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## IMPORTANCE OF HYGIENIC AND SANITARY CONDITIONS IN THE MANUFACTURE OF ARTISAN COALHO CHEESE

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**Abstract:** Brazil is among the largest milk producers in the world and, therefore, has a wide range of products derived from this raw material. Cheese is a food widely consumed by Brazilians, with a variety of types. Coalho cheese is popular throughout the country, especially in the northeastern culture. This highly nutritious food is also a great source of income for many producers and traders, especially small and medium-sized ones. In this way, this study aims to carry out a literature review on the influence of good manufacturing practices in the production of artisanal Coalho cheese, considering its predominance in the commercialization of free fairs. Thus, it was observed that artisanal production allows different presentation modes for the same product. Due to its composition, lack of standardization of preparation steps and little action by health surveillance agencies and inspection services, in addition to the use, in many cases, of raw milk, this food becomes a potential vehicle for pathogens, which can bring health risks. However, if Good Manufacturing Practices and current legislation are respected, the negative influence of physical-chemical and microbiological parameters on the quality of the final product will be minimized.

**Keywords:** Good manufacturing practices; Free fairs; Microbiology; Physical-chemical parameters; Handmade products.

## INTRODUCTION

Cheese is one of the dairy products with a high nutrient content, including protein, calcium, phosphorus and zinc (Silva *et al.*, 2020). It is a food that is widespread throughout the world and, with the increase in technology aimed at processing it, there has been diversification into extensive varieties, and in many cases, they are characterized as regional products, as they are well accepted by the local population (Freitas Filho *et al.*, 2009).

One of the most widely consumed cheeses in Brazil is Coalho cheese. It is produced both industrially and by hand and it is a cheese that is easy to manipulate and manufacture for its final production. Because it has a high socio-economic and often cultural value, Coalho cheese is widely consumed in various regions of Brazil, especially in the northeast of the country, and is linked to different manufacturing techniques (Magalhães *et al.*, 2019).

Because it is heavily used in the artisanal production of family farmers, several flaws are notorious in its manufacture, making Coalho cheese susceptible to contamination by bacteria present in the environment or by cross-contamination, including *Staphylococcus aureus*, which is present in the human epidermis, *Escherichia coli* and *Salmonella* spp. which are pathogenic microorganisms for the consumer. In this way, the use of good manufacturing practices and registration with the competent body are key points for the production of a quality cheese, being used safely, allowing a quality Coalho cheese without the presence of alterations that interfere with the taste and appearance, and above all, that does not cause harm to the health of the consumer (Barros *et al.*, 2019).

As a way of ensuring the quality of food production in terms of hygienic and sanitary conditions, along with good manufacturing practices, the Ministry of Agriculture, Livestock and Supply's Ordinance No. 368/1997 was created in 1997 (Brasil, 2019). This set of standards is based on ensuring the precise handling of food throughout the production chain and is linked to factors such as storage and environmental control, which leads to better food quality and safety (Santos *et al.*, 2020).

Some standards are also used in the production of Coalho cheese and are specific to the production of milk and its derivatives, using good manufacturing practices to minimize risks to human health, although they are not widely applied in some regions. However,

in order to make Coalho cheese, it is necessary to be aware of all the legislation that applies to its production, which ensures that the raw material is suitable for consumption (Freitas Filho *et al.*, 2012). One of the most widely used pieces of legislation is called the Technical Regulation for the Identity and Quality of Dairy Products (RTIQ), which makes it possible to designate an appropriate production technology, ensuring a quality product that is acceptable for consumption, within the microbiological, physical and chemical aspects of rennet cheese production, thus making it possible to guarantee registration with a competent body (Brasil, 2001).

Thus, the aim of this article was to carry out a literature review on the influence of good manufacturing practices on the production of artisanal Coalho cheese, considering its predominance in the commercialization of free markets, since it is widely consumed in Brazil and has a great cultural aspect.

## **ECONOMIC IMPORTANCE OF COALHO CHEESE**

Dairy production is one of Brazil's main economic activities, ranking third in the production and development of by-products, leading to significant economic development, especially for small producers. Currently, Brazil has around 1.3 million dairy farms, which generate employment and income for many families (Ribeiro *et al.*, 2022).

