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Application of lysine, taurine, disodium inosinate and disodium guanylate in fermented cooked sausages with 50% replacement of NaCl by KCl

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ABSTRACT

The effects of 50% replacement of NaCl by KCl and addition of the amino acids lysine and taurine and the 5′-ribonucleotide disodium inosinate and disodium guanylate on some sensory and physicochemical parameters of fermented cooked sausages were evaluated. The partial replacement of NaCl by KCl did not alter the manufacturing process; however, defects in the sensory quality were detected. Lysine at a concentration of 0.313% and a mixture of taurine (750 mg/kg) with disodium inosinate (300 mg/kg) and disodium guanylate (300 mg/kg) reduced the sensory defects caused by KCl, allowing the fermented cooked sausages to be elaborated with reduced sodium content and high sensory quality.

1. Introduction

Several studies have related high level of sodium intake to incidence of hypertension, which is one of the main risk factors of cardiovascular disease (He and MacGregor, 2003; Obarzanek, Proscham, Vollmer, Moore, Sacks, Appel et al., 2003; Paik, Wendel and Freeman, 2005; Dickinson and Havas, 2007). Consumers are increasingly aware of the importance of reduction in sodium intake, and, therefore, the demand for a variety of reduced salt meat products in many countries has increased (Ruusunen & Puolanne, 2005).

Sodium chloride (NaCl) is the main source of sodium in meat products (Ruusunen & Puolanne, 2005). This ingredient is considered essential for the elaboration of safe and sensory pleasant meat products, contributing to microbiological safety, salty taste, colour and texture (Wirth, 1989; Toldrá, 2002). One of the main approaches used to reduce the amount of sodium in meat products is NaCl replacement by other chloride salts that have similar microbiological and sensory functions.

Potassium chloride (KCl) is probably one of the most frequently used NaCl substitutes (Desmond, 2006) and appears to be the best alternative to reduce the amount of sodium in meat products. KCl is considered safe (generally recognized as safe or GRAS) and has an antimicrobial efficiency equivalent to that of NaCl (Bidlas & Lambert, 2008). Moreover, potassium intake has not been related to development of hypertension and cardiovascular disease (Buemi, Senatore, Corica, Aloisi, Romeo, Tramontana et al., 2002; Kimura, Lu, Skurnick, Awad, Bogden, Kemp et al., 2004; Geleijnse, Witteman, Stijnen, Kloos, Hofman & Grobbee, 2007). However, when used in high concentrations, KCl can diminish the sensory quality because it gives a metallic and bitter taste (Kilcast & den Ridder, 2007). In fermented sausages, a substitution levels of between 40 and 50% could affect the sensory quality (Gou, Guerrero, Gelabert, & Arnau, 1996; Gelabert, Gou, Guerrero & Arnau, 2003).

The research for ingredients that have the capacity of reducing or suppressing the sensory defects caused by using high levels of KCl is an important strategy to reduce the amount of sodium of fermented sausages, without depreciating their quality. Some reports have reported that lysine, taurine and the 5′-ribonucleotide disodium inosinate (IMP) and disodium guanylate (GMP) can reduce the sensory defects caused by KCl (Kurtz & Fuller, 1997; Zolotov, Braverman, Genis, & Biale 1998; Berglund & Alizadeh, 1999; Salemme & Barndt, 2008). However, there are no references about the use of these ingredients in combination with KCl to reduce the amount of sodium in fermented sausages. Therefore, this study proposes to evaluate the influence of amino acids (lysine and taurine) and 5′-ribonucleotides (IMP and GMP) on some sensory and physicochemical parameters of fermented cooked sausages that have 50% of NaCl replaced by KCl.

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2. Materials and methods

2.1. Treatments

Treatments have been carried out with a 50% replacement of NaCl by KCl. The NaCl concentration was reduced from 2.5% to 1.25%. After the KCl replacement treatment, the amino acids lysine and taurine were added, in addition to the flavour enhancers Ajitide® IMP and Ajitide® I + G (50% IMP and 50% GMP) (Table 1).

