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# Partial replacement of sodium chloride in Italian salami and the influence on the sensory properties and texture

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**ABSTRACT.** Cured meat products, such as Italian salami, exhibit high levels of sodium from NaCl, added to ensure flavor and texture. Studies indicates a close relationship between the consumption of these products and hypertension and cardiovascular diseases. The objective of this study was to evaluate the effect of partial replacement of sodium chloride by potassium chloride, magnesium chloride, and calcium chloride on the texture and sensory attributes of Italian salami and to quantify the levels of minerals in the finished product. Four formulations were prepared: without a starter culture (F1); with a starter culture (F2); partial replacement of 60% sodium chloride by potassium chloride (F3); and partial replacement of sodium chloride by a mixture containing potassium chloride, magnesium chloride, and calcium chloride (F4). Analyses of $Na^+$, $K^+$, $Ca^{+2}$ and $Mg^{+2}$ contents, texture profile and sensory attributes (acceptance test) were carried out. Formulations F1, F2, F3 and F4 presented levels of $Na^+$ 0.53, 0.44, 0.36 and 0.30, respectively. The formulations presented a reduction in the sodium chloride content over 25%, thus complying with the requirements of the current legislation. The addition of these salts affected certain important sensory attributes, such as flavor and global impression, and increased hardness and chewiness values.

**Keywords:** meat products, salts, sodium content, texture profile.

## Substituição parcial do cloreto de sódio em salames tipo italiano e a influência nas características sensoriais e de textura

**RESUMO.** Os produtos cárneos curados, como o salame tipo italiano, apresentam teores elevados de sódio, principalmente provenientes do NaCl adicionado para garantir o sabor e a textura. Estudos indicam uma estreita relação entre o consumo destes produtos e problemas de hipertensão arterial e doenças cardiovasculares. O objetivo do trabalho foi avaliar o efeito da substituição parcial do cloreto de sódio, por cloretos de potássio, magnésio e cálcio na textura e atributos sensoriais de diferentes formulações de salame tipo italiano. Foram elaboradas 4 formulações: sem cultura *starter* (F1), com cultura *starter* (F2), com substituição parcial de 60% do cloreto de sódio por cloreto de potássio (F3) e substituição parcial de 60% de cloreto de sódio por uma mistura contendo cloreto de potássio, cloreto de magnésio e cloreto de cálcio (F4). Foram realizadas análises de teor de $Na^+$, $K^+$, $Ca^{+2}$, $Mg^{+2}$, perfil de textura e análise sensorial (teste de aceitação). As formulações F1, F2, F3 e F4 apresentaram teores de $Na^+$ de 0,53; 0,44; 0,36 e 0,30, respectivamente. As formulações apresentaram redução no conteúdo de sódio superior a 25%, atendendo as exigências da legislação vigente. A adição de KCl, $MgCl_2$ e $CaCl_2$ afeta alguns importantes atributos sensoriais, tais como sabor e impressão global, além de aumentar os valores de dureza e mastigabilidade.

**Palavras-chave:** produto cárneo, sais, teor de sódio, perfil de textura.

## Introduction

When added to fermented sausages, sodium chloride (NaCl) plays a key role in ensuring microbiological stability, flavor and texture, helping to solubilize the myofibrillar proteins responsible for fat emulsification, increasing water retention capacity, and contributing to the maintain their basic characteristic flavor (TERRA et al., 2004).

Generally, amounts of 2.0-4.0% NaCl are added to meat products, and the concentration tends to increase in the final products due to the drying process. Besides NaCl, other salts, such as nitrite ($NaNO_2$), nitrate ($NaNO_3$) and sodium erythorbate ($C_6H_7NaO_6$), used for color stabilization, texture improvement, characteristic flavor development, warmed-over flavor elimination, and antimicrobial activity, may also increase sodium concentration (ZANARDI et al., 2010).

Reducing sodium in processed foods is a concern of the cured meat industry, due to the association between salt intake, blood pressure, and

hypertension. The recommended daily intake of sodium is below 2.400 mg $day^{-1}$ (OPARIL; CALHOUN, 2000; GUARDIÁ et al, 2006). In Brazil, the estimated daily sodium intake is 12.3 g (NAKASATO, 2004). Meat contains sodium, though less than 100 mg 100 $g^{-1}$.

