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Effect of an edible alginate coating with essential oil to improve the quality of a Fresh cheese

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ABSTRACT. This study focuses on an alginate edible coating with oregano and rosemary essential oils (EO) as well as its application in a Fresh cheese. The practical application was carried out by analyzing microbial contents, centesimal composition, texture (shear force) and instrumental color, sensory acceptance and mass loss. The coatings containing rosemary EO retained minimal numbers of Coliforms (35°C) during storage; thus, a positive effect of the coatings on improving the microbiological cheese quality was observed. Sensorial results were satisfactory for all edible coating samples (Acceptance Index > 77%) highlighting the one with oregano essential oil, proving that this coating can be an alternative to improve technological parameters of Fresh Cheese quality.

Keywords: minas frescal; oregano essential oil; rosemary essential oil; sensorial quality; sodium alginate.

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Introduction

Consumers are increasingly more demanding and concerned about the quality of foods, leading industries to seek safer forms of food production with greater shelf life (Azevedo, 2012). The use of films and edible coatings is a topic of great interest for its potential to prevent the deterioration of foods; it has been proven an efficient technique to preserve foods by maintaining their appearance, taste, and quality, which increases the commercial value (Cerqueira, Jacomino, Sasaki, & Alleoni, 2011).

Another option that has become increasingly important in researches regarding food conservation is the use of essential oils from seasonings such as preservatives (Azevedo, 2012) due to their biological activity in decreasing the negative effects of microorganisms that could cause damage in the food industry. Essential oils (EO) are natural substances categorized as GRAS (generally regarded as safe) by the Food and Drug Administration, and they are widely used due to their flavoring function. From the chemical point of view, EO are complex mixtures composed by several components, and this complexity often makes it difficult to explain their aforementioned activities. According to Moarefian, Barzegar, and Sattari (2013), lipid oxidation and microbial contamination are factors that affect food quality and shelf life. EOs from oregano (*Origanum vulgare L.*) and rosemary (*Rosmarinus officinalis L.)* have been of great importance because they play an important role as antimicrobial and antifungal due to their composition, the reasonit was used in this study.

Edible coatings based on essential oils are an excellent option regarding food conservation for their capacity to extend shelf life, restrict the transport of moisture (Luvielmo & Lamas, 2012). Considering their function as food components, coatings based on essential oils should present characteristics such as good sensory quality, barrier properties and efficient mechanical, biochemical, physical, chemical, and microbiological stability. Among the major components in coating formation, it can be named polysaccharides (natural polymers) such as starch, alginates, carrageenan, chitosan and gums. Alginate has excellent gelling properties and its viscosity increases in solution (Olivas & Barbosa-Canovas, 2008).

According to Galgano et al. (2015) alginates can also be used to prepare edible coatings and films. In general, a cross linking solution is necessary to use as an example, a calcium chloride solution (5% w v^{-1}) to promote the alginate gel forming process. The differential of this work is the use of two essential oils allied to the edible coating in fresh cheese. The application of an edible coating is indicated for foods that are more susceptible to contamination, especially those with high levels of water and high protein content, crucial factors for microbial development, such as in dairy products. Among dairy products, it can be highlighted the fresh cheese, as Minas Frescal cheese, which is widely consumed and whose production can involve contamination by several microorganisms, compromising its quality and the consumer's safety. According to Diamantino, Beraldo, Sunakozawa, and Penna (2014), Minas Frescal cheese is a popular dairy product in Brazil, one of the most highly produced cheeses in the country (9.1%), along with Mozzarella (33.3%) and Prato (26.3%) varieties.

In this context, the objective of this study was to test the application of edible coatings with sodium alginate, oregano and rosemary EO in a Minas Frescal cheese, as well as assess their effects on the products quality.

Material and methods

Preparation of Minas Frescal cheese

For the preparation it was used 98.73% non-homogenized pasteurized milk (Batavo®), 1.15 salt (Cisne®), 0.10 liquid bovine rennet (Estrela®), and 0.02% calcium chloride purchased at the local commerce in Maringa-PR-BR. The oregano and rosemary essential oils proceeded from Ferquima® industry. The products were derived from a single batch to avoid variations in the formulations. Minas Frescal cheese was produced according to the methodology proposed by Santos et al. (2015).