Lysine was added at concentrations of 0.139, 0.313, 0.54, and 0.833 g per 100 g of meat mixture, corresponding to a mixture of lysine and KCl (w/w) of 10/90 (0.139 g lysine and 1.25 g KCl), 20/80 (0.313 g lysine and 1.25 g KCl), 30/70 (0.54 g lysine and 1.25 g KCl), and 40/60 (0.833 g lysine and 1.25 g KCl), respectively. Taurine was added at a concentration of 750 mg/kg and the flavour enhancers at 600 mg/kg. The amino acids and the flavour enhancers were provided by Ajinomoto Interamericana Indústria and Comércio Ltda (São Paulo, Brazil).

2.2. Fermented cooked sausage preparation

Fermented cooked sausages were prepared using pork (650 g/kg), beef (200 g/kg) and pork back fat (150 g/kg). The raw material was ground using an 8 mm disk and mixed with the appropriate amount of NaCl and other corresponding ingredients required for each treatment, as described in Table 1. Subsequently, the following ingredients were added: glucose (10 g/kg), sodium nitrate (0.15 g/kg), sodium nitrite (0.15 g/kg), sodium ascorbate (2.5 g/kg), white pepper (2 g/kg), garlic (3 g/kg), nutmeg (0.02 g/kg), and starter culture (Bactoferm™ F1, Chr. Hansen) (0.25 g/kg). After mixing, the mass of meat was ground using a 3 mm disk and stuffed in collagen casings of 50 mm diameter. The pieces were then placed for 36 h in a fermentation room maintained at 28 ± 0.1 °C and a relative humidity of 85–90%. For heat processing, the pieces were placed in the smokehouse and initially heated at 50 °C for an hour, 60 °C for 30 min, then at 70 °C until an internal temperature of 62 °C was attained. Following heat processing, the fermented cooked sausages were cooled to 20 °C and placed in a 15 °C drying room (relative humidity 65–75%). The fermented cooked sausages were kept in the drying room for 180 h.

2.3. Physicochemical analysis

The pH was determined before the stuffing process, every 12 h of fermentation, and every 36 h after heat processing using a pH MA-130 meter (Mettler Toledo Indústria and Comércio Ltda, SP, Brazil). Water activity (Aw) was determined every 36 h of preparation, using an Aqua lab CX-2 water-activity meter (Decagon Devices, Inc., Pullman, WA). Three sausages per batch were used to evaluate the pH and Aw and each analysis was performed in duplicate. The colour determination was performed at the end of fermented cooked sausage production, with a Hunter Lab colourimeter (Colourquest-II, Hunter Associates Laboratory Inc., Virginia, USA) using a 10 mm port size, illuminent D_{65} and a 10° standard observer. CIELAB L*, a* and b* values were determined as indicators of lightness, redness and yellowness. Colour variables were measured at four points on the central part of the cut surface of three slices of the five sausages. The weight loss was determined by the weight difference among ten sausages just after the stuffing process and after the end of of sausage production. At the end of fermented cooked sausage production, three sausages per batch were used to evaluate the concentrations of sodium and potassium and each analysis was performed in triplicate, according to the methodology described by the Association of Official Analytical Chemists (2005).

The texture profile analysis (TPA) parameters were determined at the end of fermented cooked sausage production, 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 TPA parameters of hardness (the peak force during the first compression cycle), springiness (the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite) and cohesiveness (the ratio of the positive force area during the second compression portion to the positive force area during the first compression) were determined.

2.4. Consumer study

This study protocol was approved by the Ethics in Research Committee of the State University of Campinas, SP, Brazil, under the number 271/2009. All participants signed a consent form agreeing to voluntarily participate in the consumer study. Consumer study was conducted by 60 untrained panelists recruited among students, faculty and staff members from the university campus, whose ages ranged from 19 to 42 years. During two sessions, consumers sat in booths with white fluorescent lighting, in an isolated room. They were asked to express their opinion of the product regarding its colour, aroma, taste and texture. All data was recorded on a questionnaire designed to indicate the degree of likeness for the sample of each treatment using a non-structured scoring scale of nine points (0 = disliked extremely and 9 = liked extremely) (Meilgaard, Civille & Carr, 1999). Samples were evaluated by each consumer in a monadic order in two sessions and were presented to the assessors balancing the first-order and the carry-over effects according to Macfie, Bratchell, Greenhoff & Vallis (1989).

