

# QUEIJO MINAS ARTESANAL PRODUZIDO NA REGIÃO DE CANASTRA: CARACTERÍSTICAS DOS PARÂMETROS DE PRODUÇÃO, QUALIDADE DA ÁGUA E DOS QUEIJOS

*MINAS ARTISANAL CHEESE PRODUCED IN THE CANASTRA REGION: PRODUCTION CHARACTERISTICS AND WATER AND CHEESE QUALITY PARAMETERS*

F. M. COURA<sup>1</sup>, F. S. FERREIRA<sup>2</sup>, J. M. BARBIERI<sup>3</sup>, S. O. D. PACIULLI<sup>4</sup>

## SUMMARY

The Serra da Canastra region is known for the production of a characteristic Minas artisanal cheese, named Canastra cheese. The objective of this study was to characterize the microbiological and physicochemical aspects of the water and cheese collected from the Minas artisanal cheese producing properties, as well as to characterize the environmental aspects of cheese manufacturing. The analyzes were carried out by private laboratories and the government in 2016 and 2017 and the results provided were tabulated and analyzed in the present study. In the physical chemical analyses of the water, the highest non-conformity was for free residual chlorine (44.69%). In the microbiological analyses of the water, 17.02% of the samples showed non-conformity for *E. coli* and total coliform parameters. In the microbiological analyses of the cheese, non-conformities were found in 7.84% of the samples for total coliforms at 30°C and 9.8% for coagulase-positive *Staphylococcus* spp. The physicochemical analyses of the cheese were all in compliance. No statistical association was found between the quality of the cheese and the water. The water sources were protected, however discard of the waste from cow pens, sanitary sewage, and garbage is still not properly handled. The study indicates that producers need to improve the quality control of the water supply for their cheese factories, fulfill the requirements of chlorine in the water and periodically verify this requirement, ensuring that the produced cheese is safe for human consumption.

**KEY-WORDS:** Food quality. Food safety. Legal parameters. Microbiological analyses. Physicochemical analyses

## RESUMO

A região da Serra da Canastra é conhecida pela produção do queijo Minas artesanal, denominado queijo Canastra. O objetivo deste estudo foi caracterizar os aspectos microbiológicos e físico-químicos da água e do queijo coletados nas propriedades produtoras de queijo Minas artesanal, além de caracterizar os aspectos ambientais do processo de produção do queijo. As análises foram realizadas em laboratórios particulares e do governo nos anos de 2016 e 2017 e os resultados obtidos tabulados e analisados no presente estudo. Nas análises físico-químicas da água, a maior não conformidade foi com cloro residual livre (44,69%). Nas análises microbiológicas da água, 17,02% das amostras apresentaram não conformidade para os parâmetros *E. coli* e coliformes totais. Nas análises microbiológicas do queijo, foram encontradas não conformidades em 7,84% das amostras para coliformes a 30°C e 9,8% para *Staphylococcus* spp. coagulase-positivo. As análises físico-químicas dos queijos estavam todas em conformidade. Não foi encontrada associação estatística entre a qualidade do queijo e da água. As fontes de água foram protegidas, porém o descarte dos resíduos da produção pecuária, esgoto sanitário e lixo ainda não é feito de forma adequada. O estudo indica que os produtores precisam melhorar o controle de qualidade do suprimento de água para as queijeiras, cumprir os requisitos de cloro na água e verificar periodicamente este requisito, garantindo que os queijos produzidos sejam seguros para o consumo humano.

**PALAVRAS-CHAVE:** Análises microbiológicas. Análises físico químicas. Parâmetros legais. Qualidade do alimento. Segurança alimentar.

<sup>1</sup> Professor, Instituto Federal Minas Gerais, Faz. Varginha - Rodovia Bambuí/Medeiros - Km 05, Zona Rural, CEP 38900000, Caixa-postal: 05, Bambuí, MG, Brasil. Autor para correspondência: [fernanda.coura@ifmg.edu.br](mailto:fernanda.coura@ifmg.edu.br).

<sup>2</sup> Graduando em Engenharia de Alimentos, Instituto Federal de Minas Gerais – IFMG, Campus Bambuí, Bambuí, MG, Brasil.

<sup>3</sup> Professor, Una Itabira, Rua São José, 27, Centro, CEP 35900-006, Itabira, MG, Brasil.

<sup>4</sup> Professor, Instituto Federal Minas Gerais, Faz. Varginha - Rodovia Bambuí/Medeiros - Km 05, Zona Rural, CEP 38900000, Caixa-postal: 05, Bambuí, MG, Brasil.

## INTRODUCTION

The Minas artisanal cheese (MAC) is produced in regions of the Minas Gerais state, Brazil, and is made using raw cow's milk with the addition of an endogenous starter culture, responsible for inoculating specific microorganisms that result in flavor and sensorial aspects characteristic of the cheese (MINAS GERAIS, 2020). The Canastra microregion produces a MAC named Canastra cheese (MINAS GERAIS, 2018a). The endogenous starter culture, also known as pingo, origins from drained whey of previously made cheeses and is used in the cheese making process the next day. MAC is manufactured in round shapes, with whitened rind, tending to transform into a thin yellowish layer during the ripening process, usually are without moulds but might presents small eye formations and a typical and markedly acid flavor (CASTRO et al., 2016; SANT'ANNA et al., 2019).

Since MAC is produced with raw milk, chesses must be ripened to reach quality standards that make them safe to consume. Moreover, some aspects of MAC production such as turning cheeses during ripening and rinsing demonstrate that the product is frequently manipulated, demanding control of microbiological contamination during cheese production process (CASTRO et al., 2016). Microbiological quality of the water used during cheese production process is one important factor that influences the bacterial communities found in MAC (SALES, 2015; CASTRO et al., 2016; SANT'ANNA et al., 2019). According to CASTRO et al. (2016), microbiological contamination in artisanal cheese occurs because of three main problems: inadequate cleaning of equipment and utensils involved in the cheese production process, the low qualification of workers, and the use of non-potable water in the production process.