According to Lira (2020), dairy production leads to the development of derivatives from the raw material of milk, which extends over a production chain linked to various stages of production, resulting in the production of butters, cottage cheese, sour cream and, above all, the production of cheeses with their high commercial potential.

According to Vilela *et al.* (2016), the Northeast region has significant dairy production, which is considered one of the most prevalent

activities in terms of milk production by cattle or goats. However, the region also has technological difficulties in increasing production, since many of the producers are family farmers. In addition, Coalho cheese is still considered to be a food with poor hygiene conditions, which allows for the presence of microbiological organisms. Even with low technological investment, the diversification of Coalho cheese based on different seasonings is growing in the Northeast, since it is the region with the highest production of the by-product, as it is linked to cultural aspects and is of great economic importance (Freitas Filho *et al.*, 2009).

Coalho cheese is a milk by-product that is widely produced in small cheese factories or is only sold to small family producers for their own consumption, adding economic and social value to these families. When compared to other dairy products produced from milk, the greater demand for Coalho cheese in the Northeast is notable (Barros *et al.*, 2019). According to Saraiva *et al.* (2023), Coalho cheese has been produced for more than 150 years, and in the Northeast, the states with the greatest visibility for production are Ceará, followed by Rio Grande do Norte, Piauí, Paraíba and the Pernambuco region, where monthly production values reach around 10 million reais, which adds considerable economic value.

Alencar *et al.* (2014) carried out a study on the economic analysis of Coalho cheese in the state of Pernambuco, highlighting that the region is considered the main producer of Coalho cheese, home to around 40% of production in the Northeast, their analysis focused on the city of Bodocó-PE. It should be noted that even with low rainfall, the state has a high production and development of dairy farming, directly influencing the production of Coalho cheese. As such, this municipality has production potential, which boosts the

local economy. According to the survey, the monthly economic value of production varies between producers, from R\$1,600.00 to R\$6,400.00, which varies according to production.

According to a survey carried out by Junior *et al.* (2019) on the consumption of Coalho cheese in the state of Paraíba, it should be noted that the by-product is considered a Brazilian intangible heritage and is highlighted as a financial source to help with family income. In addition to this, 56.8% of those interviewed in the study report that they are in the habit of consuming Coalho cheese, which further increases its economic importance in the region.

### **THE IMPORTANCE OF MANUFACTURING CONDITIONS FOR ARTISANAL COALHO CHEESE**

Considered a typical product of northeastern Brazil, Coalho cheese has relatively simple production stages, without much technological implementation or complex equipment in its manufacture. In fact, the production of Coalho cheese is characterized by its artisanal origin, and is predominantly made by small rural producers, who sometimes have no quality criteria or standardization in the process of making this cheese, making it difficult to sell (Araújo *et al.* 2012; Menezes *et al.* 2012; Nassu, Macedo, Lima, 2006).

As a result, the image of this product is occasionally linked to poor hygiene and health conditions in its manufacturing process, since when it is produced by hand, there is a high probability of contamination due to the use of unsafe inputs, the possibility of lack of hygiene during processing, storage and transportation until it reaches the final consumer (Almeida *et al.*, 2013).