When added to cured products during processing, sodium chloride contains about 39.3% sodium (RUNSSUNEN; PUOLANNE, 2005). Even though processed meat products contribute in 20-30% of daily intake of salt (JIMÉNEZ-COLMENERO et al., 2001), researchers are looking for alternatives to reduce sodium chloride in processed meat products (PAULINO et al, 2006; NASCIMENTO et al, 2007; ZANARDI et al, 2010; HORITA et al, 2011; CAMPAGNOL et al. 2011; CARRARO et al, 2012).

Reduction in sodium content or its partial replacement may lead to undesirable effects on the quality of sausage meat, such as sensory and microbiological quality changes and increased lipid oxidation. Carraro et al. (2012) recommend that reduction or partial replacement of sodium chloride be made with a rigorous assessment of the effects generated by the reduction in product acceptance and shelf life stability. Sensory changes may occur in the product as result of NaCl reduction or partial replacement, such as metallic taste or astringent flavor (CARRARO et al., 2012). According to Zanardi et al. (2010), sodium reduction has a decisive influence on acceptance of a product, interfering in its color, purchase intent, and overall acceptance.

The objective of this study was to evaluate the effect of partial replacement of sodium chloride by potassium chloride, magnesium chloride, and calcium chloride on texture and sensory attributes of Italian salami.

## Material and methods

### Material

The following ingredients were used for the preparation of Italian salami: pork (boneless ham), beef (chuck) and back fat (swine back pat), salt (NaCl) (Diana, Curitiba, Paraná State, Brazil), sucrose (granulated sugar) curing salt (Doremus Cura K001, Guarulhos, São Paulo State, Brazil), white pepper, powdered garlic, and nutmeg (local market), sodium erythorbate (Doremus New Color F014, Guarulhos, São Paulo State, Brazil). The salts used were potassium chloride (KCl) (Vetec, Duque de Caxias, RJ, Brazil), magnesium chloride ($MgCl_2$) (Nuclear, São Paulo, São Paulo State, Brazil) and calcium chloride ($CaCl_2$) (Vetec, Duque de Caxias, Rio de Janeiro State, Brazil). Analytical PA grade reagents were used in the analyses.

The starter culture Texel® AS-308 (Dupont Danisco, São Paulo, São Paulo State, Brazil) was used, containing *Lactobacillus sakei*; *Staphylococcus carnosus* and *Staphylococcus xylosus*, with a total count of approximately 4.5 E +10 CFU $g^{-1}$.

### Preparation of Italian salami

Four formulations of Italian salami were prepared: F1, F2, F3, and F4 (Table 1). For the preparation of the sausages, the amount of raw material, sodium chloride, sugars and spices was based on formulations described by Terra (2005) and Terra et al. (2004), substituting 60% of the amount of chloride sodium. The starter culture was not used in formulation F1; NaCl was replaced by KCl in formulation F3 (1:1.5); and replaced by KCl, $CaCl_2$ and $MgCl_2$ (1:1:1) in formulation F4.

**Table 1.** Formulations used in the manufacture of Italian salami.

| Ingredients % | F1 | F2 | F3 | F4 |
|---|---|---|---|---|
| Pork | 71 | 71 | 71 | 71 |
| Beef | 15 | 15 | 15 | 15 |
| Swine back fat | 10 | 10 | 10 | 10 |
| Sucrose | 0.3 | 0.3 | 0.3 | 0.3 |
| Curing salt | 0.3 | 0.3 | 0.3 | 0.3 |
| White pepper | 0.1 | 0.1 | 0.1 | 0.1 |
| Garlic powder | 0.1 | 0.1 | 0.1 | 0.1 |
| Nutmeg | 0.02 | 0.02 | 0.02 | 0.02 |
| Sodium erythorbate | 0.25 | 0.25 | 0.25 | 0.25 |
| Starter Culture | - | 0.01 | 0.01 | 0.01 |
| NaCl | 2.5 | 2.5 | 1 | 1 |
| KCl | - | - | 1.5 | 0.5 |
| $CaCl_2$ | - | - | - | 0.5 |
| $MgCl_2$ | - | - | - | 0.5 |