Water used in the production of artisanal cheeses must be safe for human consumption, evidenced by physical-chemical and microbiological analysis. According to regulation, in order to achieve potability, water treatment in cheese factories can be performed by filtration and chlorination or by the use of another proven efficiency treatment process, and physical-chemical and microbiological analysis are required every six months (MINAS GERAIS 2018b). The most common way of disinfecting water is with chlorine. If enough chlorine is added, some will remain in the water after all possible organisms have been destroyed, this is called free chlorine. Free chlorine will persist in the water until it dissipates or is used to destroy new contamination. Therefore, if water is tested and found to contain some free chlorine, it proves that the it is likely to be safe to drink. This process is called measuring the chlorine residual and should be checked regularly (WHO, 2011). However, high chlorine concentrations are unwanted in cheese, causing abnormal flavors and resulting in possible consumer health concerns because of the toxic effects of excessive chlorine intake (CASTRO et al., 2016).

Chlorine must be incorporated into water with a safety residue control, so it does not impairs the water disinfection process or the quality of the cheese due to use of water in the cheese-making process. The presence of a

high number of coliforms in the cheese-making water may cause some defects in the food product, such as early blowing defect, which results in the presence of small holes in the cheese. The high incidence of these microorganisms in water is mainly due to environmental contamination or inefficient chlorination (FAROOQ et al., 2008; TRMČIĆ et al., 2016) and it is important to guarantee the quality of water to avoid contamination of milk and cheese (RIBEIRO et al., 2019). However, according to Saraiva et al. (2012), just over half of the producers demonstrated some control over water use, such as chlorination control or periodic physicochemical and microbiological analyses..

The disinfection of water, equipment, and surfaces is important for the food industry and chlorine-based chemicals are the main disinfectant used; however, during the disinfection process, disinfection by-products (DBPs) are generated. Therefore, the disinfection process results in the presence of DBPs in foods, which some are known to be carcinogenic and toxic to humans, such as trihalomethanes (THMs) and the non-volatile haloacetic acids (HAAs) (CARDADOR et al., 2017). Moreover, as the ripening time advances, the cheese loses moisture and the enzymatic processes act on the fat, proteins, and carbohydrates, affecting the presence of DBPs in the final product. One study showed a significant correlation between THMs and fat contents (owing to the lipophilic nature of THMs), and non-volatile haloacetic acids and volatile THMs increase in concentration as the moisture content in cheese decreases during the ripening process due to a concentration effect (CARDADOR et al., 2016).

The use of raw milk for cheese production is gaining popularity among consumers. The use of non-pasteurized milk for cheese production preserves the indigenous bacteria that, through their enzymatic modification, are important and responsible for physical-chemical characteristic. However, unpasteurized milk poses a microbiological risk since pathogens may be present in raw milk (COSTANZO et al., 2020).

Pathogenic *Escherichia coli* can be detected in raw milk (RIBEIRO et al., 2019). *E. coli* presence in raw milk cheese may indicate a milk contamination of fecal origin or mammary infections (CONTANZO et al., 2020). *E. coli* is normally found in the intestines of animals and humans. Ruminants are important reservoirs and defecation during milking is a significant event for milk contamination (TORRES, 2017; RIBEIRO et al., 2019; COSTANZO et al., 2020). Therefore, good manufacturing practice, milking and hygiene practices must be provided to avoid raw milk contamination and to produce a safe food for consumption (RIBEIRO et al., 2019).

Staphylococci can contaminate milk directly from cows with mastitis caused by this group of bacteria. Environment including human handling can also be a contamination source, highlighting the need for improvements in production hygiene and selection of raw materials (COSTANZO et al., 2020). Listerial contamination may occur in various steps of the production chain and *Listeria* spp. species can persist in food and dairy processing environments (TRMČIĆ et al., 2016; COSTANZO et al., 2020). Therefore, the risks for

contamination of milk and its derived cheeses with pathogens for humans must be considered and requires not only good manufacturing practices, but also adequate animal health status management.

The production of MAC is socially and economically important to the state of Minas Gerais, and studies regarding the characteristics of the producers and their food products are important for strengthening the food chain and informing political legislation. Moreover, to straighten the food chain, it is important to know the microbiological quality of the cheese produced. Thus, this study aimed to characterize Canastra cheese producers registered at the Instituto Mineiro de Agropecuária (IMA) – Brazil; evaluate the qualities of the water used and cheese produced; and verify the relationship between the microbiological and physicochemical quality parameters of the water and cheese.

## MATERIAL AND METHODS

For this study, an observational cross-sectional study was performed using a secondary database, containing information from the years 2016 and 2017 on the qualities of the water and cheese from three cities in the Canastra microregion, which makes up part of the sectional office of the IMA, located in Bambuí – MG. The cities included in the study were Bambuí, Medeiros, and Tapiraí. The IMA is responsible for the inspection of animal products from the state of Minas Gerais, among other activities, and provided the information for the study. Also, information regarding the cheese production process was obtained.

During the study in 2016 and 2017, 33 cheesemakers were registered with the IMA and were included in the study. The characteristics obtained from the production and analyzed were set using the legal legislation for MAC production (MINAS GERAIS, 2018b). All data were provided by IMA.

### Water quality parameters.

The parameters were as follows: Microbiological analyses of water: *E. coli*, total coliforms, and heterotrophic bacteria (Standard Methods For The Examination of Water And Wastewater, 2012).

Physicochemical analyses of water: chlorine, free residual chlorine, color, hardness, iron, nitrate, nitrite, odor, pH, turbidity (Standard Methods For The Examination of Water And Wastewater, 2012).

### Cheese quality parameters.

Physicochemical analyses of the cheese: moisture, phosphatase, peroxidase (MINAS GERAIS, 2008).

Microbiological analyses of the cheese: total coliforms at 30°C (ISO 4832), coliforms at 45°C (BRASIL, 2003), coagulase-positive *Staphylococcus* spp. (ISO 6888-1/2), *Listeria monocytogenes* (AOAC 2004.02), and *Salmonella* spp. (AOAC 2011.03).

