PHYSICOCHEMICAL CHARACTERISTICS AND SENSORY ACCEPTABILITY OF ROAST BEEF WITH PARTIAL REPLACEMENT OF SODIUM CHLORIDE

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Abstract – Excessive sodium intake is a risk factor for chronic diseases. Sodium chloride in meat products provides microbiological stability and desirable technological and sensory effects. Therefore, the reduction of this ingredient is a challenge for the meat industry. The objective of this study was to evaluate the physicochemical and sensory characteristics of roast beef with partial replacement of sodium chloride by a commercial additive mostly composed of potassium chloride. The chemical composition, cooking yield, and post defrosting loss were analyzed and the sensory analysis of acceptance was performed. There was higher moisture content in the control treatment (without the presence of the replacement additive) and all treatments were not significantly different over the cooking yield and in post-defrosting loss. The sensory evaluation showed no difference between the control treatment and T1 treatment (with replacement of 35% of NaCl added in brine), while the T2 treatment (with replacement of 70% of NaCl added in brine) had the lowest average values in all attributes. The study showed that the replacement of 35% NaCl added in brine for commercial additive mostly composed of potassium chloride in roast beef is feasible since no changes were observed in sensory and technological characteristics evaluated.

Key Words – cooking loss, potassium chloride, post defrosting loss.

I. INTRODUCTION

Chronic Noncommunicable Diseases - NCDs - represent the main causes of morbidity: hypertension, an important risk factor for cardiovascular diseases, is the major cause of death and public health expenditure in developed countries [1, 2].

Excessive intake of food containing high rates of saturated fats, sugars and salt are considered precursor factors for NCDs. Among them, sodium stands out as a cause for concern for public health [3]. The clear relationship between excessive sodium consumption and the incidence of hypertension [4, 5] has led public healthcare regulatory agencies in various countries to recommend sodium reduction in food products [6]. It is estimated that in most of the developed countries, the daily intake of sodium chloride 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 [7, 8].

Research about the amounts of sodium in processed foods in Brazil showed that they contained an average of 710 mg of sodium / 100g of the products [9]. In the face of these significant sodium values, ANVISA agreed with the Brazilian Association of Food Industries (ABIA) targets for the reduction of sodium in foods. The purpose is to reduce individual consumption to below 5 g / day by 2020 [10].

Among the processed products consumed in Brazil, meat products stand out because of their growing demand. However, such products have high sodium levels that contribute to an excess of this nutrient in the diet. Roast beef is a ready-to-eat meat product and is characterized by brine injection into a beef top round.

Sodium chloride, besides giving desirable sensory characteristics and assisting in the microbiological stability, also performs an important role in the processing of meat products. Sodium chloride extracts and solubilizes the myofibrillar proteins by increasing the ionic strength and promoting technological properties such as the binding power and the water holding capacity. In fact, several authors have observed changes in salt penetration when replacing NaCl by a mixture of salts (KCl, $CaCl_2$ and $MgCl_2$) [11, 12]. Carraro *et al*. [12] verified the effect of sodium reduction and the use of herbs and spices in the quality and safety of bologna. They concluded that the replacement of 50% NaCl with KCl by the addition of functional herbs and spices resulted in a product with satisfactory quality and microbiological safety.

The study aimed to evaluate the effect of replacing 35% and 70% NaCl added in brine by a commercial additive mainly composed of potassium chloride on the physicochemical properties and sensory acceptance of ready-to-eat roast beef .

II. MATERIALS AND METHODS

All the treatments were produced at Minerva Fine Foods Industry and Trade Protein S/A, in the twon of Barretos, Brazil. The sodium chloride replacement used in the study was NS-969-435-4 Givaudan®, composed of potassium chloride, dipotassium phosphate, natural flavor, potato maltodextrin, sodium glutamate, lactic acid, potassium citrate, tricalcium phosphate, silicon dioxide, disodium guanylate, flavoring reaction, disodium inosinate, tartaric acid and natural flavoring.

Before processing, the raw meat was defrosted in refrigerated conditions until reached 3°C. In the production of the three treatments brine formulations were used, as shown in Table 1, and they were injected only 30% by weight.

Table 1. Roast beef brine of the treatments.

	C %	T_1 %	T_2 %
Water	83.7	83.7	83.7
Sodium Chloride	4.5	2.95	1.31
Milk Powder	4.2	4.2	4.2
Onion Powder	2.5	2.5	2.5
Sodium Tripolyphosphate	2.1	2.1	2.1
Garlic Powder	1.5	1.5	1.5
Beef flavour seasoning	1.1	1.1	1.1
Hydrolyzed protein	0.2	0.2	0.2
Sugar	0.2	0.2	0.2
Commercial additive mainly composed of potassium chloride.	-	1.55	3.19

The replacement of sodium chloride added by a commercial additive mostly composed of potassium chloride was in the brine at 35% (T_1 treatment) and 70% (T_2 treatment), while the standard control treatment (C) had the standard formulation (no added replacement of NaCl). Beef top round (95% to 97% lean) were injected at a temperature of 1.5 °C and tumbling to a vacuum of 150 mbar at 7 revolutions per minute for 40 minutes. The treatments were put in polythene roasting bags (no vacuum) and cooked for 3 hours and 30 minutes at 90°C. After cooking, the treatments were cooled to 4°C. The treatments were removed from the bags and cut into 3mm slices.

