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Shelf life and consumer preference for sun dried meat produced with different levels of sodium chloride

Vida útil e preferência do consumidor de carne de sol produzida com diferentes níveis de cloreto de sódio

Periodo de validez y preferencia del consumidor de la carne solar producida con diferentes niveles de cloruro de sodio

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Abstract

The objective was to evaluate the variation of salt content in sun-dried meat and its impacts on shelf life and consumer preference. For this purpose, beef steaks of the hard topside type (*Biceps femoris*) were cut and then salted with 2.5, 5, 7.5 and 10% sodium chloride. Microbiological and physical-chemical analyses were performed on days 0, 24hrs after salting, and again after 3,6,9,12 and 14 days of refrigerated storage, in addition to the sensory profile. It was observed that the increased sodium chloride content in meat provided greater microbiological stability during the storage period. However, the characteristics of water retention capacity, weight loss by cooking and shear strength of the meat varied negatively, with the increase in salt content, showing greater weight loss after cooking and lower water retention capacity, resulting in a meat with a harder texture, greater loss of juiciness and softness. Regarding the sensory analysis, the different salt contents did not interfere in the visual quality attributes analyzed, however, the 2.5% salt level showed good acceptance and purchase intention, being the salt concentration the ideal to guarantee qualitative attributes and food safety for the elaboration of sun-dried meat.

Keywords: Quality; Meat; Sensory analysis; Sodium chloride.

Resumo

Objetivou-se avaliar a variação do teor de sal na carne de sol e seus impactos sobre a vida de prateleira e a preferência do consumidor. Para isso, bifes de carne bovina tipo coxão duro (*Bíceps femoris*) foram cortados e depois salgados com 2,5, 5, 7,5 e 10% de cloreto de sódio. Foram realizadas análises microbiológicas e físico-químicas nos dias 0, 24hrs após a salga, e novamente após 3,6,9,12 e 14 dias de armazenamento refrigerado, além do perfil sensorial. Observou-se que o aumento do teor de cloreto de sódio nas carnes proporcionou maior estabilidade microbiológica durante o período de armazenamento. Porém, as características de capacidade de retenção de água, perda de peso por cocção e força de cisalhamento da carne variaram negativamente, com o aumento do teor de sal, apresentando maior perda de peso após o cozimento e menor capacidade de retenção de água, resultando em uma carne com textura mais dura, maior perda de suculência e de maciez. Em relação à análise sensorial, os

diferentes teores de sal não interferiram nos atributos visuais de qualidade analisados, no entanto, o nível de 2,5% de sal apresentou boa aceitação e intenção de compra, sendo a concentração de sal o ideal para garantir atributos qualitativos e segurança alimentar para a elaboração da carne da carne de sol.

Palavras-chave: Qualidade; Carne; Análise sensorial; Cloreto de sódio.

Resumen

El objetivo fue evaluar la variación del contenido de sal en la carne de sol y sus impactos en la vida útil y la preferencia del consumidor. Para ello, se cortaron filetes de ternera (Biceps femoris) y luego se salaron con cloruro de sodio al 2.5, 5, 7.5 y 10%. Se realizaron análisis microbiológicos y físico-químicos en los días 0, 24 h después de la salazón, y nuevamente después de 3,6,9,12 y 14 días de almacenamiento en frío, además del perfil sensorial. Se observó que el aumento del contenido de cloruro de sodio en la carne proporcionó una mayor estabilidad microbiológica durante el período de almacenamiento. Sin embargo, las características de capacidad de retención de agua, pérdida de peso de cocción y resistencia al corte de la carne variaron negativamente, con un aumento en el contenido de sal, mostrando una mayor pérdida de peso después de la cocción y una menor capacidad de retención de agua, lo que resultó en en una carne de textura más dura, mayor pérdida de jugosidad y ternura. En relación al análisis sensorial, los diferentes niveles de sal no interfirieron en los atributos de calidad visual analizados, sin embargo, el nivel de 2.5% de sal mostró buena aceptación e intención de compra, siendo la concentración de sal la ideal para garantizar atributos seguridad cualitativa y alimentaria para la preparación de carne a partir de sol.

Palabras clave: Calidad; Carne; Análisis sensorial; Cloruro de sodio.

1. Introduction

The conservation of meat by means of salting and drying, is an old technique used until today mainly in products considered local. In Brazil, among the traditional salted meat products, such as dried meat, charcuterie and sun-dried meat (Ishihara & Madruga, 2013).