### Production parameters.

Production parameters used by IMA during inspection of cheese making properties were as follows:

- Origin of the water used in the cheese factory: water source (well or COPASA-MG ([sanitation company of Minas Gerais]).
- Up-to-date vaccinations for foot-and-mouth disease (FMD) and Brucellosis according to regulations.
- Annual brucellosis and tuberculosis examinations of the cattle according to regulations.
- Mastitis diagnostic tests (California mastitis test and mesh-screen or black background mug test).
- Adequate destination of dairy washing water.
- Adequate destination of cheese whey.
- Adequate destination of garbage.
- Destination of sanitary sewage.
- Number of animals on the properties.
- Information related to water source: if the water source is protected from animal access, if the water is channeled from the source to the tank, if the water is filtered and chlorinated before reaching the water tank, if the water tank is conserved and protected, if the water tank is cleaned as recommended by the Manual of Good Manufacturing Practices (GMPs) (every six months), and if the chlorine dosage and pH of the water are checked daily.

### Statistical analysis.

Data on the cheese and water quality were organized into two categories: conformity (within the legal parameters) and non-conformity (outside the legal parameters). Water quality parameters was analyzed according to BRASIL (2011) and cheese quality according to IMA (MINAS GERAIS, 2002a; 2008). The other parameters were also characterized according criteria judged by state inspectors and provided by IMA (conformity and non-conformity). Some of these criteria can be found in IMA (MINAS GERAIS, 2002a; 2002b), but their conformity were provided and analyzed by IMA inspectors. The statistical analyses were performed using R statistical software (R CORE TEAM, 2018). After verifying the normality of the data using the Shapiro–Wilk test (SHAPIRO & WILK, 1965), a Pearson correlation analysis was performed between the results of conformity and non-conformity from the microbiological and physicochemical analyses of cheese, water, and the other results to assess the relationship between these variables.

Univariate analysis was performed using the chi-square test ( $\chi^2$ ) or Fisher's exact test to determine the variables associated with the microbiological and physicochemical parameters of both the cheese and water, using a significance level of  $P \leq 0.05$  (ZAR, 2010). Correspondence analysis (GREENACRE & BLASIUS, 2006) was used to study the interactions between the parameters of cheese (coliforms and coagulase-positive *Staphylococcus*) and water (odor, turbidity, residual chlorine, coliforms, and *E. coli*). In the correspondence analysis, the relationship between the categories was represented in a two-dimensional graph. The relationship between the selected parameters was demonstrated by visualizing in the graph which variables were grouped or plotted closer to each other.

## RESULTS AND DISCUSSION

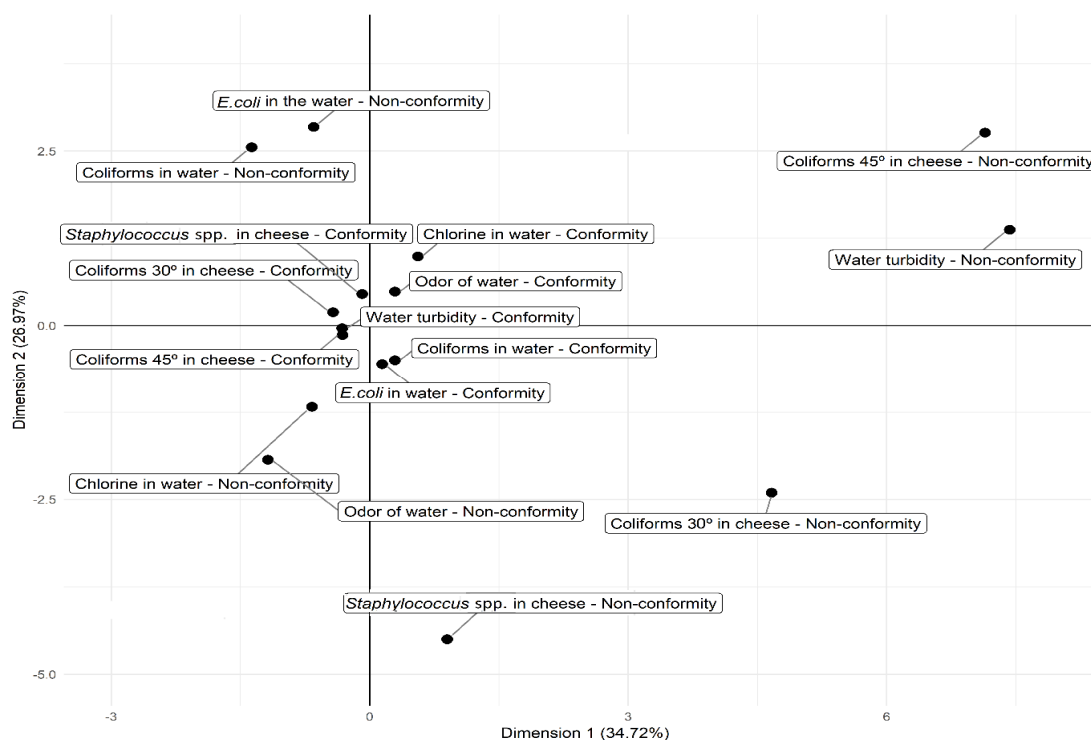
Only complete analyses of each property in each year were considered; therefore, data from 47 microbiological and physicochemical analyses of water and cheese were obtained from 33 registered properties. The characteristics of production were also accessed and analyzed.

The results of the physico-chemical and microbiological analyses of water are summarized in Table 1. The most important non-conformity found was related to free residual chlorine. According to the legislation, the content of free residual chlorine must be

between 0.2 and 2 mg/L (BRASIL, 2011). Of the 21 water samples that were found to be outside the standard required by current legislation, 16 were above the chlorine limit allowed, and the other five were below the limit. Two properties were above the chlorine standard in 2016 and below in 2017, which demonstrates a lack of control in the use of chlorine for water treatment. The nine properties that showed non-conformity for the odor parameter had a chlorinated water odor and chlorine analysis above the standard. This relationship is demonstrated in the correspondence analysis, of which chlorine above the limit was plotted near non-conformity odor (Figures 1 and 2).

**Table 1** - The results of the physical, chemical, and microbiological parameters analyses of the water from the registered cheese properties in the Canastra microregion, collected from properties in the municipalities of Bambuí, Medeiros, and Tapiraí in the years 2016 and 2017.