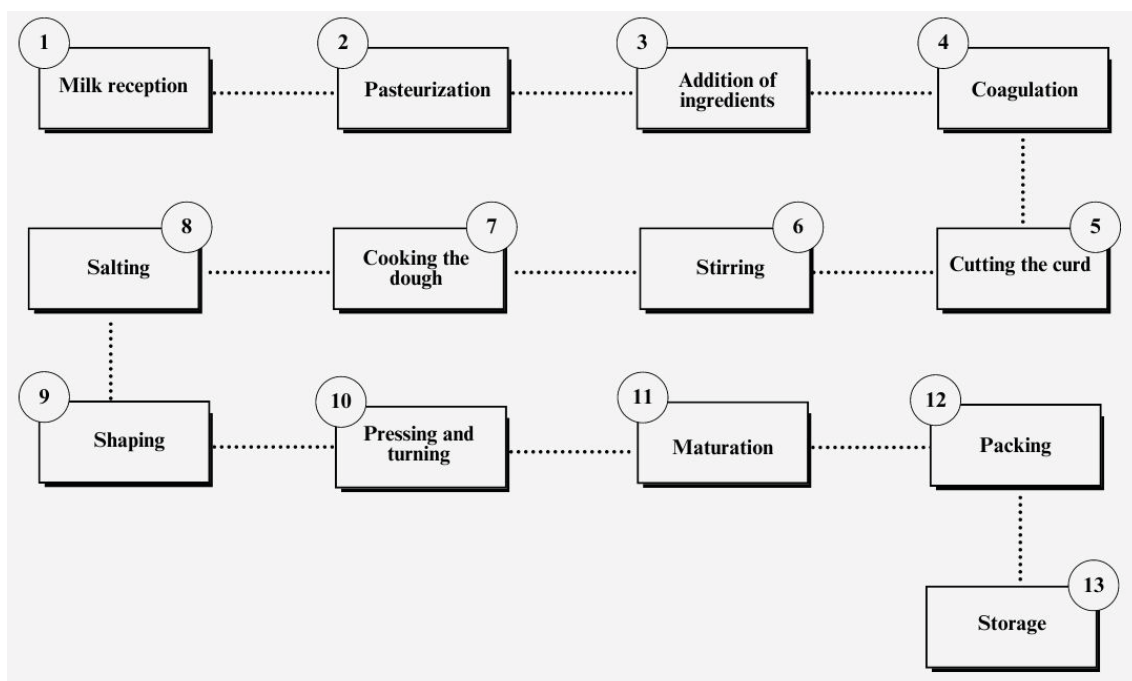
Reinforcing this aspect, studies suggest the inclusion of good practices in the manufacture of artisanal cheeses to increase the quality

of the product, favoring the health of consumers, as well as strengthening the cultural identity of northeastern municipalities, generating profits for producers, most of whom depend on this income to survive (Araújo *et al.*, 2010, Barros *et al.*, 2019, Nassu, Macedo, Lima, 2006). Knowledge through training milk producers and effective surveillance by the competent bodies are measures that would contribute to improving the entire cheese production chain (Araújo *et al.*, 2010).

According to the Technical Regulation on the Identity and Quality of Coalho Cheese, Normative Instruction No. 30 of July 26, 2001, Coalho cheese can be defined as cheese obtained by coagulating milk using rennet or other appropriate coagulating enzymes, complemented or not by the action of selected lactic acid bacteria, and normally marketed up to 10 (ten) days after manufacture (Brasil, 2001).

According to the manual produced by Nassu, Macedo and Lima (2006), the stages in the production of Coalho cheese are receiving the milk, pasteurization, adding yeast, calcium chloride and rennet, coagulation, cutting the curds, stirring, cooking the dough, salting, pressing, turning, maturing, packaging and storage (**Figure 1**). The aim of the manual is to standardize the production stages, as well as to provide appropriate manufacturing practices, eliminating possible health risks for consumers of the final product.

In the production of cheeses, it is essential that the milk used has ideal quality conditions, obtained from healthy females, freshly milked or refrigerated (up to 7°C) (Brasil, 2018), however, in a study carried out by Santos *et al.* (2020), it was found that the majority of producers often did not properly process this raw material, whether in its milking, packaging or transportation, essential phases for the control of contamination, generally due to a lack of technical assistance.



**Figure 1** - Flowchart of Coalho cheese production. Source: Adapted from EMBRAPA (2006).

And, since the legislation allows the production of artisanal cheeses from raw milk, following what is established in Art. 6 of Law No. 13.860, of July 18, 2019 (Brasil, 2019), it is essential to adopt Good Agricultural Practices (GAPs) during the milking process and Good Manufacturing Practices (GMPs) during cheese production, because although Cavalcante *et al.* (2007) observed that bacterial isolates from raw cow's milk and artisanal Coalho cheese constituted quality Coalho cheese, the absence of thermal treatments, such as pasteurization, which aims to reduce the microbial load, may end up affecting the final quality of this product if hygiene standards are not prioritized (Borges *et al.* 2008), 2008).