Sun-dried meat is widely consumed in Brazil and is characterized as a slightly salty product, partially dehydrated and semi-preserved by brine (Lira & Shimokomaki, 1998). Despite the name "carne do sol", the product is not directly exposed to the sun during its production, its manufacture is based on salting, which causes the product to partially dehydrate with water activity ranging from 0.94 to 0.96, and therefore, microbial development

is slowed down (Salviano et al., 2015).

The process of salting food represents an obstacle to the growth of deteriorating microorganisms. However, when salt does not penetrate effectively into the tissues of the product, deteriorating microorganisms can easily grow (Costa & Silva, 2001). In this way, producers of sun-dried meat make use of high concentrations of salt to ensure a longer commercial life for the product.

In turn, the consumption of large quantities of sodium chloride has been much discussed and concerns have been raised about the health problems it can cause. According to the World Health Organization, the maximum consumption of sodium chloride should not exceed 5 g / day / person. Furthermore, studies have shown that the amount consumed varies from 9 to 12 g / day / person (Hes et al., 2012; Who, 2012). High consumption of NaCl can cause serious health problems and has a direct influence on the development of hypertension, which is the main risk factor for cardiovascular disease (Lim et al., 2012; He et al., 2013).

There is no legislation to determine the production parameters of sun-dried meat, so there is variation in the sodium chloride content added in its production. This can be proven by studies that indicate NaCl values ranging from 2.9 to 11.9% w/w (Costa & Silva, 2001). Given this wide range of sodium chloride concentrations used in the production of sun-dried meat, variations in its sensory, nutritional and mainly microbiological characteristics are easily observed. The objective of this study was to evaluate the impact of salt content on lifetime of sun-dried meat and consumer preference.

2. Methodology

For the production of sun-dried meat, hard topside meat (*Biceps femoris*) was purchased in local commerce, vacuum packed, with federal inspection seal. The meat was cut into pieces approximately 4 centimeters thick and salted with fine salt in concentrations of 2.5, 5, 7.5 and 10% (w/w) NaCl. After salting, the samples were stored at a cooling temperature of 4°C ± 1°C. All the processing and preparation of meat made use of good food handling practices. For microbiological and physico-chemical testing, *fresh* meat, which was not subjected to the salting process, was used as a control group.

2.1. Physico-chemical analysis of sun-dried meat with different levels of NaCl

The physicochemical tests were performed in triplicate, in zero storage time, 24 hours after the salting process and again after 3, 6, 9, 12 and 15 days of refrigerated storage at 4ºC ± 1ºC.

2.1.1. pH

The pH of the samples was determined according to the methodology established by AOAC, 2005, where the HANNA® digital pHmeter model HI 99163 was used, coupled to a penetration electrode. The pH was measured directly on the muscle (AOAC, 2005).

2.1.2. Color

The color was evaluated by the Konica Minolta colorimeter, CM-700d/600d (CIE System L*a*b*), whose system considers the coordinates L* luminosity (black/white), a* red content (green/red) and b* yellow content (blue/yellow).

2.1.3. Water Retention Capacity

The determination of water retention capacity (WRC) was based on the measurement of water loss released when pressure was applied to muscle tissue. Through the difference in weights (initial - final) the water retention capacity was determined, expressed as a percentage of lost weight of the initial sample (HAMM, 1960).

2.1.4. Shearing Force

The shear force was measured by means of a TEXTURE ANALYZER TA-XT- 125, coupled to the Warner-Bratzler device, which expresses the force in kgf/cm2 (HAMM, 1960).

2.1.5. Weight Loss by Cooking

For the analysis of weight loss by cooking (PPC), a weighing was performed and then the samples were cooked using a *grill*, where the internal temperature of the muscle reached

71 to 75°C. The samples were later taken from the *grill* and weighed again to calculate the percentage of water loss during the thermal process (ORIUM; ORIUM 1998).

2.1.6. Thiobarbituric Acid Reactive Substances (TBARS)

For the thiobarbituric acid (TBARS) reactive substances test, 0.5g of sun-dried meat was used, with the addition of the stock solution (0.375% thiobarbituric acid, 15% trichloroacetic acid and 0.25M HCL), in which the positive samples develop pink color during heating. The absorbance of the solution was determined at 532nm against the white. The amount of TBARS was expressed as milligrams of malonaldehyde per kg of sun-dried meat (Amsa, 2012).

