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Reducing fat and sodium content in pork sausage

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This work aimed to prepare pork sausage using xanthan gum and light salt (NaCl/KCl) to replace the fat and common salt (NaCl), respectively, and to assess the impact of the changes in the chemical and sensory characteristics of the product. The consumers evaluated sensory acceptance with respect to flavor, odor, texture and appearance (mixed 9-point structured hedonic scale). The use of xanthan gum resulted in a decrease of 27.27% in fat content, 19.54% in the energy value and an increase in the percentage of moisture, thus giving a higher industrial yield. With the use of light salt, there was a reduction of 71.77% in sodium and an increase of 124.73% in potassium content. Formulation 1 scored the highest means for acceptance of appearance. On the other hand, formulation 2 scored the highest means for acceptance for the other attributes.

Key-words: Meat products, light salt, sensory acceptance.

INTRODUCTION

Government agencies recommend that the population adopts dietetic practices and life styles that promote health and reduce the occurrence of chronic degenerative diseases. Among the various dietetic practices, the reduction of fat and sodium intake stands out. It is estimated that 35% of the population in Brazil over 40 years of age suffers from high blood pressure (HBP), corresponding to 17 million Brazilians. The main factors of risk for HBP are reported in the V Brazilian Directive of High Blood Pressure of the Brazilian Society of Cardiology (BSC) as follows: age, sex and race, socioeconomic factors, salt-rich diet, obesity, abusive use of alcohol and sedentarism. With respect to diet therapy, the same directive classifies foods rich in sodium and saturated fats as “risk foods” for HBP, and those rich in fibers and potassium as “protective foods” (BSC et al., 2007). For processed meat products, salt is important for the solubilization of myofibrillar proteins, for altering the product’s texture, and also for changing the flavor and the aroma as well as increasing the commercial shelf life (Ruusunen

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et al., 2003). Salt (NaCl) is the main source of sodium in our diets, work
as a preservative in foods because of its osmotic effect at high concentrations and its ability to reduce the lower water activity in food, thus reducing or even stopping vital microbial processes. (Tobin et al, 2012).

An important role of food technology is to develop products for consumers with different profiles. Meat products processing can be done with reduced sodium content and this strategy should be encouraged by the Ministry of Health of Brazil (Sichieri et al., 2000). The reduction and substitution of sodium in processed meats are intensively studied; there is still a need to develop new approaches to reduce sodium without sacrificing quality and safety of the product being especially important to identify approaches to keep the salty taste that is traditionally associated with the meat processed and at the same time avoiding the introduction of non-traditional fragrances that are often associated with a decline in consumer acceptance (McGough et al., 2012).

There has been a worldwide increase in the consumption of industrialized foods due to a lack of availability for the acquisition and preparation of foods and meals, mainly because of a lack of time. The adoption of this new food habit is characterized by the ingestion of high calorie-dense foods, rich in refined sugars, fats, sodium and preservatives, and poor in complex carbohydrates and dietary fibers (Diez Garcia, 2003). Evidence that the consumption of sodium in the diet can be crucial to a consumer group with hypertension, must be limited to reduce the risk of heart disease. There is excess sodium intake as dietary recommendations in most industrialized countries, therefore reducing the sodium in foods can be of great interest from the point of view of health (Armenteros et al, 2012). Due to the current consciousness of the population with respect to the benefits of a healthy diet, capable of preventing and/or aiding in the treatment of various diseases, the food industry aims to improve the quality of their products by the use and/or substitution of their additives (Miravalhes and Garcia, 2009). Meat products and their derivatives are no exception. Apart from the investment in technology to decrease the fat content of the products, as in the case of light products, various studies have investigated the possibility of improving the quality of meat products even more by introducing dietetic fibers into the formulation and substituting the common salt (100% NaCl) with light salt (50% NaCl and 50% KCl), consisting of a mixture of sodium and potassium chlorides (Nascimento et al., 2007).

Meat products contain about 20 to 30% fat for technological reasons and for sensory characteristics that gives the product. The indiscriminate consumption of fat can cause health related problems such as atherosclerosis, colon cancer, obesity, among others. Thus, consumers have preferred products with low or reduced fat, while having the sensory properties of traditional food. The fat substitutes are products that provide physical and sensory properties similar to fat, but without providing calories (Galvan et al., 2011). The production of low fat may cause technological problems due to the fact that it affects texture. One of the most promising fat substitutes is carrageenan gum, which give product sensory characteristics closer to those of the traditional product (Cierach et al., 2009).

