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Original

The effect of sodium reduction and the use of herbs and spices on the quality and safety of bologna sausage

O efeito da redução de sódio e o uso de ervas e especiarias sobre a qualidade e segurança de mortadela

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Abstract

In this study, the replacement of 50% NaCl by KCl in Bologna sausage with the addition of herbs and spice blends (coriander, onion, white pepper, cardamom, and Jamaican pepper) was evaluated. The formulations tested showed a significant reduction in the sodium content with no major alterations in the emulsion stability, texture, and microbiological characteristics. The use of 50% KCl caused a reduction in the sensory quality leading to a significant decrease in the consumers' purchase intention. The formulations with the addition of herbs and spice blends presented better results in the sensory evaluation indicating that this strategy can reduce the negative effects resulting from the use of KCl.
Keywords: *sodium reduction; sodium chloride; potassium chloride; herbs; spices; bologna sausage.*

Resumo

Neste trabalho, foi avaliada a substituição de 50% de NaCl por KCl em mortadela com adição de misturas de ervas e especiarias (coentro, cebola, pimenta branca, cardamomo e pimenta Jamaica). As formulações testadas apresentaram redução significativa nos teores de sódio, sem alterações importantes na estabilidade de emulsão, textura e características microbiológicas. A utilização de 50% de KCl causou uma redução na qualidade sensorial com significativa diminuição na percentagem de intenção de compra dos consumidores. As formulações com adição de ervas e especiarias apresentaram melhores resultados para avaliação sensorial, evidenciando que essa estratégia é capaz de reduzir os efeitos negativos resultantes da utilização de KCl.
Palavras-chave: *redução de sódio; cloreto de sódio; cloreto de potássio; ervas; especiarias; mortadela.*

1 Introduction

Hypertension, an important risk factor for cardiovascular diseases, is the major cause of death and public health expenditure in developed countries (MERZ et al., 2009; FOOD…, 2005; ANTONIOS; MACGREGOR, 1997). The clear relationship between excessive sodium consumption and hypertension incidence (MACGREGOR, 1997; STAMLER et al., 1996) has led public healthcare regulatory agencies in various countries to recommend sodium reduction in food products (ASARIA et al., 2007). It is estimated that in most of the developed countries, the intake of sodium chloride, the main sodium source in our diet, varies from 8 to 13 g, which is much higher than the 5 g recommended by the World Health Organization (WHO) and the maximum amount to be ingested daily by adults (EUROPEAN…, 2005; WORLD…, 1990). Specifically in Brazil, the intake of sodium chloride was estimated to be 12.3 $g.day^{-1}$ (NAKASATO, 2004).

Meat products are a major source of sodium in human diet contributing to approximately 20% to 30% of the daily intake (JIMÉNEZ-COLMENERO; CARBALLO, J.; COFRADES, 2001). In Brazil, the highest volume of sales in the meat industry is represented by the segment of popular meat products, and Bologna sausage is one of the major representatives. Due to the great consumption of this product, studies on the reduction of sodium content are important to promote quality improvements in population's diet. However, sodium chloride influences the quality and safety of meat products. Its reduction cannot occur without a strict evaluation of the consequences generated by the reduction in the sensory acceptance and shelf life stability Among the major properties of the sodium chloride in meat products are its preservative action, the increase in the water holding capacity of the myofibrillar proteins promoted by the increase of the ionic force, and therefore a higher extraction yield, reduction of water loss during storage, and the increase in the stability of meat emulsion due to better incorporation of fat and water in the mixture (TERRELL, 1983).

One of the ways to reduce sodium content in meat products is by replacing sodium chloride with other ingredients (TERRELL, 1983). Various studies have recommended potassium chloride as a partial replacement for sodium chloride in meat products (NASCIMENTO et al., 2007; JIMÉNEZ-COLMENERO; AYO; CARBALLO, 2005; GELABERT et al., 2003; GIMENO; ASTIASARÁN; BELLO, 1998; GOU et al., 1996). KCl has ionic force properties similar to those of sodium chloride, but its addition to meat products can damage its

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sensory quality by reducing the salty taste resulting in a bitter, metallic, and astringent taste (ASKAR; EL-SAMAHY; TAWFIK, 1994; GOU et al., 1996; DESMOND, 2006).

