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Does the collective manual press change Minas Artisanal Cheese characteristics from Campo das Vertentes region?

[*A prensa coletiva manual altera as características do Queijo Minas Artesanal da região do Campo das Vertentes?*]

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ABSTRACT

The production of Minas Artesanal Cheese (MAC) is a centuries-old activity that involves a great deal of physical effort on the part of the producer, especially during the pressing stage, which is carried out by hand. Inspection agencies do not allow manual stainless-steel presses in MAC production. Studies are still needed to prove whether this technique changes the cheese characteristics. Therefore, this study tested two types of MAC production in the Campo das Vertentes region: traditional hand pressing and a new technology, a stainless-steel press. After the cheeses were made, analyses of their physicochemical composition and microbiological analysis were made, as well as their texture profile and instrumental color, over four ripening periods (7, 14, 22, and 30 days) to see if the pressing interfered with the characteristics of the MAC from the Campo das Vertentes-MG region. Pressing in a stainless-steel press did not change the main characteristics of the MAC studied, with changes only observed in some texture profile attributes. Therefore, a stainless-steel press is recommended in manufacturing and pressing MAC due to the health benefits for producers.

Keywords: equipment, technology, innovation, quality

RESUMO

A produção do Queijo Minas Artesanal (QMA) é uma atividade secular que envolve grande esforço físico do produtor, principalmente na etapa de prensagem, que é realizada com as mãos. Os órgãos fiscalizadores não permitem o uso de prensas manuais de inox na produção de QMA. Ainda não há estudos que comprovem se o uso dessa técnica modifica as características do queijo. Assim, no presente estudo, foram testados dois tipos de fabricação de QMA da região do Campo das Vertentes: utilizando-se a prensagem tradicional com as mãos e uma nova tecnologia, com a prensagem em prensa de aço inoxidável. Após a fabricação dos queijos, foram feitas análises de composição físico-química, microbiológicas e de perfil de textura e cor instrumental, ao longo de quatro tempos de maturação (7, 14, 22, 30 dias) para se verificar se o tipo de prensagem interfere nas características do QMA da região do Campo das Vertentes-MG. A prensagem em prensa de inox não modificou as principais características do QMA pesquisadas, tendo sido observadas alterações apenas em alguns atributos do perfil de textura. Portanto, recomenda-se o uso da prensa de inox na fabricação e prensagem dos QMA, em virtude dos benefícios trazidos para a saúde dos produtores.

Palavras-chave: equipamentos, tecnologia, inovação, qualidade

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INTRODUCTION

Minas Artisanal Cheese (MAC) is an essential source of income for thousands of Minas Gerais producers. In addition to its economic value, it has a significant cultural value since its production technology is passed on from generation to generation, from father to son (Costa *et al*., 2022).

According to Ordinance No. 1969 (Minas Gerais, 2020a), MAC is that made from raw, healthy, whole milk, produced in-house, using natural starter culture (“pingo”), rennet and salt, and the product has a firm consistency, unique color and flavor, uniform mass, free of dyes and preservatives, with or without mechanical eyes. The manufacture of MAC includes some steps such as filtration, the addition of natural starter culture (popularly known as pingo) and rennet, coagulation, curd cutting, mixing, draining, moulding, and pressing, followed by salting and ripening (Minas Gerais, 2020a). The MAC production contemplates many manual steps, which can be tiring and exhausting for the producers, especially in pressing, done by hand. In the pressing stage, the cheese is placed in draining cloths like a bag and pressed by the cheesemakers with their hands to remove excess whey. Cheese pressing must be done correctly, as it is an important manufacturing stage and complements draining, avoiding defects such as excess moisture between curd grains, excessive lowering of the pH of cheese, preventing fermentation problems, cheese releasing whey, stains, extra mechanical eyes, among others (Sobral *et al*., 2023).

MAC production comes from family farming, usually carried out by two people in the family, one responsible for animal handling and milking and the other one for manufacturing, ripening and selling the cheese, so the number of tasks performed by artisanal producers is high (Pinto, 2004; Araújo, 2004). In addition to the work overload, manual techniques are used, which, in addition to greater manipulation and the possibility of cheese contamination, can influence the health of MAC producers. The daily pressure exerted repeatedly by the hands in the pressing step can cause repetitive strain injury (RSI) in the producers' hands. Repetitive Strain Injury (RSI) or Work-Related Musculoskeletal Disorder (WMSD) is a syndrome that compromises the musculoskeletal system of workers who perform repetitive and excessive movements, such as pressing cheese with their hands, and is mainly characterized by pain and inflammation in the upper limbs (Oliveira *et al*., 2020).