The objectives of the present study were to develop a cured meat product (pork sausage) containing xanthan gum for the reduction of the fat content and the replacement of common salt with light salt and carry out chemical, microbiological and sensory evaluations of the product, with the aim of obtaining a healthier meat product.

MATERIALS AND METHODS

Processing

The pork sausage samples were manufactured from legs of pork provided by the slaughterhouse under Federal Inspection Service (FIS) in Campos dos Goytacazes, Rio de Janeiro State, Brazil. The legs of pork were cleaned and prepared in the Animal-Derived Technology Sector of UENF and the meat temperature was determined using a digital check temp thermometer. Meat with a temperature above 7°C was removed from the production line so as to avoid affecting the quality of the product. They were then deboned using the semi-membranous, biceps femoral and vastus cuts, and the intramuscular fat removed. After preparing the cuts, they were divided and weighed. Based on these weights, the amounts of the ingredients and additives were determined for each treatment (Table 1). For each of the three formulations, five portions were prepared.

Physico-chemical analyses

The analyses were conducted in the food chemistry and biochemistry sector of the Center for Agricultural Sciences and Technology of Food Technology Laboratory of North Fluminense State University and done in duplicate. Moisture content was determined after the sample was heated in an oven at 105°C until constant weight (Brazil, 1981). Protein percentage was determined by the Kjeldahl method (Brazil, 1981). Fat percentage was determined by the method proposed by Bligh and Dyer (1959), which is intended for the analysis of food with high moisture content. Ash was determined by incineration in a muffle furnace between 500 and 550°C (Brazil, 1981). Energy value was calculated by adding the percentage of protein times four to the fat content times nine. The sodium and potassium contents were determined by flame photometry after wet oxidation of the organic matter in the samples using nitric and perchloric acids (Brazil, 1999).

Table 1. Composition of three pork sausage formulations.

Raw material	Formulation 1 (%)	Formulation 2 (%)	Formulation 3 (%)
Pork meat	82.03	85.03	82.03
Pork jowl	14.60	7.30	14.60
Xanthan Gum	-	0.60	-
Cold water	1.00	4.70	1.00
Common salt (NaCl)	1.80	1.80	-
Light salt (NaCl/KCl)	-	-	1.80
Sugar	0.095	0.095	0.095
Garlic	0.19	0.19	0.19
Black pepper	0.24	0.24	0.24
Sodium nitrite	0.015	0.015	0.015
Sodium erythorbate	0.030	0.030	0.025

Microbiological analyses

All the microbiological analyses (*Salmonella* spp., Sulfur-reducing Clostridia, fecal Coliforms and *Staphylococcus aureus*), were carried out according to Silva et al. (1997). Portions of 25 g from each sample were weighed aseptically and placed in 225 mL of 0.1% sterilized peptone water, for posterior homogenization in a Stomacher, thus obtaining the initial dilution of 10^{-1}. Further dilutions were prepared form the first one, up to 10^{-3}, by diluting 1 mL of the previous dilution with a further 9 mL of the diluent.

Sensory evaluation for acceptance

The three pork sausage formulations were submitted to a sensory consumer acceptance test carried out in the Sensory Analysis Laboratory of the Center of Agriculture Science of Federal University of Espírito Santo, Alegre, ES, Brazil. 41 consumers were recruited after an evaluation of their replies to the recruitment questionnaire, distributed amongst the employees and graduate and postgraduate students of the Center of Agriculture Science of Federal University of Espírito Santo. The questionnaire contained a Consent Form which was signed by the consumer if he accepted taking part voluntarily in the test, as demanded by Resolution n^{o}.196 of 10/10/1996 of the National Health Council (Brazil, 2003). The consumer recruitment criteria were as follows: Age between 18 and 45 years, liking pork sausage to a degree equal or above “like moderately”, have no history of diseases involving diet restrictions for any of the ingredients in the pork sausage, and also showing themselves to be interested and morally bound to the research project.

The consumers evaluated the acceptance of the three formulations (1, 2 and 3) with respect to flavor, odor, texture and appearance using a mixed 9-point structured hedonic scale (Stone and Sidel, 1993). The evaluation of flavor, odor and texture was carried out in individual booths, illuminated by a red light. The samples were served at a temperature of 10 ± 2°C in the form of 5 mm thick slices of approximately 5 cm in diameter, on disposable white plastic plates coded with 3 digit numbers defined at random, and were accompanied by tooth picks, paper napkins, a cracker and mineral water. The evaluation of acceptance according to appearance was carried out under white incandescent light. For the latter, the samples were exposed as 5 mm thick slices of approximately 5 cm in diameter on white disposable plastic plates, coded at random with 3-digit numbers. The order in which the consumers evaluated the samples was sequential, following a randomized complete block design.