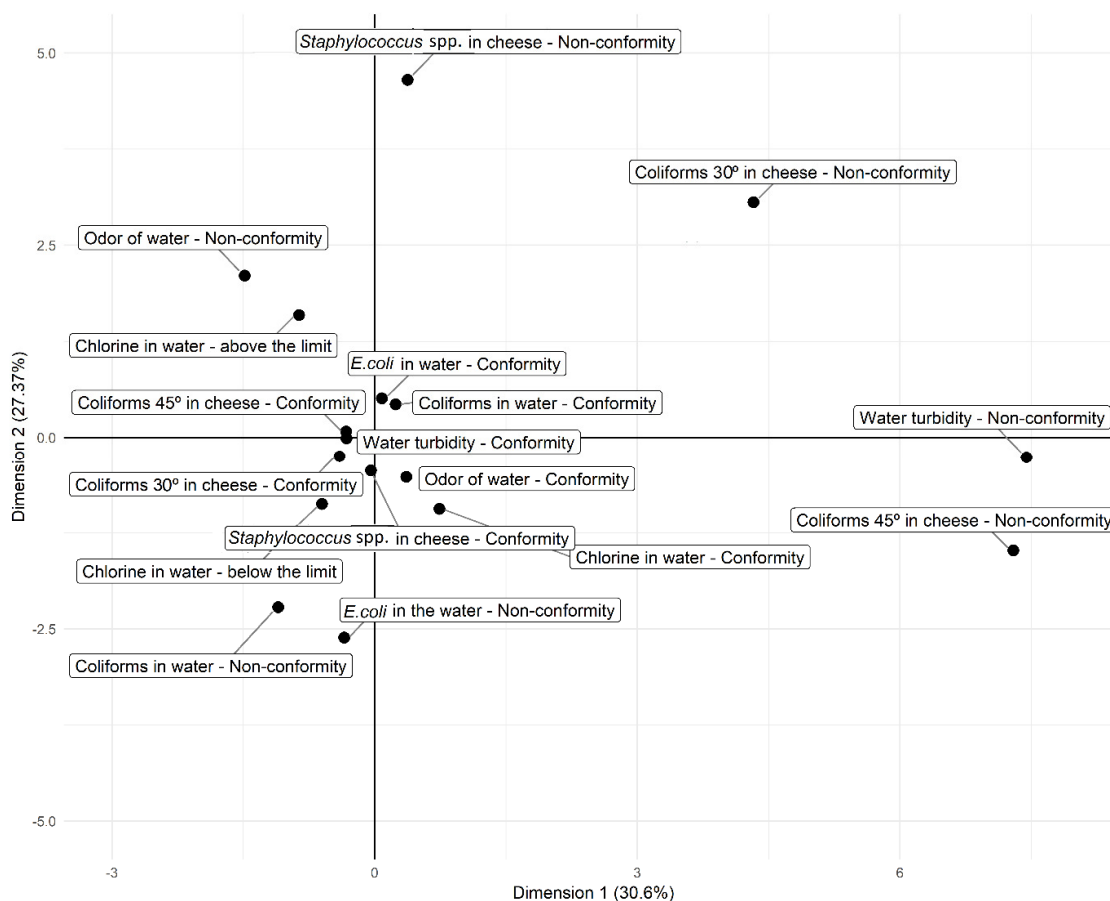
Parameter	Conformity		Non-conformity	
	Number of analyses	%	Number of analyses	%
Chlorine	47	100	0	0
Free residual chlorine	26	55.32	21	44.69
Color	44	93.62	3	6.38
Hardness	47	100	0	0
Iron	43	91.49	4	8.51
Nitrate	47	100	0	0
Nitrite	47	100	0	0
Odor	38	80.85	9	19.15
pH	39	82.98	8	17.02
Turbidity	45	95.74	2	4.25
<i>E. coli</i>	39	82.98	8	17.02
Total coliforms	39	82.98	8	17.02
Heterotrophic bacteria	47	100	0	0



**Figure 1** - Correspondence analysis for the analyzed variables. The two-dimensional representation explains 61.69% of the total variation, with 34.72% explained by the first dimension, and 26.97% by the second dimension. Related variables are plotted on the graph next to each other.

Correspondence analysis was used to study the interaction between the results of the analysis of total coliforms at 30°C, coliforms at 45°C, and positive-coagulase *Staphylococcus* spp. in the cheese and the results of odor, turbidity, residual chlorine, total coliforms, and *E. coli* in the water. In the correspondence analyses, the relationship between the categories was represented in a two-dimensional graph

(Figures 1 and 2). The relationship between the selected parameters was demonstrated by visualizing in the graph which variables were grouped or plotted closer to each other. Figure 2 demonstrates the results considering the parameters of Figure 1, but separates the results of chloride non-conformity as above or below the legal limit.



**Figure 2** - Correspondence analysis for the analyzed variables. The two-dimensional representation explains 57.97% of the total variation, with 30.6% explained by the first dimension, and 27.37% by the second dimension. The related variables are plotted on the graph next to each other.

*E. coli* is normally found in the intestines of animals and humans, but can cause enteric disease and other syndromes in its hosts, highlighting the importance of its control for public health (TORRES, 2017). Our study found some water samples positive for this bacterium; the correspondence analysis indicates a relationship between the non-conformity of chlorine in the water and the presence of *E. coli* and coliforms in water. In a study of dairy farms in Minas Gerais, the results of the microbiological analyses of the quality of the water used for cleaning milking areas and utensils showed that all of the water samples were outside of the drinking standard limits (PEREIRA & ARAÚJO et al., 2009). RIBEIRO et al. (2019) detected *E. coli* in water samples from non-technified dairy farms in São Paulo, highlighting the risk to public health due to the transmission of waterborne diseases

and raw milk contamination during milking. Therefore, this parameter is important for guaranteeing the safe use of water, since it is used in the production of cheese. Moreover, washed rind cheese showed a 4 times higher risk of coliform detection than cheese without treated rind (TRMČIĆ et al., 2016), and Canastra cheese is washed rind cheese, reinforcing the importance of water quality.