The cheeses are produced and pressed in small industries using a collective stainless-steel press, which consists of piling the cheese molds in a stainless steel support called a press. A weight is placed on top of the last cheese, also made of stainless steel. This weight must be ten times the cheese weight; for example, a one-kilo cheese must weigh 10 kilos. The cheeses spend an average of 3 to 12 hours in the press, and during this time, the turnings are also carried out for better pressure distribution. In large industries, pressing is done by compressed air, also collectively, appropriate large presses, different from manual presses (Sobral *et al*., 2023).

In Minas Gerais, the manual collective press pressing technique is not allowed by the inspection service for MAC production. The use of a manual collective press is controversial, as it is believed that such a technique may violate the traditional way of knowing passed from father to son and that it may even modify the MAC characteristics. However, according to Ordinance n. 48.024 of August 19, 2020, which determines conditions for artisanal cheese production, in article 6, item 5, it is said that cheese processing can be guided by regional culture using traditional techniques, however, technical innovations are allowed that guarantee appearance and flavour specific to the type of artisanal cheese (Minas Gerais, 2020b). Therefore, using the collective stainless-steel press would be a great innovation reflecting the health of Minas Artisanal Cheese producers. This technique is also manual, but that could improve the quality of life for producers, avoiding excessive use of hands. However, it is still being determined whether this new technology modifies the Minas Artisanal Cheese characteristics, as no published studies exist.

Therefore, the present work aimed to manufacture Minas Artisanal Cheese in Campo das Vertentes-MG, varying only the pressing way, one manufacturing using hand pressing and the other using the new technology: collective stainless steel manual press. The cheeses were analyzed regarding physical-chemical composition, texture profile, instrumental color and microbiological counts to verify whether the pressing method modifies MAC characteristics.

MATERIAL AND METHODS

Minas Artisanal Cheeses were produced according to local tradition in a certified cheesemaking facility in Campo das Vertentes-MG (Figure 1). All manufacturing steps were the same as passed down from generation to generation, except for the pressing step. In this experiment, two treatments were performed (cheese pressed by hand and in a collective stainless steel manual press), three repetitions (different manufacturing days) and the cheeses were analyzed over 4 ripening times (7, 14, 21, 30 days). Before the experiment, pre-tests were carried out to establish the best pressing condition, defined as 60 minutes of pressing in a stainless-steel press and a weight of 10 kilos, with a turn after 30 minutes. After being removed from the press, cheeses were salted with coarse salt, like hand-pressed cheeses. The other steps were similar for both treatments; the cheeses were produced and ripened in the same cheese factory to maintain the ripening conditions (temperature and humidity).

