CONSUMER ACCEPTANCE OF DRY FERMENTED SAUSAGES WITH 50% OF THEIR NACL CONTENT REDUCED OR SUBSTITUTED WITH KCl AND/OR $CaCl_2$

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The NaCl contents in dry fermented sausages were reduced by 50% or were substituted with KCl, $CaCl_2$, or a blend of KCl and $CaCl_2$ (1:1). The just-about-right (JAR) sensory test was applied to dry fermented sausage consumers. Overall, the sensorial acceptance decreased in dry fermented sausages with reduced sodium content. However, cluster analysis and internal preference mapping revealed that there was a potential for commercialization of samples with 50% of the NaCl content substituted with KCl or with a mixture of KCl and $CaCl_2$ (1:1).

I. INTRODUCTION

Excess consumption of sodium chloride, the main source of sodium in the human diet, is associated with increased blood pressure, cardiovascular disease, and some types of cancer [1]. For these reasons, over the past few decades, public health bodies and regulatory authorities have established programs to promote the reduction in dietary sodium chloride intake, so as to decrease the incidence of chronic diseases related to high sodium [2]. These global recommendations are highly relevant due to the fact that approximately 80% of sodium consumed by people originates from the consumption of industrialized food [1]. Of all meat products, fermented sausages are amongst those with higher sodium contents. Depending on the formulation, fermentation, and maturation conditions, this type of product may contain approximately 60% of the recommended sodium intake stated by the World Health Organization [2, 3] in a 50 gram portion.

Sodium chloride (NaCl) is the main source of sodium in dry fermented sausages, and therefore, in order to obtain healthier products, this ingredient must be eliminated or reduced. However, tackling this is a huge challenge, since in addition to being a low cost ingredient, NaCl significantly affects sensorial quality. In addition to providing the characteristic salty taste of meat, NaCl also accentuates the taste and flavor of other components and reduces the perception of other stimulants, such as the bitter taste of some compounds [4].

Potassium chloride (KCl) is one of the ingredients most often used reducing the sodium content [3, 5, 6, 7]. However, sensorial defects related to emerging bitterness and decreased saltiness have been reported when KCl is used as a sole substitute, constituting the main limitations of its use as a substitute of NaCl in fermented meat products [5, 7, 8]. Calcium chloride ($CaCl_2$) is another ingredient that may be used as a NaCl substitute in meat products. However, there is little information about the effect of using $CaCl_2$ alone or in conjunction with KCl on the sensory quality of dry fermented sausages with reduced NaCl content.

Thus, the aim of this study was to assess the sensorial characteristics of dry fermented sausages with 50% of their NaCl content reduced or substituted with KCl, $CaCl_2$, or a blend of KCl and $CaCl_2$ (1:1).

II. MATERIALS AND METHODS

Treatments

Dry fermented sausages with 50% of their NaCl content reduced or substituted with KCl, $CaCl_2$, or a blend of KCl and $CaCl_2$ (1:1) were produced (Table 1).

Table 1. Levels of sodium chloride, potassiun chloride, and calcium chloride used in dry fermentec sausage formulations.

	Treatments (%)				
	Control	F1	F2	F3	F4
NaCl	2,5	1,25	1,25	1,25	1,25
KCl	-	-	1,25	-	0,625
$CaCl_2$	-	-	-	1,25	0,625

* Control- 100% NaCl, F1- 50% NaCl, F2- 50% NaCl andd 50% KCl, F3- 50% NaCl and 50% $CaCl_2$, F4- 50% NaCl, 25% KCl and 25% $CaCl_2$.

Consumer study

The study protocol was approved by the Research Ethics Committee of the University of Campinas under number 130260. The just-about-right (JAR) and overall acceptability sensory test was applied to 106 dry fermented sausage consumers, with 57% being women and 43% being men, ranging in age from 18 to 54 y. The sensorial acceptance test was performed using a non-structures nine-point hedonic scale. JAR questions were answered on a nine point scale, where 1–4 is extremely less than optimal, 5 is optimal, and 6–9 is extremely more than optimal. This scale was used to assess salty flavor and the texture of dry fermented sausages [9]. In both the tests, samples were assigned a three-digit code and were evaluated by each consumer in a monadic order, and the order of presentation followed a balanced design as described by Stone, Bleibaum, and Thomas [10]. The consumer study was performed in normalized booths under fluorescence lighting.