2.2. Sensory profile of sun-dried meat with different levels of NaCl

For the sensory test, the project was submitted to the research ethics committee and approved under protocol number 62765816.5.0000.5294. Sensory analysis was performed 96 hours after the meat was salted. For this trial, 62 untrained male and female tasters aged between 18 and 50 were recruited. They claimed to be regular consumers of meat and meat products and not to be allergic to any of the ingredients present in the products according to the signature of the Free and Informed Consent Term (TCLE). The tasters received samples of each treatment with the different concentrations of salt, weighing approximately 25g, cooked to an internal temperature of approximately 73ºC, where they were asked to take notes of their impressions based on a hedonic scale of preference.

To evaluate the sensory characteristics of sun-dried meat samples, a quantitative descriptive test with a structured 9-point scale was used, evaluating the following attributes: aroma, evaluating the characteristic meat aroma varying from mild (0) to strong (9); color, indicating 0 for light meat to 9 for dark meat; hardness, indicating soft (0) to very hard (9); succulence, varying from poorly succulent (0) to very succulent (9); taste, indicating as meat with mild taste (0) to meat with strong taste (9) and scale of the ideal, which evaluated the salty taste in meat indicating extremely less salty than the idela (0) and extremant more salty than the ideal (9). The general acceptance was based on nine points that ranged from very much liked to very much disliked. The "intent to buy" for the samples was assessed through a scale of attitudes ranging from 5 (would certainly buy) to 1 (would certainly not buy) according to the methodology described by Dutcosky (2013).

2.3. Microbiological testing of sun-dried meat with different levels of NaCl

Microbiological tests on sun-dried meat samples were performed on day zero, 24 hours after salting, and again after 3, 6, 9, 12 and 15 days of refrigerated storage at 4ºC ± 1ºC. The samples of sun-dried meat were weighed (25g) aseptically and transferred to sterile plastic bags where 225 mL of sterile buffered pepton water was added for subsequent homogenization in Stomacher for 2 minutes, thus obtaining the dilution 10-1, from which the remaining decimal dilutions up to 10-4 were obtained. After dilution, the samples were submitted to the most probable number (MPN) of coliforms at 35 and 45°C, total psycrotrophic count, mesophilic aerobic bacteria, quantification of coliforms at 35 and 45°C, count of coagulase-positive *Staphylococcus* and presence of *Salmonella* sp., using the methodology described by Downes & Ito (2001).

2.4. Statistical analysis

The homoscedasticity and normality of the data were calculated, in the case of no outliers observed, the data were submitted to analysis of variance (ANOVA) and significant differences were observed using the Tukey test at 5% of significance, all data were worked through the statistical software SISVAR 5.6.

3. Results and Discussion

3.1. Physico-chemical tests

Sun-dried meat with the addition of sodium chloride and control meat presented pH values (Table 1) within the standards established for beef, being considered ideal for consumption, with average values ranging from 5.26 to 6.17 (Table 1). However, it can be observed that the higher the concentration of sodium chloride added to the meat, the lower the pH values, NaCl directly influences the pH values of salted meats (Leistner, 2000).

Regarding the results for water retention capacity, the lowest values were observed in samples treated with 10% salt ($p < 0.05$) (Table 1). Therefore, it can be assumed that the high salt content reduces the ability of the meat sample to retain water. According to Puolanne and Peltonen (2013), the effect of salt on water retention in meats may be related to the selective binding of caotopic chloride ions on hydrophobic ions, which act on myosin filaments. At

concentrations of approximately 2% salt and pH 6.0, there is a maximum water holding capacity. According to Puolanne and Peltonen (2013), when the pH values are lower, i.e., acids, there is a reduction in the binding activity of the Cl- and Na + ions and, consequently, the capacity to retain water decreases, which may explain the results found in this study.

Table 1. pH, water holding capacity (WAC), cooking loss (PPC) and shear force (FC) in prepared sun-dried meat with different salt concentrations.

