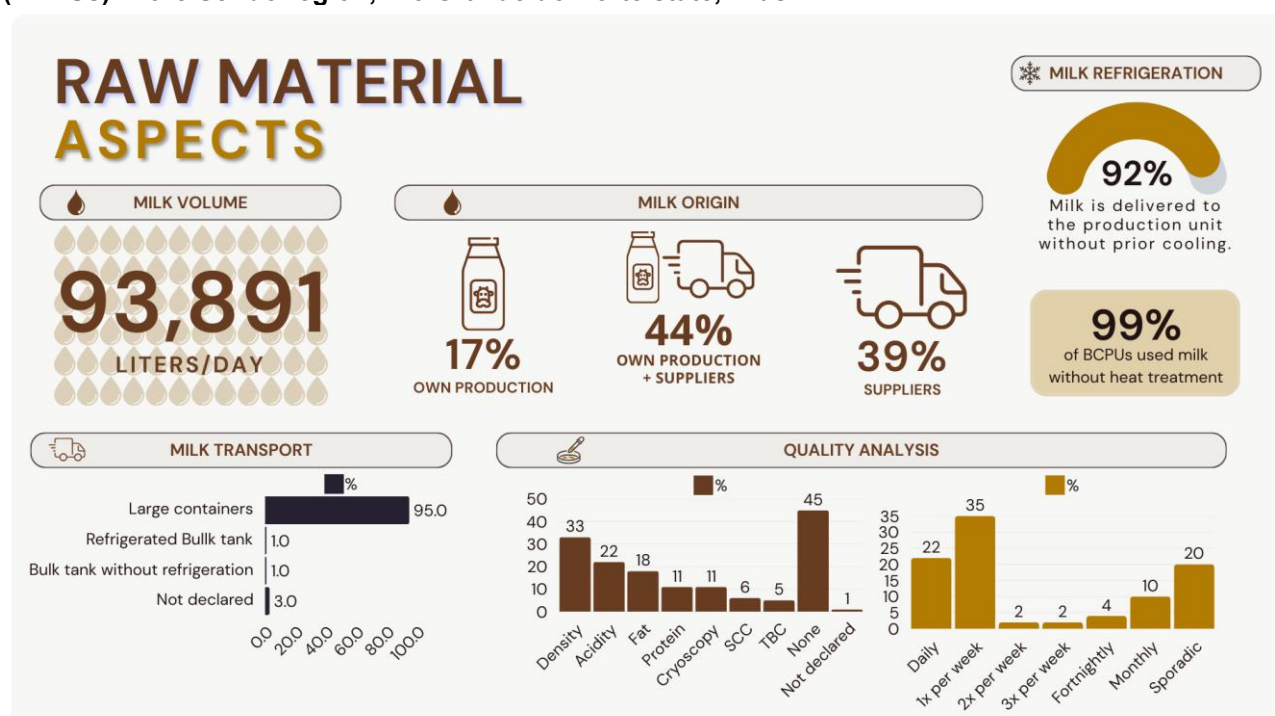
A name or trademark is applied to the cheese in 65.5% of the **BCPUs**, even those which do not have a formalized company (Figure 5). Identifying the product creates a bond between the consumer and the product, solidifying the company in the memory of those who consume it. In addition, products with identification, name or brand differentiate

themselves from competing offers for the customer and can be a success factor for companies (Oliveira; Luce, 2011).

ASPECTS RELATED TO THE RAW MATERIAL

The variables relating to the raw material (raw milk) are shown in Figure 6.

Figure 6 - Aspects related to the raw material (raw milk) of the Butter Cheese Production Units (BCPUs) in the Seridó region, Rio Grande do Norte state, Brasil.



Source: Authors 2025

Volume of raw material

Approximately 12 liters of milk are needed to produce 1 kg of butter cheese (Azevedo; Locatel, 2009). Production units with a small production scale (processing from 50 liters of milk per day) to industrial scale units (processing up to 10,000 liters of milk per day) were identified (Table 1).

Table 1 - Total value, mean and median for the volume of milk received per day by Butter Cheese Production Units (BCPUs).

Variable	Volume (L)		
	Total	Mean	Median
Milk processed	93,891	1,078.63	700.00
Milk from own production	16,085	303.49	200.00
Milk from suppliers	77,806	1,080.63	775.00

Min = 50 L; Max = 10,000 L; Mean = 1,000 L. Source: Authors 2025

The state inspection service only registers artisanal cheese production units that have a small production scale, supported by State Law, which only recognizes artisanal production units that process up to 2,000 liters of milk per day (RN, 2017). Thus, 92% of the production units participating in the study were classified as artisanal.

The **BCPUs** registered with the inspection services processed an average of 998 liters of milk per day, and those not registered processed an average of 1,104 liters. The average milk volume processed by **BCPUs** was around 1,000 liters per day, which is higher than studies by Dos Santos et al. (2017) (average of 100 liters per day) and Saraiva et al. (2020) (average of 300 liters per day) in artisanal cheese-producing regions in Minas Gerais, another traditional artisanal cheese-producing region in Brazil. This can be explained by the fact that Minas Gerais' legislation on artisanal cheese stipulates that the milk must be self-produced, with exceptions (MG, 2020), which depends on greater complexity, such as maintaining a dense and productive dairy herd on the same rural property. Milk used from surrounding properties to make artisanal butter or rennet cheeses is a cultural practice in the state of Rio Grande do Norte. For this reason, its legislation allows milk to be produced in-house or from suppliers (RN, 2021), increasing the capacity of artisanal production units to obtain raw materials.

Just five **BCPUs** were responsible for processing around 29% of the daily volume of milk in the entire Seridó region. The municipality of Cruzeta was home to the three **BCPUs** which processed the largest volume of milk per day. The other two units were in Caicó and Florânia.

Origin of raw materials

Most of the **BCPUs** worked with milk from third parties and depended on the production of suppliers (83%) (Figure6), as also observed by Nassu et al. (2003) and Azevedo; Locatel (2009) in the same region. In all, around 750 suppliers delivered 77.8 thousand liters of milk a day to the artisan units (Table 1). The number of suppliers varied from 1 to 45 per production unit.

The majority of suppliers (70%) were located in the same municipality as the production unit. When they were located differently, they came from other municipalities in the Seridó region (Acari, Carnaúba dos Dantas, Cruzeta, Jardim de Piranhas, Jucurutu, Parelhas, São Fernando, São José do Seridó and Serra Negra do Norte); from other

regions of the state, such as Paraú and Triunfo Potiguar; or even from the neighboring state of Paraíba.

The owners of most of the production units were also dairy farmers. In addition, 44% combined their milk with that of suppliers to produce butter cheese, and only 17% worked solely with their own milk (Figure 6). The milk volume from own production ranged from 20 to 1,200 liters/day, while the volume from suppliers ranged from 30 to 10,000 liters/day, corresponding to most of the milk used by the **BCPU**, as Azevedo; Locatel (2009) also found.

This configuration is historically very common in the Seridó, where the centuries-old activity of cheese production was born in family kitchens in the region out of the need to make the most of surplus milk from farm production for longer. Later, surplus cheeses were sold among neighbors and at street markets. Today, artisan cheeses with a Seridó identity are found in shops in the state's major urban centers and have also become very popular throughout Brazil and beyond. The cheese market boosts dairy farming in the Seridó region, providing an alternative way to use and value milk all year round.