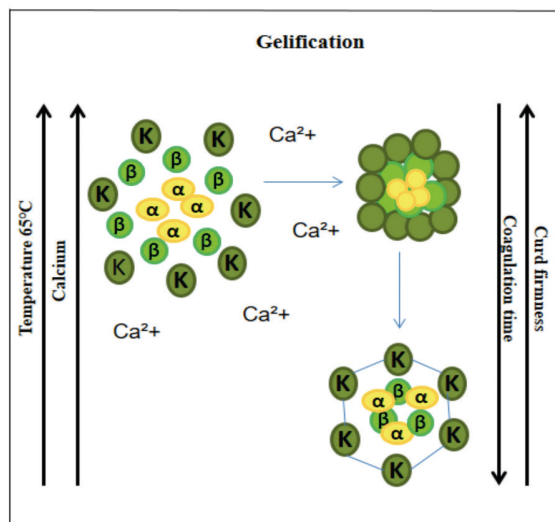
According to Barros *et al.* (2019), after reception, this milk must be weighed, followed by filtration, where many producers use cotton cloth or fine mesh sieves in their artisanal units, where this equipment aims to eliminate dirt that could contaminate the final product. Subsequently, during the ingredient addition stage, the rennet is added, which should preferably be industrialized, following the manu-

facturer's guidelines (Nassu, Macedo, Lima, 2006). Thus, the addition of pieces of calf's stomach to carry out the coagulation, which used to happen a long time ago and interfered with the sanitary and hygienic quality of this product due to the high contamination caused, is no longer a reality, and the use of artificial coagulants is recommended by Coalho cheese producers (Almeida *et al.*, 2013).

Coagulation is the phase in which milk undergoes a profound physical and rheological change, called gelation. The milk gel is formed by the aggregation of the milk proteins, the caseins (**Figure 2**) (Gunasekaran, Ak, 2002). Milk with adequate coagulation capacity produces curds with better rheological properties (food rheology is the science that studies the deformation of solids and the fluidity of liquids due to the influence of applied mechanical forces, relating three variables: deformation, tension and time), affecting the yield and quality of the cheese. Cheeses obtained from milk with low coagulation capacity are more susceptible to losses in storage and can be subjected to incomplete and inhomogeneous



geneous serum drainage, generating defects in the ripening stage (Silva, Costa, 2017; Silva *et al.*, 2020). For these reasons, the quality of the milk is essential, as it influences the subsequent stages of Coalho cheese production.



**Figure 2** - Gelification process and effect of temperature and calcium content on curd firmness and coagulation time. Source: Adapted from Silva and Costa (2019); Silva *et al.* (2020).

Once its production is complete, during the time that this product is not destined for distribution and sale, it must be stored in a refrigerated environment, at a temperature between 10°C and 12°C (Nassu, Macedo, Lima, 2006). It must remain in these conditions for a maximum period of 10 days of maturation, developing the characteristic flavor, texture and aroma of Coalho cheese, after which it is released for consumption (Cavalcante *et al.*, 2007). The duration of this maturation directly influences the moisture content of the cheeses, with an inverse relationship between the two (Gobbetti, Neviani, Fox, 2018). The study carried out by Cavalcante *et al.* (2007) shows that it is possible to standardize traditional Coalho cheese using national lactic cultures without losing the organoleptic characteristics of handmade Coalho cheese. Often, the final characteristics of the cheeses will be

determined by the metabolites generated by the added lactic cultures, making them essential in the ripening phase. Cheeses matured by bacteria, as is the case with Coalho cheese, have as their main process the metabolization of residual lactose, lactate and citrate, since the starter culture has already metabolized most of the lactose (Gobbetti, Neviani and Fox, 2018; Fox *et al.*, 2017).

## EFFECTS OF THE MANUFACTURING PROCESS ON THE PHYSICO-CHEMICAL QUALITY OF COALHO CHEESE

In dairy products in general, the physico-chemical characteristics can be influenced by various stages of the technological process, which will vary depending on the product produced. In cheese, these processing steps have a significant influence on the quality of the final product and, consequently, on consumer acceptability.