According to Freitas et al. (2001), free residual chlorine values below 0.2 mg/L justify the increase in the presence of *E. coli* in the water, confirming that chlorine has a beneficial effect on the elimination of bacteria. Although no association was found between residual chlorine and the presence of coliforms and *E. coli* in the cheese, the correspondence analysis indicates that chlorine below the limit is related to the non-conformity of *E. coli* and total

coliforms in the water (Figure 2). A study evaluated cheese available on the market for presence of coliforms and key pathogens and investigated the coliforms present to assess their likely sources and public health relevance. The results suggested that the majority of *E. coli* isolates detected in cheese samples are an actual direct or indirect fecal contamination of cheese and that raw milk is a very important source of coliforms in cheese made from unpasteurized milk (TRMČIĆ et al., 2016), such as Canastra cheese.

There are also risks that come with the use of chlorine above the standard in water disinfection. Excess chlorine can generate DBPs and cause the contamination of trichloromethanes (TCM) in the cheeses. Milk and dairy products have acetoin, diacetyl, and other methyl ketones that can react with chlorine and form TCM, a substance considered to be carcinogenic (SIOBHAN et al., 2012; CARDADOR et al., 2016, 2017). In Brazil, there is no legislation for the quantification of TCMs in food. Research carried out in Ireland has shown that the addition of chlorine to the milking wash water increases the amount of TCM present in the milk (SIOBHAN et al., 2012).

The presence of iron at levels above the standard may have a natural origin, referring to the region's soil having high concentrations of iron, or it may be an indicator of anthropogenic pollution, as the presence of dumps and ditches can increase the concentration of iron in the water (FREITAS et al. 2001). Regarding the pH of the water, it is known that the soil in each region interferes with this parameter, in addition to the presence of industrial waste (SILVA et

al. 2010). All of the samples that showed a pH < 6 were from cities without industries, suggesting that the region's soil may have influenced this non-conformity.

Water turbidity above the limit can indicate a high presence of organic and/or inorganic matter in suspension, and these particles serve as shelter for microorganisms. Therefore, the water used for food production must be filtered (KAMIYAMA & OTENIO, 2013) and the non-conformity with the parameter may be due to the non-periodic replacement of the filters; according to legislation for cheese makers, the use of a filter is mandatory when the microbiological or physical chemical analyzes of the water show non-conformities (MINAS GERAIS, 2018b). The physico-chemical analyzes of the cheeses were all within the standard, important parameters to guarantee the identification and quality of the milk-derived product. Ripening was carried out according to the legislation, which recommends 22 days of maturation for the Canastra microregion, and uses raw milk, which is confirmed by the conformity of phosphatase and peroxidase results (MINAS GERAIS, 2017). As mentioned before, ripening is important to reach quality standards that make cheese safe to consume, since Canastra cheese is produced with raw milk (CASTRO et al., 2016).

The results of the microbiological analyses of the cheeses are shown in Table 2. There was no association between the microbiological and physicochemical parameters analyzed from the cheese and water samples by univariate analysis.

**Table 2** - The results of the microbiological analyses of the cheeses collected from properties in the municipalities of Bambuí, Medeiros, and Tapiraí in the years 2016 and 2017.

Parameter	Conformity		Non-conformity	
	Number of analyses	%	Number of analyses	%
Total coliforms at 30°C	43	91.49	4	8.51
Coliforms at 45°C	45	95.74	2	4.26
<i>Staphylococcus</i> spp.	45	95.74	2	4.26
<i>Listeria</i> spp.	47	100.00	0	0.00
<i>Salmonella</i> spp.	47	100.00	0	0.00

Coliforms are indicative of hygiene issues, and coliforms at 45°C of fecal contamination. In this study, there were few cheese samples that were outside the parameters for total coliforms at 30°C and coliforms at 45°C. In the Alto Paranaíba microregion, Fernandes et al. (2011) found that all cheeses analyzed had microbiological standards outside of the legislation and, therefore, were prohibited for human consumption. In the microregion of Triângulo, Ferreira et al. (2011) found that 70% of the analyzed cheese samples were above the legal parameters for total

coliforms at 30°C and 80% for thermotolerant coliforms (coliforms at 45°C). Coliforms present in cheese may contribute to the final quality of cheese and the isolation of *E. coli* suggests fecal contamination and is indicate unsanitary manufacturing conditions (TRMČIĆ et al., 2016). Overall, our results indicate that cheese-making properties are most within the legal parameters, and the microbiological quality of the cheese produced in region of study is generally safe to consume.

*Listeria* spp. and *Salmonella* spp. were not detected in cheese samples studied. *Listeria* spp. species can persist in food and dairy processing environments and washed rind cheese presents the highest risk of contamination with different *Listeria* species. Furthermore, pathogen testing improve ability to detect actual public health hazards since *E. coli*-negative samples may still test positive for *L. monocytogenes* (TRMČIĆ et al., 2016). According to Sant'anna et al. (2018), who conducted a study in the Canastra region, although some improvements have been made, the development of cheese manufacturing in the region is necessary. MAC from the Canastra microregion is made from raw milk product, and negative results for *L. monocytogenes* and *Salmonella* spp. are important to guarantee a safe food product.

Correspondence analysis indicates visual trends, demonstrating possible relationships between variables. The correspondence analysis indicates that the presence of *E. coli* in the water is related to the presence of coliforms. This result is common in water analysis, since they can have the same source of contamination. Some properties did not clean the water tank, promoting contamination. In addition, failures in the chlorination process could also affect the presence of these microbiological hazards, as well as the odor of water. These results prove the importance of hygiene processes in the water tanks and the control of the chlorination process, which can influence both the sensory characteristics of the product and the microbiological quality of the water used in the

manufacturing of the cheese. Our results did not find an association between the microbiological parameters of the water and cheese; however, the findings of coliforms at 45°C in the cheese and the turbidity of the water were plotted in same quadrant in both figures, indicating that these parameters might be related. Therefore, the parameters of odor, residual chlorine, coliforms at 45°C in the cheese, and turbidity of the water are related. Moreover, the presence of total coliforms at 30°C and positive-coagulase *Staphylococcus* spp. in the cheese may be associated, indicating problems in the cheese-making process and failures in GMPs, since no relationships were found with the water quality, suggesting that cheese quality is related more to the cheese handlers and the cleaning process in the factory. It can be concluded from the correspondence that chlorination interferes with water microbiological and odor parameters, and water filtration might be reflected in cheese microbiological parameters. GMP and cheese-making failures, on the other hand, could result in cheese quality problems, especially the presence of coliforms and positive-coagulase *Staphylococcus* spp., resulting in changes in the characteristics of the cheese and possibly even contamination for humans.