Refrigeration of raw materials

Local law allows the use of raw milk in the production of traditional butter cheese up to two hours after milking, but also allows the use of milk cooled for up to 24 hours in individual or collective cooling tanks, or frozen in the freezer (RN, 2017). The majority of **BCPUs** (92%) received milk at room temperature (Figure 6), as was also observed in 100% of the artisanal units sampled in the states of Rio Grande do Norte (Nassu, R. T. *et al.*, 2003) and Sergipe (Santos, Joanna S. *et al.*, 2008), and in 78.9% in Ceará (Nassu, Renata Tieko *et al.*, 2001), all of which are traditional artisanal cheese producing states in Northeast Brazil.

Milk kept under refrigeration after milking remained in expansion tanks (individual or collective) (3%) or in the freezer (2%). Refrigerating milk reduces the multiplication of mesophilic microorganisms and their acidification, but does not prevent selection and growth of psychotrophic microorganisms, which can develop at temperatures below 7°C. Martins *et al.* (2013) identified low hygiene and sanitary quality, with high microbial and somatic cell counts, and the presence of antimicrobial substances in refrigerated milk samples from individual and collective tanks. Therefore, care with the time-temperature binomial of milk before processing must also be associated with hygienic procedures from

the farm to the **BCPU**, guaranteeing safe and quality cheese for the consumer and avoiding economic losses for producers.

Transportation of raw materials

Most producers (67%) transported their milk to the **BCPU** in plastic drums, a material suitable for packaging food products (Figure 6), in accordance with the Brazilian standard for utensils and equipment used to transport milk (Brasil, 2020).

Raw material quality control

Producing quality cheese directly depends on the microbiological and chemical composition of the milk, which must be free of antibiotics and other adulterating substances (Paula; Carvalho; Furtado, 2009). Therefore, quality analyses are essential for selecting the raw material to be processed into cheese.

It was observed that 45% of the **BCPUs** participating in the study did not analyze the milk received for processing, followed by those that performed only one type of analysis (21%), two types (17%) and three types (4%). The producers who conducted some quality control reported that they mainly tested the milk for density (33%), acidity (22%) and fat (18%) (Figure 6). These results are higher than those of Santos et al. (2008) and Vidal (2011) (25%), and similar to those found by Nassu et al. (2003) who identified 33% of artisanal cheese establishments in the same region carrying out density analysis.

An increase in acidity indicates that the milk was not refrigerated or that milking was performed without proper hygiene. On the other hand, changes in density are usually associated with fraud through the addition of water to save raw materials, increase yields and make more profit (Vargas *et al.*, 2019). This type of alteration in milk density is critical because it affects the softness, color, consistency and final taste of cheeses due to the reduction in fat content as a result of dilution Nassu et al. (2001).

It was found that 35% of the **BCPUs** performed milk analyses on a weekly basis (Figure 6). However, the frequency must be combined with the appropriate types of analyses and depends on the type of health registration (whether artisanal or industrial). The frequency of analyses at the evaluated **BCPUs** currently depends on the inspection sphere (whether state or federal) and the milk origin (whether own or from suppliers). The state legislation on artisanal dairy products (RN, 2017) requires three types of analysis to be conducted at least once a year: the milk's centesimal composition (fat, protein, lactose,

total solids, non-fat solids), somatic cell count (SCC) and total bacterial count (TBC). This law also stipulates that suppliers' milk must be subjected to the 72% Alizarol test. However, federal legislation (Brasil, 2018) requires eight types of analysis (centesimal composition, SCC, TBC, titratable acidity, cryoscopic index, relative density at 15/15°C, acid neutralizer tests and preservative substance tests). Own-source milk must be analyzed at least every three months and milk from suppliers every month (Brasil, 2018). Most of the production units participating in this study maintained quality control that did not meet the legal requirements, either in the quantity or frequency of analysis, regardless of the milk's origin.

Milk samples were analyzed at the **BCPU** itself (68%), in private laboratories (26%) and in public laboratories or state universities (6%). The samples analyzed were collected when the milk arrived at most **BCPU**s (87%), only at the beginning of the manufacturing process (9%) or in the cooling tank (4%) even before it arrived at the **BCPU**.

The categorical health inspection and milk analysis variables are dependent ($p < 0.05$) by the Chi-squared test. The fact that the **BCPU** has sanitary inspection directly influences the maintenance of quality controls on the raw material (Table 2)..

Table 2. Contingency table for the sanitary inspection and the number of milk analyses variables performed by non-industrial Butter Cheese Production Units (**BCPU**s), in the Seridó region, Rio Grande do Norte state, Brasil.

Sanitary Inspection	N	Not Declared	No Analysis	Performs Analyses (No. of Analyses)							Total
				1	2	3	4	6	7		
It is in the process of being adapted	16	0	6	3	3	2		1	1	16	
Not declared	1	0					1			1	
Does not have	57	1	30	10	13	1	1	1		57	
Has	13	0	3	8	1	1				13	
Total	87	1	39	21	17	4	2	2	1	87	
p = 0.0000056											

$p \leq 0,05$, the null hypothesis is rejected. **Source:** Authors 2025

The production units which did not have sanitary inspections were those that conducted the fewest milk analyses. In turn, those which did carried out between one and two types of analysis. The majority of the **BCPU** group which had periodic inspection reported that they only performed one analysis on their milk. Three **BCPU**s did not carry out any analysis.

It was found that most **BCPU**s did not maintain an adequate analysis routine, even those with health inspection records. This lack of criteria in raw material selection results in a product of questionable quality, especially in terms of consumer safety. This data shows

that the supervision and rigor of the Municipal Inspection Services needs to improve, as most of the artisan units were registered with this health system.

Nassu et al. (2003) also identified problems with milk quality control and technical guidance in the majority of artisanal cheese production units in the micro-regions considered in this study. This reinforces the need for planning, guidance, training and technical assistance to standardize procedures in artisanal units, along with microbiological and physical-chemical studies on the finished product.

Heat treatment of raw materials

The milk used as raw material for making butter cheese was raw in 99% of the **BCPUs**. Only one production unit thermally treated the milk, which was done using the slow pasteurization method at a temperature of between 62 and 65°C for 30 minutes during the initial manufacturing stage. These results are similar to the studies by Mesquita; Rocha; Carneiro (2009), Ferreira; Filho (2008) and Santos et al. (2008), who obtained 100% use of raw milk; and close to the studies by Nassu et al. (2001) (85%) and Nassu et al. (2003) (80%).

Milk can be a contamination source for cheese if it is not subject to any heat treatment. However, there is no extreme need to pasteurize milk to produce butter cheese because during cooking it undergoes a more drastic heat treatment than pasteurization. However, hygienic care during and after processing is essential regardless of whether the milk is pasteurized.

The hygienic sourcing of milk is the first critical point in the manufacturing process of dairy products (Perry, 2004). The health of the animals' mammary glands influences the cellular, microbiological and sensory quality of the milk and dairy products. Bezerra et al. (2021) evaluated the sensory acceptance and consumption intention of pasteurized milk and rennet cheese produced with milk with low and high somatic cell counts (SCC). Pasteurized milk with lower SCC scored higher in terms of aroma, consistency, taste and flavor compared to pasteurized milk with high SCC. There were also higher scores for all attributes for Coalho cheese produced with milk with low SCC. The study found that a high SCC content is detrimental to the milk and rennet cheese quality, and causes consumers to accept it less sensorially.