Days of storage	Variables	Control	NaCl				CV (%)
			2.5%	5%	7.5%	10%	
0	pH	6.17 Aa	5.97 Abc	5.86Abc	5.75Ac	5.64Ac	1.6
3		5.96 Aab	5.92 Ab	5.89 Ab	5.73 Ac	5.48 Ad	
6		6.02 Aa	5.90 Abc	5.73 Bb	5.44 Bc	5.40 Ac	
9		6.06 Aa	5.93 Abc	5.56 Cbc	5.52 Bc	5.49 Ac	
12		6.07 Aa	5.75 Bb	5.50 Cc	5.50 Bb	5.47 Ac	
15		5.73 Ba	5.64 Bab	5.63 CBab	5.43 Bbc	5.26 Bc	
0	Water holding capacity (%)	70.33 Aa	72.37 Aa	66.08 Ab	65.18 Ab	65.08 Ab	3.36
3		64.52 Bb	69.23 Aa	64.44 Ab	63.99 Ab	61.7 Bc	
6		65.78 Ba	68.85 Aa	67.27 Aa	67.23 Aa	62.47 Bb	
9		69.64 Aa	70.73 Aa	67.92 Aa	65.45 Aab	63.6ABb	
12		68.43 Aa	71.11 Aa	68.02 Aa	64.45 Ab	60.44 Bc	
15		67.44 Aa	69.98 Aa	68.32 Aa	65.44 Aa	58.33 Bb	
0	Loss of weight per cooking (%)	28.44 Cb	26.77 Abb	30.44 Bb	34.55 Ba	36.77 Ca	4.44
3		26.23 Cbc	24.66 Bc	31.22 Bb	33.32 Bb	37.45 Ca	
6		28.89 Cbc	25.75 Bc	32.43 Bb	35.67 Aab	40.22Ba	
9		32.35 BCb	30.32 Ab	31.11 Bb	35.44 Aab	44.53 Ba	
12		36.74 Abb	33.98 Ac	36.77 Abc	39.21 Ab	48.77 Aa	
15		39.91 Ab	34.01 Ab	37.87 Ab	39.69 Ab	49.22 Aa	
0	Shearing force (kgf/cm)	3.66 Ac	3.33 Ac	4.56 Abc	5.77 Ab	7.44 Aa	2.58
3		3.12 Abc	2.98 Ac	4.44 Abc	5.98 Aa	6.99 Aa	
6		2.99 Ac	3.78 Abc	4.1 Ab	5.04 Ab	7.02Aa	
9		3.45 Ac	4.01 Ac	4.98 Abc	6.22 Ab	7.99 Aa	
12		3.67 Ac	4.11 Ac	4.75 Abc	5.99 Ab	8.01 Aa	
15		3.33 Ab	3.73 Ab	4.93 Ab	6.15 Aa	7.3 Aa	

A,B,C Different lower case letters in the same column indicate significant difference between treatments according to Tukey's 5% test. a, b, c Different capital letters on the same line indicate significant difference between the days of storage according to Tukey's 5% test. Source: Authors.

The cooking weight loss tests showed that the samples containing the highest concentrations of salt, 7.5% and 10%, also showed higher weight loss during cooking and, consequently, lower water retention capacity (Table 1), i.e., the longer the storage time the higher was the weight loss per cooking.

The shearing force was directly proportional to the increase in the NaCl content added to the meat, that is, the greater the amount of salt used to prepare sun-dried meat the greater the force required to cut a portion of the meat. Meats of intermediate softness are considered to have shear force values between 3.9 kgf / cm² and 4.6 kgf / cm² and hard meats are those that obtain shear force values above 4.6 kgf / cm² (Bellew et al., 2003). In this study, samples of 2.5% NaCl salted sun-dried meat were considered soft or of intermediate softness. Meats with 5%, 7.5% and 10% of sodium chloride had shear strength values above 4.6 kgf / cm², which means they can be classified as hard meat. These results show that salt directly interferes with the texture of meat, one of the most important attributes for consumer acceptance and satisfaction, being a decisive factor in the purchase of food (Ishihara et al., 2016).

Salts like Sodium Chloride, in small proportions, influence the hydration of proteins, increasing the capacity of water retention and, consequently, softening the texture of meat and increasing yield in the production stages. High sodium chloride concentrations can directly interfere with meat quality, leaving them harder, with lower water retention capacity and yield (Shimokomaki et al., 2006; Rocha Garcia et al., 2010), as can be seen in the results obtained in this study.

When analyzed together the parameters of pH, water retention capacity, weight loss by cooking and shear force, we can observe that high concentrations used of sodium chloride did not favor the physicochemical characteristics preferred by consumers. Therefore, although sun-dried meat does not have special legislation to guide its production, establishing technological standards for manufacturing, it was observed that the concentration of 2.5% of salt in sun-dried meat offers a product with greater water retention capacity, which in turn ensures lower cooking losses and less force required for shearing, preserving the quality attributes of succulence and texture required by consumers.

Just as the increase in sodium chloride provided a reduction in the quality characteristics of meat attributed to consumers, the storage time also boosted the reduction in pH, water retention capacity and increased weight loss by cooking.

In color analysis, samples of sunflower meat with 7.5% and 10% sodium chloride showed higher values of L* (measures the luminosity of the samples) when compared with

the other treatment groups on all sample days (Table 2). When comparing meats with added salt and control meat without added salt, it was possible to observe that the salted meats had higher luminosity values when compared to meat without salt.