The properties had an average of 114 animals each, ranging from 4 to 345., which indicates the heterogeneity of the herd sizes, which may be reflected in the diversity in the forms of production. The other parameters analyzed by the government are shown in Table 3.

**Table 3** - The parameters of production obtained by the IMA for the registered cheesemakers in the Canastra microregion in 2016 and 2017.

Parameter	Conformity		Non-conformity	
	Number	%	Number	%
Brucellosis vaccination	44	93.62	3	6,38
FMD vaccination	47	100.00	0	0.00
TCM	24	51.06	23	48.94
Mesh-screen or black background mug test	40	85.11	7	14.89
Protected water source	47	100.00	0	0.00
Piped water from the source to the dairy	47	100.00	0	0.00
Filtered water	47	100.00	0	0.00
Chlorinated water	47	100.00	0	0.00
Water tanks in suitable conditions	47	100.00	0	0.00
Water tank cleaned every 6 months	46	97.87	1	2.13
Sufficient water flow	46	97.87	1	2.13
Producer checks daily for pH and chlorine of water	1	2.13	46	97.87
Semester analysis of water	34	72.34	13	27.66
Destination of stable garbage	47	100.00	0	0.00
Destination of milking wash water	47	100.00	0	0.00
Destination of the dairy washing water	41	87.23	6	12.77
Destination of cheese whey	45	95.74	2	4.26
Garbage destination	47	100.00	0	0.00
Destination of sanitary sewage	47	100.00	0	0.00

MAC producers must vaccinate cattle against brucellosis and FMD. All the properties studied vaccinated against FMD. For brucellosis, all females between three and eight months of age must be vaccinated, but improvement in the use of the available vaccine is needed. Vicentini et al. (2013), in a survey of cheese producers in Campo das Vertentes (MG), demonstrated that 96% of producers vaccinated cattle against FMD and 80% against brucellosis.

Mastitis control in bovine milk-producing herds used for the production of MAC is important because of the existence of several pathogenic microorganisms related to the disease that can be transmitted by milk, such as *Staphylococcus aureus*, *Streptococcus agalactiae*, *Pseudomonas* sp., *Actinomyces pyogenes*, *Serratia* sp., and *Corynebacterium bovis* (LAFFRANCHI et al., 2001). According to regulations, MAC producers must prevent and control mastitis which is necessary to produce a good quality milk.

In the registered properties participating in the research, all of the water sources were protected from animals and the water undergoes filtration before reaching the reservoir tank, where it is chlorinated, as required by regulations. However, only one property controls the chlorine content in the water. In a study carried out in the Canastra microregion, all the producers stated that the destination of the water waste is the land itself (SARAIVA et al., 2012), which is also the case in this research. The results of our study highlight the need for more public policies to help producers improve their wastewater destination, to protect the environment and water resources. This study found that 4.3% of the farms surveyed did not have pigs and dumped the whey on the land close to the cheese factory. The use of pig farming concomitantly with cheese production contributes to environmental preservation, economic stability, and the strengthening of small producers (SÁ et al., 2012), since it is an alternative destination for the cheese whey.

## CONCLUSION

This study found that registered producers of MAC in the Canastra microregion need to improve their control over the water supply of their cheese factories, fulfilling the requirements of checking the chlorine content in the water daily and conducting annual water analyses. GMPs also need attention, because the microbiological analyses of the final product showed non-conformities for the coliform parameter and positive-coagulase *Staphylococcus* spp., which are indicative of failures in GMPs and hygiene-sanitary conditions.

## ACKNOWLEDGEMENTS

The authors want to thank IMA, in particular the head of the office in Bambuí, Reginaldo, for

providing the data available and Editage (www.editage.com) for English language editing.

## REFERENCES

AOAC. Official Methods of Analysis. Method number. 2004.02

AOAC. Official Methods of Analysis. Method number. 2011.03

BRASIL. Instrução Normativa Nº 62, de 26 de Agosto de 2003. **Oficializa os Métodos Analíticos Oficiais para Análises Microbiológicas para Controle de Produtos de Origem Animal e Água**. Available at: <<http://extranet.agricultura.gov.br/sislegis-consulta/consultarLegislacao.do?operacao=visualizar&id=2851>>. Accessed on: Nov. 10 2018.

RASIL. Portaria n. 2914, de 12 de dezembro de 2011. **Dispõe sobre os procedimentos de controle e de vigilância da qualidade da água para consumo humano e seu padrão de potabilidade**. Available at: <[https://bvsmis.saude.gov.br/bvsmis/saudelegis/gm/2011/prt2914\\_12\\_12\\_2011.html](https://bvsmis.saude.gov.br/bvsmis/saudelegis/gm/2011/prt2914_12_12_2011.html)>. Accessed on: Nov. 10 2018.

CARDADOR, M.J.; GALLEGOS, M.; CABEZAS, L.; FERNÁNDEZ-SALGUERO, J.. Detection of regulated disinfection by-products in cheeses. **Food Chemistry**, v.204, p.306–313, 2016. DOI: <https://doi.org/10.1016/j.foodchem.2016.02.146>

CARDADOR, M.J.; GALLEGOS, M.; PRADOS, F.; FERNÁNDEZ-SALGUERO, J. Origin of disinfection by-products in cheese. **Food Additives Contaminants - Part A Chemistry, Analysis, Control, Exposure and Risk Assessment**, v.34, p.928–938, 2017. DOI: <https://doi.org/10.1080/19440049.2017.1311421>

CASTRO, R.D., OLIVEIRA, L.G., SANT'ANNA, F.M., LUIZ, L.M.P., SANDES, S.H.C., SILVA, C.I.F., SILVA, A.M., NUNES, A.C., PENNA, C.F.A.M., SOUZA, M.R. Lactic acid microbiota identification in water, raw milk, endogenous starter culture, and fresh Minas artisanal cheese from the Campo das Vertentes region of Brazil during the dry and rainy seasons. **Journal of Dairy Science**, v.99, p.6086–6096, 2016. DOI: <https://doi.org/10.3168/jds.2015-10579>.