The pasteurization of milk used to make artisanal cheeses is the subject of discussion, as it can influence the taste and texture of the product due to the destruction of

specific microorganisms during the heating process which are responsible for giving the cheese desirable characteristics, inactivating natural milk enzymes and denaturing proteins (Paula; Carvalho; Furtado, 2009) Thus, the state legislation on artisanal cheeses in Rio Grande do Norte allows the use of raw milk, but with strict control of the health of the herds, mainly regarding the absence of brucellosis and tuberculosis in the herds, control of mastitis and infectious diseases, and the adoption of good agricultural practices (RN, 2017). The same legislation only allows simple heat treatment, such as heating, thermization and slow pasteurization for innovative cheeses, which are those developed from the creativity of the cheesemaker, and may contain specific ingredients and must be submitted for appraisal and registration with the health agency (RN, 2021).

Araújo et al. (2010) conducted a study with local consumers and showed that the acceptance level of cheeses produced from raw milk was higher than that of cheeses produced with pasteurized milk, demonstrating the local population's preference for cheeses produced in the traditional way, without pasteurizing the milk.

Viana et al. (2009) detected the presence of coagulase-positive *Staphylococcus*, *Staphylococcal Enterotoxin B (SEB)*, *Toxic Shock Syndrome Toxin (TSST-1)*, *Escherichia coli*, yeasts and possibly aflatoxigenic fungi in Requeijão do Norte samples in Minas Gerais. The researcher observed evidence of inadequate processing practices and handling of ingredients, and poor post-processing hygienic and sanitary conditions, which may have reflected in the presence of contamination. A study by Mesquita et al. [18] identified butter cheeses in inadequate storage conditions at the point of sale, that increase the risk of contamination.

Therefore, butter cheeses should be stored under appropriate temperature and packaging conditions to preserve them from microbiological contamination and guarantee durability (shelf life), regardless of whether they were obtained from raw or pasteurized milk.

BUTTER CHEESE PRODUCTION PROCESS

Several stages are involved in transforming milk into butter cheese: skimming, coagulation, curd breaking, desorbing, washing the mass, cooking, adding salt, melting, adding and incorporating the butter from the earth, and shaping. The producer can control the characteristics of the cheese by intervening in these stages.

Skimming

The whole raw milk received undergoes a skimming process in 96% of the **BCPUs**, and the cream is reserved for butter cheese production. Some of this cream is used to make butter, another important dairy product in the region. Nassu et al. (2003) identified that 90% of the butter cheese production units in the Seridó did not skim the milk. Later, Mesquita; Rocha; Carneiro (2009) found that all the **BCPU**s participating in the study in the Seridó region skimmed their milk mechanically. The practice of skimming milk in processing butter cheeses in the region has become more common in recent decades.

Standardization of this stage is important for the identity of the final product, as removal of the milk's fat content at the start of the process influences the physical-chemical composition, the texture and flavor characteristics, and the yield of the cheese.

Acid coagulation

The curd was obtained through natural action (without the use of rennet), the addition of acid whey (starter culture) or through both techniques (S1 Fig). Whey was used for acid coagulation (77%) in the majority of cases in this study, in which the lactic acid bacteria present in the whey acidify the milk through lactose fermentation, accelerating curd formation from forming lactic acid (Mesquita; Rocha; Carneiro, 2009; Paula; Carvalho; Furtado, 2009). Whey acts as an advantageous natural leavening agent for small producers of artisanal cheeses, because it contains its own autochthonous bacterial flora, carrying all the territorial identity and adding a characteristic aroma and flavor to the cheeses.

Acidification in 20% of the cases only occurred through the natural action of the microorganisms in the milk (without the use of whey or lactic acid), but at a slower rate. In these cases, large variation in this microbiota can reduce the cheese quality, which is why most producers opt to use whey or yeast (Paula; Carvalho; Furtado, 2009).

This coagulation process was performed in plastic containers by at least 72% of the **BCPU**s, and in the others in stainless steel tanks (S2 Fig). A similar result was found by Nassu et al. (2003).

The average milk coagulation time was 9 hours, with a variation from 1 to 24 hours according to the producers interviewed. Different conditions regarding time, temperature, substrate quantity, pH, quantity and typology of the initial microbiological population

influence the characteristics of the curd mass obtained by this process (Mesquita; Rocha; Carneiro, 2009).

1st whey drainage

Most of the milk used in cheese making results in whey after coagulation. It contains almost half of the milk's total solids, including soluble proteins, salts and lactose. The **BCPU** used various natural or synthetic materials, from cotton bags to plastic sieves, with the nylon bag being the most used to separate the whey content from the mass obtained (S3 Fig).

The drainage time varied from 10 minutes to 24 hours, concentrated in the range between 2 and 12 hours, with an average of 7 hours. The period that the curd spends draining can promote variations in the humidity, pH, proteolysis and lipolysis parameters in the cheese, as well as the fat content (Mesquita; Rocha; Carneiro, 2009; Nassu, R. T. *et al.*, 2003). Thus, the producer can easily control the humidity and stability of the cheese controlling syneresis (Paula; Carvalho; Furtado, 2009).

Washing the mass

Most of the **BCPU**s washed the mass with milk (98%), usually skimmed milk (92%). Milk was added to the mass at an average rate of 5.2 liters of milk per kg of mass. This stage varied greatly, with one **BCPU** using 0.5 liters of milk per kg of mass, and another using 12.5 liters per kg of mass. Two **BCPU**s mentioned that they also washed the mass with water. The use of water at the beginning of the washing process means that essential acid is removed to precipitate the casein in the milk for the second wash, reducing the final cheese yield. The lack of standardization in this stage can lead to drastic differences in the final product, as a higher proportion of content in the wash, especially water, can generate different pH values in the curd, which interferes with the melting process and the sensory characteristics of the cheese (Mesquita; Rocha; Carneiro, 2009).

Cooking the mass

The mixture of washed curds and milk was heated in the wood-fired oven by most (91%) of the **BCPU** (S4 Fig) and beaten by hand for an average of one and a half hours. **BCPU**s are allowed to use a wood oven, gas or steam stove, or any other heat source (RN, 2021). The ADESE; GTZ (2008) found that 99% of artisanal cheese production units

in the Seridó used wood in their production process, and 73% of them admitted that the wood was extracted from native species. Nassu et al. (2003) and Mesquita; Rocha; Carneiro (2009) found that 92% and 100% of **BCPUs** used firewood in the production of butter cheese, respectively. Firewood and charcoal are widely used for cooking, heating and protection from animals and insects, and these biofuels currently provide 6% of global primary energy, with around 3 billion people in the world depending on them.

Firewood is the second most used fuel for cooking in Brazil. Particularly in the Seridó region in Northeastern Brazil, 73% of the firewood used in artisanal cheese production units is extracted from the native vegetation of the Caatinga Biome (ADESE; GTZ, 2008).