Table 2. Results for color analysis in sun-dried meat prepared with different salt concentrations.

Days of storage	Color	NaCl				CV (%)
		Control	2.5%	5%	10%	
0		33.47 Ab	37.55 Aa	38.81 Aa	42.85 Aa	
3		33.09 Ab	34.89 Bb	35.09Aba	39.38 Aa	
6		30.51 Ab	32.25 Bb	33.28 Bb	41.19 Aa	
9	L*	32.11 Ab	33.99 Ab	34.09 Ba	38.09 Aa	16.48
12		33.11 Ab	34.55 Ab	33.22 Bb	40.09 Aa	
15		31.04 Ab	32.14 Bb	33.22Bab	38.99 Aa	
0		13.04 Aa	7.37 Ab	7.10 Ab	3.89 Ac	
3		10.99 Ba	7.44 Ab	6.90 Ab	3.99 Ac	
6		9.87 Ba	7.98Aab	7.02 Ab	4.01 Ac	
9	a*	7.45 Bca	7.02 Aa	7.22 Aa	3.60 Ab	9.33
12		6.99 Cb	7.55 Ab	7.09 Ab	3.55 Ab	
15		6.8 Ca	7.12 Aa	6.89 Aa	3.32 Ab	
0		10.67 Ca	10.67 Aa	9.34 Aa	6.03 Ab	
3		11.54 Ca	12.33 Aa	8.99 Ab	6.11 Ac	
6		14.55 Ba	10.98 Ab	8.65 Abc	6.32 Ac	
9	b*	16.76 Tab	11.98 Ab	8.98 Abc	5.97 Ac	8.75
12		16.44 Tab	12.33 Ab	7.88 Ac	6.05 Ac	
15		18.98 Aa	10.56 Ab	7.65 Ab	6.23 Ac	

L* = brightness; a* = red/green coordinate; b* = yellow / blue coordinate. ^{A,B,C} Different small letters in the same column indicate a significant difference between treatments according to Tukey's 5% test. $^{a, b, c}$ Different capital letters on the same line indicate significant difference between storage times according to Tukey's 5% test. Source: Authors.

By analysing the results for parameters a* and b*, which measure the variation of the contents from green to red and from blue to yellow, respectively, it was possible to observe an inversely proportional relationship between these results and those obtained for variable L*.

All salted meat samples had lower a* and b* values when compared to the control on all sampled days. The storage time had no significant effect on the colour of the meat. The reduction in bright red colour was gradually accentuated as the amount of salt used to produce

sun-dried meat increased. The red color in meat depends on the chemical state of the myoglobin in the muscle pigment. The presence of oxygen and the period of contact with salt can directly influence the loss of bright red color in meat, due to the fact that such aspects interfere with the oxidation reactions of myoglobin to metamoglobin (Ferrocino et al., 2002; Salviano et al., 2015), which is expected in the production of sun- dried meat.

In meat, salt interacts as a pro-oxidant agent, tending to increase concentration, leaving a brown color, therefore, a greater introduction of salt in meat is expected to intensify the oxidation of myoglobin, justifying the decrease in bright red color, as well as the darkening of samples (King & Whyte, 2006; Bower et al., 2017).