When making Coalho cheese, the physico-chemical quality needs to be assessed in order to obtain a safe product that is acceptable to consumers. Once the curd has been obtained, the physicochemical changes resulting from enzymatic actions or acidification of the casein micelles (milk protein) are fundamental for cheese production (Assunção *et al.*, 2018; Barros *et al.*, 2019; Silva *et al.*, 2021).

According to the literature, the main physicochemical parameters evaluated for Coalho cheese are hydrogenionic potential (pH), humidity, water activity (*A<sub>w</sub>*), titratable acidity and fat (Assunção *et al.*, 2018; Barros *et al.*, 2019). These are the main tests used to determine the quality of the cheese (Table 1), which is the main constituent of this product and requires special attention as it is used raw in most artisanal productions.

Parameter	Effect	Reference
pH	Influence on milk coagulation	Sousa <i>et al.</i> , (2014)
Humidity	Influence on the development of bacteria and fungi	Freitas Filho <i>et al.</i> (2009)
Water activity	Encourages micro-biological growth	Barros <i>et al.</i> (2019) Silva <i>et al.</i> (2021)
Titrateable acidity	Raw material quality indicator	Freitas Filho <i>et al.</i> , (2012) Assunção <i>et al.</i> (2018)

**Table 1** - Effects of physicochemical parameters on the technological processing of Coalho cheese.

Determining pH is important due to its strong contribution to creating a suitable environment for microbiological action, as well as being linked to aspects of texture and maturation of the final product (Sousa *et al.*, 2014). The pH is directly influenced by lactic acid, which plays a major role in controlling pathogens, as well as acting on coagulation, a fundamental stage in obtaining Coalho cheese.

The moisture content directly interferes with the Aw of the cheese, affecting the metabolic activities of milk bacteria and fungi during the ripening stage, consequently altering some attributes such as flavor, texture, aroma and pH (Freitas Filho *et al.* 2009). According to Brasil (2001), Coalho cheese with a high moisture content is more susceptible to microbiological deterioration,

Obtaining titrateable acidity values is an important indicator of standardization in the cheese-making process, as high coefficient of variation values indicate a lack of standardization during the production stages. In addition, this parameter can be directly linked to pH and the amount of salt, having a strong effect on flavor, the release of free water and the formation of the rind, as well as acting on bacteria during ripening (Freitas Filho *et al.*, 2012). Titrateable acidity is related to the quality of the raw material used and may indicate the use of low-quality milk.

In the study carried out by Sousa *et al.* (2014) in several states in the Northeast region of Brazil, the physicochemical parameters of artisanal Coalho cheese were evaluated, the samples were prepared according to the official analytical methods recommended by Brasil (2001), and tests were carried out for moisture, water activity, pH and acidity. In the aforementioned study, for the hydrogenionic potential (pH) parameter, the samples with inspection had an average of 5.68 and without inspection had an average of 5.18.

In the work carried out by Freitas Filho *et al.* (2009) in the municipality of Jucati-PE, the physicochemical parameters of artisanal rennet cheese were also assessed in accordance with the official analytical methods described by Brasil (2001). The moisture content was found to be between 46.91% and 60.48%, classifying the samples as having high humidity.

According to the study by Assunção *et al.* (2018) in the city of Nossa Senhora da Glória - SE, the physicochemical parameters of Coalho cheese were also evaluated according to the methodology described in Normative Instruction No. 68 (Brasil, 2006). Titrateable acidity values were found to vary between 12°D and 23°D, indicating a lack of standardization in the manufacturing process and/or the use of inferior quality milk.

Barros *et al.* (2019) reported in their work that the Aw of Coalho cheese in the literature is described as being higher than 0.85, which means that the product is easily susceptible to microbiological compromise. In the study conducted by Silva *et al.* (2021), water activity (Aw) was found to be higher than 0.60. Special care must be taken to guarantee the quality of artisanal Coalho cheeses.

