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Preservation of chicken sausages using oregano and rosemary essential oil

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ABSTRACT
The aim of this study was to evaluate the oregano and rosemary essential oils as partial substitutes the salt on the quality of chicken sausage. Three formulations of 6 kg each were made: the formulation 1 was made the sausage with no reduction of salt, and the formulations 2 (O1) and 3 (O2) were prepared using sausages with a partial reduction of salt added with essential oils of oregano and rosemary. The products obtained were subjected to physicochemical, microbiological, technological and sensory analyses. The samples differed ($p<0.05$) in the emulsion stability, cooking weight loss, and exudation weight loss. The essential oils used significantly reduced the microbial load. In the sensory analysis, the essential oils samples had the worst flavor and odor, but this influenced neither the global acceptance nor the purchase intention of the product. The inclusion of essential oils of oregano and rosemary promoted satisfactory physico-chemical, microbiological and technological characteristics in the formulations of chicken sausages.
Keywords- Consumers, Natural antimicrobials, Quality, Spices, Meat products.

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I. INTRODUCTION

Sausage production represents an important segment within the food sector, as it is a product consumed by millions of people around the world in their own homes, as well as in restaurants and fast food establishments. However, at the same time as it offers practicality and convenience to its consumption, it has been associated with health damage, since the presence of chemical preservatives, especially sodium chloride, contributes to an increased risk of heart diseases [1].

In this sense, many meat products have been reformulated by partial substitution of this additive (sodium chloride). With Magnesium chloride, phosphates, citrates and ascorbates [2,3].An innovative alternative is the use of essential oils and their bioactive compounds extracted from aromatic plants, which have antimicrobial properties and can promote food safety. The use of these natural additives has been widely reported in the control of microorganisms of interest in foods [4]. Some of these additives are the essential oils of rosemary (Rosmarinus officinalis L) and oregano (Origanum vulgare L). Its inhibitory effects on Salmonella, Listeria monocytogenes, Escherichia coli, and Staphylococcus aureus make it promising to be applied in food products; however most of these studies are still concentrated only in in vitro tests, and the data on its application directly into food matrices are still incipient [5]. Thus, the aim of this study was to evaluate the potential of the essential oils of rosemary and oregano as partial substitutes for salt in the preservation of sausages.

II. MATERIAL AND METHODS

Raw Materials

To formulate the sausages, we purchased chicken meat, poultry skin, and garlic paste from local shops. The company Bremil (Food Products industry LTDA-RS., Brazil) provided the isolated soy protein and the sausage mix. The liquid smoke was from Citromax Essences LTDA. The essential oils of oregano (Origanum vulgare L.) and rosemary (Rosmarinus officinalis L.) were supplied by the Aromatherapy and Essential Oils - MG. The other ingredients were obtained from the Meat Products Laboratory of the Federal University of Paraíba.

Sausages Formulation

Three sausage formulations were developed, each one with 6 kg. The control formulation (C) had no salt reduction, and formulations O1 and O2 had a partial salt reduction but added with essential oils of oregano and

rosemary at different concentrations as can be seen in table 1.

Table 1: Sausage formulations with partial salt reduction, containing essential oils of oregano and rosemary (O1 and O2), and without essential oils (C).

		Concentrations for testing (%)	
Ingredients	**C**	**O1**	**O2**
Chicken MSM	60	60	60
Water	10	10	10
Salt	1.9	1.7	1.7
EO of oregano	-	0.3	0.3
EO of rosemary	-	2.5	5
Sausage mix	1	1	1
Cassava starch	2	2	2
ISP	4	4	4
Sodium Nitrite	0.3	0.3	0.3
Garlic paste	0.3	0.3	0.3
Poultry meat	7	7	7
Bird skin	5	5	5
Giblets (liver)	5	5	5
Smoke aroma	0.24	0.24	0.24
Master coral	0.05	0.05	0.05

MSM: Mechanically separated meat; ISP: Isolated soy protein

For sausage manufacturing, the meat raw materials were first chilled to 5°C and then emulsified with the other ingredients in a stainless-steel cutter. The emulsions were subsequently embedded in cellulosic 22-mm caliber artificial casings and cooked at 75ºC for 3 hours. After baking, the sausages were cooled for five minutes in water at room temperature so that their artificial wrappings could be removed manually using stainless steel knives. Afterward, the sausages were vacuum packed and stored for 60 days at 4ºC.