Pork, beef and swine back fat were ground using an 8 mm disc. The ingredients were mixed manually. Primarily, salts were added to extract the myofibrillar proteins to mix the meat fragments in the salami. The starter culture was mixed with 50 mL of distilled water and allowed to rest for 30 min. before being carefully added to the formulation, with rapid incorporation into the dough. The remaining ingredients were added, with sodium erythorbate, previously diluted in water, being the last one. When a homogeneous mass was obtained, the meat was stuffed in 40 mm caliber collagen casings, hung on sticks and kept inside an industrial refrigerator at 7°C for 12 hours, followed by smoking for 6 hours in an oven (Arprotec, Valinhos, São Paulo State, Brazil) at temperatures between 28 and 35°C, relative humidity of 85% with natural smoke injection. After curing, the salami were incubated for B.O.D. (Logen, LS334, São Paulo, São Paulo State, Brazil), for 32 days, with a range of relative humidity (95-75%) and

temperature (25-18°C), according to the maturation stage. The process of preparing Italian salami followed the stages outlined in Figure 1.

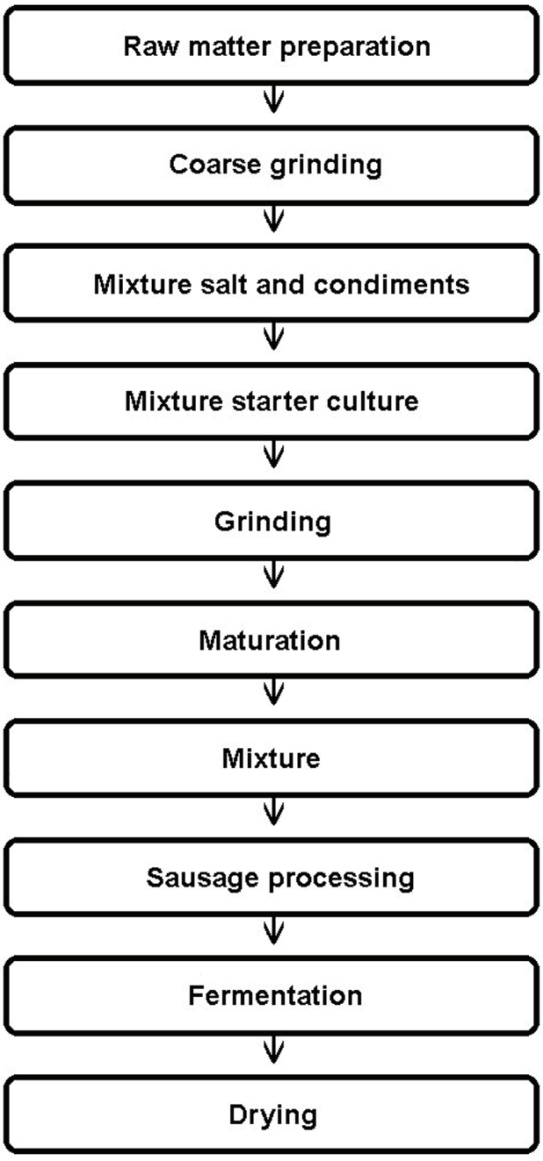


**Figure 1.** Flowchart of the operations for processing Italian salami with partial replacement of NaCl.

### Determination of minerals

For the determination of the mineral content ($Na^+$, $K^+$, $Ca^{+2}$, $Mg^{+2}$), a sample digestion was performed to remove organic compounds (TEDESCO et al. 1995). Sodium and potassium contents were determined using a Micronal flame photometer (Model B462, São Paulo State, Brazil) and calcium and magnesium contents by an atomic absorption spectrophotometer GBC (Avanta, Kingston, Australia). The results were expressed in g 100 $g^{-1}$ of sample.

### Texture profile analysis

Texture profile analysis (TPA) was performed on the 32nd day of maturation, using a Stable Micro Systems texture meter (TA-TXplus, Godalming, Surrey, UK) with a 50 kg load cell. Each sample was cut into 2-inch cylinder and compressed into two consecutive cycles of 20% compression, with a 40 mm diameter probe, moving at a constant speed of 1 mm $s^{-1}$. Data collection and TPA curve construction were performed using the Texture Expert software (version 1.11, Stable Micro Systems). The parameters hardness, elasticity, cohesiveness, adhesiveness, and chewiness were evaluated. Hardness was the peak force during the first compression cycle; elasticity was the ratio between the time from the start of the second area up to the second peak, and the time from the start of the first area up to the first peak (b/a). Cohesiveness was the ratio between the areas of the second and first peaks (a2/a1). Adhesiveness corresponded to the area of negative force between the two compression cycles (a3). Chewiness was calculated by multiplying hardness, elasticity, and cohesiveness (NASCIMENTO et al., 2007).

