THE ROLE OF POTASSIUM AND CALCIUM CHLORIDE IN TECHNOLOGICAL AND SENSORY PROPERTIES OF SODIUM-REDUCED HYBRID BOLOGNA SAUSAGES

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I. INTRODUCTION

The growing consumer demand for healthier and more sustainable food options has stimulated research into developing meat alternatives, including hybrid meat products, which are partially replaced by more sustainable protein sources, primarily plant proteins. Although interest in hybrid meat products has increased in recent years, only a limited amount of research has evaluated the impact of replacing sodium chloride with potassium and/or calcium chloride in these products. Therefore, this study investigates the reduction of NaCl in soy-based hybrid bologna sausage, specifically focusing on its replacement with KCl and $CaCl_2$.

II. MATERIALS AND METHODS

Six treatments were elaborated in three independent batches, as displayed in Table 1. The formulations were prepared following a previous methodology [1]. Emulsion stability, water activity (Aw), and pH were measured at room temperature (24-25 °C) in nine replicates according to methodologies described by Paglarini et al. 2019 [1] . Texture was evaluated based on a previous methodology [2] using 18 samples from each treatment. Sensory tests received approval from the Ethics in Research Committee under CAAE number 31660120.0.0000.5404. Sensory acceptance and the Check All That Apply (CATA) test were conducted with 112 consumers according to a previous methodology [3]. Differences between treatments were evaluated using one-way ANOVA and the post-hoc Tukey's test with 95% confidence in SPSS software.

Table 1 – Formulations (g/100g) of sodium-reduced hybrid Bologna sausages

Ingredients	Treatments					
	C	HC	H-NaCl	H-KCl	H-$CaCl_2$	H-KCl/$CaCl_2$
Beef	65.00	32.50	32.50	32.50	32.50	32.50
Hydrated soy protein*	-	32.50	32.50	32.50	32.50	32.50
NaCl	2.00	2.00	1.00	1.00	1.00	1.00
KCl	-	-	-	1.275	-	0.6375
$CaCl_2$	-	-	-	-	0.6264	0.3132
Water	12.04	12.04	13.04	11.76	12.41	12.09
Ionic Strength	0.3422	0.1711	0.3422	0.3422	0.3422	0.3422

All treatments were elaborated with 10% pork back fat and 10% canola oil, 0.015% nitrite, 0.05% sodium erythorbate, 1.5% Bologna sausage condiment, and 0.003% carmine dye. * 20% of crude protein content.

III. RESULTS AND DISCUSSION

The emulsion stability (Figure 1A), pH, Aw, springiness, and cohesiveness (Table 2) were higher in hybrid bologna sausages compared to the traditional one (C), except for the treatments containing $CaCl_2$. This salt disrupted the protein matrix by reducing protein solubility, affecting emulsification and

gelation properties. The results can likely be attributed to the effect of divalent ions on protein chains and the pH reduction caused by $CaCl_2$. The control treatment exhibited greater hardness, which was expected since soy does not have the same gelling behavior as meat. Both hybrid bologna sausages, with either 100% NaCl or 50% NaCl and the addition of KCl, demonstrated high sensory acceptability.

Table 2 – Physicochemical results of sodium-reduced hybrid Bologna sausages

Parameters	Tratamentos						SEM
	C	HC	H-NaCl	H-KCl	H-$CaCl_2$	H-KCl/$CaCl_2$	
pH	5.95^{D}	6.30^{B}	6.34^{A}	6.33^{A}	5.76^{E}	6.08^{C}	0.03
Aw	0.9744^{F}	0.9782^{D}	0.9862^{A}	0.9776^{E}	0.9830^{B}	0.9801^{C}	0.001
Hardness (N)	44.91^{A}	33.65^{B}	27.62^{D}	30.74^{C}	23.37^{E}	25.47^{E}	0.88
Springiness (mm)	0.861^{B}	0.883^{A}	0.878^{A}	0.890^{A}	0.858^{B}	0.870^{B}	0.002
Cohesiveness	0.569^{B}	0.691^{A}	0.598^{B}	0.669^{A}	0.423^{D}	0.481^{C}	0.013

Treatments with the same letters in the lines did not differ according to the Tukey's test. SEM: Standard error of mean.

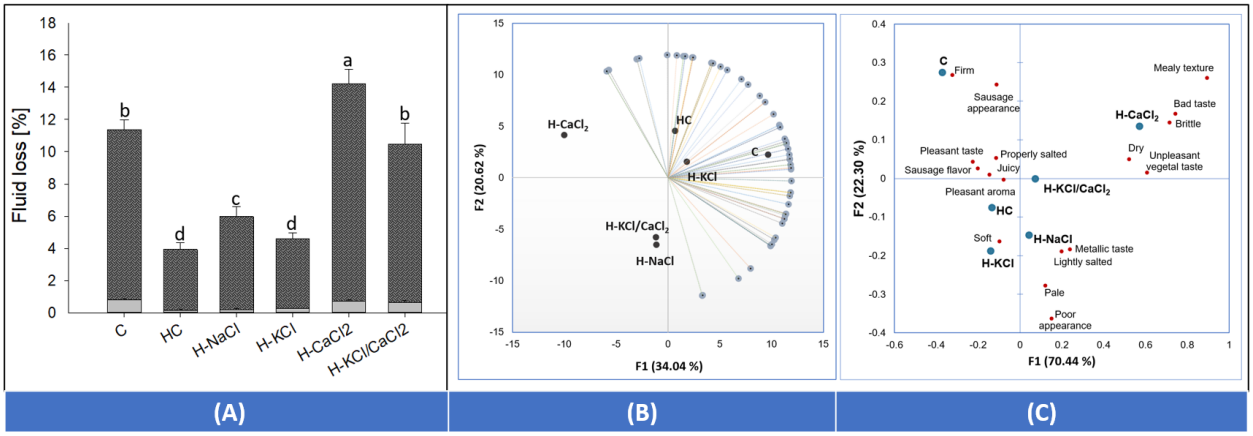

Figure 1. (A) Fluid loss (water in black and dry matter in grey), (B) internal preference mapping of overall acceptance and (C) CATA results of sodium-reduced hybrid Bologna sausage treatments. Treatments with the same letter in the columns did not differ from each other according to Tukey's test.

IV. CONCLUSION

We concluded that the impact of salt reduction in hybrid bologna sausages was partially minimized by the soy protein. Overall, the partial substitution of NaCl with KCl is feasible considering technological and sensory aspects hybrid emulsifying meat products. $CaCl_2$, on the other hand, is not suitable for reducing NaCl in soy-based hybrid Bologna sausages.

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