Using herbs and spice blends is a promising alternative to improve the quality of meat products when the partial replacement of sodium chloride with potassium chloride occurs. Since they can give a spicy flavor and different aroma, these blends can suppress or diminish the sensory effects caused by the use of potassium chloride. Moreover, some herbs and spices have a proved antioxidant and antimicrobial activity (AHN; GRÜN; MUSTAPHA, 2004; YIN; CHEN, 2003).

Therefore, the objective of this study was to evaluate the influence of the addition of herbs and spices combinations, commonly used in meat products, on the quality and safety of Bologna sausages with the replacement of 50% sodium chloride content by potassium chloride.

2 Material and methods

2.1 Formulation

Four formulations were prepared in order to determine the influence of the replacement of 50% sodium chloride content (NaCl) by potassium chloride (KCl) and the addition of combinations of selected herbs and spices on the quality and safety of Bologna sausages. According to what is shown in Table 1, the following formulations were prepared: Control formulation - CF (20 g.kg^{-1} of NaCl); T_1 (10 g.kg^{-1} of NaCl + 10 g.kg^{-1} of KCl); T_2 (10 g.kg^{-1} of NaCl + 10 g.kg^{-1} of KCl + 5 g.kg^{-1} of coriander + 4 g kg^{-1} of onion + 1 g.kg^{-1} of white pepper), and T_3 (10 g.kg^{-1} of NaCl + 10 g.kg^{-1} of KCl + 5 g.kg^{-1} of cardamom + 3 g.kg^{-1} of onion + 2 g.kg^{-1} of Jamaican pepper). The control formulation was prepared with the main additives and ingredients usually used in Bologna sausages according to the Brazilian Identity and quality standard for this product (BRASIL, 2000).

Table 1. Bologna sausages: formulation with replacement of 50% NaCl by KCl and additon of herb and spice blends

(%)	CF	T_1	T_2	T_3
Lean Beef	52	52	52	52
Meat mechanically separated from poultry	20	20	20	20
Pork back fat	13	13	13	13
Texturized soy protein powder (Solae)	1.3	1.3	1.3	1.3
Cassava starch (Cassava)	2	2	2	2
Sodium chloride (Cisne)	2	1	1	1
Potassium Chloride (Merck)	–	1	1	1
Sodium Nitrite (Griffith)	0.015	0.015	0.015	0.015
Sodium Tripolyphosphate (Haifa)	0.5	0.5	0.5	0.5
Sodium erythorbate (Roquette)	0.05	0.05	0.05	0.05
Black Pepper (Fuchs)	0.2	0.2	0.2	0.2
Garlic (Fuchs)	0.2	0.2	0.2	0.2
Ice	8	8	8	8
Blend 1 – coriander (0.5%), onion (0.4%), and white pepper (0.1%) (Fuchs)	–	–	1	–
Blend 2 – cardamom (0.5%), onion (0.3%), and Jamaican pepper (0.2%) (Fuchs)	–	–	–	1

2.2 Bologna sausages processing

Lean meat was ground through 3 mm discs with previous removal of apparent fat at a 12 °C environment. The product final temperature was not higher than 4 °C. After cleaning, pork back fat was ground through 8 mm discs with temperature control. The raw meat materials were previously weighed, vacuum packed, and frozen until use. According to the formulations presented in Table 1, the raw meat materials, sodium chloride and/or potassium chloride, and half of the ice were placed in the blender (MADO INC) for approximately 3-4 minutes until the temperature reached 7 °C

Next, the additives and ingredients (sodium tripolyphosphate, sodium nitrite, sodium erythorbate, herb and spice blends, and the remaining ice) were added. Lastly the pork back fat was added and the final batter homogenization was performed for 3-4 minutes. The final temperature during the comminution phase was not higher than 17 °C. The mixture was stuffed in 60 mm artificial casing (Spel Embalagens Ltda, Atibaia, Brazil), clipped at both ends (Polyclip system, Niedecker, Germany), and cooked in a water bath. The bologna sausages were kept in the bath until the geometric center of each chub which corresponds to the thickest part of the product reached 74 °C. A thermocouple probe (Omega Engineering, Inc., Stamford, CT) positioned in the geometric center of the bologna was used to monitor product temperature. When the endpoint temperature was achieved, the sausages were immediately chilled with ice. After reaching room temperature, they were transferred to the laboratory in insulated boxes containing recyclable ice. The bologna sausages (500 g each) were stored at 5 °C until analysis.