Experimental design and statistical analyses

The results of chemical composition (moisture, protein, fat, ash, Na and K), microbiological analyses (*Salmonella* spp., *Staphylococcus aureus,* fecal coliforms at 45°C and sulfite-reducing Clostridia 46°C) and sensory acceptance were compared according to a completely random design (CRD). The results from the analyses were submitted to the analysis of variance (ANOVA) followed by Tukey’s test at the 5% level to compare the averages of each analysis in the three treatments (SAS, 2003). The sensory data were also evaluated by frequency distribution of consumer responses, in percentage.

RESULTS AND DISCUSSION

Chemical analysis

The percent composition and energy average values for the samples analyzed are shown in Table 2. Sample 2 with the addition of xanthan gum showed the highest moisture level, which can be explained by xanthan gum’s ability to retain water. From the industry perspective, this is a desirable characteristic, since it increases the product’s yield. Hsu and Chung (2000) evaluated the effect of adding carragenean gum to emulsified meat products and observed that there was a significant difference ($p<0.05$) in the percent composition of the products prepared. Values close to 60% of moisture were found for the products with carragenean gum, which agrees with the present research work. The replacement of part of the swine fat with xanthan gum in sausage 2 resulted in a reduction of 71.77% of fat content and of 14.33% of energy value, as expected. Similar results have been

Table 2. Energy value and chemical composition of the three pork sausage formulations.

Composition	Formulation		
	1	2	3
Energy value (Kcal/100g)	170.9 ±16.4	153.6 ±14.9	179.3 ±31.4
Moisture (%)	63.5 ± 0.5[b]	65.2 ± 0.6[a]	61.9 ± 1.5[b]
Protein (%)	19.1 ± 1.4[a]	18.6 ± 0.8[a]	17.6 ± 2.9[a]
Fat (%)	10.5 ± 1.2[a]	8.8 ± 1.3[b]	12.1 ± 2.2[a]
Ash (%)	3.6 ± 0.2[b]	3.8 ± 0.1[a]	2.5 ± 0.1[c]
Na (mg/100g)	1053.1 ± 1.6[a]	1096.4 ± 4.1[a]	309.5 ± 0.5[b]
K (mg/100g)	234.3 ± 0.3[b]	234.1 ± 0.9[b]	526.1 ± 0.6[a]

*Averages on the same line followed by different letters vary significantly from each other according to Tukey's test (p<0.05).

Table 3. Results of the microbiological analyses and maximum permitted limits for the microorganisms according to ANVISA (BRAZIL, 2001).

Microorganism	Result*	Legislation (limit)
Salmonella spp.	Absent	Absence
Staphylococcus aureus	Absent	5×10^3
Fecal Coliforms at 45° C	Absent	5×10^3
Sulfite-reducing Clostridia 46° C (maximum)	Absent	3×10^3

*The results were the same for the 3 formulations.

observed in other studies, which showed a reduction in product's fat content as the use of carragenean gum increased (Abiola and Adegbaju, 2001; Paulino et al., 2006). The average protein contents were about 18.5% and did not show statistical difference (p>0.05) among the different formulations. Protein contents close to 19% are extremely desirable for meat products, placing them in compliance with the standards defined by the Technical Rules for Sausage Identity and Quality (Brazil, 2000). All formulations showed significant statistical differences among the ash content (p<0.05). Sample 2 (3.8%) showed the highest ash content value. This is probably due to the reduction in fat content, because as this occurs, an increase in moisture, protein and ash contents is expected.

Ash values of 1.82% were found for the control formulation as well as an average of 3.54% for the formulations in which fat was replaced with carragenean gum (Abiola and Adegbaju, 2001). In those samples, the ash values almost doubled after the gum was added. Ash values of 3.87% for fresh pork meat products have been found before (Zanardi et al., 2002) and associated to the known effect of xanthan gum on the reduction of fat content. They were closer to the value found for formulation 2 from the present research work, in which the type of salt used resulted in a range of ash values. When the replacement of common salt with light salt is analyzed, a decrease in the ash content is observed (p<0.05). According to these data, both the addition of another salt and the use of xanthan gum influenced the ash content of meat products. For formulation 3, in which common salt (NaCl) was replaced by light salt, there was a reduction in sodium (Na) content of 71.77%. Thus, 100 g of traditional product contains 1096.4 mg of sodium while 100 g of the product prepared with light salt had 309.5 mg. The highest potassium (K) content were observed for formulation C, due to the use of light salt, and was 2.25 greater than those contents present in formulations 1 and 2, in which common salt was used. This is considered a benefit and is recommended by the BSC (2004), since potassium helps the metabolism and reduces the risk for high blood pressure.