2.5. Statistical analysis

The data were evaluated through a variance analysis (ANOVA). The averages were compared by Tukey's test at a confidence level of 5% ($p \leq 0.05$) using the SPSS statistical package (SPSS Inc., Chicago, IL, USA).

3. Results and discussion

3.1. Physicochemical analysis

The evolution of pH during the processing of fermented cooked sausages is presented in Table 2. There were small differences in initial

Table 1
Percentages of sodium chloride, potassium chloride, amino acids and 5′-ribonucleotides used in the formulation of fermented cooked sausage treatments.

	TREATMENTS (%)								
	Control (NaCl)	Control (KCl)	L10/90	L20/80	L30/70	L40/60	T750	T750 + IMP/GMP600	T750 + IMP600
Sodium chloride (NaCl)	2.5	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Potassium chloride (KCl)	–	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Lysine	–	–	0.139	0.313	0.54	0.833	–	–	–
Taurine	–	–	–	–	–	–	0.075	0.075	0.075
Disodium inosinate (IMP)							–	–	0.06
50% IMP + 50% disodium guanylate (GMP)	–	–	–	–	–	–	–	0.06	–

Table 2
pH (± standard deviation) in the fermented cooked sausages with reduced sodium content.

	Before cooking (h)				After cooking (h)					
	0	12	24	36	0	36	72	108	144	180
Control (NaCl)	6.06 ± 0.02^{ab}	5.81 ± 0.01^{a}	5.36 ± 0.01^{a}	5.03 ± 0.02^{a}	5.13 ± 0.03^{a}	5.26 ± 0.03^{a}	5.25 ± 0.02^{a}	5.26 ± 0.02^{a}	5.25 ± 0.02^{a}	5.40 ± 0.03^{a}
Control (KCl)	6.00 ± 0.03^{de}	5.72 ± 0.02^{bc}	5.30 ± 0.01^{bc}	4.97 ± 0.02^{c}	5.11 ± 0.01^{ab}	5.22 ± 0.02^{bc}	5.21 ± 0.01^{ab}	5.25 ± 0.01^{ab}	5.24 ± 0.01^{a}	5.32 ± 0.02^{b}
L10/90	6.03 ± 0.02^{bcd}	5.72 ± 0.02^{b}	5.32 ± 0.01^{b}	4.98 ± 0.01^{bc}	5.11 ± 0.02^{ab}	5.23 ± 0.01^{abc}	5.22 ± 0.02^{ab}	5.26 ± 0.02^{a}	5.25 ± 0.02^{a}	5.29 ± 0.02^{bc}
L20/80	5.99 ± 0.02^{de}	5.66 ± 0.02^{d}	5.28 ± 0.01^{cd}	4.97 ± 0.01^{bc}	5.08 ± 0.01^{bc}	5.21 ± 0.02^{c}	5.20 ± 0.02^{b}	5.22 ± 0.01^{b}	5.24 ± 0.02^{a}	5.29 ± 0.03^{bc}
L30/70	5.98 ± 0.01^{e}	5.73 ± 0.01^{b}	5.33 ± 0.01^{ab}	5.01 ± 0.01^{ab}	5.13 ± 0.02^{a}	5.24 ± 0.02^{abc}	5.24 ± 0.01^{a}	5.27 ± 0.02^{a}	5.25 ± 0.01^{a}	5.35 ± 0.02^{ab}
L40/60	5.98 ± 0.01^{e}	5.69 ± 0.01^{c}	5.31 ± 0.01^{bc}	4.98 ± 0.03^{bc}	5.12 ± 0.01^{a}	5.17 ± 0.02^{d}	5.23 ± 0.01^{ab}	5.26 ± 0.02^{a}	5.24 ± 0.02^{a}	5.30 ± 0.04^{bc}
T750	6.04 ± 0.01^{bc}	5.63 ± 0.01^{e}	5.25 ± 0.02^{d}	4.92 ± 0.02^{d}	5.06 ± 0.02^{c}	5.07 ± 0.02^{f}	5.16 ± 0.03^{c}	5.17 ± 0.01^{c}	5.18 ± 0.01^{b}	5.24 ± 0.05^{c}
T750 + IMP/GMP600	6.01 ± 0.01^{cd}	5.58 ± 0.02^{f}	5.19 ± 0.01^{e}	4.86 ± 0.02^{e}	4.95 ± 0.02^{d}	5.12 ± 0.03^{e}	5.07 ± 0.02^{d}	5.09 ± 0.02^{d}	5.09 ± 0.01^{d}	5.23 ± 0.05^{c}
T750 + IMP 600	6.07 ± 0.01^{a}	5.57 ± 0.01^{f}	5.20 ± 0.04^{e}	4.89 ± 0.02^{de}	4.99 ± 0.05^{d}	5.16 ± 0.01^{e}	5.13 ± 0.03^{c}	5.14 ± 0.03^{c}	5.12 ± 0.03^{c}	5.23 ± 0.02^{c}