3 Physicochemical analysis

3.1 Determination of the Bologna´s Chemical Composition

Moisture, ash, protein, and fat content were determined according to Association of Official Analytical Chemists (2006) methods. Moisture (AOAC Official Method 934.01) was determined by drying a 3 g sample at 105 °C to constant weight. Ashing was performed at 550 °C for 2 hours (AOAC Official Method 942.05). Protein (AOAC Official Method 984.13) was analyzed according to the Kjeldahl method. Factor 6.25 was used to convert nitrogen to crude protein. Fat (AOAC Official Method 920.39) was determined by six-cycle extraction with petroleum ether (40 – 60 °C boiling range) in a Sohxlet apparatus and calculating the weight loss.

3.2 Chlorides determination

The determination of chloride was carried out after the samples' mineralization following the Mohr's titulometric method (TERRA; BRUM, 1988).

3.3 Sodium and potassium determination

Sodium and potassium contents were evaluated by atomic absorption spectroscopy (Perkin Elmer Analyst 200, Perkin–Elmer, Norwalk, CT, USA), as described by AOAC Official Method 968.08. (ASSOCIATION…, 2006).

3.4 Emulsion stability analysis

Around 100 g of the sample from the recently processed mixtures (emulsion formulations without cooking) was placed in polyamide (nylon) and polyethylene packs, weighed, and thermally sealed. Next, the package was placed in a boiling water bath at 70 °C for 60 minutes and later cooled at room temperature. The exuded liquid from the cooked samples was carefully separated; the cooked emulsions were weighed again to determine the weight loss percentage using the following formula: (weight of the batter sample – weight of the cooked sample)/weight of the batter sample (PARKS; CARPENTER, 1987).

3.5 Texture profile analysis

The determination of the texture profile was carried out in the Bologna sausages after 24 hours storage at 5 °C using a TA-TX2 Texture Analyzer (Stable Micro Systems Ltd., Surrey, England) with a load cell of 10 kg. Fifteen cylinders per batch were used to evaluate the texture. The samples, approximately 2 cm thick and 2 cm in diameter, were axially compressed into two consecutive cycles of 20% of compression, with a 30 mm diameter probe, at a constant speed of 1 mm/s. The data collection and the TPA curves preparation were done using the Texture Expert software version 1.11 (Stable Micro Systems Ltda.). Parameters for hardness, springiness, cohesiveness, and chewiness were calculated. Hardness was defined as the peak force during the first compression cycle. Springiness was defined as a ratio of the time between the start of the second area and the second peak and the time between the start of the first area and the first peak (b/a). Cohesiveness was calculated as the ratio between the areas under the second and under the first peak (A2/A1). Chewiness was obtained by multiplying hardness × elasticity × cohesiveness.

3.6 Microbiological analysis

Three bologna sausages per batch were used to evaluate the microbiological quality of the treatments. Fecal coliforms, *Staphylococcus* coagulase-positive, *Clostridium* sulphite reducers, and *Salmonella sp.* were quantified according to the methodology described by Vanderzant and Splisttoesser (1992).

3.7 Sensory analysis

This study protocol (270/2009) was approved by the Ethics in Research Committee of the University of Campinas (SP, Brazil). All participants signed a consent form agreeing to voluntarily participate in the sensory analysis.

3.8 Acceptance and purchase intent test

The Bologna sausages acceptability was evaluated by 60 untrained assessors, who are consumers of this type of product. The test was carried out at a Sensory Analysis Laboratory equipped with the necessary devices to register the information provided by the tasters with standardized procedures under controlled conditions.The samples were offered to the assessors in a monadic way, randomly coded with three-digit numbers. A hedonic test was carried out using a non-structured 9-point scale (0 = dislike extremely and 9 = like extremely), in which the assessors evaluated different attributes: color, aroma, taste, and texture (MEILGAARD; CIVILLE; CARR, 2006).

An assessment related to the consumers' purchase intention was also carried out regarding the four studied samples. A 5-point scale was used, in which 1 indicated that the consumers definitely would not buy; 2-the consumers would probably not buy; 3-the consumers may/may not buy; 4-consumers would probably buy and 5-consumers would definitely buy.