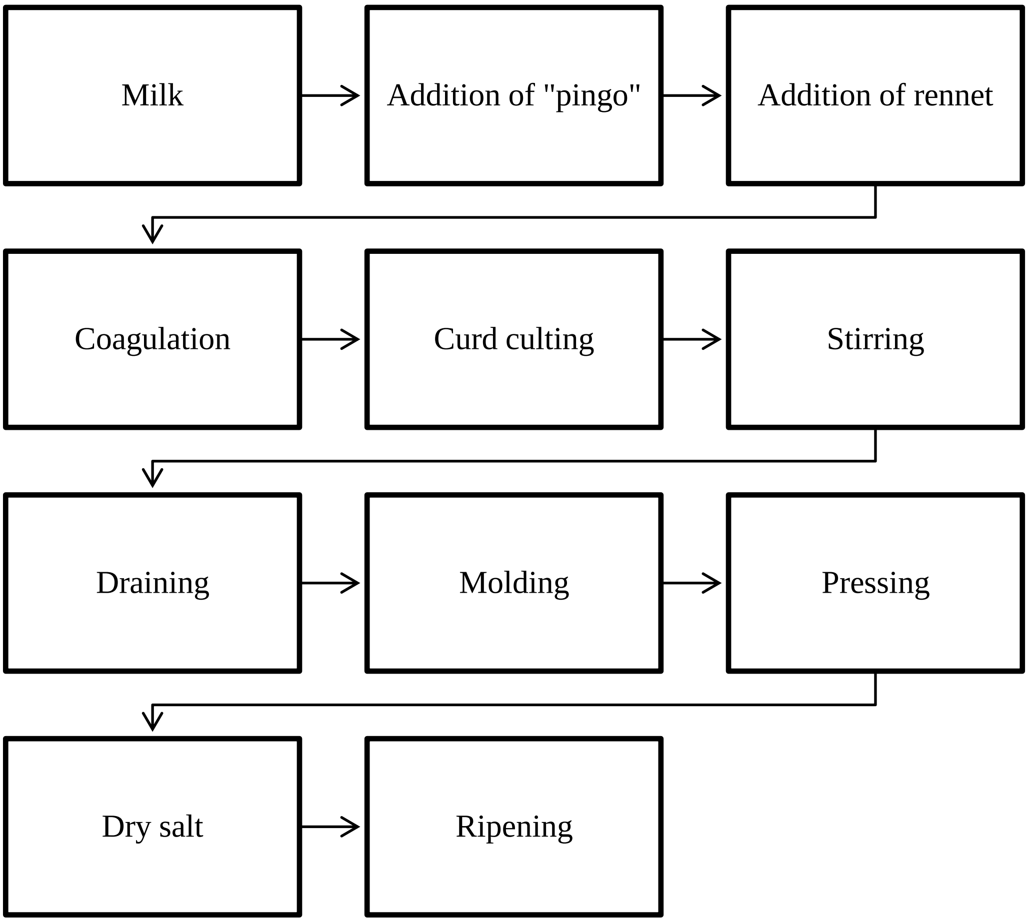

Figure 1. Cheesemaking steps of Campo das Vertentes artisanal cheese.

Samples were prepared by cutting fractions proportional to all cheese parts, followed by homogenization in a Blender Plus Tepron® grinder (AOAC 970.30, 2012). The total solids content (% w/w TSS) was obtained by the gravimetric method in an oven at 102±2°C (Cheese…, 2004), and the moisture percentage by the difference 100-% TSS. The fat content (% w/w fat) was obtained using the Van Gulik butyrometric method with a calibrated butyrometer (Cheese…, 2008). The Aqualab Decagon® water activity analyzer was used for water activity analysis, following the procedures indicated by the manufacturer. The pH was measured using a calibrated pH meter. The chloride content (expressed as % w/w salt (NaCl)) was obtained by reaction with silver nitrate and titration "by the rest" with potassium thiocyanate (Costa Júnior, 2020). Percentage contents of total nitrogen - %TN, nitrogen soluble in pH4.6 - % SN-pH4.6 and nitrogen soluble in 12% trichloroacetic acid - % SN-12% TCA were obtained using the Kjeldahl method, as described in Costa Júnior (2020), for the calculation of proteolysis indices - % extent (%SN-pH4.6×100/%TN) and % depth (%SN-12% TCA ×100/%TN) of proteolysis (Chemical…, 1999 - and total protein, using the nitrogen to a protein conversion factor of 6.38 (Robert and Bradley, 2012). The percentage fat content in the dry extract (% FDM) was calculated using the ratio %fat×100/%TSS and salt in moisture (% S/U) using the ratio %salt×100/(%moisture+%salt). Regarding the microbiological analysis, counts of coliforms at 35°C, coliforms at 45°C, *Staphylococcus aureus*, filamentous fungi and yeasts and lactic acid bacteria (LAB) were performed. For the detection of coliforms at 35°C, coliforms at 45°C, S. aureus and filamentous fungi and yeasts, Petrifilm® plates were used, following the manufacturer's guidelines. Sample preparation and necessary dilutions were performed as described in Normative Instruction No. 30 of June 26, 2018 (Brasil, 2018). For *Salmonella* spp. and *Listeria* spp., Neogen® detection kits were used according to the manufacturer's instructions. Lactic acid bactéria (LAB) counts were conducted according to Silva *et al*. (2010), using Man, Rogosa & Sharpe agar (MRS – Oxoid Ltd. Basingstoke, England), incubated in anaerobiosis. Five colonies from each plate were selected for catalase and Gram staining. Gram-positive cultures (cocci or bacilli) and catalase-negative were considered LAB.

The texture profile analysis (TPA) was carried out using a Texturometer CT3, Texture Analyzer (Brookfield, Middleboro, USA) with the methodology (Pinto *et al*., 2011) for Minas Artisanal Cheese from Serro. Instrumental colour analysis was performed using a Konica Minolta colourimeter, model CM5. The colourimetric parameters were determined by directly reading the chromatic coordinates L*, a*, and b* using the CIELAB scale. The D65 illuminant and observation angle of 10º were used, following the methodology defined by the manufacturer (Konica Minolta, sd). The shredded cheese sample was placed in a cylindrical optical glass container specific to the equipment, followed by analyses. In CIELAB, L* represents brightness (L* = 0 is darkness, and L* = 100 is total brightness). The coordinates a* and b* indicate the direction of the colours: +a* (red) and –a*(green); + b* (yellow) and –b*(blue).