Preparation and application of coating solutions

Four samples were developed: with no coating added (NoCoat); sodium alginate with calcium chloride added (Alg+$CaCl_2$); sodium alginate with calcium chloride supplemented with oregano oil at 0.06% (Alg+$CaCl_2$+Oreg), and another with rosemary oil at 0.10% (Alg+$CaCl_2$+Rose).

The preparation of edible coatings consisted of the solubilization of sodium alginate in distilled water heated at 50°C in a water bath at a concentration of 2.0% (w v^{-1}), and a six-minute homogenization with stirring at 1500 rpm until complete dissolution was achieved (Groppo, 2009). The coating was cooled to 25ºC and then supplemented with 0.06% oregano oil, and 0.1% rosemary oil. These concentrations were established based on laboratory studies regarding the Minimum Inhibitory Concentrations (MICs) of oregano and rosemary essential oils, according to results not published yet.

After preparation of the coatings, Minas Frescal cheese was sliced in dimensions of 2 x 5 x 13 cm (thickness, width and length) with an average weight of 80 g. The slices were immersed during five seconds, in suspension, at room temperature (25ºC), in the gel already supplemented with essential oil. The excess gel was removed, with the coating corresponding on average to 3.0% of the sample weight. Each experimental treatment was submitted to just one coating cycle.

A cross linking solution of calcium chloride (5% w v^{-1}) was used to promote the alginate gel forming process by dipping the product for 1 min (Mastromatteo et al., 2015). Subsequently, the cheeses were packed in polystyrene trays with 3 mm thick walls and dimensions of 2.7 x 15 x 15 cm (height, width and length) and covered with stretched polyvinyl chloride (PVC) film with 0.02 mm thickness; the samples were produced in duplicate. Samples were stored in BOD at refrigeration temperature (5ºC) for thirty days; their position was chosen randomly.

Microbiological analyses

In order to verify the quality of the developed products, four samples of Minas Frescal cheese were submitted to microbiological analyses as follows: Coliforms at 35 and 45ºC, *Coagulase positive Staphylococcus*, *Salmonella* sp and *Listeria monocytogenes*. These analyses were accomplished according to methodology suggested by Downes and Ito (2001). The analyses were carried out on days 0, 6, 12, 18, 24, and 30.

Percentage of composition, sodium, pH, mass loss and instrumental color and texture

Moisture, pH, ashes and crude protein (Kjeldahl) were carried out according to methodology recommended by the Association of Official Analytical Chemists (AOAC, 2016). Analyses of lipids were performed using the Bligh and Dryer (1959) method. Carbohydrates analyses were carried out using the difference method. Analysis of the sodium content were conducted in an atomic absorption spectrometer. For the spectral reading, the digestion of the samples was done according to the technique described by the AOAC (2016). The physical and chemical analyses were carried out in triplicate on storage days zero and thirty for comparison.

A triplicate analysis of texture was also performed on days 0 and 30 using a Texturometer model Stable Micro Systems Texture Analyser TAXT Plus (Texture Technologies Corp, England). The characteristics of the test were as follows: Warner-Bratzler probe, test velocity 3.0 mm s^{-1}, post-test velocity 7.0 mm s^{-1}, and distance of 10 mm (Corradine et al., 2013).

Color was evaluated on days 0, 6, 12, 18, 24 and 30 using a Minolta® CR400 portable colorimeter, obtaining parameters of luminosity (L), red (a+), green (a-), yellow (b+), and blue (b). The mass loss was determined starting from day zero, used as control, followed by measurements on days 6, 12, 18, 24, and 30. The percentage of mass loss was established by weighing the products on an electronic scale with a precision of 0.001 g and calculated using Equation 1 according to Mahfoudhi, Chouaibi, and Hamdi (2015).

$$\text{Loss mass (\%)} = \frac{\text{(Initial mass - mass per interval of time)}}{\text{(Initial mass)}} \times 100 \qquad (1)$$

Sensory analysis

Before performing the sensory tests, this study was approved by the Research Ethics Committee of UEM with a favorable report - CAAE 25081613.8.0000.0104. The products were submitted to sensory analysis using the nine-point hedonic scale test (9 extremely like; 5 indifferent, and 1 extremely dislike) to assess the attributes of color, odor, taste, texture, and overall appearance. We also assessed purchase intention using a three-point scale (1 definitely will not buy; 2 might buy; 3 definitely will buy). The sensory test was performed on storage day two.