3.9 Control difference test

The control difference test as carried out with 20 trained assessors, who were able to discriminate samples in relation to the investigated attributes. The test consisted in the presentation of the control formulation (CF), followed by four coded samples: CF (2% NaCl), T_1 (1% NaCl + 1% KCl), T_2 (1% NaCl + 1% KCl + 0.5% coriander + 0.4% onion + 0.1% white pepper), and T_3 (1% NaCl + 1% KCl + 0.5% cardamom + 0.3% onion + 0.2% Jamaican pepper) to be evaluated by the assessors according to the difference in intensity regarding the control of the spicy taste, salty taste, stringent sensation, and texture (MEILGAARD; CIVILLE; CARR, 2006).

3.10 Statistical analysis

The analyses were carried in a completely randomized design at least three times. The data were evaluated using analysis of variance (ANOVA). The average result of the physicochemical analysis and the sensory acceptance test was compared by the Tukey test and the averages of the control difference sensory test were compared using the Dunnett test considering a 5% level of significance. The statistics package SPSS for Windows (SPSS V 11.5, SPSS Inc., Chicago, IL) was used.

4 Results and discussion

4.1 Chemical composition, Na and K content, and emulsion stability

The physicochemical characteristics of Bologna sausages formulated with 50% reduction of NaCl and with addition of herb and spice blends are presented in Table 2. In all treatments, moisture, fat, and protein contents met the standards set by the current Brazilian legislation for this type of meat product (BRASIL, 2000). Statistical differences were observed in the moisture and fat values among the treatments. This was probably due to the variations in the centesimal composition of the raw material used without having any relation to the replacement of NaCl by KCl and the addition of herbs and spices.

The treatments with the replacement of NaCl with KCl presented a significant reduction in the content of sodium and a significant increase in that of potassium (Table 2). The control formulation (CF) presented a sodium content considered normal for cooked emulsion products (DESMOND, 2006; COLLINS, 1997). The replacement of 50% NaCl by KCl generated a reduction of approximately 31% in the sodium content in relation to the control formulation. This reduction in the sodium content provides the modified products with a healthier appeal since the decrease of sodium intake in our diet is seen as a way to reduce risk factors for hypertension and, consequently, heart diseases (ANTONIOS; MACGREGOR, 1997). Moreover, the increase in the potassium levels also offers benefits; some epidemiological studies suggest that the intake of K is inversely related to the level of blood pressure and hypertension prevalence (KAWANO et al., 1998).

The 50% reduction of sodium chloride as an ingredient of the studied formulations did not promote high total sodium reduction due to the presence of this element in the raw material and also in the other additives used such as sodium nitrite, sodium erythorbate, and sodium polyphosphate. In addition, it is possible that some spices and herbs contained small amounts of sodium chloride since commercial products which are commonly used by the large companies in the meat industry segment were used as ingredients.

A future study should determine the sodium content in each ingredient and additive selected for the formulation to carry out a quantitative analysis for sodium reduction from the reduced content of sodium chloride.

The emulsion stability of the mixtures was preserved even after 50% NaCl was replaced with KCl, a fact that was also observed by Nascimento et al. (2007) and that can be partially attributed to the high concentration of myofibrillar proteins present in most of the selected raw material in the formulations and close values of ionic force for both NaCl and KCl salts. As expected, there was no significant difference among the chloride contents in all the formulations.

Table 3 shows the analysis of the Bologna sausages texture profile following reduction of 50% NaCl and addition of herbs and spices. It can be observed that the replacement of NaCl by KCl and the addition of herbs and spices did not caused alterations in the product parameters for hardness, springiness, cohesiveness, and chewiness. In the present study, a basic meat formulation, which had various components that contributed to the texture properties through the bonding of water and fat (non-meat extenders, such as soy protein isolate and starch) was applied at industry level. Moreover, a sodium polyphosphate concentration at the maximum limit allowed by the Brazilian Legislation (0.5%) was added. Barbut, Maurer and Lindsay (1988) reported that the phosphates improved the emulsion stability in turkey frankfurters, especially in formulations with 40% reduction of sodium chloride, with increase in hardness when compared to products without this additive. The replacement of NaCl by KCl, salts with very similar ionic force, has also contributed to the good extraction of myofibrillar proteins. However, contrary results were reported by Jiménez-Colmenero et al. (2001) and Matulis et al. (1995), who found alterations in the reduction of the cooked meat emulsions' texture properties when reducing the concentration of sodium chloride. Jiménez-Colmenero, Ayo and Carballo (2005) reported that frankfurters formulated with NaCl in the control samples presented higher values for hardness, springiness, and chewiness, which was attributed to the formation of more

Table 2. Average values (± standard deviation) of the centesimal composition, chlorides, sodium and potassium, and emulsion stability (ES) of bologna sausages with 50% NaCl reduction and addition of herbs and spices.