A split-plot design was used, with treatment as the main factor and time as a subfactor. Data were analyzed by analysis of variance (ANOVA), followed by Tukey's test with a significance level of $P<0.05$.

RESULTS AND DISCUSSION

The MAC centesimal composition was not affected by hand pressing, compared to the stainless-steel press ($P>0.05$). There was no significant interaction between the treatments ($P>0.05$). However, as expected, there was an effect of time in both treatments ($P<0.05$), with the cheeses losing moisture over time and an increase in the solid constituents (fat, protein) (Table 1).

Artisanal Minas cheese is ripened without packaging, and over time, it loses moisture due to dehydration, affecting its chemical composition (Lourenço Neto, 2013). This decrease in moisture is frequent in artisanal cheeses and is related to ripening carried out without packaging and in an environment without humidity and temperature control (Oliveira *et al*., 2018).

Notably, because of possible differences in the force exerted on cheese by the pressing (hands or the press), it was expected that pressing interfered mainly with the cheese moisture, but this did not happen in practice. Besides, Minas Artisanal Cheese has variations, even when produced by the same producer, so a cheese pressed by hand at the beginning of production can receive a different force from the end of pressing due to the number of cheeses produced, the first ones can receive more pressure than the last ones when the producer is already more physically exhausted. A last factor that can cause variation in the MAC composition would be the variation in the milk composition. In MAC manufacturing, neither the milk nor the microbiota is standardized as in industrial cheeses. Therefore, the milk and cheese compositions may vary due to the dry and rainy season, the cow's lactation stage, and the animal's diet, among other factors (Sobral *et al*., 2019).

Table 1. Centesimal composition of hand-pressed and press-pressed MAC over-ripening time (mean±SD)

Parameter	Ripening (days)	Treatment	
		Hand-pressed	Press-pressed
Moisture (% w/w)	7	42.90 ± 0.14 ^{aA}	44.80 ± 1.36 ^{aA}
	14	39.10 ± 1.34 ^{aB}	39.28 ± 1.70 ^{aB}
	22	33.80 ± 1.67 ^{aC}	36.34 ± 1.47 ^{aC}
	30	30.31 ± 2.70 ^{aD}	32.99 ± 3.10 ^{aD}
Protein (%w/w)	7	24.53 ± 1.03 ^{aB}	23.37 ± 0.84 ^{aB}
	14	26.24 ± 2.51 ^{aB}	26.02 ± 1.06 ^{aB}
	22	26.77 ± 4.38 ^{aBA}	27.76 ± 2.53 ^{aBA}
	30	31.51 ± 2.38 ^{aA}	29.73 ± 2.95 ^{aA}
Fat (%w/w)	7	31.60 ± 0.29 ^{aB}	30.02 ± 1.56 ^{aB}
	14	34.20 ± 3.39 ^{aA}	35.60 ± 2.97 ^{aA}
	22	36.17 ± 0.85 ^{aA}	36.25 ±1.77 ^{aA}
	30	37.50 ± 1.41 ^{aA}	36.53 ± 2.17 ^{aA}
FDM[1]	7	54.34 ± 0.66 ^{aA}	54.38 ± 1.92 ^{aA}
	14	56.15 ± 6.33 ^{aA}	58.63 ± 6.57 ^{aA}
	22	54.64 ± 1.10 ^{aA}	56.94 ± 2.85 ^{aA}
	30	53.81 ± 3.92 ^{aA}	54.52 ± 1.50 ^{aA}
A_w (water activity)	7	0.96 ± 0.01 ^{aA}	0.96 ± 0.01 ^{aA}
	14	0.95 ± 0.01 ^{aA}	0.96 ± 0.01 ^{aA}
	22	0.95 ± 0.01 ^{aAB}	0.95 ± 0.02 ^{aAB}
	30	0.93 ± 0.02 ^{aB}	0.93 ± 0.00 ^{aB}
Salt (%w/w)	7	1.08 ± 0.58 ^{aA}	1.12 ± 0.41 ^{aA}
	14	1.44 ± 0.89 ^{aA}	1.90 ± 0.86 ^{aA}
	22	1.48 ± 0.38 ^{aA}	1.32 ± 0.13 ^{aA}
	30	1.33 ± 0.24 ^{aA}	1.46 ± 0.39 ^{aA}
Salt in moisture (%)	7	2.49 ± 1.28 ^{aB}	2.43 ± 0.81 ^{aB}
	14	3.56 ± 2.29 ^{aAB}	4.61 ± 2.19 ^{aAB}
	22	4.19 ± 1.18 ^{aA}	3.51 ± 0.34 ^{aA}
	30	4.29 ± 1.02 ^{aA}	4.24 ± 1.34 ^{aA}
pH	7	5.16 ± 0.07 ^{aB}	5.08 ± 0.03 ^{aB}
	14	5.18 ± 0.07 ^{aB}	5.12 ± 0.05 ^{aB}
	22	5.30 ± 0.11 ^{aA}	5.29 ± 0.15 ^{aA}
	30	5.37 ± 0.11 ^{aA}	5.26 ± 0.08 ^{aA}
Extent of proteolysis index (%)	7	10.95 ± 1.88 ^{aB}	11.61 ± 2.20 ^{aB}
	14	14.82 ± 1.01 ^{aAB}	14.96 ± 1.98 ^{aAB}
	22	16.67 ± 1.89 ^{aA}	17.82 ± 2.33 ^{aA}
	30	15.70 ± 4.76 ^{aA}	18.38 ± 5.94 ^{aA}
Depth of proteolysis index (%)	7	6.09 ± 0.88 ^{aB}	6.56 ± 0.91 ^{aB}
	14	9.32 ± 0.74 ^{aAB}	9.41 ± 1.09 ^{aAB}
	22	10.70 ± 1.81 ^{aA}	11.10 ± 2.74 ^{aA}
	30	9.81 ± 3.55 ^{aA}	13.10 ± 4.79 ^{aA}