Although the use of firewood is traditional in manufacturing various products, it can cause environmental damage through the destruction of vegetation, emission of greenhouse gases and damage to producers' health through exposure to fine particles and carcinogenic compounds. In view of this, it is necessary to minimize firewood use and rationalize deforestation through forest management with replanting of native species, together with increased environmental inspection of producers in the region.

The pans used to cook the butter cheese were made of stainless steel in most of the **BCPUs** (95%), or of iron (3%) or copper (1%). The fire intensity varied from high, medium, low and a combination of high and low heat, with 67% of the **BCPUs** citing that they used low heat to warm the mass.

2nd whey separation

Heating the curd shrinks the casein mesh and releases a clearer whey. Removing this whey helps to reduce the humidity and define the cooking point of the mass (Mesquita; Rocha; Carneiro, 2009).

Most of the **BCPUs** drained the mass after the first heating, mainly using nylon bags (26%) or plastic sieves (15%), for around 45 minutes. Approximately a third of them did not drain the mass, but only removed the whey from the pot using plastic utensils (76%), such as buckets, basins and plastic molds. The majority of **BCPUs** reported that they used this residual whey for animal feed and did not use it to make another dairy product (81%).

Addition of salt

Common salt was added to the mass without a standard in the proportion kg salt/kg of mass and then returned to the pot. Nassu et al. (2003) found no standardization in the addition of salt, and found that the chloride content varied between 0.71 and 1.95% in butter cheeses. Vidal (2011) reported that salt gives flavor, improves texture and regulates milk fermentation, providing the ideal level of acidity, helping to remove whey, inhibiting the development of pathogenic microorganisms and regulating biochemical processes. Mesquita; Rocha; Carneiro (2009) observed that the amount of sodium chloride used varied from 1.1% to 3.2% of the initial amount of mass, causing sensory changes in the final product. Cavalcante; Costa (2005) used 0.8% to 1% of sodium chloride in butter cheese. Paula; Carvalho; Furtado (2009) observed that the average salt content used in cheeses generally ranges from 0.5% to 2.5%. Four producers (4.6%) reported that they also add sodium bicarbonate at the time of salting.

Addition of butter (Manteiga da Terra)

Few **BCPU**s let the mass rest before returning it to the pot and starting to add the butter (9%). Those that chose to let the mass rest did so for an average of 15 minutes. Once back in the pot, the mass was added to the butter made at the **BCPU**. This butter was basically obtained by cooking the cream in stainless steel pots, and then stirring with stainless steel utensils (71%) for an average of 2.5 hours (S5 Fig).

Butter was added to the mass in proportions ranging from 0.2:1 to 2:1, with an average of 0.56:1 (56%) by volume over the initial amount of mass, i.e. 0.56 liters of butter for every kilogram of mass. On the other hand Mesquita; Rocha; Carneiro (2009) found added butter values ranging from 30 to 50%, and stated that this high variation results in differences in the product's fat content, consistency and taste.

Mass fusion and forming

After adding the butter, the mass was stirred for around 1 hour and cooked (fusion) for a total of around 1.5 hours. The mass was formed immediately after cooking in the majority of **BCPU**s (98%) or within an hour of the end of cooking (2%). The cheese remained in the molds for an average of 16 hours, which could be more than 3 days or until it was sold.

Most of the **BCPUs** used plastic molds to accommodate the butter cheese (95%) and only one mentioned using a wooden mold as was done by their ancestors (S6 Fig). State legislation allows the use of wood for forming, pressing, packaging and maturing traditional cheeses and it has been used over the years in the Seridó (RN, 2021). Wood use in food products is a risk because it is porous and difficult to sanitize, facilitating development of undesirable microorganisms that can reduce their shelf life. However, wood use in cheese production is safe and consists of a very efficient system for the diversity of cheese microbiota because it contains a biofilm with various lactic species such as *Streptococcus thermophilus*; it has hygroscopic properties that help to dry out the cheese rind; it prevents the moisture which comes off the cheese from getting between it and the shelf. In addition, some types of wood have antimicrobial properties, such as pine, cedar and oak (Mourão, 2019).

Only two **BCPUs** refrigerated butter cheese after shaping (2.3%). Current legislation allows for packaging or maturing at room temperature, however, refrigeration increases the shelf life of products.

Branding and packaging

Half of the **BCPUs** branded the cheese with a hot iron as a way of identifying the product, especially those sold without packaging (S7 Fig). The hot iron imprints a traditional **BCPU** or family brand on the cheese. This is a technique historically used in the region and permitted by state legislation - the iron must be made of stainless steel exclusively for the purpose and must be included in the establishment's regulations (RN, 2021).

The **BCPUs** produced butter cheeses of varying weights, ranging from packages weighing 0.5 kg to over 3 kg, where the majority worked with cheeses weighing 3 kg (S4 Table; S7 Fig).

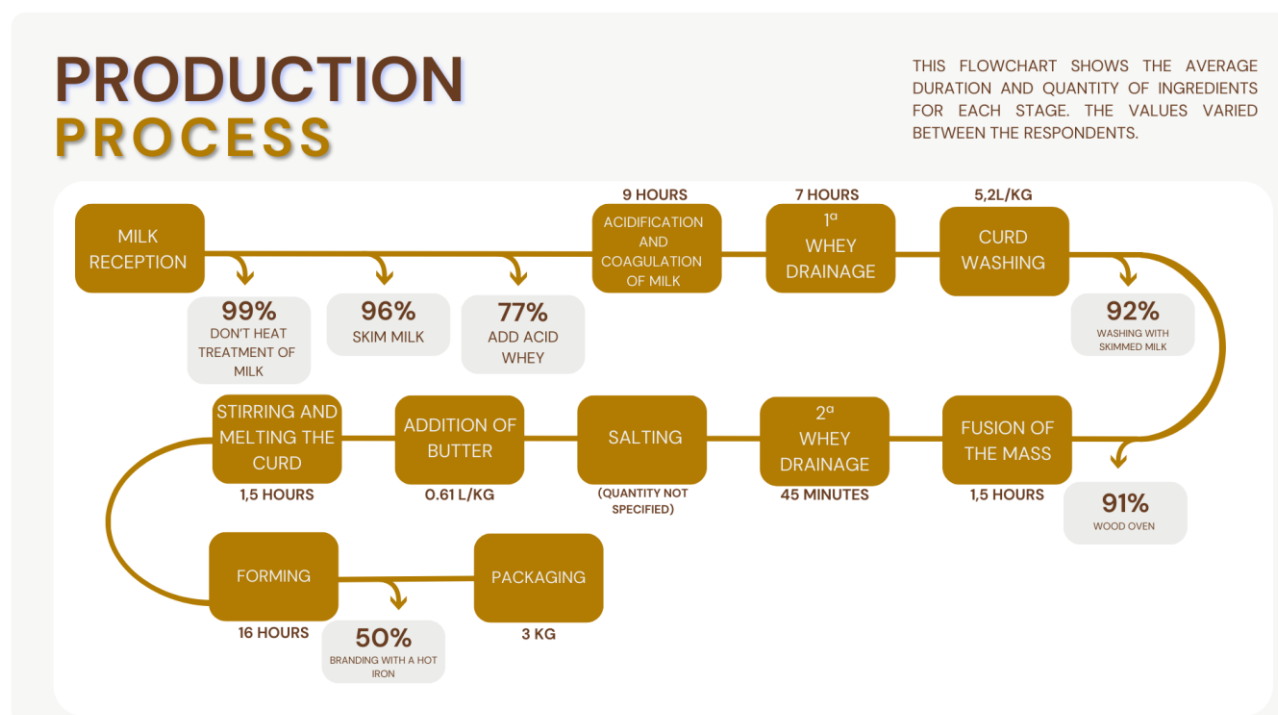
The majority of **BCPUs** packaged their products (85%) in a plastic vacuum bag (96%) or a regular plastic bag (3%) or the form itself (1%). The plastic vacuum bag prevents the food from coming into contact with the air, providing a longer shelf life and safety. The lack of contact with oxygen protects the cheeses from the proliferation of bacteria and fungi, and also prevents them from drying out. There is a greater risk of product contamination from using ordinary bags and film. State law allows artisanal cheeses to be sold without packaging, as long as specific information such as the product

variety, registration number, municipality of origin and manufacturing and expiry dates are stamped on the piece or accompanied by it (RN, 2021, 2017).