Physicochemical and technological analysis

The pH, water activity (aw), and proximate composition variables were measured three times following the instructions described by [6]. The objective color analysis was performed on the external and internal surface of the sausages using a Colorimeter Colorquest XE Hunter Lab with standard illuminant D65 and observer 10 (Cie-Lab). Parameters of luminosity (L*), red (a*), and yellow (b*) indexes were obtained by calculating the average of three readings taken at different points on the sausages. The technological characteristics were measured by emulsion stability tests (EE) according to [7]. Weight loss by cooking (PPC) was performed by calculating the weight difference before and after cooking. Weight loss by exudation (PPE) was performed by calculating the weight difference of the sausage samples packed in vacuo by the release of juice exuded during the 60 days of storage. The shear force (HR) was determined in a TA - TX2i texturometer (Stable Micro Systems) by measuring the sheer force of the cross section of the sausages.

Microbiological analysis

Microbiological analyses were carried out in accordance with the requirements of Resolution RDC No. 12 of 2001 of the National Agency of Sanitary Surveillance [8], following the methodological recommendations of Normative Instruction No. 62 (August 26, 2003) of the Ministry of Livestock Agriculture and Supply [9], verifying the presence of coliforms at 45 ºC, coagulase-positive Staphylococci, sulfite-reducing Clostridium and Salmonella sp.

Sensory analysis

This study was subjected to the Ethics and Research Committee of the Federal University of Paraíba and was approved under protocol No. 46789215.0.0000.5188. Sensory analyses were performed at the Food Sensory Analysis Laboratory of the Federal University of Paraíba (UFPB) with the participation of a panel of 100 untrained judges, comprised by the university students and technical staff The evaluation consisted of three different tests, as follow: 1) acceptance test, using a hedonic scale from 9 (extremely liked) to 1 (extremely disagreeable), evaluating the overall impression at the end; 2) purchase intention test, performed using a 5-point scale from 1 (certainly would not buy) to 5 (would

certainly buy), and 3) preference test, which was also carried out where the judges ranked the samples of each treatment from the most preferred to the least preferred. The evaluations were performed in individual booths, and four samples were presented to the judges (~10 g each) in disposable cups coded with a random three-digit number.

Statistical analysis

For statistical analysis, a completely randomized design (DIC) was used with a factorial scheme 3 x 4 x 3 (three treatments, four storage periods and three replications). The data were subjected to analysis of variance (ANOVA) to evaluate the existence of significant differences between the means. The differences were evaluated using the Tukey test with a 5% significance level, using Assistat (Statistical Assistance) software version 7.7 beta.

III. RESULTS AND DISCUSSION

The centesimal composition, pH, Aw, color, as well as the technological analyzes (loss of weight by exudation and shear force) were performed every 20 days for a period of 60 days under storage at 4ºC. Except for the standard formulation (control) that, after 20 days of refrigerated storage, showed black and green patches on the surface of the sausages, possibly because of the microbial growth, so they were discarded. The mean values of the centesimal composition of the analyzed sausages are shown in Table 2.

Table 2: Mean values (± standard deviation) of the chemical composition of sausages.