[1]FDM: fat in dry matter. Means within a row (amog treatments) with different superscript lowercase letters and within a column (amog different days of the ripening) with different superscript uppercase letters are significantly different (P <0.05) (Tukey test).

According to Ordinance 2033 of January 23, 2021 (Minas Gerais, 2021), Minas Artisanal Cheese must have a maximum moisture content of 45.9%. In the current study, the MAC produced in both treatments met the moisture content required by law (45,9%), already in the first ripening period (7 days), which was 43.85% (Table 1). Lopes *et al*. (2022) found values of 44.71% of moisture for MAC from Cerrado region, close to this study. Oliveira *et al*. noticed an average of approximately 52% moisture for MAC from Serro region with three days of ripening and 31% for cheese with 30 days of ripening, proving the water loss over time.

The fat and protein contents of the cheese increased during ripening ($P<0.05$) (Table 1), considering that cheese lost moisture to the environment and there was a concentration of solids. Castilho *et al*. (2019) found an average protein content ranging from 24.97% to 33.05% in artisanal cheeses from Paraná, values close to the present study. Milk protein and, consequently, cheese can be influenced by environmental factors, such as the cow's diet, due to the different levels and sources of nitrogen in the feed and energy availability (Castilho *et al*., 2019).

Regarding fat in dry matter (FDM), it was verified that the value remained constant throughout ripening (Table 1). As the fat is concentrated during ripening and the dry matter, this ratio remains invariable during ripening (Lourenço Neto, 2013).

Moisture loss also influenced cheese Aw (Table 1) in this experiment. Water activity (Aw) is an important factor in cheese making, as it can influence the activity of reactions occurring during cheese ripening and affect microbial growth. In the present study, Aw was not different between the treatments ($P<0.05$); only time influenced it ($P<0.05$).

As for salt content, there was no difference between treatments or concerning time ($P>0.05$). A very high standard deviation can be noticed about the salt content, if compared to the other constituents, due to how the cheese is salted, with the addition of salt on cheese top, without any standardization of the amount added.

There was also no significant difference ($P>0.05$) between treatments for pH and indices of extent and depth of proteolysis (Table 1), only about time ($P<0.05$). This increase in pH is expected due to cheese ripening. The enzymatic activity in cheese ripening comes from the rennet retained in cheese curd, from native milk enzymes and also from bacteria present in pingo and raw milk. These enzymes release alkaline nitrogen compounds from protein degradation, increasing the pH of cheese (Vale *et al*., 2018), as occurred in the present study.

There was a gradual increase in extent and depth indexes throughout cheese ripening (Table 1). The extent index refers to primary proteolysis with the release of high molecular weight peptides from casein mainly by the action of chymosin and natural milk proteinases. The depth of proteolysis refers to the peptides generated in the primary proteolysis that are hydrolysed primarily to lactic acid bacteria enzymes with the generation of low molecular weight peptides. Costa Junior *et al*. (2014) verified in a study with MAC of Campo das Vertentes that the cheeses from the rainy season had higher average indexes (extent 13.2% and depth 8.0%) when compared to the dry period (extent 10.8% and depth 5.9%).