The reference values for the analysis of pH, water activity (Aw), titrateable acidity and fat in Coalho cheese are not described in Brazilian legislation, but are only observed in the literature (Sousa *et al.*, 2014; Assunção *et al.*,

2018). This results in a lack of physical-chemical uniformity in the final product offered to consumers, leading to food insecurity.

## EFFECTS OF THE MANUFACTURING PROCESS ON THE MICROBIOLOGICAL QUALITY OF COALHO CHEESE

Artisanal Coalho cheese is a product of popular northeastern culture and is a food that is highly appreciated by different socioeconomic classes, however, due to its compositional characteristics, in addition to the manufacturing process, it facilitates contamination and multiplication of undesirable microorganisms leading to compromised quality and food safety of this product (Barros *et al.*, 2019; Silva, Damasceno, 2021).

The microbiological standards for Coalho cheese are recommended by Ordinance No. 146, of March 7, 1996, of the Ministry of Agriculture, Livestock and Supply (Brazil, 1996). This establishes a maximum tolerable limit of  $5 \times 10^5$  NMP/g (Most Probable Number per gram) of coliforms at 30°C,  $5 \times 10^3$  NMP/g of coliforms at 45°C,  $1.0 \times 10^3$  UFC/g (Colony Forming Units per gram) of coagulase positive staphylococci per gram of weight and no presence of *Salmonella* spp. and *Listeria monocytogenes* per 25 grams of weight. However, it is worth noting that artisanal Coalho cheese is made up of natural microorganisms that are inherent to its production and that help in the manufacturing process, giving it its characteristic taste, aroma and smell, namely *Enterococcus faecalis*, *Enterococcus faecium*, *Streptococcus thermophilus* and *Lactococcus lactis* (Figure 3) (Silva *et al.*, 2012).

The main pathogens used to check the hygiene and health conditions of Coalho cheese are mesophilic aerobic bacteria (which develop at an average temperature of 20 to 45°C), total coliforms (currently called coliforms at 30°C), thermotolerant coliforms (called coli-

forms at 45°C), coagulase positive *Staphylococcus*, *Escherichia coli* and the absence of *Salmonella* sp. and *L. monocytogenes* (Figure 3) (Brasil, 1996; Brasil, 2001; Silva *et al.*, 2018; Tavares *et al.*, 2019). Many of these microorganisms are found mainly on poorly sanitized hands and utensils.

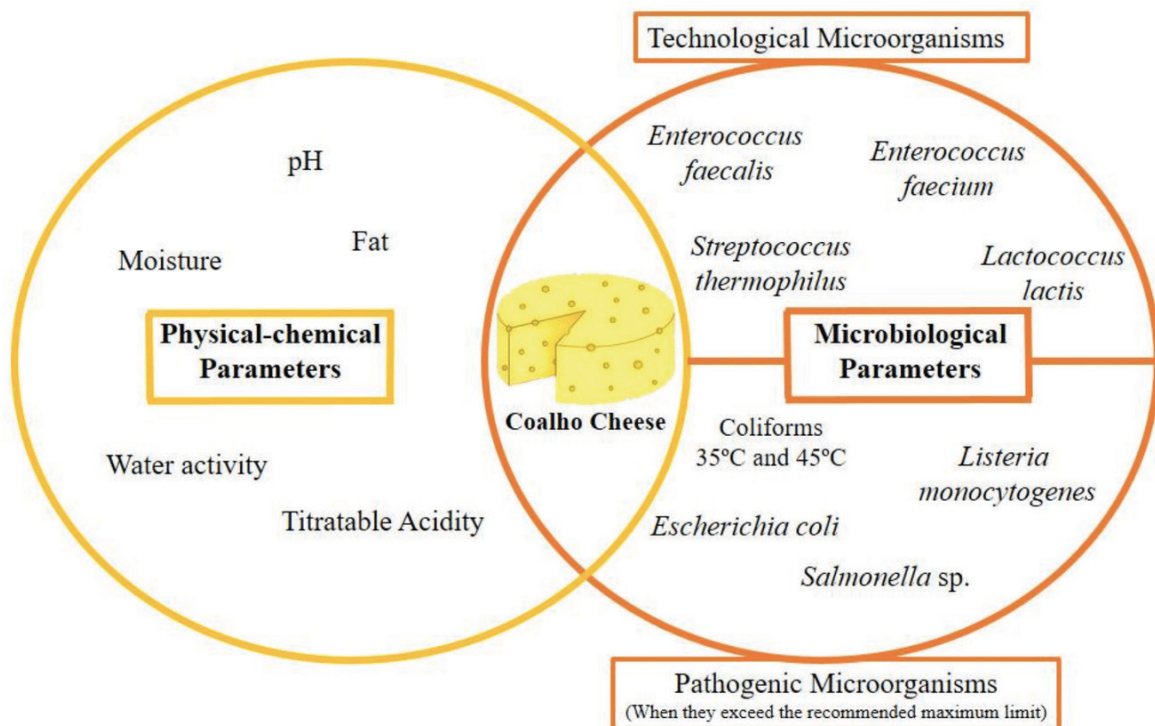
According to Silva *et al.* (2018), a study was carried out in four large open-air markets in the city of Petrolina-PE, and values above the acceptable levels of coliforms 35°C and 45°C were observed according to the legislation in force for microbiological control, with 52.78% of the Coalho cheese samples being positive for *Escherichia coli*.