### Sensory analysis

An acceptance test was conducted to assess whether consumers like or dislike the product using a balanced hedonic scale (MINIM, 2006), ranging from 1 (extremely disliked) to 9 (extremely liked).

Sensory analysis was performed on the final product of the maturation process at the Sensory Analysis Lab (UTFPR) in individual booths, under controlled conditions.

The formulations F1, F2, F3, and F4 were coded and randomLy presented; 100 untrained testers, (58 female, 44 male, 93% aged 17-30 years), evaluated the samples according to the attributes color, odor, flavor, texture, and overall impression, according to the evaluation form.

Data were evaluated using analysis of variance (ANOVA), considering jointly all the evaluations, and assuming that all exhibit the same behavior, regardless of individual differences, since the testers were not trained and their performances do not interfere. The Tukey test ($p \leq 0.05$) was carried out due to variations between the means.

The protocol of this study was approved by the Research Ethics Committee of the Universidade Estadual do Oeste do Paraná under no. 461.231/2013. All participants signed a Term of Consent agreeing to participate voluntarily in the sensory analyses.

### Statistical analysis

The data obtained in the Italian salami analyses were subjected to analysis of variance (ANOVA), and the Tukey test was applied to compare the means at a significance level of 5% ($p < 0.05$), using the software Statistica 7.0 (2008).

## Results and discussion

Sodium content in the formulations of Italian salami.

The sodium contents of the samples of Italian salami formulations F1, F2, F3, and F4 are presented in Figure 2.

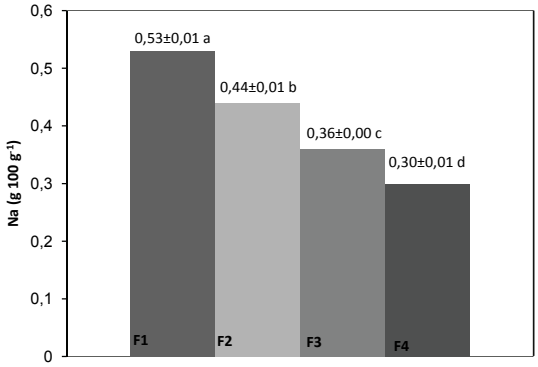


**Figure 2.** Determination of sodium content (g 100 $g^{-1}$) in the formulations of Italian-type salami after the maturation stage (days). Mean values ± standard deviation; three replicates; Means followed by the same letter are not significantly different ($p \leq 0.05$) by the Tukey test. F1: NaCl ; F2: NaCl + starter culture; F3: NaCl + KCl + starter culture; F4: NaCl + KCl + $CaCl_2$ + $MgCl_2$ + starter culture.

Formulation F1 presented sodium content significantly ($p \leq 0.05$) higher than the other ones. Formulations F2, F3, and F4 presented a reduction in the sodium content of approximately 16, 32 and 43%, respectively.

It must be emphasized that formulations F3 and F4 comply with the regulations for reduced sodium-products, i.e., presented a sodium reduction higher than 25% (BRASIL, 1998). As for dry fermented meat products, Gimeno et al. (1998, 1999, 2001) obtained reductions in $Na^+$ content with partial replacement of NaCl by the combinations of the salts KCl, $MgCl_2$, and $CaCl_2$.

Replacement of 60% of NaCl by KCl in formulation F3 resulted in a decrease of 32% in the content of $Na^+$, while the use of the mixture of salts (KCl, $MgCl_2$ and $CaCl_2$) as a substitute for NaCl (formulation F4) resulted in a reduction in the sodium content of approximately 43%. Similar results were found by Zanardi et al. (2010) for Italian salami when half of the sodium chloride used in the formulation KCl, $MgCl_2$, $CaCl_2$ was substituted, reducing approximately 40% the $Na^+$ content. The replacement of NaCl does not imply a proportional reduction in sodium content, since other ingredients (nitrite, nitrate, and sodium erythorbate) used in this formulation, also present this ion (CARRARO et al., 2012).

### Determination of minerals in the Italian salami formulations

The presence of potassium, calcium, and magnesium was determined in the formulations of Italian salami (Table 2). The importance of quantifying these ions must be stressed, since their intake attenuates the hypertensive effect of sodium (KARPPANEN; MERVAALA, 2006).