Statistical analysis

The results of the consumer test were analyzed using an analysis of variance (ANOVA) test, and the mean values were compared using the Tukey post-test, with a significance level of 5% ($p \leq 0.05$). Penalty analysis was performed on overall liking scores based on JAR question responses [11]. Agglomerative hierarchical clustering was used to cluster consumer segments, using a dissimilarity matrix with Euclidean distance with Ward's method [7]. An ANOVA was again performed on these overall liking scores to see if differences existed among the consumer clusters, in which cluster and treatment were fixed effects and consumers were random effects. Internal preference mapping was performed by the principal component analysis (PCA) on the correlation matrix of consumers by products. Internal preference maps transformed consumer acceptance scores into a set of preference dimensions that represent the differences among the samples. Individual acceptance scores are represented by vectors that show the individual directions of increasing preference [12]. In this method, PCA was first applied on the consumer data in order to interpret the consumer feelings about the different products. This helped obtain a PCA scores plot and a PCA loadings plot, with the samples as scores and the individual consumer preferences as loadings. Next, all of the sensory attributes were regressed onto the estimated PCA scores from the consumer data, using the linear model [13]. All the analyses were performed using the software XLSTAT 2013 for Windows (Adinsoft, Paris, France).

III. RESULTS AND DISCUSSION

Using JAR scores (Table 2), no treatment was considered excellent for the analyzed attributes. From the sensory standpoint, the acceptance did not reach 70% of the responses in the range of 5–9 points [14]. For salty flavor, values varied from 46.23% (control) to 23.58% (F2 and F3). For texture, these values varied from 52.89% (control) to 32.08 (F3). Penalty analysis indicated that for salty taste, the highest values were recorded for treatments F3 (50% NaCl and 50% $CaCl_2$) and the control, with 2.274 and 1.007 ($p < 0.0001$ and $p < 0.003$, respectively). However, for texture, the value varied between 1.154 ($p < 0.001$, control) and 0.596 ($p < 0.094$, F4; 50% NaCl, 25% KCl, and 25% $CaCl_2$). Generally speaking, the results suggest that the addition of $CaCl_2$ to dry fermented sausages must be done with caution in order to not have a negative impact on the consumer's perception of salty taste. Interestingly, the penalty values for treatments with 50% reduced NaCl substituted with KCl were intermediate, with values between 0.692 and 0.926 for salty taste and 0.596 and 0.846 for texture. This suggests that KCl should be added to mixtures of substitute salts that are added to the dry fermented sausages. Our results generally reinforce the current challenge of reducing the sodium chloride content in meat products, indicating that further strategies are needed to minimize the sensorial defects caused by using other chloride salts.

Table 2. Sensorial acceptance and just-about-right (JAR) results of dry fermented sausages with 50% NaCl substituted with KCl and/or $CaCl_2$.

Salty taste (%)	Control	F1	F2	F3	F4
Too less	25.47^{c}	38.68^{b}	41.51^{a}	51.89^{a}	41.51^{a}
JAR	46.23^{a}	44.34^{a}	23.58^{b}	23.58^{b}	33.02^{a}
Too more	28.30^{a}	16.98c	34.91^{a}	24.53^{b}	25.47^{b}
Texture (%)					
Too less	17.92^{b}	28.30^{b}	39.62^{a}	45.28^{a}	45.25^{a}
JAR	52.89^{a}	48.11^{a}	39.62^{a}	32.08^{b}	42.45^{a}
Too more	29.35^{a}	23.58^{b}	20.75^{b}	22.64^{b}	12.26^{c}

Means in the same line with the same lower case letter are not significantly different according to a Tukey post-test ($p \geq 0.05$). Just JAR values are displayed as percentages of consumer ratings from options: 1–4 for much lower, 5 for optimal, and 6–9 for much higher. Treatments as described in Table 1.

The internal preference map (Figure 1) explained 64.70% of the variation in consumer acceptance of dry fermented sausages, with 45.02% and 19.68% in the first and second dimensions, respectively. The first dimension separated the treatments into two groups: 1) control (100% NaCl) and F1 (50% NaCl) and 2) F2 (50% NaCl and 50% KCl). The second dimension separated the treatments into a third group composed of treatments with added calcium chloride (F3 + F4). Most consumers were located to the right side (Figure 1) of the map providing evidence that the Control, F1 (50% NaCl), and F2 (50% NaCl and 50% KCl) treatments were preferred. These treatments were characterized by the reduction in NaCl as well as the addition of KCl. On the other hand, treatments F3 (50% NaCl and 50% $CaCl_2$) and F4 (50% NaCl, 25% KCl and 25% $CaCl_2$) were not well accepted amongst consumers.