*Averages within the same column followed by the same letters did not show any significant difference ($p \leq 0.05$) by Tukey's test. Control (NaCl): 2.5% NaCl; Control (KCl): 1.25% NaCl and 1.25% KCl; L10/90: 1.25% NaCl, 1.25% KCl, and 0.139% lysine; L20/80: 1.25% NaCl, 1.25% KCl, and 0.313% lysine; L30/70: 1.25% NaCl, 1.25% KCl, and 0.54% lysine; L40/60: 1.25% NaCl, 1.25% KCl, and 0.833% lysine; T750: 1.25% NaCl, 1.25% KCl, and 750 mg/kg taurine; T750 + IMP/GMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, 300 mg/kg disodium inosinate, and 300 mg/kg disodium guanylate; T750 + IMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, and 600 mg/kg disodium inosinate.

pH values among the treatments, varying from 5.98 to 6.07. After fermentation for 36 h, the pH reached values lower than 5.2 in all treatments because of the acidification caused by lactic acid bacteria (Muguerza, Fista, Ansorena, Astiasarán & Bloukas, 2002). This quick decrease in pH is of extreme importance for the product's microbiological safety, because it causes reduction or inhibition of numerous food-degrading and pathogenic microorganisms (Garriga, Hugas, Gou, Aymerich, Arnau & Monfort, 1996; Castano, Fontan, Fresno, Tornadijo & Carballo, 2002; Hughes, Kerry, Arendt, Kenneally, McSweeney & O'Neill, 2002). The pH decrease was significantly higher in treatments with amino acids added, especially in those with taurine added, suggesting stimulation of lactic acid bacteria metabolism by this amino acid. The pH values increased after cooking and during maturation, reaching a final pH in the range of 5.23 to 5.40, in accordance with the results obtained by Vural (1998), and thus able to be considered normal for this type of meat product.

The evolution of Aw is presented in Table 3. Reduction in NaCl levels or its replacement by other salts can damage the drying process of fermented sausages, turning it into a product with higher water activity, as shown by Ibáñez, Quintanilla, Cid, Astiasarán and Bello (1996) and Gimeno, Astiasarán and Bello (1998); this can in turn compromise its microbiological safety and reduce its shelf life. In this study, the final values of Aw varied between 0.905 and 0.916, a significant difference not being observed between the modified products and the control (NaCl).

Values obtained for colour determination are shown in Table 4. NaCl replacement by KCl did not change the L*, a* and b* values significantly. Only in T750 treatment, a decrease in the red colour (a*) was observed in relation to the control (NaCl). A greater acidification observed in the T750 treatment was probably responsible for this reduction in the a* value, because lactic acid can cause denaturing of nitrosomyoglobin pigment, the latter being responsible for the red colouring (Pérez-Alvarez, Sayas-Barberá, Fernández-López and Aranda-Catalá, 1999).