The test involved 105 non-trained tasters in a single section with each taster receiving four samples of Minas Frescal cheese simultaneously – standard (no coating); coating added with no oil; coating with oregano oil added, and coating with rosemary oil added. The samples were encoded with three digits and in a random order along with a glass of water at room temperature to rinse the mouth in between samples. The test was carried out in individual cabins with fluorescent light bulbs (day light). The acceptance index (AI) was calculated using Equation 2.

$$AI = \frac{X^{*}\,100}{N}$$

where:
X= sample average;
N= maximum sample score provided by the tasters.

Statistical analysis

Data analysis were treated using ANOVA with Tukey test when significant to identify at which levels the difference occurred ($p < 0.05$) in treatment and in time (initial and final). To verify the variation in each variable of percent composition during the thirty days of the experiment, we modeled a function through linear or quadratic regressions. These analyses were carried out using StatisticTM 7.0 software (Statsoft, 2005).

Results and discussion

Microbiological analyses

To assess microbiological characteristics of the cheeses and the different coatings analyzed in this study, the obtained results were compared with the microbiological standards determined in Resolution RDC 12, Agência Nacional de Vigilância Sanitária ([Anvisa] Brasil, 2001) establishing the maximum tolerance for indicated samples of very high-moisture Minas Frescal cheese for groups of microorganisms indicating quality, as follows: $5x10^2$ NMP g^{-1} for Coliforms at 45°C g^{-1}, $5x10^2$ UFC g^{-1} for *Coagulase positive Staphylococcus*/g, and absence of *Salmonell*a sp and *L. monocytogenes*. During the thirty days of storage, the different samples presented the following results: < 3 NMP g^{-1} for Coliforms at 45°C, < $1.0x10^2$ UFC g^{-1} for *Coagulase positive Staphylococcus*, and absence of *Salmonella* sp and L. *monocytogenes*.

Results evidence the good quality of the raw material, the efficiency of the pasteurization treatment, the correct use of Good Manufacturing and Handling Practices during production of the cheeses, the preparation and application of the coatings followed by adequate storage, making the product safe for consumers.

In order to assess the effect of the different coatings on the microbiological characteristics of the samples, we carried out an analysis of Coliforms at 35°C (Table 1). This type of microorganism is generally an environmental contaminant that when present in large amounts indicates deficiency in the hygienic and sanitary quality. According to Sienkiewicz, Łysakowska, Pastuszka, Bienias, and Kowalczyk (2013) the antimicrobial properties of essential oils are connected with their chemical composition, mainly phenolic compounds and, the authors reported that the studied rosemary contains thirty-seven components: 1.8 cineole (46.4%), camphor (11.4%), α-pinene (11.0%), β-pinene (9.2%) and camphene (5.2%). The antimicrobial effect the mechanism of action of OE is by altering the permeability of the cell membrane.

The sample comparison during thirty days of storage revealed the interference of the coatings regarding the number of Coliforms at 35°C, since the three covered samples presented quantities below the sample with no coating from storage day 18, especially the coating containing rosemary essential oil, which contained minimum amounts during the entire storage period. These results showed the positive effect that the coatings can offer for future use by food industries.

The literature presents only a few studies about the use of edible coatings supplemented with essential oils in cheeses. Tavares et al. (2014) studied the application of an edible coating supplemented with oregano and rosemary essential oils in ricotta and observed that samples presented satisfactory results for microbiological analyses of Coliforms at 45°C, *Salmonella*sp and *Coagulase positive Staphylococcus*. Regarding Coliforms at 35°C, after storage day 21, only the treatment containing rosemary oil presented a difference in relation to the remaining ones. Ribeiro, Siqueira, Veloso, and Guimarães (2013) assessed the addition of rosemary essential oil directly in curdled cheese at a concentration of 200 $\mu L\ mL^{-1}$, and concluded that the essential oil in the study had an inhibitory activity against isolated *Escherichia coli*, enabling its use in the control of pathogenic bacteria.