Microbiological analyses

Table 3 shows the results for the microbiological analyses. The microbiological analyses were performed immediately after preparation. As can be seen, the microorganisms under investigation were not found in any of the three formulations, showing the efficiency of the good manufacturing practices with respect to handling of the ingredients, slaughter, manufacturing process and storage of the pork sausage. Serio et al. (2009) showed indications of inadequate hygienic- sanitary conditions during

Table 4. Sensory acceptance means for the pork sausage (n = 41 consumers).

Formulation	Acceptance mean [1, 2]			
	Appearance	Odor	Flavor	Texture
1	6.9^{a}	5.5^{b}	6.8^{ab}	5.7^{b}
2	4.6^{b}	6.8^{a}	6.9^{a}	7.1^{a}
3	4.9^{b}	6.6^{a}	6.0^{b}	5.6^{b}

[1]The same letters in the same column do not differ significantly, $p < 0.05$. [2]1 = dislike extremely / detested; 5 – neither dislike / nor like; 9 = like extremely /adored.

the processing, transport and distribution of 10 samples of hot-boned pork sausage commercialized in Fortaleza, CE, Brazil. The samples showed contamination by coliforms at 35°C, in addition to the growth of molds, yeasts and aerobic, mesophilic bacteria. This was contrary to the report of Blesa et al. (2008), who investigated the influence of different salt mixtures in the partial substitution of NaCl of raw hams during the post-salting period, and found satisfactory microbiological results, guaranteeing that the substitution of NaCl by KCl did not interfere with the microbiological safety of the product, as confirmed by the results of the present study.

Sensory acceptance

Table 4 shows the means for sensory acceptance for the pork sausage formulated according to Table 1. In general, these means were between 4.6 and 7.1, between the categories "dislike slightly" and "like moderately" on the hedonic scale (Table 4).

In the evaluation of appearance, formulation 1 showed significantly ($p \leq 0.05$) higher means for acceptance, close to the categories "like moderately". On the other hand, formulations 2 and 3 did not differ from each other ($p \leq 0.05$) for either acceptance, with means for acceptance between "dislike slightly" and "neither like nor dislike" (Table 4). These results can be confirmed from the graphic visualization of the frequency distribution of the consumer responses with respect to the appearance of the pork sausage (Figure 1): formulation 1 showed 88% of the responses in the region of acceptance on the hedonic scale, in a category equal or above "like slightly".

With respect to the evaluation of the odor of the pork sausage, the inverse occurred, and formulations 2 and 3 presented the highest means for acceptance, between "like slightly" and "like moderately", differing significantly from formulation 1, which had a mean in the neutral region (5.5). In fact, analyzing the score frequency distribution for the hedonic attribute of odor (Figure 1), it can be seen that formulations 2 and 3 presented greater proportions of scores in the region of acceptance (80%), whereas formulation 1 was only 66%. It can also be seen that formulation 2 had a greater proportion of scores in the categories "like moderately" and "like extremely / adored" than formulation 3.

Formulation 2 presented higher means for the acceptance of both flavor and texture, both close to the category "like moderately". With respect to flavor, this formulation only differed significantly from formulation 3, and with respect to texture, it differed significantly from the other two formulations. Analyzing the figure for the score frequency distribution for the flavor of the pork sausage (Figure 1), formulations 1 and 2 were confirmed to be equal with 83% of the scores in the acceptance region, differing from formulation 3 with 61% in this region. With respect to texture, formulation 2 was the best accepted by the consumers with 88% of the scores in the acceptance region, that is between "like slightly" and "like extremely/adored".

On adding insoluble wheat fiber to one of his cooked ham formulations, Baldissera (2007) showed that the addition of fiber to meat products could modify their texture, making them less soft and/or less succulent, thus decreasing their acceptance. In the sensory evaluation of dehydrated, fermented Frankfurter-type sausages with added pectin, extracted from different fruits, Garcia et al. (2002) showed that a concentration up to 1.5% of fiber did not alter the flavor or texture of the products as compared to the control, whereas the addition of 3% fiber decreased acceptance of the texture. In a study to evaluate the quality of light mortadella sausage and fat-free frankfurter sausage with added oats, Steeblock et al. (2001) also showed reduced softness of the products. Thus, with respect to the interference by xanthan gum in the flavor and texture of the pork sausage, this study is in agreement with that of Garcia et al. (2002) who showed that fiber percentages above 1.5% could decrease the acceptance of meat products.