Manufacturing stages

It was possible to draw up a hierarchy chart based on the frequency of the interviewees' responses about the manufacture of their **BCPU'S** butter cheese (S8 Fig). The hierarchy chart described the main manufacturing stages and their variations between the **BCPU's**, which served as the basis for the decision to draw up a general butter cheese manufacturing flowchart with the main processes involved in production (Figure 7).

Figure 7. Flowchart of butter cheese production in the Seridó region, Rio Grande do Norte state, Brazil.



Source: Authors 2025

The manufacturing process is all manual, according to the general report of the interviewees. It consists of skimming the raw milk, transferring it to large plastic containers, and adding acid whey (natural yeast or Starter culture) to induce fermentation, acidify and coagulate the milk for an average of 9 hours. The curd is then placed in bags to drain off the whey for varying lengths of time, but an average of 7 hours. The curd is washed with skimmed milk, transferred to stainless steel pans and heated in a wood-fired oven at a low temperature for an average of one and a half hours. The curd is drained again for an

average of 45 minutes. Then, sodium chloride and butter are added in varying proportions and the mixture is stirred over the heat until it is completely melted. The finished cheese is transferred to plastic molds, marked with a hot iron and vacuum-packed in plastic bags.

It should be stressed that taking care to standardize these production stages and reduce variations between producers is essential to achieving uniformity and refinement in the quality and identity of the region's butter cheeses.

ACTIVITY MANAGEMENT

Annual production

Practically all the butter cheese produced in 2021 by the **BCPUs** participating in the study was sold, totaling 2,566,237 Kg per year (Table 3), lower than that found by Azevedo; Locatelli (2009) (2.895.936 Kg/year). The milk supply influences this variation in production, since there is higher milk and cheese production in years with more rainfall.

Table 3 - Distribution of the annual volume of cheese produced in 2021 by the Butter Cheese Production Units (BCPUs), by micro-region and municipality.

Microregion/Municipality	No. of BCPUs	Annual production (kg)	% of overall total
Western Serido	41	882,666	34.40
Caicó	15	342,704	13.35
São João do Sabugi	8	158,715	6.18
Timbaúba dos Batistas	6	146,000	5.69
Jardim de Piranhas	3	86,596	3.37
São Fernando	3	73,262	2.85
Ipueira	3	56,025	2.18
Serra Negra do Norte	3	19,364	0.75
Eastern Serido	27	1,107,659	43.16
Cruzeta	9	688,150	26.82
Acari	4	153,075	5.96
São José do Seridó	4	127,750	4.98
Parelhas	4	55,662	2.17
Currais Novos	2	35,025	1.36
Santana do Seridó	1	29,200	1.14
Jardim do Seridó	1	9,125	0.36
Ouro Branco	1	7,800	0.30
Carnaúba dos Dantas	1	1,872	0.07
Equador	0	0	0.00
Serra de Santana	11	335,085	13.06
Florânia	5	154,440	6.02
Santana do Matos	3	131,400	5.12
São Vicente	1	32,850	1.28
Tenente Laurentino Cruz	1	10,920	0.43
Lagoa Nova	1	5,475	0.21
Bodó	0	0	0.00
Cerro Corá	0	0	0.00
Vale do Açu	8	240,827	9.38
Jucurutu	8	240,827	9.38
Overall total	87	2,566,237	100.00

Source: Authors 2025

The average price of 1 kg of butter cheese in the Seridó Region was R\$24.00 during the research period. The municipalities with the highest annual production of butter cheese in the study were Cruzeta (26.82%), Caicó (13.35%), Jucurutu (9.38%) and São João do Sabugi (6.18%) (Table 3). Cruzeta has two **BCPUs** with annual production of over 180,000 kg. Caicó has the largest absolute number of **BCPUs**, but two of them did not report their annual production, which may have influenced the proportional result in relation to Cruzeta.

The length of time that the **BCPU** has been active did not influence the annual production of butter cheese in the Seridó region according to the Chi-squared test ($p=0.44$) (Table S6). Annual production per **BCPU** was concentrated in the range between 10,001 and 40,000 kg, and most of the **BCPUs** which produce the most are those that have been in business the longest. However, the majority of older **BCPUs** produce between 10,001 and 40,000 kg per year. On the other hand, **BCPUs** that have been on the market for less time produce less, up to 10,000 kg per year.

The location of the **BCPUs** by micro-region had no influence on the annual production of butter cheeses in the Seridó Region according to the Chi-squared test ($p=0.83$) (Table S7). It was found that most of the **BCPUs** in the Seridó Region's micro-regions produce between 10,001 and 40,000 kg/year.

Annual turnover

BCPU turnover in 2021 was above R\$200,000.00 for 42% of them, even in a year when the economy was still recovering from the COVID-19 pandemic (S9 Fig). It is an essential part of every business that the owner has knowledge of their turnover for more efficient management, the success of the company and its sustainability (Grandchamp, 2022). Despite this, 15% of respondents were unable to provide information or preferred not to provide information on their latest annual turnover.

Marketing

Direct sales and small markets were the main destinations for produce, followed by supermarkets (Table 4).

Table 4 - Places where cheeses are sold by the Butter Cheese Production Units (87 respondents).

Local	Responses		
	Absolute frequency	Relative Frequency	Cumulative frequency
Selling directly to customers	50	21.5%	21.5%

Small market	50	21.5%	42.9%
Supermarket	37	15.9%	58.8%
Online sales	34	14.6%	73.4%
Retailer	29	12.4%	85.8%
Trade shows and industry events	18	7.7%	93.6%
Own shop	8	3.4%	97.0%
Open market	4	1.7%	98.7%
Association/cooperative	1	0.4%	99.1%
Marketing centre	1	0.4%	99.6%
Did not answer	1	0.4%	100.0%
Total	233	100.0%	

Source: Authors 2025

Online sales have emerged as a highly representative form of commerce in **BCPU** activity. In many cases, production was also sent to a reseller (middleman) who facilitates production flow, especially to the most distant locations, but often has an exploitative economic advantage over the **BCPU**, which is at the beginning of the production chain, furthest from the trade and the end consumer (Azevedo; Locatel, 2009).