	CF	T_1	T_2	T_3
Moisture (%)	53.98 ± 0.19^{ab}	54.88 ± 0.26^{a}	52.98 ± 0.19^{b}	52.68 ± 1.15^{b}
Protein (%)	13.79 ± 025^{a}	14.05 ± 0.26^{a}	13.87 ± 0.28^{a}	13.8 ± 0.28^{a}
Fat (%)	25.89 ± 0.23^{ab}	25.3 ± 0.47^{b}	26.22 ± 0.17^{ab}	26.79 ± 0.60^{a}
Ashes (%)	3.04 ± 0.01^{a}	3.06 ± 0.02^{a}	3.07 ± 0.01^{a}	3.03 ± 0.03^{a}
Chlorides (%)	1.73 ± 0.02^{a}	1.7 ± 0.04^{a}	1.71 ± 0.01^{a}	1.67 ± 0.01^{a}
Sodium (mg.100 g^{-1})	998.15 ± 28.25^{a}	687.35 ± 6.07^{b}	680.19 ± 8.06^{b}	683.73 ± 15.93^{b}
Potassium (mg.100 g^{-1})	286.98 ± 7.03^{c}	824.91 ± 23.88^{b}	872.26 ± 6.54^{a}	880.92 ± 9.26^{a}
ES (%)	93.66 ± 0.28^{a}	93.51 ± 0.57^{a}	93.70 ± 0.75^{a}	93.65 ± 0.28^{a}

Averages followed by the same letter in the same line do not show significant difference ($p \leq 0.05$) in the Tukey test. CF– standard control sample (2% NaCl); T_1 – replacement of 50% NaCl by KCl; T_2 – replacement of 50% NaCl by KCl and addition of herbs and spices (0.5% coriander, 0.4% onion, and 0.1% white pepper); T_3 – Replacement of 50% NaCl by KCl and addition of herbs and spices (0.3% onion, 0.5% cardamom, and 0.2% Jamaican pepper).

Table 3. Texture profile analysis (± standard deviation) of bologna sausages with 50% reduction of NaCl and addition of herbs and spices.

	CF	T_1	T_2	T_3
Hardness (N.cm^{-2})	22.74 ± 1.69^{a}	24.99 ± 2.16^{a}	25.39 ± 1.28^{a}	24.20 ± 2.14^{a}
Springiness (cm)	0.90 ± 0.01^{a}	0.90 ± 0.009^{a}	0.89 ± 0.01^{a}	0.90 ± 0.01^{a}
Cohesiveness	0.77 ± 0.01^{a}	0.78 ± 0.01^{a}	0.77 ± 0.01^{a}	0.77 ± 0.01^{a}
Chewiness (N.cm^{-1})	15.76 ± 1.08^{a}	17.59 ± 1.71^{a}	16.61 ± 1.22^{a}	16.93 ± 1.60^{a}

Averages followed by the same letter in the same line do not show significant difference ($p \leq 0.05$) in the Tukey test. CF– standard control sample (2% NaCl); T_1 – #@replacement of 50% NaCl by KCl; T_2 – replacement of 50% NaCl by KCl and addition of herbs and spices (0.5% coriander, 0.4% onion, and 0.1% white pepper); T_3 – Replacement of 50% NaCl by KCl and addition of herbs and spices (0.3% onion, 0.5% cardamom, and 0.2% Jamaican pepper).

Table 4. Results of the microbiological tests of bologna sausages with 50% reduction of NaCl and addition of herbs and spices.

	CF	T_1	T_2	T_3	Specification standard
Clostridium sulphite reducer	<10	<10	<10	<10	$\leq 5.0 \times 10^2$
Coliforms at 45 °C	<10	<10	<10	<10	$\leq 1.0 \times 10^3$
Staphylococcus coagulase-positive	<100	<100	<100	<100	$\leq 3.0 \times 10^3$
Salmonella sp.	ABSENCE	ABSENCE	ABSENCE	ABSENCE	ABSENCE

CF– standard control sample (2% NaCl); T_1 – replacement of 50% NaCl by KCl; T_2 – replacement of 50% NaCl by KCl and addition of herbs and spices (0.5% coriander, 0.4% onion, and 0.1% white pepper); T_3 – Replacement of 50% NaCl by KCl and addition of herbs and spices (0.3% onion, 0.5% cardamom, and 0.2% Jamaican pepper).