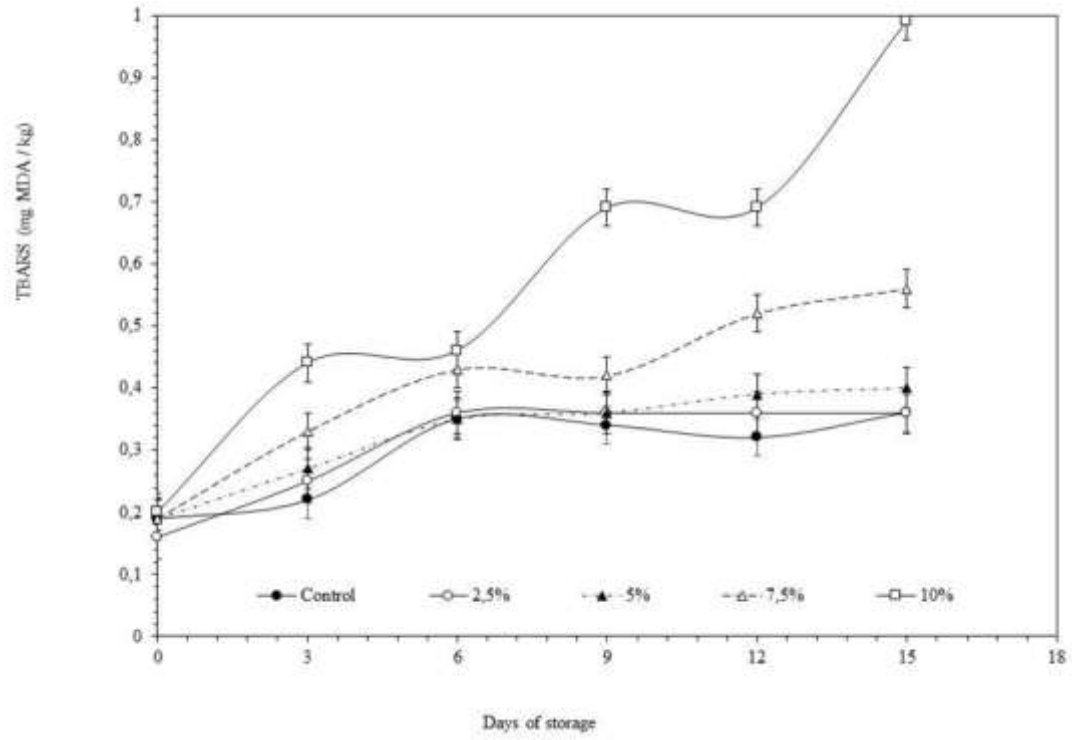
TBARS values (Figure 1) increased considerably when meat was exposed to higher values of sodium chloride, 7.5% and 10%. Treatments with 2.5% and 5% sodium chloride showed quantities of malonaldehyde similar to the values found in the control samples, which means that these concentrations do not significantly alter the lipid oxidation generated in meat during refrigerated storage. However, the incorporation of high levels of sodium chloride caused biochemical alterations in the meat, causing the association of the lipids present in the samples with the salt to cause rancidity, prematurely, when in contact with oxygen, causing alterations in color, taste, aroma and consistency. The mechanism by which salt initiates or catalyzes lipid oxidation is not yet fully understood, but it is believed that salt has the ability to damage the integrity of cell membranes, which allows oxidizing agents easier access to lipids in food (Mariutti & Bragagnolo, 2017).

According to Campos et al. (2006) TBARS values of up to 2 mg MDA / kg are the maximum limits considered acceptable for lipid oxidation in meat, and the samples analyzed in this experiment are all below this limit.

Lipid oxidation in meat begins immediately after slaughter and continues during post-mortem processing and storage. Several factors may intensify the lipid oxidation process, including the use of additives such as salt (Mariutti & Bragagnolo, 2017).

Salt provides preservative and antimicrobial properties to meat and meat products, due to its ability to reduce water activity in food, in addition to increasing taste and water retention capacity. However, it accelerates lipid oxidation, changing the colour and odour of meat in a negative way, promoting the occurrence of rancidity, which is obviously not appreciated by consumers. Consequently, high concentrations influence the commercial life of meat products (Jin et al, 2012).

Figure 1. Analysis of TBARS in sun-dried meat prepared with different salt concentrations.



Source: Authors.

3.2. Sensory test

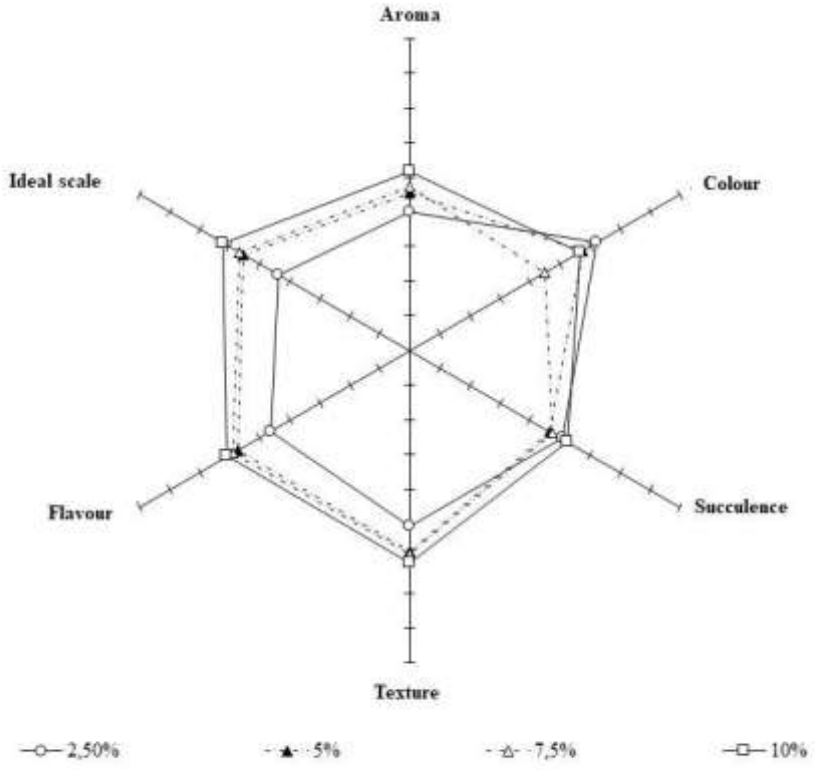
Samples of sun-dried meat treated with different concentrations of sodium chloride were subjected to a sensory test to record the tasters' perception of the differences between each treatment group in the following parameters: aroma, color, juiciness, taste, texture, ideal scale, purchase intention and overall acceptance (Figure 2).