		Formulations		
Parameters Evaluated (g/100g)	**Storage Time (day)**	**C**	**O1**	**O2**
Moisture	**1**	70.7 ± 0.52^{Bab}	69.9 ± 0.11^{Ba}	70.9 ± 0.3^{Ba}
	20	72.0 ± 0.20^{Aa}	71.3 ± 0.15^{Ab}	72.0 ± 0.40^{Aa}
	40	-	71.2 ± 0.1^{Ab}	72.5 ± 0.63^{Aa}
	60	-	71.2 ± 0.00^{Ab}	72.2 ± 0.1^{Aa}
Ashes	**1**	2.13 ± 0.03^{Ab}	2.48 ± 0.03^{Aa}	2.13 ± 0.00^{Ab}
	20	1.48 ± 0.02^{Bc}	1.64 ± 0.01^{Ba}	1.52 ± 0.00^{Bb}
	40	-	1.10 ± 0.04^{Ba}	0.91 ± 0.04^{Bb}
	60	-	1.64 ± 0.06^{Aa}	1.43 ± 0.01^{Ab}
Protein	**1**	19.5 ± 0.52^{Aa}	21.7 ± 2.65^{Aa}	19.5 ± 0.97^{Aa}
	20	20.1 ± 1.25^{Aa}	19.1 ± 1.44^{Aa}	19.9 ± 0.70^{Aa}
	40	-	19.9 ± 1.17^{Aa}	18.5 ± 1.56^{Aa}
	60	-	20.9 ± 1.08^{Aa}	18.9 ± 1.49^{Aa}
Lipids	**1**	4.60 ± 0.45^{Ba}	4.49 ± 0.43^{Ba}	4.78 ± 0.39^{Ba}
	20	7.58 ± 0.46^{Aa}	7.96 ± 0.49^{Aa}	7.48 ± 1.15^{Aa}
	40	-	8.76 ± 1.30^{Aa}	9.25 ± 2.00^{Aa}
	60	-	11.2 ± 0.95^{Aa}	10.3 ± 4.99^{Aa}

Carbohydrate	**1**	3.05±1.44^{Aa}	2.82±0.76^{Aa}	2.65±0.50^{Aa}
	20	1.38±0.13^{Aa}	1.86±0.55^{Aa}	1.82±0.78^{Aa}
	40	-	1.01±0.21^{Aa}	1.80±1.21^{Aa}
	60	-	1.01±0.13^{Aa}	1.52±0.88^{Aa}

C = Control sausage with 1.9% salt (conventional); O1 = Formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = Formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product. Means in the same row **(lowercase letters)** and column **(upper case letters)** followed by the same letter are not statistically different from each other. The Tukey test was applied at a 5% probability level.

The O2 formulation had the highest moisture content ($p<0.05$). After checking storage periods, there was a significant increase from the first day, which remained constant up to 60 days of storage. This can be explained by the use of the isolated soy protein in the sausage formulation. [10], observed that the moisture content also increased during storage in samples of sausages formulated with different levels of water and isolated soy protein to replace the fat. The same author emphasized that this occurred due to the hygroscopic properties of the protein ingredient isolated soy protein [11], reported that low-fat content also increases the moisture content in meat products. An increase in moisture content can directly affect the microbiological quality of sausages since it favors microbial growth. However, it was observed that the presence of the essential oils controlled microbial growth during the storage period (Table 8).

The mean values of pH and aw are shown in Table 3. The pH of the sausages was influenced ($p <0.05$) by treatments and storage time. The pH decreased steadily during the 60 days of storage. According to [12], the pH decrease is due to three main factors: the characteristics of the antioxidants (essential oils), the stabilizer used in the processing, and the possible presence of lactic acid bacteria.

Table 3: Mean (± SD) data of pH and water activity of sausages.

		Formulations		
Parameters Evaluated	**Storage Time (day)**	**C**	**O1**	**O2**
pH	**1**	6.18±0.01^{Ab}	6.15±0.01^{Ab}	6.30±0.01^{Aa}
	20	6.36±0.11^{Aa}	6.15±0.01^{Ab}	6.17±0.01^{Bb}
	40	-	5.51±0.10^{Ab}	5.69±0.00^{Da}
	60	-	5.46±0.19^{Ab}	6.04±0.07^{Ca}
Water Activity (AW)	**1**	0.994±0.00^{Aab}	0. 993±0.00^{Ab}	0.997±0.00^{Aa}
	20	0.981±0.00^{Ba}	0. 972±0.00^{Ba}	0. 979±0.00^{Ba}
	40	-	0. 982±0.00^{Aa}	0. 978±0.00^{Ba}
	60	-	0.989±0.00^{Aa}	0. 992±0.00^{Aa}

C = Control sausage with 1.9% salt (conventional); O1 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of

oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product. Means in the same row **(lowercase letters)** and column **(upper case letters)** followed by the same letter are not statistically different from each other. The Tukey test was applied at a 5% probability level.

There was no difference in water activity between the samples at 20 days of storage. For [13], the Aw increases in sausages as a function of composition; excessive incorporation of mechanically separated meat produces a juicier and softer product.