The results of TPA are presented in Table 5. Literature results indicate that NaCl reduction or replacement can cause changes in the texture of fermented sausages. Gimeno, Astiasarán & Bello (2001), when evaluating calcium ascorbate as a partial substitute for NaCl, found a decrease in the hardness. Similarly, Gimeno, Astiasarán & Bello (1999) observed a significant reduction in hardness and cohesiveness when using KCl and $CaCl_2$ as partial substitutes for NaCl in fermented sausages; however, they were considered sensorially acceptable. In this study, significant differences with reference to control (NaCl) were observed only in L10/90, T750 and T750 + IMP600 treatments. In the L10/90 and T750 treatments, a significant reduction in the cohesiveness was observed, whereas hardness was significantly reduced in T750 + IMP600. The significantly lower pH observed in L10/90, T750 and T750 + IMP600 treatments in contrast to control (NaCl) could partially explain these results. The higher acidification could have caused a greater denaturation process, decreasing the binding capacity of proteins (Gimeno, Astiasarán & Bello, 1999). In some types of fermented sausages, an alteration of the texture, especially the reduction in hardness, can be considered a positive effect (Melendo, Beltrán, Jaime, Sancho & Roncalés, 1996). However, in fermented sausages elaborated with lower minced size (3 mm), a significant softening could be considered as a defect (Gimeno, Astiasarán & Bello, 1999).

Weight loss varied from 34.85 to 39.5%, a significant difference not being observed between the control (NaCl) and the modified products (Table 6). Agreeing with these results, Guàrdia, Guerrero, Gelabert, Gou & Arnau (2008) did not find alterations in weight loss when replacing 50% of NaCl content by KCl in dry-fermented sausages.

Sodium and potassium percentages in the fermented cooked sausages are presented in Table 6. The replacement of NaCl by KCl

Table 3
Water activity (± standard deviation) in the fermented cooked sausages with reduced sodium content.

	Before cooking (h)		After cooking (h)					
	0	36	0	36	72	108	144	180
Control (NaCl)	0.986 ± 0.007^{ab}	0.966 ± 0.001^{a}	0.963 ± 0.003^{ab}	0.961 ± 0.001^{abc}	0.943 ± 0.002^{b}	0.946 ± 0.004^{ab}	0.938 ± 0.002^{a}	0.905 ± 0.004^{ab}
Control (KCl)	0.987 ± 0.005^{a}	0.966 ± 0.003^{a}	0.965 ± 0.003^{ab}	0.960 ± 0.002^{abc}	0.954 ± 0.006^{ab}	0.953 ± 0.003^{a}	0.943 ± 0.002^{a}	0.908 ± 0.004^{ab}
L10/90	0.986 ± 0.003^{ab}	0.969 ± 0.003^{a}	0.967 ± 0.003^{a}	0.961 ± 0.001^{abc}	0.955 ± 0.001^{a}	0.942 ± 0.003^{bc}	0.947 ± 0.001^{a}	0.910 ± 0.004^{ab}
L20/80	0.981 ± 0.003^{ab}	0.967 ± 0.001^{a}	0.962 ± 0.002^{ab}	0.961 ± 0.002^{abc}	0.952 ± 0.003^{ab}	0.940 ± 0.003^{bc}	0.941 ± 0.006^{a}	0.908 ± 0.006^{ab}
L30/70	0.979 ± 0.003^{b}	0.966 ± 0.003^{a}	0.962 ± 0.001^{ab}	0.958 ± 0.002^{c}	0.953 ± 0.004^{ab}	0.943 ± 0.004^{bc}	0.939 ± 0.003^{a}	0.906 ± 0.006^{b}
L40/60	0.980 ± 0.002^{ab}	0.964 ± 0.004^{a}	0.958 ± 0.004^{b}	0.963 ± 0.002^{ab}	0.953 ± 0.001^{ab}	0.934 ± 0.003^{c}	0.938 ± 0.002^{a}	0.905 ± 0.005^{b}
T750	0.983 ± 0.004^{ab}	0.967 ± 0.001^{a}	0.964 ± 0.003^{ab}	0.959 ± 0.003^{bc}	0.958 ± 0.006^{a}	0.940 ± 0.002^{bc}	0.939 ± 0.002^{a}	0.913 ± 0.006^{ab}
T750 + IMP/GMP600	0.981 ± 0.003^{ab}	0.968 ± 0.001^{a}	0.962 ± 0.004^{ab}	0.965 ± 0.002^{a}	0.955 ± 0.004^{a}	0.936 ± 0.007^{bc}	0.924 ± 0.001^{b}	0.916 ± 0.005^{a}
T750 + IMP600	0.987 ± 0.005^{ab}	0.966 ± 0.003^{a}	0.965 ± 0.003^{ab}	0.960 ± 0.002^{abc}	0.954 ± 0.006^{ab}	0.953 ± 0.003^{bc}	0.943 ± 0.002^{a}	0.912 ± 0.004^{ab}