**Table 2.** Presence of $K^+$, $Ca^{+2}$ and $Mg^{+2}$ (g 100 $g^{-1}$) in different formulations of Italian salami, after the maturation stage.

| | $K^+$ | $Ca^{+2}$ | $Mg^{+2}$ |
|---|---|---|---|
| F1 | $0.99 \pm 0.09^c$ | $0.02 \pm 0.00^c$ | $0.13 \pm 0.00^b$ |
| F2 | $1.08 \pm 0.09^c$ | $0.01 \pm 0.00^c$ | $0.14 \pm 0.00^b$ |
| F3 | $3.87 \pm 0.09^a$ | $0.62 \pm 0.08^b$ | $0.15 \pm 0.02^b$ |
| F4 | $2.01 \pm 0.15^b$ | $1.24 \pm 0.06^a$ | $0.57 \pm 0.01^a$ |

Mean values ± standard deviation; three replicates; Means followed by the same letter in the same column are not significantly different ($p \leq 0.05$) by the Tukey test. F1: NaCl; F2: NaCl + starter culture; F3: NaCl + KCl + starter culture; F4: NaCl + KCl + $CaCl_2$ + $MgCl_2$ + starter culture.

The amounts of potassium and calcium in formulations F1 and F2 were very similar, with no significant difference ($p \leq 0.05$). As expected, formulation F3 presented amounts of potassium ($p \leq 0.05$) significantly higher than the other formulations, since NaCl was replaced exclusively by KCl. Formulation F4 presented significantly higher levels ($p \leq 0.05$) of calcium and magnesium.

Calcium plays a role in blood pressure regulation, muscle contraction, and bone density (GIMENO et al, 2001), while potassium intake helps to protect against hypertension (KATSIARI et al., 2001). Magnesium acts in enzymatic reactions, duplication of nucleic acid, neural excitability and nerve impulse transmission (OLIVEIRA et al., 2008).

Despite the benefits of increased intake of these ions, some care must be taken. Their presence may affect the activity of lipolytic enzymes, change the profile of free fatty acids, and consequently change the flavor of fermented products (RIPOLLÉS et al., 2011). Besides, the addition of potassium, calcium, and magnesium to meat products is limited by the bitter flavor, metallic taste, and astringent sensation they confer to these products (BLESA et al., 2008).

### Texture profile of Italian type sausages

A texture profile analysis was performed on the salami after 32 days of maturation (Table 3).

**Table 3.** Texture profile analyses of samples of Italian salami produced with different formulations after the maturation stage.

| | F1 | F2 | F3 | F4 |
|---|---|---|---|---|
| Hardness (N $cm^{-2}$) | $14.52\pm0.60^{b}$ | $13.79\pm0.31^{b}$ | $14.06\pm1.01^{b}$ | $31.75\pm0.22^{a}$ |
| Elasticity (cm) | $1.08\pm0.04^{b}$ | $1.03\pm0.05^{b}$ | $1.42\pm0.09^{a}$ | $1.19\pm0.03^{ab}$ |
| Cohesiveness | $0.16\pm0.03^{a}$ | $0.11\pm0.00^{a}$ | $0.13\pm0.01^{a}$ | $0.11\pm0.00^{a}$ |
| Adhesiveness (N.s) | $-0.55\pm0.17^{a}$ | $-0.50\pm0.08^{a}$ | $-0.24\pm0.02^{a}$ | $-0.23\pm0.10^{a}$ |
| Chewiness(N $cm^{-1}$) | $2.56\pm0.39^{b}$ | $1.65\pm0.04^{b}$ | $2.61\pm0.42^{b}$ | $4.20\pm0.22^{a}$ |

Mean values ± standard deviation; three replicates; Means followed by the same letter in the same row are not significantly different ($p \leq 0.05$) by the Tukey test. F1: NaCl; F2: NaCl + starter culture; F3: NaCl + KCl + starter culture; F4: NaCl + KCl + $CaCl_2$ + $MgCl_2$ + starter culture.

The formulation F4 with partial replacement of NaCl by the combination of other salts presented higher hardness and chewiness, significantly differing ($p < 0.05$) from the other treatments. The higher hardness and chewiness values found for formulation F4 are probably related to significant ($p \leq 0.05$) reduction in the content of sodium chloride. According to Horita et al. (2011), NaCl concentrations commonly added to meat products provide the ionic strength necessary for dissolution and extraction of the myofibrillar proteins responsible for emulsification, gelatinization and water retention capacity, among others. When NaCl concentration is reduced, the amount of extracted protein may be decreased by changing the properties of the texture.