The data from the technological analysis of the sausages are shown in Table 4. Regarding the emulsion stability (ES), there was no difference between the control sample and O2, indicating that higher concentrations of essential oils did not imply in a greater loss of liquid during cooking. This result corroborates the data of cooking weight loss since the O2 sample had the lowest amount of loss ($p<0.05$).

Table 4: Technological analyses of sausages

Technological Analysis	**Storage Time (day)**	**Formulations**		
		C	**O1**	**O2**
Emulsion Stability (ES)	**-**	87.5 ± 0.75^{a}	80.8 ± 1.38^{b}	86.3 ± 1.84^{a}
Cooking Weight Loss (CWL)	**-**	4.87^{a}	3.97^{b}	2.16^{c}
Exudation Weight Loss (EWL)	**1**	1.92 ± 0.04^{Ac}	2.51 ± 0.03^{Ab}	4.37 ± 0.06^{Ba}
	20	2.32 ± 0.79^{Ab}	2.32 ± 0.79^{Ab}	5.31 ± 0.23^{Aa}
	40	-	4.10 ± 0.17^{Bb}	5.26 ± 0.07^{Ba}
	60	-	4.44 ± 0.10^{Ab}	6.25 ± 0.14^{Aa}

C = Control sausage with 1.9% salt (conventional); O1 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product**.** Means in the same row **(lowercase letters)** and column **(upper case letters)** followed by the same letter are not statistically different from each other. The Tukey test was applied at a 5% probability level.

We evaluated shelf life based on the sausages EWL for a period of 60 days under refrigerated storage. The O2 treatment presented the highest exudation value at the end of the storage period, which suggests that lower salt contents cause the product to exude. Color results of the outer and inner surfaces of the sausages are shown in Table 5 and 6, respectively.

Table 5: Instrumental color mean and standard deviation of the parameters L (luminosity), a* (intensity of red and green) and b* (intensity of yellow and blue) of the outer surface of the sausage.

		Formulations		
Colorimetry Analysis	**Storage Time (day)**	**C**	**O1**	**O2**
L*	**1**	29.8 ± 3.05^{Aa}	34.4 ± 1.05^{Ca}	31.7 ± 0.15^{Ca}
	20	29.0 ± 7.83^{Aa}	34.1 ± 2.41^{Ca}	31.2 ± 2.43^{Ca}
	40	-	63.6 ± 1.13^{Aa}	61.7 ± 2.16^{Aa}
	60	-	55.0 ± 1.95^{Ba}	56.4 ± 1.15^{Ba}

a*	**1**	6.83±3.87^{Aa}	2.93±0.73^{Ca}	5.90±0.78^{Ba}
	20	7.13±3.47^{Aa}	4.13±0.98^{Ca}	7.16±1.09^{Ba}
	40	-	27.6±2.20^{Aa}	23.1±1.66^{Ab}
	60	-	18.2±1.41^{Ba}	21.6±3.40^{Aa}
b*	**1**	8.16±0.92^{Ab}	18.7±2.42^{Ba}	17.4±1.23^{Ba}
	20	7.26±1.45^{Ab}	18.2±3.90^{Ba}	17.6±1.70^{Ba}
	40	-	23.2±1.16^{ABb}	29.5±1.50^{Aa}
	60	-	30.4±4.09^{Aa}	29.1±0.96^{Aa}

C = Control sausage with 1.9% salt; O1 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product. Means in the same row **(lowercase letters)** and column **(upper case letters)** followed by the same letter are not statistically different from each other. The Tukey test was applied at a 5% probability level.

Table 6: Instrumental color mean and standard deviation parameters of the L (luminosity), a* (intensity of red and green) and b* (intensity of yellow and blue) of the inner surface of the sausages.