Percentage of composition, sodium, pH and mass loss analyses

Values found for pH during the thirty days of storage varied between 6.0 and 6.96. Statistical analysis on these data indicated that the pH values were not influenced ($p < 0.05$) by the different types of edible coating used in the cheese samples in relation to no coating added (NoCoat). This is similar to what was found by Cunha, Spadoti, and Viotto (2002), who assessed the effect of retentate concentration regarding the performance of low-fat Minas Frescal cheese produced through ultrafiltration, finding pH values close to 6.45 with no significant differences among the composition of the different cheeses.

Regarding mass loss (Table 2), it can be observed that samples with a coating presented lower values in relation to the sample with no coating (loss of 26% of the total weight). However, the presence of essential oils in coating decreased the efficiency of the coating in reducing mass loss. Samples with coatings supplemented with oregano and rosemary oil obtained close final values – between 20 and 21%, respectively – while the sample with the coating with oil added alone presented the lowest percentage (16%).

Table 1. Coliforms at 35°C (NMP g^{-1}) found in different samples during 30 days of storage.

	T = 0	T = 6	T = 12	T = 18	T = 24	T = 30
NoCoat	< 3	< 3	< 3	210	> 1100	> 1100
Alg+$CaCl_2$	< 3	< 3	< 3	9.2	21	93
Alg+$CaCl_2$+Oreg	< 3	< 3	< 3	< 3	9.2	21
Alg+$CaCl_2$+Rose	< 3	< 3	< 3	< 3	< 3	< 3

Table 2. Percentage of mass loss during storage.

Sample/ Mass loss (%)	Day 6	Day 12	Day 18	Day 24	Day 30
NoCoat	4.56	9.84	15.90	20.78	26.14
Alg+$CaCl_2$	2.44	5.48	8.84	11.86	15.90
Alg+$CaCl_2$+Oreg	3.13	7.45	11.61	18.40	20.67
Alg+$CaCl_2$+Rose	3.66	9.25	14.14	19.12	21.87

*Regression equation and R^2: NoCoat ($y = 0.3746+0.8831x$; $R^2 = 99.89\%$); Alg+$CaCl_2$ ($y = 0.5176+0.5293x$; $R^2 = 99.51$); Alg+$CaCl_2$+org ($y = 0.7417+0.7302x$; $R^2 = 98.64$); Alg+$CaCl_2$+Rose ($y = 0.1332+0.765x$; $R^2 = 99.28$).

These results showed the efficiency of edible coatings as a semi permeable barrier to moisture, aiming at reducing the loss of water vapor in relation to the sample with no coating. Tavares et al. (2014) assessed an edible coating supplemented with oregano and rosemary essential oils in ricotta cheese, observing as well that the sample of ricotta with no coating presented higher mass loss in relation to the samples with coatings.

Regarding the comparison between initial and final time of storage, only the analyses of moisture and carbohydrates presented significant differences on NoCoat sample (Table 3).

Sample with no coating presented high moisture loss throughout the 30 days of storage, which may be related to the sample mass loss since it also obtained the highest percentage of mass loss during storage. Samples containing the three different coatings presented no significant difference ($p < 0.05$) with less variation in moisture in relation to time, which may be explained by the semi-permeable barrier function that such coatings confer, preventing a higher decrease in moisture and consequently a lower variation in the values of carbohydrates.

By establishing a comparison among the samples, it can be observed that after thirty days of storage, the sample with no coating once again presented different behavior with a significant difference from the remaining samples concerning moisture and carbohydrates, proving the functional action of the edible coating in relation to loss or excessive gain of water.

The values founded for moisture were in agreement with a study by Cunha et al. (2002), who assessed the effect of retentate concentration regarding the performance of low-fat Minas Frescal cheese produced through ultrafiltration, finding a moisture content between 67.85 and 65.54% in different compositions of Minas Frescal cheese. The behavior of the samples regarding carbohydrates was equivalentto what was presented for moisture, once the carbohydrates were established by using the difference method, that is, when a decrease in the moisture percentage of a sample occurs, it consequently accrues an increase in its percentage of carbohydrates.

Zhong, Cavender, and Zhao (2014) evaluated three different edible coating materials (chitosan, sodium alginate, and soy protein isolate) and four different coating application methods in Mozzarella cheese and observed the best overall physicochemical properties during storage for sodium alginate, while differences in the preservation were not significant among the four coating methods. Upon initial storage, it can be observed that only the values of lipids presented significant differences, obtaining very close averages.