Management difficulties

The main difficulties in the business cited by producers were: shortage of qualified labor, availability of raw materials, lack of working capital, competitiveness or unfair competition and problems with inspection bodies (Table 5).

Table 5 - Main difficulties encountered by small producers in managing Butter Cheese Production Units (87 respondents).

Variable	Responses		
	Absolute frequency	Relative frequency	Cumulative frequency
Lack of skilled labor	36	13.5%	13.5%
Availability of raw materials	34	12.8%	26.3%
Lack of competition	25	9.4%	35.7%
Lack of working capital	25	9.4%	45.1%
Inspection problems	20	7.5%	52.6%
Covid-19 pandemic	19	7.1%	59.7%
Lack of bank credit	18	6.8%	66.5%
Technical training/instruction	12	4.5%	71.0%
Inadequate facilities	11	4.1%	75.2%
Access to advanced technology	8	3.0%	78.2%
Lack of market knowledge	7	2.6%	80.8%
Pricing	7	2.6%	83.4%
Lack of customers	6	2.3%	85.7%
Lack of management skills	6	2.3%	87.9%
Bad debts	6	2.3%	90.2%
Commercialization	4	1.5%	91.7%
Advertising/Marketing	4	1.5%	93.2%
Obsolete equipment	3	1.1%	94.3%
Packaging	2	0.8%	95.1%
Bank debts	2	0.8%	95.8%

Other	5	1.9%	97.7%
Did not answer	6	2.3%	100.0%
Total	266	100.0%	

Source: Authors 2025

The shortage of skilled labor is a problem in many sectors of the economy. A trained employee helps to reduce production costs by reducing errors and mistakes, improving the use of working time and available resources. It is suggested that **BCPU** workers receive training in order to improve their performance.

The availability of raw materials is seasonal in the Seridó region due to the characteristics of the semi-arid climate with prolonged drought periods, which makes it difficult to provide bulky feed for cattle, and which causes a tendency towards seasonality in the milk supply in the region.

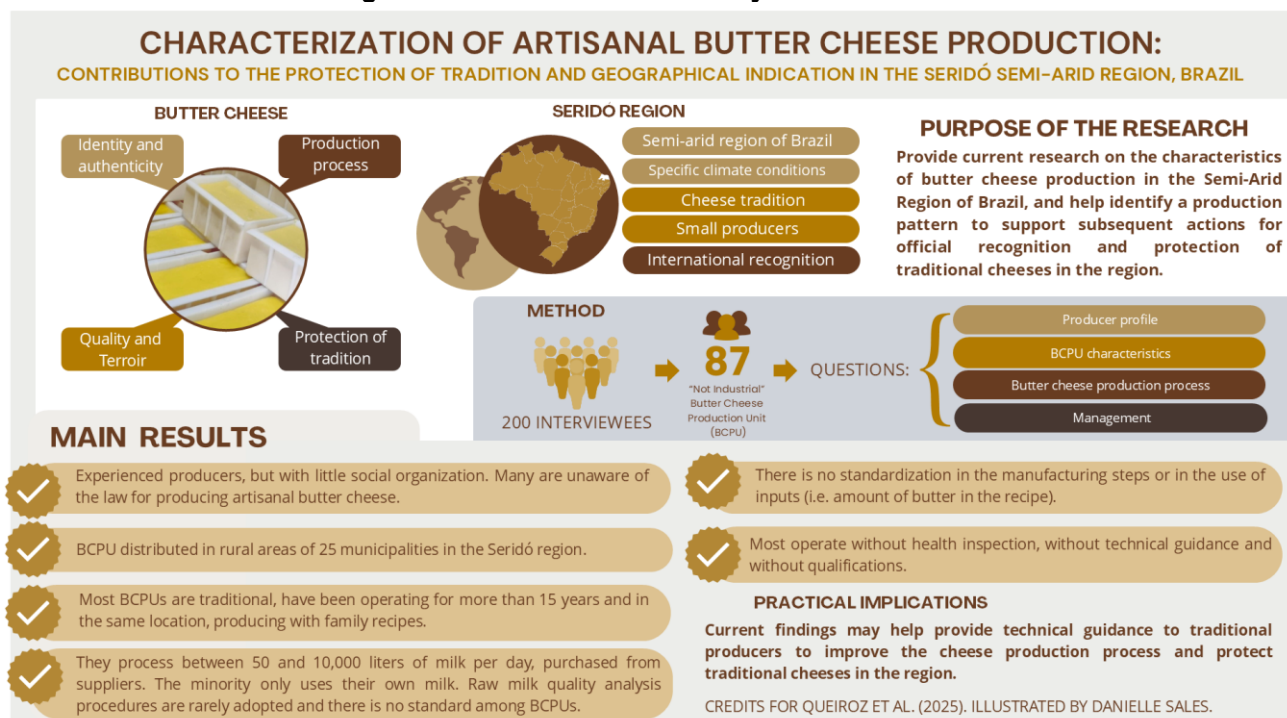
Non-industrial butter cheese seems to be preferred by many consumers in the region, which gives it an advantage over industrial cheeses. However, in addition to competition for the raw material, cheese producers in the Seridó region and the state as a whole face unfair competition with some producers who adulterate the cheese (adding vegetable oil or starch, for example), seeking to increase yield and reduce costs and the final value of the cheese (Leite, 2018).

Working capital is made up of the resources needed for the company's liquidity and the lack of it may be a reflection of tax informality, since formal companies have more access to bank loans to increase their working capital at different interest rates (Fameli, 2022). The tax formalization of **BCPUs** with the national registry could minimize this difficulty.

Many owners also mentioned having difficulties with sanitary inspection, especially with the State Inspection Service and the Regional Council of Veterinary Medicine. Misinformation and bureaucratization seem to be the main reasons for the distance between small producers and the entities involved in their activity. Bringing them closer together therefore directly avoids economic losses resulting from fines, notices and bans, and consequently guarantees sustainability of the activity.

The main results of the research are summarised in Figure 8.

Figure 8 – Illustration of the study's main results.



Source: Authors 2025

CONCLUSIONS

The majority of butter cheese producers in the Seridó region are family farmers with no links to social organizations. Most of the production units are in rural areas, are long-established family businesses and have no health or tax records. Milk is supplied by third parties and there are no standard quality control procedures in most production units. The region has a tradition of butter cheese production, but there is no uniformity in the production stages or in the use of materials and ingredients. This could be an obstacle to the protection of the region's traditional cheeses and their recognition as a geographical indication.

The current results could help to provide technical guidance to traditional producers to improve the cheese production process. Future studies should evaluate the microbiological and physico-chemical aspects of artisanal butter cheeses from this region. It is important that the authorities take action to bring small producers closer to complying with legislation by increasing the control of artisanal production units, supporting the preservation of traditional practices and the production of authentic and safe products, which are essential for the official recognition of products with a protected origin.

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SUPPLEMENTARY TABLES AND FIGURES

Supplementary S1 Table - Responsible for making cheese in the Butter Cheese Production Units (BCPU).