*Averages within the same column followed by the same letters did not show any significant difference ($p \leq 0.05$) by Tukey's test. Control (NaCl): 2.5% NaCl; Control (KCl): 1.25% NaCl and 1.25% KCl; L10/90: 1.25% NaCl, 1.25% KCl, and 0.139% lysine; L20/80: 1.25% NaCl, 1.25% KCl, and 0.313% lysine; L30/70: 1.25% NaCl, 1.25% KCl, and 0.54% lysine; L40/60: 1.25% NaCl, 1.25% KCl, and 0.833% lysine; T750: 1.25% NaCl, 1.25% KCl, and 750 mg/kg taurine; T750 + IMP/GMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, 300 mg/kg disodium inosinate, and 300 mg/kg disodium guanylate; T750 + IMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, and 600 mg/kg disodium inosinate.

Table 4
Colour characteristics (± standard deviation) of the fermented cooked sausages with reduced sodium content.

	L*	a*	b*
Control (NaCl)	48.37±1.80^{a}	16.15±0.73^{ab}	12.73±0.54^{a}
Control (KCl)	48.77±2.88^{a}	16.35±0.99^{a}	12.48±0.51^{a}
L10/90	50.61±2.09^{a}	15.37±0.72^{abc}	11.46±0.68^{a}
L20/80	48.62±2.48^{a}	15.62±0.88^{ab}	12.08±0.68^{a}
L30/70	51.75±2.38^{a}	15.23±0.67^{abc}	12.06±0.96^{a}
L40/60	49.24±2.54^{a}	15.54±0.83^{abc}	11.22±1.20^{a}
T750	51.58±2.01^{a}	14.18±0.29^{c}	11.83±0.35^{a}
T750 + IMP/GMP600	50.95±1.95^{a}	14.96±0.79^{abc}	12.00±1.33^{a}
T750 + IMP600	52.01±0.98^{a}	14.81±0.77^{bc}	12.25±1.18^{a}

*Averages within the same column followed by the same letters did not show any significant difference ($p \leq 0.05$) by Tukey's test. Control (NaCl): 2.5% NaCl; Control (KCl): 1.25% NaCl and 1.25% KCl; L10/90: 1.25% NaCl, 1.25% KCl, and 0.139% lysine; L20/80: 1.25% NaCl, 1.25% KCl, and 0.313% lysine; L30/70: 1.25% NaCl, 1.25% KCl, and 0.54% lysine; L40/60: 1.25% NaCl, 1.25% KCl, and 0.833% lysine; T750: 1.25% NaCl, 1.25% KCl, and 750 mg/kg taurine; T750 + IMP/GMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, 300 mg/kg disodium inosinate, and 300 mg/kg disodium guanylate; T750 + IMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, and 600 mg/kg disodium inosinate.

significantly reduced the sodium content and increased the potassium content. The percentage of sodium reduction compared to the control (NaCl) was 40.21, 45.29, 45.71, 47.65, 45.15, 42.33, 45.29, and 43.88% for control (KCl), L10/90, L20/80, L30/70, L40/60, T750, T750 + IMP/GMP600 and T750 + IMP600, respectively. The percentage of potassium increase compared to the control (NaCl) was 66.05, 70.99, 84.16, 76.81, 87.27, 92.70, 86.62, and 90.19% for control (KCl), L10/90, L20/80, L30/70, L40/60, T750, T750 + IMP/GMP600 and T750 + IMP600, respectively. These modifications could result in nutritional benefits because the reduction of sodium intake in the diet is indicated as a way to reduce the risk factors of hypertension (Antonios & Macgregor, 1997). In addition, the increase in the potassium content can also give benefits, as epidemological studies suggest that potassium intake is inversely correlated with the level of blood pressure and hypertension prevalence (Kawano, Minami, Takishita & Omae, 1998).