The slices were packaged in 500 gram portions and were frozen and kept at -18 ° C during the entire study to determine the moisture, ash and protein, according to AOAC [13]. The quantification of fat was performed using Bligh and Dyer method [14]. The calculation of cooking yield was done during the preparation of the treatments. The cooking yield was calculated as the percentage difference in weight between the injected raw beef top round and the cooked treatment. In determining the post-defrosting loss, the samples were weighed before and after thawing at refrigerator temperature for 48h. The post-defrosting loss was calculated as the sample weight of the thaw exudate drained liquid as a percentage of the weight of the frozen sample. All the above-mentioned analyses were performed in triplicate.

In the sensory analysis, all the treatments were labelled with 3-digit random numbers and served in random order to assessors in individual booths. Sixty-eight untrained assessors evaluated the roast beef. A hedonic test was carried out using 5-point scales in which the assessors evaluated different attributes: taste, juiciness, color and overall acceptability. The data were analyzed using analysis of variance - ANOVA, and the differences between the average results were evaluated using the Tukey test at a confidence level of 5%. The software used was MINITAB v.16 Statistical Software.

III. RESULTS AND DISCUSSION

The results of the chemical composition analysis are presented in Table 2.

Table 2. Average values (± standard deviation) of the percentage composition of the treatments.

%	C	T1	T2
Moisture	70.64 ± 0.18^{a}	68.86 ± 0.05^{b}	67.32 ± 0.21^{c}
Ashes	2.63 ± 0.02^{a}	2.49 ± 0.04^{b}	2.02 ± 0.01^{c}
Protein	26.65 ± 1.39^{a}	25.42 ± 0.25[illegible]	25.62 ± 0.32^{a}
Fat	2.44 ± 0.04^{a}	2.47 ± 0.01^{a}	1.87 ± 0.10^{b}

Averages followed by the same letter in the same line do not show significant difference ($p \leq 0.05$) in the Tukey test. C – standard control treatment; T_1 – with replacement of 35% NaCl added in brine; T_2 – with replacement of 70% NaCl added in brine.

In relation to moisture, there was a significant difference between the treatments. T2 treatment presents significantly lower fat content, probably due to difference in the raw materials (beef top round) used. The lowest fat content can affect moisture.

Table 3 presents the average of cooking yield and post defrosting loss in the three treatments.

Table 3. Average values (± standard deviation) of the cooking yield and defrosting loss

	Cooking yield (%)	Post defrosting loss (%)
C	63.89 ± 3.00^{a}	1.75 ± 1.41^{a}
T1	62.93 ± 3.09^{a}	1.22 ± 0.21^{a}
T2	62.16 ± 0.81^{a}	0.64 ± 0.52^{a}

Averages followed by the same letter in the same column do not show significant difference ($p \leq 0.05$) in the Tukey test. C – standard control treatment; T_1 – with replacement of 35% NaCl added in brine; T_2 – with replacement of 70% NaCl added in brine.

For the treatments with replacement of 35% and 70% of NaCl added in brine (T1 and T2 respectively), cooking yields did not differ significantly from the control treatment (C). Regarding the post-defrosting loss, there was also no significant difference among treatments ($p<0.05$) but it is possible to observe a tendency among values, probably due other ingredient of commercial additive like potato maltodextrin, which assists in water retention capacity. Ruusunen & Puolanne [15] reported that when the salt content is reduced, water exudates are affected first, and low-sodium meat products have a problem in both water retention capacity and emulsion stability. The study reported by Choi *et al* [16] on frankfurter sausages showed no significant effect on cooking loss in the level of NaCl reduction (addition level of 1.2%).

The results of the sensory evaluation in the acceptance test are shown in Table 4. The T1 treatment, with replacement of 35% NaCl added did not differ statistically from the C treatment in any of the measured sensory attributes. In relation to T2 treatment, with the replacement of 70% NaCl added, there was a significant decrease in average scores compared to the other treatments.

It is important to explain that the sodium reduction in the final treatments (T1 and T2) were smaller that the values reported for the replacement of sodium chloride added, since there are other ingredients in the formulation of brine that containing sodium, and the level of injection was 30%.

Table 4. Average values (± standard deviation) of the sensory evaluation.

	C	T1	T2
Taste	7.53 ± 1.24^{a}	6.91 ± 1.74^{a}	5.90 ± 1.71^{b}
Juiciness	7.40 ± 1.29^{a}	7.06 ± 1.46^{a}	5.68 ± 1.95^{b}
Color	6.85 ± 1.66^{a}	6.57 ± 1.65^{a}	5.71 ± 2.03^{b}
Global acceptance	7.04 ± 1.42^{a}	6.77 ± 1.74^{a}	5.85 ± 1.76^{b}

Averages followed by the same letter in the same line do not show significant difference ($p \leq 0.05$) in the Tukey test. C – standard control treatment; T_1 – with replacement of 35% NaCl added in brine; T_2 – with replacement of 70% NaCl added in brine.

IV. CONCLUSION

It is possible to replace NaCl by mixture of additive mostly composed of potassium chloride in brine of roast beef without impairing the cooking yield and post-defrosting loss. Replacement of 35% of NaCl added in brine by a substitute mainly composed of potassium chloride in roast beef is possible without sensory changes in the final product (with 30% level injection).

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