According to a study carried out by Tavares *et al.* (2019), Coalho cheeses sold in the cities of Canguçu, Rio Grande, Pelotas, São Lourenço do Sul, Pedro Osório and Morro Redondo located in Rio Grande do Sul were analyzed using the methodology described by the Ministry of Agriculture, Livestock and Supply (MAPA), and it was observed that 86.66% of the samples evaluated were outside the acceptable standard, however, all samples were absent for *Salmonella* spp. and *Listeria monocytogenes*.

As mentioned above, the presence of 30°C and 45°C coliforms higher than those indicated by the official bodies responsible makes the artisanal Coalho cheese produced and marketed in much of the country unsuitable for consumption and is a strong indication of inadequate hygienic-sanitary conditions both in the raw material and in the processing, storage and marketing stages (Silva *et al.*, 2018; Tavares *et al.*, 2019). It is worth noting that many street markets and establishments in inland regions are not properly inspected due to failures on the part of the local bodies responsible.

The presence of *E. coli* in most of the samples studied points to a lack of uniformity and hygiene in the handling of Coalho cheeses during and after their manufacture (Silva *et al.*, 2018), and it is commonly observed that em-





**Figure 3** - Physicochemical and microbiological parameters that influence the process of manufacturing Coalho cheese. Source: Adapted from Brasil (1996); Brasil (2001); Silva *et al.* (2018); Tavares *et al.* (2019).

ployees of small companies and producers of this food do not follow the hygiene and quality procedures of the standardization manuals. According to Medeiros *et al.* (2021), their study highlights the importance of using Good Agricultural Practices (GAP) and Good Food Manufacturing Practices (GMP) manuals in the cheese production chain.

## CONCLUSIONS

Artisanal Coalho cheese is a product that deserves attention. As well as being considered a cultural food in the northeastern states of Brazil, it is widely accepted throughout the country, becoming the main source of income for many producers and small businesses, and an important boost to the economy of many cities.

In addition to its cultural appeal, artisanal Coalho cheese is a rich source of nutrients, mineral salts, proteins, and also has a high moisture content and high pH, making it an excellent food option for human diets. Howe-

ver, these constituents also favor the development of undesirable microorganisms, making it an easily spoiled product.

Because it is also a handmade product, made in various regions with raw milk as the main source of raw material, combined with a lack of standardization in the manufacturing stages and a deficiency on the part of the responsible bodies in demanding registration with the inspection service and carrying out periodic inspections, this product is a potential carrier of pathogenic microorganisms that compromise its quality and put consumers' food safety at risk, as seen in the aforementioned studies.

It is therefore necessary to intensify the actions of the bodies responsible for food quality and safety, to raise awareness among producers, consumers and traders, as well as more studies that highlight the importance of Coalho cheese, both as a cultural heritage and as a highly nutritious product that generates income for many small producers and local businesses.

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