As for the aroma attribute, meat prepared with 2.5% sodium chloride showed, according to the tasters, a softer aroma compared to the other samples. Regarding color evaluation, the tasters indicated that meat with 7.5% salt had a lighter color than the other sample groups, among which there was no significant difference ($p < 0.05$).

When the texture and succulence attributes were evaluated, no significant difference ($p < 0.05$) was observed between the sample groups, which demonstrates that the salt content did not influence these characteristics. The texture of sun-dried meat is one of the most important parameters for consumers. This attribute can also be instrumentally evaluated by the shear force test using a Warner Bratzler blade, which means that in this case it is possible to correlate the data of both tests. In the present study, samples of sun-dried meat with 5%, 7.5% and 10%

salt were presented as hard meat, according to Bellew et al. (2003), in the shear force test. However, when asked to assign scores from 0 to 9 to the samples, the tasters perceived the meat to be of intermediate softness, with average scores ranging from 5.08 to 6.11.

Figure 2. Sensory test performed on samples of sun-dried meat prepared with different salt concentrations, where the following parameters were evaluated: Aroma, mild (0) to strong (9); Color, light meats (0) to dark meats (9); Hardness, soft (0) to very hard (9); Juiciness, meats not very juicy (0) to very juicy (9); Taste, mild taste (0) to strong taste (9); Ideal scale, extremely less salty than idela (0) and extremant more salty than ideal (9); Overall acceptance: I liked it very much I disliked it very much; Intention to buy, I would certainly buy (5) á certainly would not buy(1).



Source: Authors.

In terms of taste, which varied from mild(0) to strong (9), sun-dried meat with 2.5% had, according to the evaluators, a mild taste when compared to the other sample groups, resembling fresh meat, probably due to the low concentration of sodium chloride which did not directly influence the taste of the food. These results can be confirmed in the evaluation

of the scale of the ideal for the salty taste, which was recorded according to the preference of the tasters. From the results of these attributes, it can be pointed out that samples treated with 2.5% sodium chloride were considered less salty than ideal for a sun-dried meat, according to the taste of the tasters, obtaining an average score of 4.37 on a scale of 0 to 9. The other sample groups with 5%, 7.5% and 10% sodium chloride did not present significant differences ($p \leq 0,05$) between the results.

The purchase intention and general attributes of acceptance were also evaluated in samples of sun-dried meat prepared with different levels of sodium chloride. On a 9- point scale, 13.11 percent of consumers reported "extremely enjoyed" sun-dried meat with 2.5 percent NaCl, correlating it positively with the intention to purchase, in which 34.42 percent of tasters reported that they certainly buy "low-sodium meat. The second best sample in the tasters' perception was sun-dried meat treated with 5% sodium chloride, since 29.50% of them reported that they would "certainly buy" the product.

3.3. Microbiological testing

Analyzing the counts obtained for mesophilic and psychrotrophic aerobic bacteria (Table 3 and 4), it was possible to observe an increasing trend in the number of these microorganisms along the refrigerated storage. It was also observed that the higher the salt concentration in the production of sun-dried meat, the lower the count of these bacteria. The samples prepared with 7.5% and 10% salt showed significant differences ($p<0.05$) when compared to the others, on days 3, 6, 9, 12 and 15 of storanemanto, and due to the high concentration of salt, showed less contamination. However, for mesophilic bacteria, there was a significant difference between the sample groups treated with 7.5% and 10% more than 2log on day 12 of refrigerated storage.

For the quantification of psychrotrophic bacteria, it was observed that samples with 7.5% and 10% showed microbial growth from day 6 and 15, respectively. The meat control and with 2.5% were similar in bacterial counts, reaching the fifteenth day of analysis with values above 7logUFC/g.