Conclusion

Xanthan gum is a good substitute for fat, resulting in a

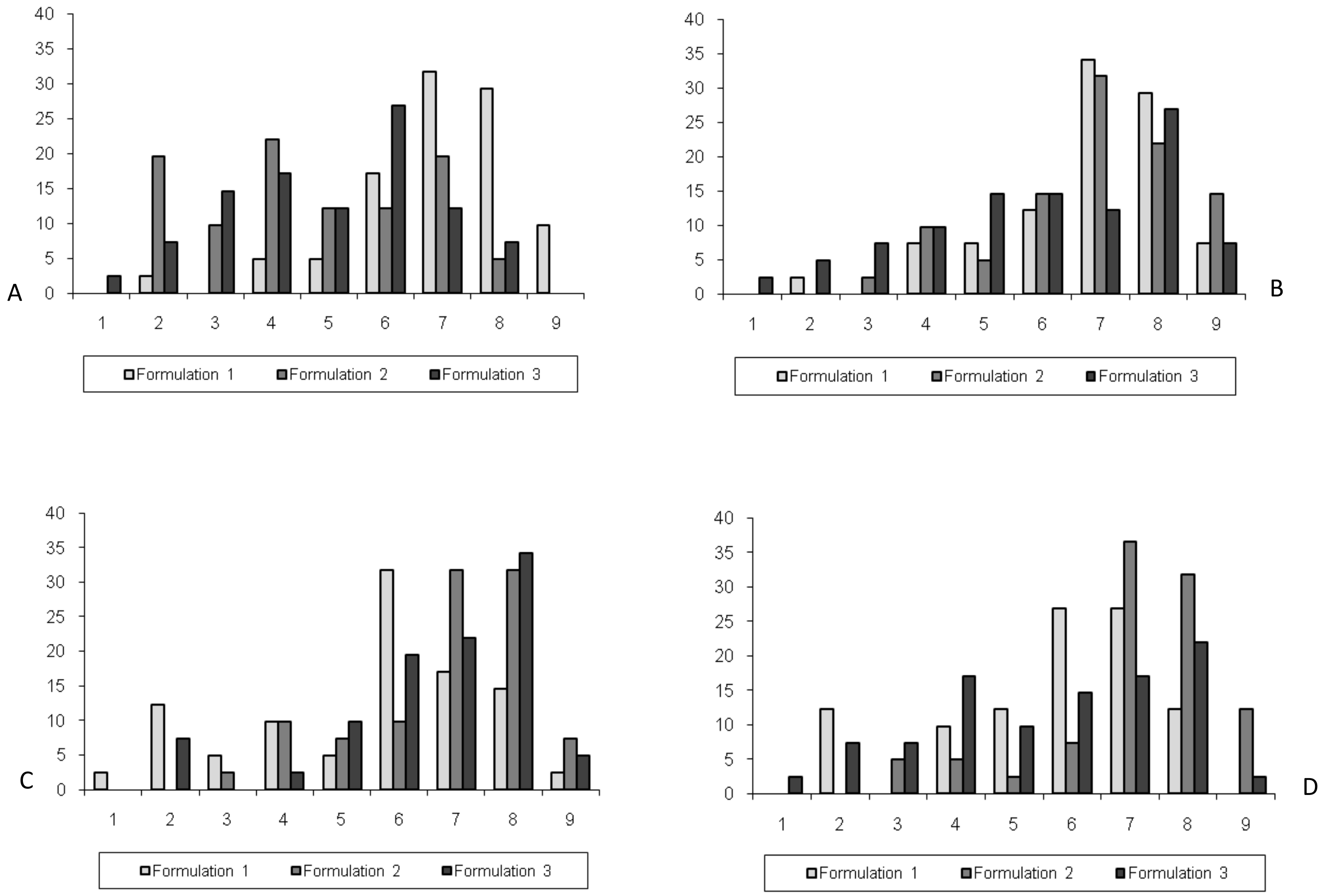

Figure 1. Distribution of the frequency of the consumer responses as a function of the following attributes: A, Appearance; B, odor; C, flavor and D, texture (1 = dislike extremely / detested, 5 = neither like / nor dislike, 9 = like extremely / adored).

decrease of the product's energy value between 14.33 and 19.54%. The use of 1.8% of light salt is feasible, and allows a reduction in sodium chloride content of 71.77% and an increase in K levels of 124.73%. The sodium and potassium contents assured that the pork sausage of the formulation 3 (1.80% NaCl/KCl) could be introduced into the diet of those suffering from circulatory disorders with a greater frequency. The sensory analyses showed that formulation 1 showed the highest means for the acceptance of appearance. On the other hand, formulation 2 obtained higher acceptance means for the other attributes (odor, flavor and texture), according to the consumers.

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