COSTANZO, N., CENITI, C., SANTORO, A., CLAUSI, M.T., CASALINUOVO, F. Foodborne Pathogen Assessment in Raw Milk Cheeses. **International Journal of Food Science**, 2020. DOI: <https://doi.org/10.1155/2020/3616713>.

FAROOQ, S.; HASHMI, I.; QAZI, I.A.; QAISER, S.; RASHEED, S. Monitoring of Coliforms and chlorine residual in water distribution network of Rawalpindi, Pakistan. **Environmental Monitoring and Assessment**, v.140, p.339–347, 2008. DOI: <https://doi.org/10.1007/s10661-007-9872-2>



- FERNANDES, R.V.B.; BOTREL, D.A.; ROCHA, V. V.; SOUZA, V.R.; CAMPOS, F.M.; MENDES, F.Q. Avaliação Físico-Química, Microbiológica E Microscópica Do Queijo Artesanal Comercializado Em Rio Paranaíba-Mg. **Revista do Instituto de Laticínios Cândido Tostes**, v.66, p.21–26, 2011.
- FERREIRA, R.M.; SPINI, J. DE C.M.; CARRAZZA, L.G.; SANT’ANA, D.S.; OLIVEIRA, M.T.; ALVES, L.R.; CARRAZZA, T.G. Quantificação de coliformes totais e termotolerantes em queijo Minas Frescal artesanal. **Publicações em Medicina Veterinária e Zootecnia**, v.5, p.1019-1026, 2011. DOI: <https://doi.org/10.22256/pubvet.v5n5.1022>
- FREITAS, M.B.; BRILHANTE, O.M.; ALMEIDA, L.M.. Importância da análise de água para a saúde pública em duas regiões do Estado do Rio de Janeiro: enfoque para coliformes fecais, nitrato e alumínio. **Cadernos em Saude Pública**, v.3, p.651–660, 2011.
- GREENACRE, M. & BLASIUS, J. **Multiple Correspondence Analysis and Related Methods**. Florida: Chapman & Hall. 2006. 581p.
- ISO 4832:2006. Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of coliforms — Colony-count technique.
- ISO 6888-1:1999/Amd 2:2018. Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of coagulase-positive staphylococci (*Staphylococcus aureus* and other species) Part 1: Technique using Baird-Parker agar medium.
- KAMIYAMA, C.M. & OTENIO, M.H.. Aspectos Sobre Qualidade Da Água E Qualidade De Produtos Na Indústria De Laticínios. **Revista do Instituto de Laticínios Cândido Tostes**, v.68, p.42–50, 2013.
- LAFFRANCHI, A.; MÜLLER, E.E.; FREITAS, J.C. de; PRETTO-GIORDANO, L.G.; DIAS, J.A.; SALVADOR, R.. Etiologia das infecções intramamárias em vacas primíparas ao longo dos primeiros quatro meses de lactação. **Ciência Rural**, v.31, p.1027–1032, 2001. DOI: <https://doi.org/10.1590/s0103-84782001000600018>
- MINAS GERAIS GERAIS. Portaria nº 1736, de 27 de Julho de 2017. **Altera a Portaria nº 1305/2013, de 30 de abril de 2013, que dispõe sobre o período de maturação do Queijo Minas Artesanal**. Available at: <http://www.ima.mg.gov.br/institucional/portarias#ano-2017> >. Accessed on: Nov. 10 2018.
- MINAS GERAIS. Portaria nº 1810, de 24 de abril de 2018a. **Inclusão do município de Córrego Danta na microrregião da Canastra**. Available at: <http://www.ima.mg.gov.br/files/1349/Ano-2018/14405/Portaria-n%C2%BA-1810,-de-24-de-abril-de-2018.pdf>>. Accessed on: Nov. 10 2018.
- MINAS GERAIS. Lei nº 23157, de 18 de Dezembro de 2018b. **Dispõe sobre a produção e a comercialização dos queijos artesanais de Minas Gerais**. Available at: <https://www.almg.gov.br/consulte/legislacao/completa/completa.html?tipo=LEI&num=23157&comp=&ano=2018> >. Accessed on: Nov. 10 2018.
- MINAS GERAIS. Decreto nº 42.645, de 05 de Junho de 2002. **Aprova o regulamento da Lei nº 14.185, de 31 de janeiro de 2002, que dispõe sobre o processo de produção de Queijo Minas Artesanal**. Available at: <https://www.legisweb.com.br/legislacao/?id=140273> >. Accessed on: Jun. 01 2020.
- MINAS GERAIS. Portaria nº 523, de 03 de Julho de 2002a. **Dispõe sobre as condições higiênic-sanitárias e boas práticas na manipulação e fabricação do queijo minas artesanal**. Available at: <http://www.ima20anos.ima.mg.gov.br/intranet/nova/gec/gec.htm> >. Accessed on: Jun. 01 2020.
- MINAS GERAIS. Portaria nº 518, de 14 de Junho de 2002b. **Dispõe sobre requisitos básicos das instalações, materiais e equipamentos para a fabricação do queijo minas artesanal**. Available at: <http://www.ima20anos.ima.mg.gov.br/intranet/nova/gec/gec.htm> >. Accessed on: Jun. 01 2020.
- MINAS GERAIS. Decreto nº 44.864, de 1º de agosto de 2008. **Altera o Regulamento da Lei nº 14.185, de 31 de janeiro de 2002, que dispõe sobre o processo de produção de Queijo Minas Artesanal**. Belo Horizonte, 01 de agosto de 2008. Available at: <https://www.legisweb.com.br/legislacao/?id=141747>>. Accessed on: Jun. 01 2020.
- MINAS GERAIS. Portaria IMA Nº 1969 DE 26/03/2020. **Dispõe sobre a produção de Queijo Minas Artesanal - QMA em queijarias e entrepostos localizados dentro de microrregiões definidas e para as demais regiões do Estado, caracterizadas ou não como produtora de Queijo Minas Artesanal - QMA**. Belo Horizonte, 26 de março de 2020.
- NÓBREGA, J.E.. **Caracterização Do Fermento Endógeno Utilizado Na Fabricação Do Queijo Canastra No Município De Medeiros , Minas Gerais**. 2007. 82p. Dissertação (Mestrado) - Universidade Federal de Viçosa.
- PEREIRA E ARAÚJO, M.M.; ALVES, P.D.D.; BARBOSA, F.H.F.; ROSA, C.A. Qualidade higiênico-sanitária do leite e da água de algumas propriedades da bacia leiteira do município de Luz - MG. **Revista de Biologia e Ciências da Terra**, v.9, p.154–171, 2009.
- R CORE TEAM. R.: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, 2018. Available from: <https://www.R-project.org/>>. Accessed: Set. 15 2019.
- RIBEIRO, L.F., BARBOSA, M.M.C., PINTO, F.R., LAVEZZO, L.F., ROSSI, G.A.M., ALMEIDA,