Regarding the sodium content, it is worth mentioning that the standard/commercial formulation of Minas Frescal cheese presents a value of 205 mg 100 g^{-1}. This study involved the production of Minas Frescal cheese with a 60% reduction in sodium content, presenting an average sodium content of 36.76 mg 100 g^{-1} for all of the samples.

Instrumental analysis of texture and color

Throughout the period of storage, only the standard sample differed from the remaining ones (Table 4) due to the absence of a coating. Regarding the initial storage, it was observed that the sample with no coating presented the lowest average, proving being softer than the samples with coatings. However, on the last storage day, the opposite occurred: the sample with no coating presented the highest average, being considered harder than the samples with coatings. It was probably related with the mass loss of the products.

Table 3. Physical and chemical results of Minas Frescal cheeses with and without coatings at initial and final times.

	Ashes (%)		Moisture (%)		Protein (%)		Lipids (%)		Carbohydrates (%)	
Sample	T = 0	T = 30	T = 0	T = 30	T = 0	T = 30	T = 0	T = 30	T = 0	T = 30
NoCoat	$2.08^{A,a}$	$2.07^{A,a}$	$65.94^{A,a}$	$57.97^{B,a}$	$15.85^{A,a}$	$15.85^{A,a}$	$10.90^{A,a}$	$10.74^{A,a}$	$6.90^{A,a}$	$13.24^{B,a}$
Alg+$CaCl_2$	$1.92^{A,a}$	$1.99^{A,a}$	$64.60^{A,a}$	$62.64^{A,b}$	$16.03^{A,a}$	$16.03^{A,a}$	$10.87^{A,b}$	$10.52^{A,a}$	$7.11^{A,a}$	$8.35^{A,b}$
Alg+$CaCl_2$+Oreg	$1.98^{A,a}$	$1.98^{A,a}$	$64.59^{A,a}$	$61.79^{A,b}$	$15.75^{A,a}$	$15.75^{A,a}$	$10.46^{A,c}$	$10.36^{A,a}$	$7.78^{A,a}$	$9.63^{A,b}$
Alg+$CaCl_2$+Rose	$1.98^{A,a}$	$1.99^{A,a}$	$66.36^{A,a}$	$62.46^{A,b}$	$15.42^{A,a}$	$15.42^{A,a}$	$10.12^{A,d}$	$10.25^{A,a}$	$6.19^{A,a}$	$8.76^{A,b}$

Different lowercase letters in a column do not differ statistically ($p < 0.05$) among samples, and different capital letters in a single line differ among the periods.

Table 4. Averages obtained in the analysis of texture (N) at initial and final storage.

Sample	T = 0	T = 30
NoCoat	$3.2921^{A,a}$	$7.1869^{B,b}$
Alg+$CaCl_2$	$5.1738^{A,b}$	$5.4240^{A,a}$
Alg+$CaCl_2$+Oreg	$4.8994^{A,b}$	$5.7482^{B,a}$
Alg+$CaCl_2$+Rose	$4.8569^{A,b}$	$6.4369^{B,a}$

Different lowercase letters in a column do not differ statistically ($p < 0.05$) among samples, and different capital letters in a single line differ among the periods.

The coated samples presented less variation in the values of texture during the thirty days of storage in relation to the sample with no coating. This difference presented between samples with no coating and samples with coatings reveal the efficiency of the edible coatings regarding Minas Frescal cheese texture. The mean values of instrumental color (L, a*, and b*) of different cheese samples were submitted to regressions (Table 5).

The values of luminosity define whether the color of a food is darker or lighter. All of the analyzed samples presented values close to 100 (on a scale of 0 to 100), indicating closer proximity to the color white in both of the analyzed periods. This tendency to a lighter color is in agreement with what was presented by Piazzon-Gomes, Prudencio, and Silva (2010), who justified the white color of the milk as a result of the dispersion of the light reflected by the fat globules and the casein colloidal particles as well as the calcium phosphate.

For parameter L, the sample with the most satisfactory adjustment in the regression, that is, the highest value of R^2, was the sample with the coating containing rosemary oil, followed by the sample with the coating alone, followed by the one with no coating, and finally the sample with the coating containing oregano oil.