The conservation of meat through the use of salt can be attributed, in part, to the reduction of water activity causing the retardation of bacterial growth, thus, the increase in salt concentration in meat linearly decreases microbial development (Bower et al., 2017).

Table 3. Aerobic mesophilic bacteria count in prepared sun-dried meat samples with different salt concentrations.

NaCl	Days of storage						CV (%)
	0	3	6	9	12	15	
Control	3.42 Ac	5.18 Ab	5.4 Ab	6.4 Aab	6.4 Aab	7.4 Aa	
2.5%	3.43 Ab	3.77 Bb	4.87 Ab	6.4 Aa	6.4 Aa	7.4 Aa	
5%	2.98 Ac	2.72 Bc	4.53 Ab	5.72 Aab	6.4 Aa	7.4 Aa	0.69
7.5%	3.77 Ab	2.8 Bb	2.36 Bb	2.54 Bb	5.73 Aa	5.01 Ba	
10%	3.11 Aa	2.9 Ba	2.51 Ba	2.78 Ba	3.27 Ba	3.18 Ca	

A,B,C Different capital letters in the same column indicate significant difference between treatments according to Tukey's 5% test. a, b, c Different lower case letters on the same line indicate significant difference between storage times according to Tukey's 5% test. Source: Authors.

According to García-Lomillo and Gonzalez-SanJosé (2017), the quantification of mesophilic aerobic bacteria is generally used as an indicator of microbial deterioration. When values equal to or higher than 7 logUFC/g are found, changes in meat quality are evident to consumers, indicating the end of the useful life of that product. Thus, among the salt concentrations studied, only meats with 7.5% and 10% of sodium chloride had a shelf life greater than 15 days, according to the counts of microorganisms in the samples.

The presence of deteriorating microorganisms in meat and meat products can result in changes in color, presence of undesirable odors and, consequently, shorter shelf life, leading to rejection of the product and economic losses. In addition, high microbial loads can pose risks to consumer health (Mann et al., 2016).

The amount of salt added to the meat influences the growth of spoilage microorganisms. The addition of sodium ions has an effect on the semipermeable membrane of bacteria, causing water loss in the bacterial cell, leading to osmotic shock, which can result in cell death or the appearance of lesions that significantly reduce the growth rate of microorganisms (Ingluglia et al., 2017). This corroborates the results found in this study, since high salt concentrations significantly reduced microbial growth.

In the coliform test at 35ºC and 45ºC, all samples showed low values (<3 MPN / g). Regarding *Staphylococcus* coagulase positive and *Salmonella* sp. in sun-dried meat prepared with different salt concentrations and in the control group, the presence of these microorganisms was not detected in any of the samples during refrigerated storage.

Table 4. Count of psychrotrophic aerobic bacteria in samples of sunflower meat with different levels of sodium chloride.

NaCl	Days of storage						CV (%)
	0	3	6	9	12	15	
Control	0	2.02 Ce	5.39 Ac	6.39 Ab	3.91 Ad	7.39 Aa	
2.5%	0	3.66 Bd	5.39 Ac	6.39 Ab	3.00 Bd	7.39 Aa	
5%	0	4.43 Ab	3.86 Bb	6.31 Aa	2.17 Cc	4.83 Bb	0,34
7.5%	0	0	2.17 Cb	0	0	3.00 Ca	
10%	0	0	0	0	0	0.2	

A,B,C Different capital letters in the same column indicate significant difference between treatments according to Tukey's 5% test. a, b, c, d Different lower case letters on the same line indicate significant difference between storage times according to Tukey's 5% test. Source: Authors.

For sun-dried meat there is no legislation setting standards of preparation or quality parameters, which means that this product is often manufactured without proper hygienic conditions or use of good handling practices. In addition, there are no standards for NaCl levels, so they are usually broad. Consequently, a product without standardisation of sensory, nutritional and, in particular, microbiological characteristics, is placed on the market, which may pose a risk to the health of consumers.

4. Conclusion

The increase in sodium chloride content in the samples has led to greater microbiological stability of sun-dried meat during the storage period. However, with regard to the physico-chemical attributes, it was found that the increased salt concentration provided less succulence and a firmer texture to the meat. As for sensory analysis, sun-dried meat with 2.5% salt showed good acceptance and high purchase intention. Therefore, despite not being able to increase the shelf life the salt concentration to 2.5% presented ideal physical-chemical and sensory characteristics to ensure quality attributes of sun-dried meat, which can be a viable alternative for the production of a healthier and more attractive food for the consumer.

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