		Formulations		
Colorimetry Analysis	**Storage Time (day)**	**C**	**O1**	**O2**
L*	**1**	31.0±0.85^{Ab}	31.8±1.21^{Bb}	36.5±0.32^{Ca}
	20	33.8±2.55^{Aa}	33.6±1.40^{Ba}	35.0±2.13^{Ca}
	40	-	60.1±2.36^{Aa}	61.8±0.51^{Aa}
	60	-	57.5±0.55^{Aa}	58.5±0.40^{Ba}
a*	**1**	5.93±0.83^{Aa}	4.16±1.05^{Ba}	4.23±1.62^{Ba}
	20	6.16±1.00^{Aa}	5.76±1.38^{Ba}	5.60±2.61^{Ba}
	40	-	29.1±5.02^{Aa}	24.9±0.51^{Aa}
	60	-	25.2±0.26^{Aa}	25.1±1.76^{Aa}
b*	**1**	18.1±3.30^{Aab}	20.2±2.92^{Ba}	10.6±2.98^{Ab}
	20	17.1±1.60^{Aab}	20.6±2.8^{Ba}	11.8±3.29^{Bb}
	40	-	28.4±5.33^{ABa}	33.6±1.56^{Aa}
	60	-	30.2±0.47^{Aa}	30.2±0.60^{Aa}

C = Control sausage with 1.9% salt; O1 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product. Means in the same row **(lowercase)** and column **(upper case letters)** followed by the same letter are not statistically different from each other. The Tukey test was applied at a 5% probability level.

The color of the sausages was evaluated both externally and internally. The results showed a significant increase ($p<0.05$), during storage, for L*, a* and b* values, especially in O1 and O2. This possibly occurred because these formulations had lower salt content. Salt acts as a pro-oxidant of myoglobin converting it to metamyoglobin (dark pigment). In addition, the presence of the essential oils in sausages O1 and O2 also contributed to their

antioxidant properties. According to [14], the interaction of salt with meat pigments alters the color of processed meat products.

The shear force test data (Table 7) showed no differences ($p<0.05$) between treatments with essential oils (O1 and O2) and control (C) during storage.

Table 7: Mean and standard deviation of the sausages' shear force.

		Formulations		
	Storage Time (day)	**C**	**O1**	**O 2**
Shear force (N)	**1**	4.85 ± 0.57^{Aa}	5.22 ± 0.33^{Aa}	4.64 ± 0.63^{Aa}
	20	5.72 ± 0.11^{Aa}	5.73 ± 0.43^{Aa}	5.10 ± 0.36^{Aa}
	40	-	5.28 ± 0.31^{Aa}	5.63 ± 0.40^{Aa}
	60	-	5.56 ± 0.49^{Aa}	4.98 ± 0.51^{Aa}

C = Control sausage with 1.9% salt; O1 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product. Means in the same row **(lowercase letters)** and column **(upper case letters)** followed by the same letter are not statistically different from each other. The Tukey test was applied at a 5% probability level.

The microbiological analyses (Table 8) were also performed every 20 days during the 60 days of refrigerated storage at 4°C. The control formulation was discarded due to the presence of Salmonella sp in the second sample taken for analysis (T20).

Table 8: Most probable number of coliforms (MPN log/g), coagulase-positive Staphylococci, sulfite-reducing Clostridium and Salmonella sp. (Log CFU/g) in sausages.

		Formulations		
Microorganisms Researched	**Storage Time (day)**	**C**	**O1**	**O2**
Coliforms at 45ºC	**1**	4.04^{Aa}	2.65^{Ab}	1.75^{Ab}
	20	4.04^{Aa}	2.66^{Ab}	2.10^{Ab}
	40	-	3.37^{Aa}	$<1.47^{Ab}$
	60	-	3.36^{Aa}	$<1.47^{Ab}$
Coagulase-Positive Staphylococci	**1**	3.64^{Aa}	4.58^{Aa}	4.80^{Aa}
	20	4.76^{Aa}	4.56^{Ab}	4.44^{Bc}
	40	-	4.53^{Ab}	5.51^{Ba}
	60	-	4.27^{Aa}	3.51^{Cb}
Sulfite-Reducing Clostridium	**1**	3.70^{Aa}	$<2.00^{Bb}$	$<2.00^{Ab}$
	20	3.10^{Bb}	3.60^{Aa}	$<2.00^{Ac}$
	40	-	$<2.00^{Ba}$	$<2.00^{Aa}$
	60	-	$<2.00^{Ba}$	$<2.00^{Aa}$
Salmonella sp	**1**	Absence	Absence	Absence
	20	Presence	Absence	Absence
	40	-	Absence	Absence
	60	-	Absence	Absence

C = Control sausage with 1.9% salt (conventional); O1= formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product. Means in the same row **(lowercase letters)** and column **(upper case letters)** followed by the same letter are not statistically different from each other. The Tukey test was applied at a 5% probability level.