- H.M.S., AMARAL, L.A. Diarrheagenic *Escherichia coli* in raw milk, water, and cattle feces in non-technified dairy farms. **Ciência Animal Brasileira**, v.20, p.1–9, 2019. <https://doi.org/10.1590/1089-6891v20e-47449>.
- RICE, E.W.; BAIRD, R.B.; EATON, A.D.; CLESCERI, L.S. **Standard Methods for the Examination of Water and Wastewater**. APHA, AWWA, WPCR, Washington. 2012. 1496p.
- SÁ, C.O.; MARINHO, G.L.O.C.; SÁ, J.L.; RONE, M.N.B.; NASCIMENTO, I.R.; SÁ, F.P. Sustentabilidade dos sistemas de produção dos agricultores familiares e produtores de queijo em Nossa Senhora da Glória, semiárido sergipano. **Revista da Associação Brasileira de Agroecologia**, v.7, p.26–39, 2012.
- SALES, G. de A. **Caracterização microbiológica e físico-química de queijo Minas artesanal da microrregião de Araxá-MG durante a maturação em diferentes épocas do ano**. 2015. 106p. Dissertação (Mestrado) - Universidade Federal de Minas Gerais, Belo Horizonte.
- SANT'ANNA, F.M.; CARVALHO, I.L.S.; FERREIRA, F.S.; ACURCIO, L.B. Microbiological Quality of Minas Artisanal Cheeses from Certified Properties at Serra da Canastra Region, Minas Gerais, Brazil in 2016. **Journal of Dairy and Veterinary Science**, v.6, p.2016–2018, 2018. DOI: <https://doi.org/10.19080/jdvs.2018.05.555682>.
- SANT'ANNA, F.M., WETZELS, S.U., CICCO, S.H.S., FIGUEIREDO, R.C., SALES, G.A., FIGUEIREDO, N.C., NUNES, C.A., SCHMITZ-ESSER, S., MANN, E., WAGNER, M., SOUZA, M.R. Microbial shifts in Minas artisanal cheeses from the Serra do Salitre region of Minas Gerais, Brazil throughout ripening time. **Food Microbiology**, v.82, p.349–362, 2019. <https://doi.org/10.1016/j.fm.2019.02.016>
- SARAIVA, C.B.; MAGALHÃES, F.A.R.; MOREIRA, V.E.; BARROS, S.O. Aspectos ambientais da produção do queijo Minas artesanal. **Revista do Instituto de Laticínios Cândido Tostes**, v.388, p.41–47, 2012. DOI: <https://doi.org/10.5935/2238-6416.20120063>
- SCHNEIDER, R. N. **Análise microbiológica e do sistema produtivo do queijo serrano produzido no município de Cambará do Sul-RS**. 2009. 60p. Monografia (Graduação) - Universidade Federal do Rio Grande do Sul, Porto Alegre.
- SHAPIRO, S. S. & WILK, M. B. An analysis of variance test for normality (complete samples). **Biometrika**, v. 52, n. 3–4, p. 591–611, 1965..
- SILVA, D.F. da; GALVÍNICO, J.D.; ALMEIDA, H.R.R. de C. Variabilidade Da Qualidade De Água Na Bacia Hidrográfica Do Rio São Francisco E Atividades Antrópicas Relacionadas. **Qualitas Revista Eletrônica**, v.9, n.3, p.1–17, 2010. DOI: <https://doi.org/10.18391/qualitas.v9i3.687>
- SIOBHAN, R.; DAVID, G.; KIERAN, J.; AMBROSE, F.; BERNADETTE, O.. Evaluation of trichloromethane formation from chlorine-based cleaning and disinfection agents in cow's milk. **International Journal of Dairy Technology**, v.65, p.498–502, 2012. DOI: <https://doi.org/10.1111/j.1471-0307.2012.00858.x>
- TORRES, A.G.. *Escherichia coli* diseases in Latin America-a “One Health” multidisciplinary approach. **Pathogens and Disease**, v.75, p.1–7, 2017. DOI: <https://doi.org/10.1093/femspd/ftx012>
- TRMČÍČ, A.; CHAUHAN, K.; KENT, D.J.; RALYEA, R.D.; MARTIN, N.H.; BOOR, K.J.; WIEDMANN, M. Coliform detection in cheese is associated with specific cheese characteristics, but no association was found with pathogen detection. **Journal of Dairy Science**, v.99, p.6105–6120, 2016. DOI: <https://doi.org/10.3168/jds.2016-11112>
- VICENTINI, N.M.; CARNEIRO, A.V.; MENDONÇA, L.C.; BRITO, M.A.V.P.; BRITO, J.R.F. Custo da adequação de pequenos produtores de queijos aos requisitos da legislação do estado de Minas Gerais. **Revista do Instituto de Laticínios Cândido Tostes**, v.68, p.5–14, 2013. DOI: <https://doi.org/10.5935/2238-6416.20130043>.
- WHO, 2011. **Technical Notes on Drinking Water, Sanitation and Hygiene in Emergencies: Measuring Chlorine Levels in Water Supplies**. Available at: < [https://www.who.int/water\\_sanitation\\_health/publications/2011/tn11\\_chlorine\\_levels\\_en.pdf?ua=1](https://www.who.int/water_sanitation_health/publications/2011/tn11_chlorine_levels_en.pdf?ua=1)>. Accessed on: Jun. 01 2020.
- ZAR, J. H. **Biostatistical analysis**. 5 ed. New Jersey: Prentice Hall, 2010. 944 p.