Responsible	N° de BCPU	%
Family	68	78,16%
Owner	43	63,24%
One son/daughter	7	10,29%
Owner and an employee	6	8,82%
Owner and spouse	3	4,41%
Owner and a son/daughter	3	4,41%
Owner, spouse and a son/daughter	1	1,47%
Owner and another family member	1	1,47%
Owner, a son/daughter and an employee	1	1,47%
Spouse	1	1,47%
Spouse, a son/daughter and another family member	1	1,47%
A son/daughter and an employee	1	1,47%
One employee	18	20,69%
Not declared	1	1,15%
Total	87	100,00%

Supplementary S2 Table. Spatial distribution of Butter Cheese Production Units (BCPU)

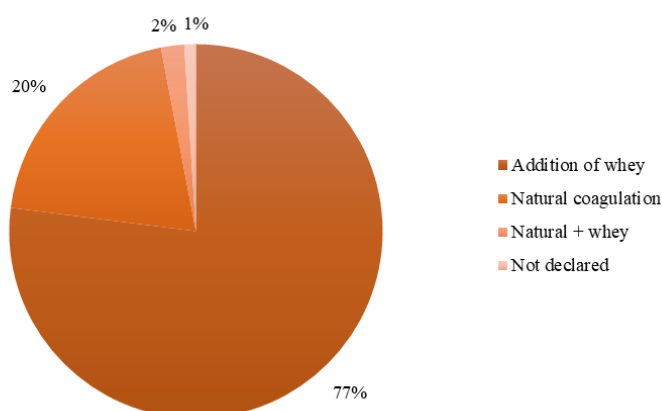
Microregion/Municipality	No. of BCPUs
Seridó Ocidental	41
Caicó	15
São João do Sabugi	8
São Fernando	6
Ipueira	3
Jardim de Piranhas	3
Serra Negra do Norte	3
Timbaúba dos Batistas	3
Seridó Oriental	27
Cruzeta	9
Acari	4
Currais Novos	4
Parelhas	4
São José do Seridó	2
Carnaúba dos Dantas	1
Jardim do Seridó	1
Ouro Branco	1
Santana do Seridó	1
Equador	0
Serra de Santana	11
Florânia	5
Santana do Matos	3
Lagoa Nova	1
São Vicente	1
Tenente Laurentino Cruz	1
Bodó	0
Cerro Corá	0
Vale do Açu	8
Jucurutu	8
Total	87

Supplementary S3 Table - Number of cheesemakers' workers by Butter Cheese Production Unit (BCPU).

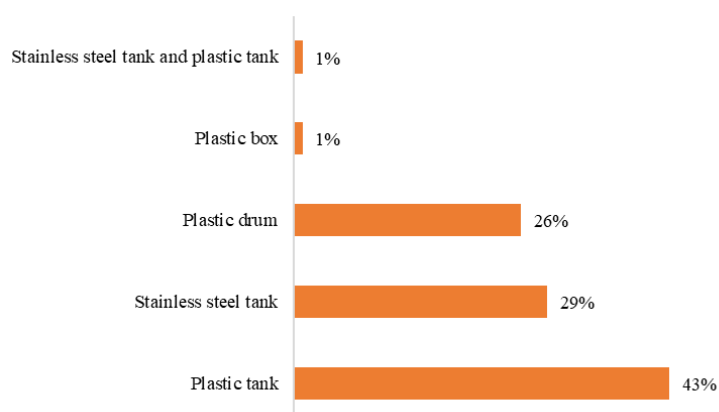
Workers	No. of BCPUs	% of total
0	8	9.2
1	9	10.3
2	30	34.5
3	21	24.1
4	5	5.7
5	6	6.9
6	2	2.3
7	1	1.1
8	3	3.4
9	2	2.3
Not declared	0	0
Total	87	100

Total of cheesemakers' workers = 243.

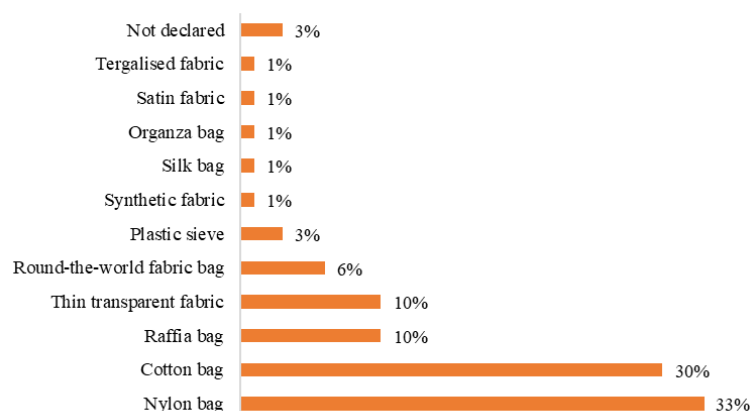
Supplementary S1 Figure - Percentage of curd-making methods used by Butter Cheese Production Units (BCPU).



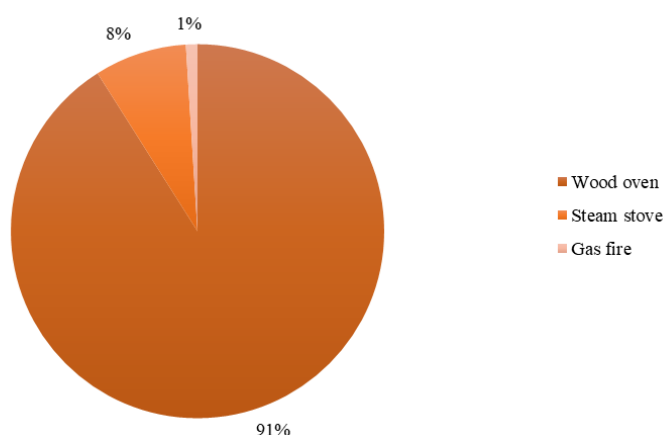
Supplementary S2 Figure - Percentage of the container type in which the milk is placed to curdle in the Butter Cheese Production Units (BCPU).



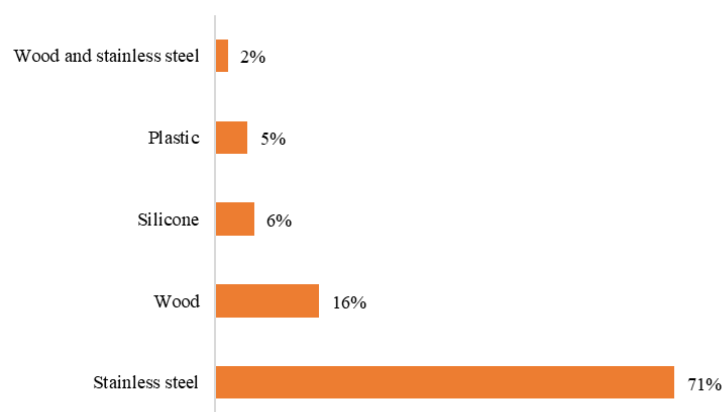
Supplementary S3 Figure - Percentage of the type of filter used to drain the curds in the Butter Cheese Production Units (BCPU).