Both moisture and water activity interfere with proteolysis (Fox and McSweeney, 1996), and as these two analyses did not vary between treatments ($P>0.05$) (Table 1), the extent index did not vary either. Proteolysis rates were also impacted when moisture and water activity decreased during ripening. Note that the values of the proteolysis indexes are cumulative, and a significant difference was detected between 7 and 14 days of ripening (Table 1), both for the extent and depth index. At times of 22 and 30 days, the indices became similar. In addition to cheese moisture, salt in moisture influences proteolysis, as the higher this value, the less water is available for hydrolysis reactions. Increasing the moisture content of salt from 7 days to 22 days slowed down proteolysis. Note that in 22 and 30 days, salt in moisture was similar, and because it is close to 4%, the impact on proteolysis is high since chymosin has a maximum proteolytic activity on paracasein between 2.5% to 4% salt in moisture content (Fox and McSweeney, 1996). It is important to evaluate salt in moisture of cheese instead of salt content because although the salt content did not differ among the evaluated times, the salt in moisture increased and directly impacted proteolysis.

The microbiological count of the MAC studied showed no significant difference regarding the pressing used (P>0.05). There was also no difference in the number of microorganisms over time (P>0.05), except for the *Staphylococcus aureus* count, where there was a reduction in the count after 22 days (Table 2).

The lactic acid bacteria (LAB) counts did not show a reduction over the ripening period (Table 2). Campos de Sá and collaborators (2021) found LAB counts in MAC from Campo das Vertentes region varying between 7.9 and 9.6 log of CFU/g, values close to the present study. The endogenous LAB present in pingo and milk are specific to each producing region and are agents of ripening, as well as rennet and other enzymes, which provide the specific sensory characteristics of Minas Artisanal Cheese, making it unique and play an important role in this cheese production (Costa *et al*., 2019). Therefore, in the present study, it was possible to establish that the pressing, whether done by hand or in a stainless-steel press, did not interfere with the lactic bacteria count of the cheese, not even during ripening.

Table 2. Microbiological analysis of hand-pressed and press-pressed QMA over-ripening time (mean±SD)

Parameter	Ripening (days)	Treatment	
		Hand-pressed	Press-pressed
LAB[1] (log CFU/g)	7	8.38 ± 0.58 ^{aA}	8.42 ± 1.12 ^{aA}
	14	8.63 ± 0.21 ^{aA}	8.44 ± 0.14 ^{aA}
	22	8.29 ± 0.26 ^{aA}	8.21 ± 0.15 ^{aA}
	30	8.37 ± 0.13 ^{aA}	8.64 ± 0.50 ^{aA}
Staphylococcus aureus (log CFU/g)	7	3.69 ± 0.65 ^{aA}	3.43 ± 0.50 ^{aA}
	14	3.50 ± 0.47 ^{aA}	2.90 ± 0.59 ^{aA}
	22	1.59 ± 1.17 ^{aB}	1.43 ± 1.02 ^{aB}
	30	1.57 ± 1.14 ^{aB}	1.33 ± 0.94 ^{aB}
Coliforms at 35°C (log CFU/g)	7	3.87 ± 1.17 ^{aA}	3.44 ± 0.89 ^{aA}
	14	4.55 ± 0.35 ^{aA}	4.23 ± 0.27 ^{aA}
	22	4.05 ± 0.42 ^{aA}	4.42 ± 1.45 ^{aA}
	30	2.76 ± 1.95 ^{aA}	4.49 ± 0.58 ^{aA}
Coliforms at 45°C (log CFU/g)	7	3.58 ± 0.85 ^{aA}	2.90 ± 0.14 ^{aA}
	14	3.73 ± 0.61 ^{aA}	3.73 ± 0.53 ^{aA}
	22	4.03 ± 0.52 ^{aA}	3.52 ± 0.25 ^{aA}
	30	2.67 ± 1.88 ^{aA}	3.79 ± 0.41 ^{aA}
Moulds and yeast (log CFU/g)	7	6.38 ± 0.53 ^{aA}	6.18 ± 0.27 ^{aA}
	14	5.48 ± 1.40 ^{aA}	5.71 ± 1.38 ^{aA}
	22	5.90 ± 1.10 ^{aA}	5.91 ± 1.23 ^{aA}
	30	5.68 ± 0.86 ^{aA}	5.59 ± 1.11 ^{aA}
Listeria spp.	7	Absence	Absence
	14	Absence	Absence
	22	Absence	Absence
	30	Absence	Absence
Salmonella spp.	7	Absence	Absence
	14	Absence	Absence
	22	Absence	Absence
	30	Absence	Absence

[1] LAB: lactic acid bacteria (LAB). Means within a row (amog treatments) with different superscript lowercase letters and within a column (amog different days of the ripening) with different superscript uppercase letters are significantly different (P <0.05) (Tukey test).