3.2. Consumer study

The results of consumer study are presented in Table 7. Colour acceptability was significantly reduced in T750 treatment compared to the control (NaCl), which may be related to the lower values of a* found in this treatment (Table 4). L10/90, T750 and T750 + IMP600 treatments showed a significant reduction in texture acceptability compared to the control (NaCl), a statement that is in compliance with the modifications observed in the texture profile analysis (Table 5).

A significant difference in colour and texture acceptability between two controls was not observed; however, similar to the observation by Gelabert, Gou, Guerrero & Arnau (2003) and Gou, Guerrero, Gelabert, & Arnau (1996), the 50% replacement of NaCl by KCl depreciated the product's sensory qualities by significantly reducing the acceptability for taste and aroma. In the treatments with lysine, a significant improvement in taste was noticed compared to the control (KCl). Related to the control (NaCl), significant changes in colour, aroma, taste and texture acceptability were not noted in L20/80, L30/70 and L40/60 treatments. Similar to what was noticed in treatments with lysine, treatments with taurine (T750, T750 + IMP/GMP600 and T750 + IMP600) showed a significant improvement in taste acceptability compared to the control (KCl). However, only the treatment with taurine and the mixture of IMP and GMP (T750 + IMP/GMP600) did not differ from the control (NaCl) in any sensory attribute analyzed.

Table 5
Average values (± standard deviation) of texture profile analysis parameters of the fermented cooked sausages with reduced sodium content.

	Hardness (N)	Springiness (mm)	Cohesiveness
Control (NaCl)	32.38±2.41^{abc}	0.76±0.01^{a}	0.77±0.03^{a}
Control (KCl)	30.60±1.69^{bcd}	0.81±0.02^{a}	0.76±0.01^{a}
L10/90	36.73±2.41^{a}	0.77±0.02^{a}	0.68±0.00^{c}
L20/80	35.76±3.45^{ab}	0.71±0.01^{a}	0.73±0.01^{ab}
L30/70	29.85±2.87^{bcd}	0.80±0.02^{a}	0.76±0.01^{a}
L40/60	30.96±2.38^{abcd}	0.78±0.02^{a}	0.74±0.01^{ab}
T750	29.05±3.11^{cd}	0.73±0.05^{a}	0.70±0.02^{bc}
T750 + IMP/GMP600	28.51±2.81^{cd}	0.68±0.04^{a}	0.73±0.04^{ab}
T750 + IMP600	26.02±2.40^{d}	0.76±0.03^{a}	0.75±0.01^{a}

*Averages within the same column followed by the same letters did not show any significant difference ($p \leq 0.05$) by Tukey's test. Control (NaCl): 2.5% NaCl; Control (KCl): 1.25% NaCl and 1.25% KCl; L10/90: 1.25% NaCl, 1.25% KCl, and 0.139% lysine; L20/80: 1.25% NaCl, 1.25% KCl, and 0.313% lysine; L30/70: 1.25% NaCl, 1.25% KCl, and 0.54% lysine; L40/60: 1.25% NaCl, 1.25% KCl, and 0.833% lysine; T750: 1.25% NaCl, 1.25% KCl, and 750 mg/kg taurine; T750 + IMP/GMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, 300 mg/kg disodium inosinate, and 300 mg/kg disodium guanylate; T750 + IMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, and 600 mg/kg disodium inosinate. Hardness: the peak force during the first compression cycle; Springiness: the height that the food recovers during the time that elapses between the end of the first bite and the start of the second bite; Cohesiveness: the ratio of the positive force area during the second compression portion to the positive force area during the first compression.

Table 6
Sodium and potassium content and weight loss (± standard deviation) of the fermented cooked sausages with reduced sodium content.

	Sodium (mg/100g)	Potassium (mg/100g)	Weight loss (%)
Control (NaCl)	1132.74±13.07^{a}	691.51±5.97^{e}	36.09±0.64^{ab}
Control (KCl)	677.19±20.37^{b}	1148.22±13.44^{d}	34.84±1.08^{b}
L10/90	619.77±8.93^{cde}	1182.48±18.91^{cd}	37.81±1.22^{ab}
L20/80	614.95±13.11^{de}	1273.48±27.29^{ab}	38.80±0.89^{ab}
L30/70	592.96±12.21^{e}	1222.66±25.60^{bc}	35.07±1.71^{b}
L40/60	621.32±0.69^{cde}	1295.02±18.56^{a}	36.23±1.15^{ab}
T750	653.26±9.63^{bc}	1332.55±42.10^{a}	39.57±4.50^{a}
T750 + IMP/GMP600	619.75±5.43^{cde}	1290.53±11.64^{ab}	39.18±1.52^{ab}
T750 + IMP600	635.67±7.16^{cd}	1315.23±36.07^{a}	35.70±0.90^{ab}