Table 5. Average values (± standard deviation) of the sensory acceptance test for the bologna sausages with 50% reduction of NaCl and addition of herbs and spices.

	Color	Aroma	Taste	Texture
CF	5.45 ± 2.19[a]	4.88 ± 1.95[b]	5.33 ± 2.07[a]	5.64 ± 2.05[a]
T_1	5.42 ± 2.05[a]	5.06 ± 1.96[ab]	4.85 ± 1.99[a]	5.80 ± 1.96[a]
T_2	5.39 ± 2.26[a]	5.71 ± 2.14[a]	5.51 ± 2.32[a]	5.56 ± 2.09[a]
T_3	5.11 ± 2.46[a]	5.79 ± 2.19[a]	5.63 ± 2.16[a]	5.69 ± 2.11[a]

Averages followed by the same letter in the same line do not show significant difference ($p \leq 0.05$) in the Tukey test. CF– standard control sample (2% NaCl); T_1 – replacement of 50% NaCl by KCl; T_2 – replacement of 50% NaCl by KCl and addition of herbs and spices (0.5% coriander, 0.4% onion, and 0.1% white pepper); T_3 – Replacement of 50% NaCl by KCl and addition of herbs and spices (0.3% onion, 0.5% cardamom, and 0.2% Jamaican pepper).

Table 6. Average values of the sensory test for control difference in bologna sausages with 50% reduction of NaCl and addition of herbs and spices.

	Spicy taste	Salty taste	Stringent sensation	Texture
CF	4.90[b]	5.00[a]	5.10[a]	5.30[a]
T_1	4.50[b]	4.80[a]	4.90[a]	4.90[a]
T_2	6.90[a]	5.70[a]	5.90[a]	5.10[a]
T_3	7.10[a]	5.40[a]	5.60[a]	5.20[a]
Standard error	0.573	0.448	0.373	0.418

Averages followed by the same letter in the same line do not show significant difference ($p \leq 0.05$) in the Tukey test. CF– standard control sample (2% NaCl); T_1 – replacement of 50% NaCl by KCl; T_2 – replacement of 50% NaCl by KCl and addition of herbs and spices (0.5% coriander, 0.4% onion, and 0.1% white pepper); T_3 – Replacement of 50% NaCl by KCl and addition of herbs and spices (0.3% onion, 0.5% cardamom, and 0.2% Jamaican pepper).

stable emulsions followed by a lower cooking losses compared to that of the formulations without the addition of NaCl. An essential aspect to be highlighted in the comparison of data from the literature is the formulation, i.e., the physicochemical differences of the raw materials and the processing conditions, since the raw materials, the pH, the lower or higher extraction of the myofibrillar proteins during the mixture preparation, and the heating rate have a major influence on the texture of meat products (COFRADES et al., 1997; MATULIS et al., 1995).

4.2 Microbiological analysis

According to Gelabert et al. (2003) and Gimeno, Astiasarán and Bello (2001), the use of KCl as a partial substitute for NaCl was a good alternative to reduce the Na content in fermented meat products without compromising the microbiological stability and safety of the products during the manufacturing and storage phases. In this study, it can be observed that all treatments fully met the microbiological specifications of the current Brazilian Legislation (BRASIL, 2001) thus showing that the replacement of 50% NaCl by KCl and the addition of herbs and spices did not alter the microbiological quality of the product (Table 4).

4.3 Sensory analysis

The results of the sensory tests for acceptance and control difference for Bologna sausages with reduction of NaCl and addition of herbs and spices are presented in Tables 5 and 6, respectively. In accordance with the data found for the objective texture, the assessors, both in the acceptance test and in the control difference test, did not observe any difference between the control formulation and the treatments with NaCl reduction.