Some studies have found differences in the effects of mono and divalent salts on the myofibrillar proteins that form ionic bonds between the adjacent carboxylic groups present in the proteins. A higher electrostatic load in the divalent salts increases the interactions with the meat matrix and limits salt diffusion, reducing water activity the product. The salts influence protein hydration, increasing water retention capacity, and, consequently, texture and process yield (GARCIA et al., 2013). The formulations with replacement of sodium chloride (F3 and F4) exhibited higher elasticity values than other formulations. They presented similar means ($p \leq 0.05$) for cohesiveness and adhesiveness.

These results are not in agreement with Carraro et al. (2012), who did not find differences in the parameters hardness, cohesiveness, adhesiveness, and chewiness in bologna with replacement of 50% of NaCl.

Sensory analysis of Italian type sausages The characterization of the testers' profiles is important, since sensory quality varies from one person to another. The characteristics age, sex, education and income are presented (MININ, 2006). The presence of female testers predominates (58%) as well as the 17-30 year-old group. The means of the attributes evaluated by the testers according to the scores for each formulation are presented in Table 4.

**Table 4.** Means of the sensory attributes in Italian salami produced with different formulations during the maturation stage.

| Sample | Color | Odor | Flavor | Texture | Overall Impression |
|---|---|---|---|---|---|
| F1 | $7.39\pm0,14^{a}$ | $6.99\pm0.16^{a}$ | $6.92\pm0.16^{a}$ | $6.96\pm0.13^{a}$ | $6.87\pm0.15^{ab}$ |
| F2 | $7.01\pm0.14^{a}$ | $7.21\pm0.11^{a}$ | $7.44\pm0.12^{a}$ | $7.15\pm0.13^{a}$ | $7.17\pm0.11^{a}$ |
| F3 | $7.32\pm0.15^{a}$ | $7.11\pm0.14^{a}$ | $6.85\pm0.17^{a}$ | $7.04\pm0.15^{a}$ | $6.87\pm0.16^{ab}$ |
| F4 | $7.43\pm0.14^{a}$ | $6.77\pm0.17^{a}$ | $6.07\pm0.21^{b}$ | $6.78\pm0.16^{a}$ | $6.41\pm0.19^{b}$ |

Mean values ± standard deviation; three replicates; means followed by the same letter in the same column are not significantly different ($p \leq 0.05$) by the Tukey test. F1: NaCl; F2: NaCl + starter culture; F3: NaCl + KCl + starter culture; F4: NaCl + KCl + $CaCl_2$ + $MgCl_2$ + starter culture.

No significant differences ($p < 0.05$) were found between the formulations for the attributes color, odor, and texture.

For the attribute flavor, formulation F4 showed a significantly lower mean than the other formulations. This may be related to an increased bitterness caused by KCl (KILCAST; DEN RIDDER, 2007). Besides, the change in odor is probably due to the replacement of 60% NaCl by KCl, providing an increase in proteolysis, generating off-flavors in the final product.

The observed depreciation of the sensory quality corroborates the results obtained by Gelabert et al. (2003) and Gou et al. (1996). These authors report that the substitution of NaCI by KCI in fermented sausages causes a significant increase in bitterness. However, Armenteros et al. (2012) observed that hams containing KCl and NaCl in equal amounts were better evaluated, except for the attribute flavor, probably due to the presence of potassium.

Regarding the attribute overall impression, the F2 sample presented a significantly higher mean ($p \leq 0.05$) than the others. However, Guardiá et al. (2008) found no differences in overall acceptability of fermented sausages formulated with 50% replacement of sodium chloride. This discrepancy may be related to differences in formulation and process conditions.

## Conclusion

Formulations F3 and F4 met the legislation requirements of a sodium-reduced product, presenting a reduction of 32 and 43%, respectively, in the sodium content. The reduction of 60% in the content of NaCl affected hardness, elasticity, and chewiness of the samples, also interfering in the attributes flavor and overall impression.

A lower concentration of sodium chloride probably did not provide an adequate dissolution and extraction of the myofibrillar proteins, altering the properties of texture. The addition of the salts

KCl, $MgCl_2$ and $CaCl_2$ in the concentrations tested reduces the acceptance of some important sensory attributes, such as flavor and overall impression.

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