The chromaticity coordinate a* is related to the color shade – from green to red, on a scale of -120 to +120, respectively. The obtained values were close to being neutral with a slight tendency to green. The sample that presented the most satisfactory adjustment in the regression for parameter a* was the one with the coating containing oregano essential oil. In the case of the parameter b*, related to the shade from blue (-60) to yellow (+60) it was obtained values that revealed a tendency of the samples to a yellowish color. In this study the most satisfactory adjustment in this case (b*) was for the sample with the coating alone, followed by the one with the coating containing rosemary essential oil.

Sensory analysis

Color and texture parameters presented no significant differences ($p < 0.05$), obtaining scores above 7.0 (like regularly) for all the samples, representing a satisfactory result considering that, despite the differences in the instrumental analysis of these attributes, it was not perceived by the tasters either in the appearance or in the products texture (Table 6.). Samples with the coating containing oregano essential oil obtained scores above seven for all of the assessed parameters, possibly because people have the habit of consuming more oregano than rosemary. The high values demonstrate that the addition of oregano oil may be used to enhance taste and add value to the product. In addition, all of the samples presented a high acceptance index (above 77%), pointing to good sensory acceptance.

Purchase intention results indicated the consumers' acceptance regarding cheeses with edible coatings, especially when supplemented with oregano essential oil, which obtained the highest sensory averages, the highest acceptance index, and the highest percentage of consumers willing to buy the product. Therefore, all samples can be considered viable for commercialization.

Conclusion

The use of edible coatings supplemented with essential oils presented a function of reducing mass loss and minimizing alterations in the product softness. Microbiological results revealed the positive effect that the use of coatings is able to offer to the microbiological quality of fresh cheeses, highlighting the rosemary essential oil.

Table 5. Regressions and mean values forthe parameters instrumental color L, a*, and b*.

Sample	L	Regression equation (y)	R^2(%)
NoCoat	93.94[a]	y = 96.3625-0.4273x	79.21
Alg+$CaCl_2$	93.41[a]	y = 95.5151-0.5595x	80.16
Alg+$CaCl_2$+Oreg	93.22[a]	y = 95.9576-0.6498x	65.52
Alg+$CaCl_2$+Rose	91.90[b]	y = 95.497-0.7017x	83.33
Samples	a*	Regression equation (y)	R^2(%)
NoCoat	-2.74[a]	y = 2.80-0.034x	87.32
Alg+$CaCl_2$	-3.14[a]	$y = 3.14-0.21x+0.03x^2-0.0007x^3$	96.41
Alg+$CaCl_2$+Oreg	-3.21[a]	$y = 3.30-0.25x0.0025x^2-0.0006x^3$	98.32
Alg+$CaCl_2$+Rose	-3.07[a]	y=y	62.06
Samples	b*	Regression equation (y)	R^2(%)
NoCoat	12.29[a]	y = 9.6416-0.4895x	73.44
Alg+CaCl2	12.51[a]	y = 11.3959-0.3836x	88.80
Alg+CaCl2+Oreg	12.53[a]	y = 12.1421-0.3073x	77.99
Alg+CaCl2+Rose	12.18[a]	y = 11.8554-0.3315x	85.55

[a,b]Means in the columns with the same letters did not differ significantly from samples at $p < 0.05$ (Tukey's test).

Table 6. Average values from the sensory evaluation.

Sample	Color	Taste	Odor	Texture	Overall	P. I	A.I (%)
NoCoat	7.62[a]	7.31[b]	6.84[b]	7.54[a]	7.47[b]	2.40[a]	83.33
Alg+$CaCl_2$	7.38[a]	7.27[b]	6.50[c]	7.41[a]	7.24[b,c]	2.30[a]	80.44
Alg+$CaCl_2$+Oreg	7.51[a]	7.80[a]	7.43[a]	7.59[a]	7.87[a]	2.49[a]	87.44
Alg+$CaCl_2$+Rose	7.38[a]	6.61[c]	6.52[c]	7.39[a]	6.98[c]	1.92[b]	77.55

Averages followed by different lowercase letters in a column differ statistically at a level of significance of 5%; P.I. = purchase intention; A.I = acceptance index.

Regarding the sensory evaluation, all samples presented a high acceptance index (> 77%), especially the sample with the coating supplemented with oregano essential oil, which presented satisfactory results for all of the attributes and a higher acceptance index. Therefore, the use of edible coatings supplemented with essential oils is an important viable alternative for the technological improvement of fresh cheese processing.

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