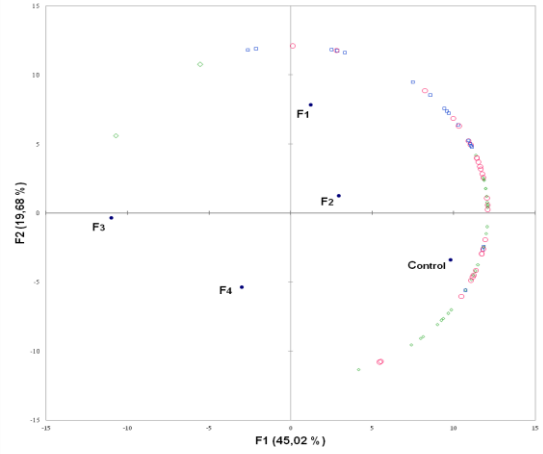

Figure 1- Internal preference map of consumers of dry fermented sausages. ○- Cluster 1 (n=34), □- Cluster 2 (n= 34) and ◊- Cluster 3 (n= 38). Treatments as described inTable 1.

The resulting dendogram of the hierarchical cluster analysis (HCA, Figure 2) resulted in three similarly distributed segments, according to the number of people, with the first and the second having 34 people (cluster 1 and 2) and the third having 38 people (cluster 3). The control sample had the highest values with regard to the overall acceptance (Table 3), varying from 8.03 to 6.35 in segments 1 and 3. However, in segment 2, sample F1 (50% NaCl) had the highest value for overall acceptance, with 7.09 ($p < 0.05$). Generally speaking, the HCA results showed that there is commercialization potential for samples with 50% reduced sodium content in formulation F2 (50% NaCl and 50% KCl) and F4 (50% NaCl, 25% KCl, and 25% $CaCl_2$), showing that there is a consumer market for these treatments. These results will be useful for the meat product industry, where it has been widely reported that success from a sensorial point of view is only possible with a 40% reduction in NaCl [5]. Future studies need to assess the development of the sensorial profile of products using descriptive testing, such as quantitative descriptive analysis [15]. Finally, methodologies that involve increased consumption of special foods, such as repeated exposure [16], should be equally evaluated.

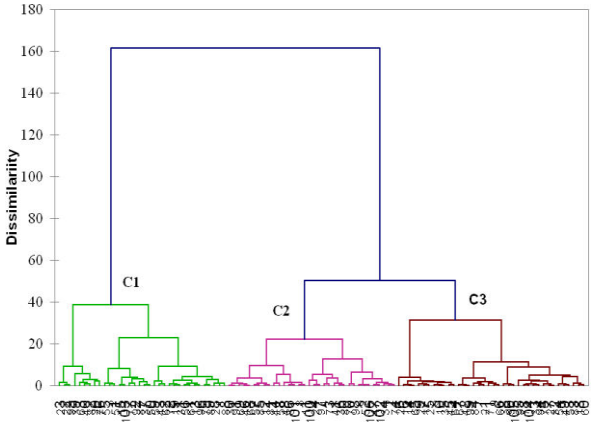

Figure 2- Dendogram of consumers of dry fermented sausages. Cluster 1 (n=34), Cluster 2 (n= 34) and Cluster 3 (n= 38). Treatments as described in Table 1.

Table 3. Means of overall acceptability of dry fermented sausages with 50% NaCl substituted with KCl and/or $CaCl_2$.

Treatments	Overall acceptability		
	Cluster 1 (n= 34)	*Cluster 2* (n=34)	*Cluster 3* (n= 38)
Control	6,35[b]	6,65[b]	8,03[a]
F1	4,85[b]	7,09[a]	6,74[a]
F2	5,29[b]	5,94[b]	7,32[a]
F3	3,09[b]	5,32[a]	5,27[a]
F4	3,47[c]	5,59[b]	7,05[a]

Means in the same line with the same lower case letter are not significantly different according to LSD test ($p \leq 0.05$) between clusters. Treatments as described in Table 1.

IV. CONCLUSION

Generally, dry fermented sausages manufactured with reduced NaCl were less accepted by the consumers. Using cluster analysis and an internal preference map identified that a group of consumers existed for dry fermented sausages with a 50% reduced NaCl content substituted with KCl or a blend of KCl and $CaCl_2$ (1:1). Thus, optimizing treatments must be noted to improve the sensorial quality by using other flavor enhancing ingredients, which minimize the sensorial defects and maintain the quality and safety characteristics of dry fermented sausages, is important.

ACKNOWLEDGEMENTS

The authors thank FAPESP (Research Support Fund of the State of São Paulo) for the financial support to the development of the research project.

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