There was a significant reduction ($p<0.05$) in the values of coliforms at 45°C and coagulase-positive Staphylococci, during storage, in the formulations containing oregano and rosemary essential oils. Furthermore, at the end of the storage period, the samples were within the recommended limits of the Brazilian legislation [8], for Coliforms at 45ºC.

[15] studied the activity of rosemary, oregano and pepper essential oils on different concentrations of 30 bacterial isolates from Staphylococcus spp (n=10), Aeromonas (n=10) and E. coli (n=10). They reported that the essential oils showed antimicrobial activity against the microorganisms. [16], evaluated the in vitro antimicrobial activity of essential oils of rosemary and Indian clove against strains of Staphylococcus aureus and E. coli and evidenced the importance of these potential additives in the control of growth of food-grade bacteria.

The sausages containing essential oils of oregano and rosemary (O1 and O2) had no sulfite-reducing Clostridium or Salmonella sp., indicating that the concentrations of the essential oils used were effective in controlling the growth of these microorganisms.

The data from sensory analyses regarding the attributes of color, taste, odor, and texture as well as the overall acceptance and purchase intention are shown in Table 9). Sensory analyses were performed after obtaining the results of the microbiological analyzes. It was observed differences ($p<0.05$) between the treatments only for the taste and odor attributes, and the formulations containing essential oils had the highest rates. This suggests that consumers may buy sausages containing essential oils. However, it is recognized that the rates were low, showing that the inclusion of aromatic substances as essential oils of oregano and rosemary is a great challenge for the scientific community.

Table 9: Sensory analysis of the control (C) samples and of those with partial reduction of salt and added with essential oils (O1 and O2) (mean and standard deviation).

	Attributes					
Formulations	**Color**	**Flavor**	**Odor**	**Shear force**	**Global Acceptance**	**Purchase Intention**
C	5.04 [a]	4.06 [a]	3.46 [b]	4.83 [a]	4.21 [a]	2.09 [a]
O1	5.32 [a]	3.74 [a]	4.34 [a]	4.94 [a]	4.13 [a]	2.10 [a]
O 2	5.17 [a]	3.11 [b]	4.15 [a]	4.84 [a]	3.92 [a]	2.07 [a]

C= Control sausage with 1.9% salt (conventional); O1 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 2.5 ml of rosemary essential oil per kilogram of product; O2 = formulation with 1.7% salt (reduction of about 10%) plus 0.3 ml of oregano essential oil and 5.0 ml of rosemary essential oil per kilogram of product. The averages of the column followed by the same letter do not differ statistically from each other. The Tukey test was applied at a 5% probability level.

[17]. evaluated the consumer profile and acceptability of cooked steaks with edible coatings containing essential oils of oregano and rosemary. In this study, the incorporation of essential oils in the product had a significant influence on the acceptability of bovine steaks. These authors have further reported that beef steaks with an edible coating containing 0.1% of oregano essential oil are most preferred. [18], evaluated the use of essential oils of oregano, rosemary, and thymol in beef meatballs and recommended the application of these additives at a concentration of 0.5% since they did not substantially alter the taste of food. [19], investigated the effectiveness of the combined application of essential oils of Origanum vulgare L. and Rosmarinus officinalis L. against E. coli, Listeria monocytogenes and Salmonella enteritidis in minimally processed vegetables and found that these essential oils combined to each other inhibit the growth these microorganisms. This suggests that they could be used in the food industry as sanitizers, especially when combined in sublethal concentrations to reduce the sensory impact and consequently improve their acceptance among consumers.

IV. CONCLUSION

The use of oregano and rosemary essential oils is a viable alternative in the preservation of sausages with reduced salt since they presented satisfactory physicochemical, microbiological, and technological characteristics. However, further studies on salt reduction and the concentrations of essential oil of oregano e rosemary to be used are needed because they directly affect the sensory aspects of the sausage.

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