In the acceptance test, no difference was observed in the attributes of color, taste, and texture. The formulations T_2 and T_3 presented values for the aroma attribute that are significantly higher than those of the control, and the pleasant smell of the added seasonings was enhanced (Table 5). In the control difference test, the assessors did not detect any decrease in the salty taste or increase in the astringency in the treatments with replacement of NaCl by KCl compared to the control, as expected based on literature data (TERRELL, 1983; PASIN et al., 1989). Similar to what was observed in the acceptance test, the assessors evidenced an improvement in treatments T_2 and T_3 giving higher scores to the attribute "seasoning taste" (Table 6).

Figure 1 shows the consumers' purchase intention regarding Bologna sausages with 50% reduction of NaCl and addition of herbs and spices. The formulation T_1 with replacement of 50% NaCl by KCl and without addition of herbs and spices was the one that presented a higher rejection rate (27.86% of the consumers stated that they would probably or certainly not buy the product), followed by treatment T_3 (22.95%), which besides having the replacement of 50% NaCl by KCl had also the addition of the mixture of cardamom, onion, and Jamaican pepper. The control formulation (CF) and T_2, with replacement of 50% NaCl by KCl and addition of the mixture of coriander, onion, and white pepper were the ones that presented the lowest rejection rate among the assessors, 18.04% and 18.03%, respectively. Regarding the percentage of consumers who would probably or certainly buy the product, there was a similarity between the control (49.17%) and treatments T_2 (52.46%) and T_3 (54.1%). However, for treatment T_1, only 36.07% of the consumers stated that they would probably or certainly buy the product. Although there was no statistical difference

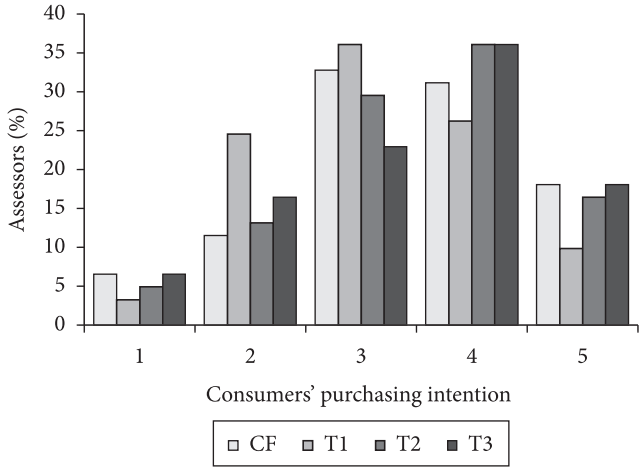

Figure 1. Consumers' purchasing intention of Bologna sausages with 50% reduction of NaCl and addition of herbs and spices. 1-the consumers definitely would not buy; 2- the consumers probably would not buy; 3-the consumers may/may not buy; 4-the consumers probably would buy and 5-the consumers definitely would buy. CF– standard control sample (2% NaCl); T1 – replacement of 50% NaCl by KCl; T2 – replacement of 50% NaCl by KCl and addition of herbs and spices (0.5% coriander, 0.4% onion and 0.1% white pepper); T3 – Replacement of 50% NaCl by KCl and addition of herbs and spices (0.3% onion, 0.5% cardamom, 0.2% Jamaican pepper).

in the sensory tests for acceptance and control difference, the evaluation of purchase intention results revealed consumers' lower preference to treatment T_1 and that the addition of herbs and spices can minimize the sensory defects caused by the replacement of 50% NaCl content by KCl.

5 Conclusion

The replacement of 50% sodium chloride content by potassium chloride promoted healthier characteristics to Bologna sausages produced with low levels of sodium and high potassium level. The physicochemical quality and the microbiological safety of the products produced with salt reduction were not altered by the replacement and addition of herbs and spices. However, the purchase intention expressed by the assessors was reduced. The two combinations of herbs and spices studied were effective at removing the sensory defects caused by the addition of potassium chloride. Therefore, it is possible to conclude that the use of these herbs and spices (0.5% coriander, 0.4% onion; 0.1% white pepper, 0.3% onion, 0.5% cardamom, and 0.2% Jamaican pepper) combined with a partial replacement of sodium chloride by potassium chloride is a way to produce Bologna sausages with reduced sodium content without damaging their safety and sensory quality. Further studies are necessary to assess the impact of this technological strategy on the products' shelf life regarding their physicochemical, sensory, and microbiological qualities. The contribution of other additives and ingredients used in the formulation, which are sources of sodium, besides NaCl, should also be quantified, and other alternative compounds that can help achieve lower sodium level in cooked emulsion meat products should be investigated.

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