The minimum ripening time required for the MAC from Campo das Vertentes was established at 22 days, which may influence the microbiological counting of pathogens required by law (Minas Gerais, 2021). At 22 days of ripening (Table 2), cheeses reached the required staphylococci count (Minas Gerais, 2021 - maximum 3.0 Log CFU/g). However, the cheeses showed values above the standard for coliform counts at 35°C and 45°C. This means there is a need to review good agricultural practices and cheese manufacturing to reduce these counts (Sobral *et al*., 2019). In the present study, *Listeria* spp. and *Salmonella* spp. were present in none of the analysed cheeses. Regarding filamentous fungi and yeasts, the count in the present study was similar to that found by Campos de Sá and collaborators (2021), also for MAC in Campo das Vertentes. This group of microorganisms, as well as lactic acid bacteria, have enzymes that can contribute to the sensory characteristics of cheese. (Martin; Cotter, 2023) and the pressing does not influence the count of these microorganisms.

One of the most important texture parameters for evaluating the cheese is hardness, which showed no difference in treatments (P>0.05). However, there was a difference in time (P<0.05), so cheese got harder with ripening. This behaviour can be explained by the gradual moisture loss (Bertolino *et al*., 2011) once MAC is ripened without packaging (Figure 2). The results of both treatments have been plotted on the same graph, as there was no significant difference between the treatments, only a difference in time.

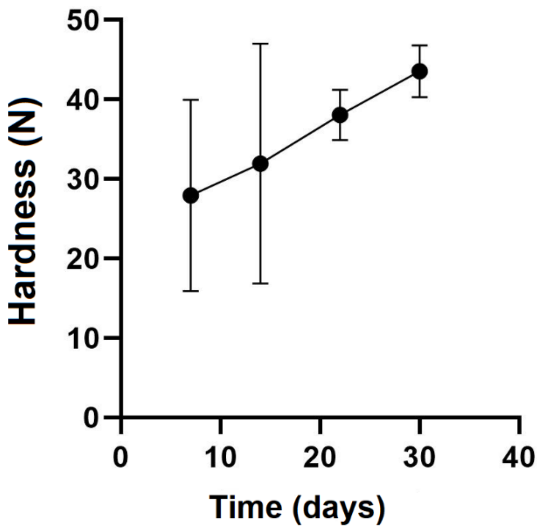

Figure 2. Increase in hardness (N) in the MAC studied over time. The data shows the values for all cheeses manufactured by hand pressing and the stainless-steel press. Source: survey data.

Regarding the adhesiveness of MAC in Campo das Vertentes, there was no significant difference between treatments or over time (P>0.05). The average of all results for cheese adhesiveness in this study was 0.000788±0.000284 J.

As for MAC chewiness (J), there was no difference over time (P<0.05). However, there was a difference in the pressing (treatments) (P<0.05). For hand-pressed and press-pressed treatments, the mean value for chewiness was, respectively, 0.0977±0.0266 J and 0.0752±0.0200 J. Carr *et al*. (2006) define chewiness as force required to disintegrate a solid food until it is ready to be swallowed. Therefore press-pressed cheeses would require less intense chewing than hand-pressed cheeses.

Regarding the cohesiveness and springiness of the studied cheeses, there was an effect of time and treatment (P<0.05) (Fig. 3). With ripening, there is a weakening of the protein network due to proteolysis, which can affect the cohesiveness and springiness of the cheeses (Lawrence *et al.*, 1987), which justifies the decrease of these values in the MAC over time. According to Fig.

3A, hand-pressed cheeses were more elastic than press-pressed cheeses. The same behaviour with cohesiveness (Fig. 3B) can be noticed in those whose hand-pressed cheeses were more cohesive than press-pressed cheeses.

Despite not affecting hardness, pressing in a stainless-steel press provided less cohesive, elastic and chewy cheeses pressed by hand.