*Averages within the same column followed by the same letters did not show any significant difference ($p \leq 0.05$) by Tukey's test. Control (NaCl): 2.5% NaCl; Control (KCl): 1.25% NaCl and 1.25% KCl; L10/90: 1.25% NaCl, 1.25% KCl, and 0.139% lysine; L20/80: 1.25% NaCl, 1.25% KCl, and 0.313% lysine; L30/70: 1.25% NaCl, 1.25% KCl, and 0.54% lysine; L40/60: 1.25% NaCl, 1.25% KCl, and 0.833% lysine; T750: 1.25% NaCl, 1.25% KCl, and 750 mg/kg taurine; T750 + IMP/GMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, 300 mg/kg disodium inosinate, and 300 mg/kg disodium guanylate; T750 + IMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, and 600 mg/kg disodium inosinate.

4. Conclusion

The manufacturing process was not altered by the 50% replacement of NaCl by KCl; however, the sensory quality was reduced.

Table 7
Consumer acceptability (± standard deviation) of colour, aroma, taste and texture of fermented cooked sausages with reduced sodium content.

	Colour	Aroma	Taste	Texture
Control (NaCl)	6.69±1.69^{a}	5.79±2.13^{a}	6.81±1.45^{a}	6.89±1.56^{a}
Control (KCL)	5.95±2.01^{ab}	4.57±1.96^{b}	4.31±1.78^{d}	5.96±2.08^{abc}
L10/90	5.93±1.95^{ab}	4.84±2.24^{ab}	5.45±2.15^{bc}	5.46±1.44^{bc}
L20/80	5.71±1.86^{ab}	5.40±2.11^{ab}	5.78±1.85^{abc}	6.04±1.98^{abc}
L30/70	6.39±1.47^{ab}	5.66±1.91^{ab}	5.81±1.58^{abc}	6.18±1.51^{abc}
L40/60	6.22±1.85^{ab}	5.56±2.23^{ab}	6.07±1.78^{abc}	6.50±1.77^{ab}
T750	5.38±1.92^{b}	5.19±2.08^{ab}	5.06±2.18^{c}	5.40±1.36^{c}
T750 + IMP/GMP600	6.33±1.85^{ab}	5.85±1.97^{a}	6.25±1.93^{ab}	5.89±1.98^{abc}
T750 + IMP600	5.95±1.88^{ab}	5.23±1.97^{ab}	5.41±1.66^{bc}	5.69±1.99^{bc}

*Averages within the same column followed by the same letters did not show any significant difference ($p \leq 0.05$) by Tukey's test. Control (NaCl): 2.5% NaCl; Control (KCl): 1.25% NaCl and 1.25% KCl; L10/90: 1.25% NaCl, 1.25% KCl, and 0.139% lysine; L20/80: 1.25% NaCl, 1.25% KCl, and 0.313% lysine; L30/70: 1.25% NaCl, 1.25% KCl, and 0.54% lysine; L40/60: 1.25% NaCl, 1.25% KCl, and 0.833% lysine; T750: 1.25% NaCl, 1.25% KCl, and 750 mg/kg taurine; T750 + IMP/GMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, 300 mg/kg disodium inosinate, and 300 mg/kg disodium guanylate; T750 + IMP600: 1.25% NaCl, 1.25% KCl, 750 mg/kg taurine, and 600 mg/kg disodium inosinate.

Lysine, at a concentration of 0.313%, and the mixture of taurine (750 mg/kg) with 5′-ribonucleotides IMP (300 mg/kg) and GMP (300 mg/kg) reduced the sensory defects caused by the replacement of 50% of NaCl by KCl, enabling the elaboration of fermented cooked sausages that are sensorially acceptable and possess healthier characteristics.

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