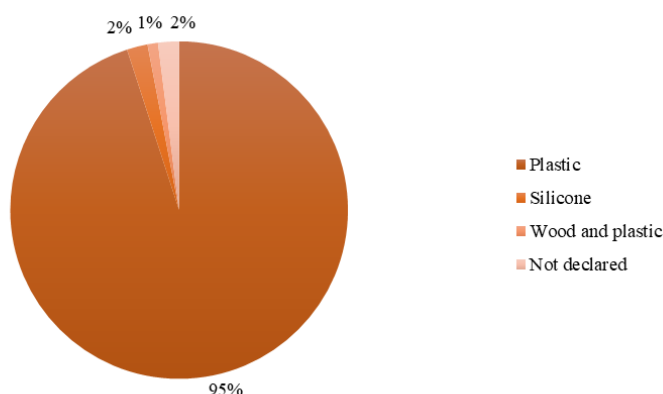
Supplementary S4 Figure - Heat source used by the Butter Cheese Production Units (BCPU).



Supplementary S5 Figure - Percentage of utensil material used to stir the dough in the Butter Cheese Production Units (BCPU).



Supplementary S6 Figure - Percentage of butter cheese mould material used in the Butter Cheese Production Units (BCPU).



Supplementary S7 Figure. Example of marking the cheese with a hot iron, with the producer's name and symbol. 0.5kg and 3.0kg cheeses in plastic moulds. Bottle butter packaged for sale, 500 mL.



Source: Authors 2025.

Supplementary S4 Table - Weight of cheeses considering all formats commercialised by the Butter Cheese Production Units (BCPU).

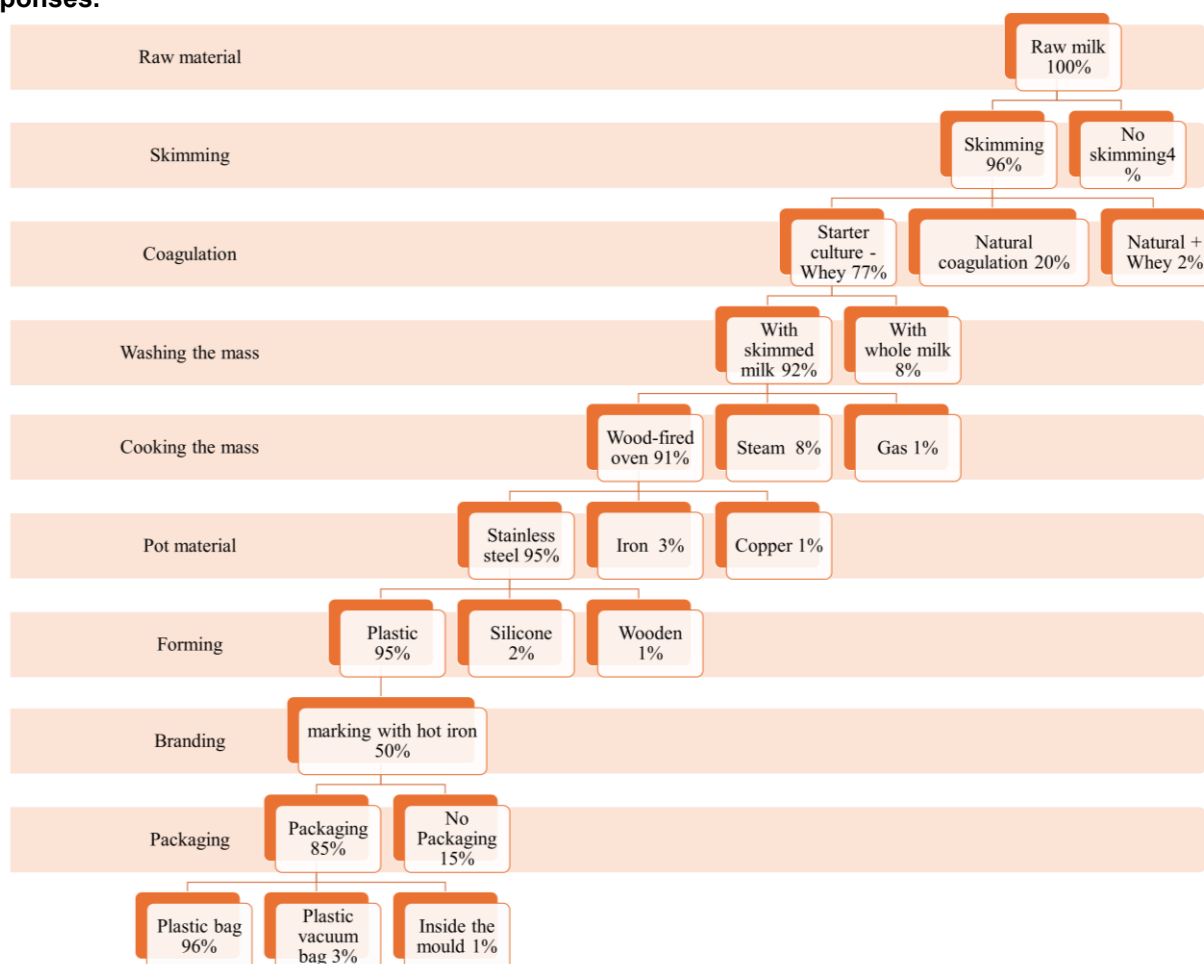
Weight	No. of BCPUs	% of total
0.5 kg	1	1%
0.5 kg. 1 kg	2	2%
0.5 kg. 1 kg. 2 kg. 2.5 kg. 3 kg	1	1%
0.5 kg. 1 kg. 3 kg	4	5%
0.5 kg. 2.5 kg. 3 kg, more than 3kg	1	1%
0.5 kg. 3 kg, more than 3kg	38	44%
1 kg. 1.5 kg	1	1%
1.5 kg. 3 kg	1	1%
2.5 kg. 3 kg, more than 3kg	3	3%
3 kg or more than 3kg	35	40%
Total	87	100%

Supplementary S5 Table - Weight of butter cheeses marketed by the Butter Cheese Production Units (BCPU).

Weight	No. of answers	% of total
0.5 kg	47	29%
1 kg	8	5%
1.5 kg	2	1%
2 kg	1	1%
2.5 kg	5	3%

3 kg	78	49%
Up to 3 kg	19	12%
Total	160	100%

Supplementary S8 Figure. Main processes in the production of butter cheese and the frequency of responses.



Supplementary S6 Table - Contingency table of the time the Butter Cheese Production Units (BCPU) have been in operation and the annual production of cheeses.

Time in business	Annual production (Kg)					Total
	Over 80,001	Up to 10,000	From 10,001 to 40,000	From 40,001 to 80,000	Not declared	
Over 20 years		9	19	8	4	40
Up to 1 year		3				3
1 to 5 years		5	8			13
11 to 15 years		5	4		1	10
16 to 20 years	1	2	4	5	1	13
6 to 10 years		4	3	1		8
Total (p = 0.44)	1	28	38	14	6	87

$p \leq 0,05$, the null hypothesis is rejected.

Supplementary S7 Table - Contingency table of the micro-regions of the Seridó Region and the annual production of butter cheeses.

Microregion	Annual production (Kg)					Total
	Over 80,001	Up to 10,000	From 10,001 to 40,000	From 40,001 to 80,000	Not declared	

Seridó Ocidental	2	15	18	5	1	41
Seridó Oriental	3	9	11	4		27
Serra de Santana		3	4	4		11
Vale do Açu	1	1	5	1		8
Total (p = 0.83)	6	28	38	14	1	87

$p \leq 0,05$, the null hypothesis is rejected.

Supplementary S9 Figure - Turnover of cheesemakers in 2021.