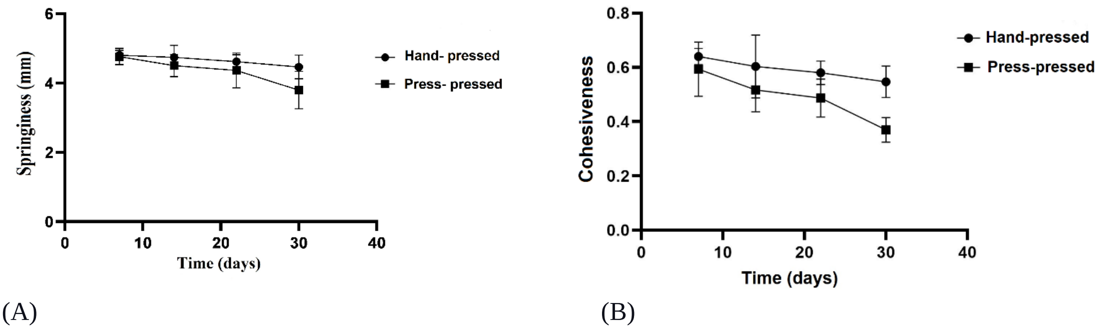

Figure 3. Difference between time and treatment for springiness (A) and cohesiveness (B) of the MAC from Campo das Vertentes region. Source: survey data.

There was no significant difference regarding the pressing used for the chromatic coordinates a* and b* and for luminosity (L*) (P>0.05). For the chromatic coordinate b*, time also did not change the colours ranging from yellow (+) to blue (-) (P>0.05). However, for brightness, which goes from white (100) to black (0), and for the chromatic coordinate a*, which goes from green (-) to red (+), there was a change over time (P< 0.05) (Table 3).

Table 3. Instrumental color of hand-pressed and press-pressed Minas Artisanal Cheeses over-ripening time (mean ± SD).

Parameter	Ripening (days)	Treatment	
		Hand-pressed	Press-pressed
L*	7	82.59 ± 2.55 aA	83.86 ± 1.27 aA
	14	80.86 ± 1.01 aA	84.29 ± 1.12 aA
	22	80.19 ± 3.49 aA	83.44 ± 1.53 aA
	30	76.05 ± 1.30 aB	77.97 ± 2.98 aB
a*	7	3.24 ± 0.44 aB	2.98 ± 0.10 aB
	14	3.79 ± 0.14 aAB	2.73 ± 0.66 aAB
	22	3.88 ± 0.70 aAB	3.08 ± 0.41 aAB
	30	4.58 ± 0.59 aA	4.26 ± 1.09 aA
b*	7	29.58 ± 3.12 aA	28.20 ± 1.32 aA
	14	31.92 ± 0.31 aA	26.94 ± 2.16 aA
	22	32.21 ± 2.08 aA	28.32 ± 1.14 aA
	30	33.25 ± 0.86 aA	31.98 ± 2.58 aA

Means within a row (amog treatments) with different superscript lowercase letters and within a column (amog different days of the ripening) with different superscript uppercase letters are significantly different (P <0.05) (Tukey test).

The cheeses generally showed high luminosity (L*), with values above 80 at 7, 14 and 22 days of ripening. The higher the L* value, the brighter the object. Only a reduction in L* was observed during the last ripening period (30 days), so the cheese became darker (Table 3).

Regarding the chromatic coordinates a* and b*, the yellow component was predominant (positive b*) over the red component (positive a*), indicating the cheese colour was yellowish orange, typical of Minas Artisanal Cheese, as expected (Costa *et al*., 2022). The red colour of the cheese began to intensify after 14 days of ripening (Table 3).

The decrease in luminosity and increase in the red colour of the cheese may have occurred due to the loss of moisture during ripening, which can make the cheese more concentrated, tending towards a darker colour (lower L* value) and redder (higher b* value). A study by Figueiredo *et al*. (2016) found that MAC colour from the Serro region changed during ripening. However, the cheese was not changed with the time of year (rainy or dry). Andrade *et al*. (2007) noticed no difference in luminosity and chromatic coordinate a* of coalho cheeses produced in an industrial or artisanal way, with L* values and a* values close to 88 and 20, respectively.

CONCLUSION

Using a manual collective press made of stainless-steel does not change the physical-chemical composition, the proteolysis indexes, the microorganism count, the hardness, or the color of Minas Artisanal cheeses produced in Campo das Vertentes region, MG, if compared to hand-pressed cheeses during the ripening periods studied. The only changes noticed were in chewiness, springiness, and cohesiveness. Artisanal Minas cheeses present acceptable natural variations in their characteristics, even from producer to producer, from the same region. Therefore, the use of the stainless-steel press as proposed did not constitute a source of variation in the MAC characteristics, and its approval by the inspection service needs to be considered due to the improvement in the life and health quality of Minas Artisanal Cheese producers.

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