THE EFFECT OF SODIUM REDUCTION ON THE MICROBIAL, CHEMICAL AND SENSORY QUALITY OF A PORK SAUSAGE

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Abstract - Research has established that too much sodium is being consumed as sodium chloride or table salt. With the focus on meat products and pork in particular, the possible effects of sodium reduction on the microbial, chemical and sensory properties of a pork banger-style sausage was investigated. Reducing the amount of table salt normally added to a pork sausage, to either one of two possible maximum target levels or completely excluding any addition of salt, had negative effects on product quality and shelf-life. This initial research established that suitable analogues to salt need to be investigated over strategies that simply aim to remove salt without maintaining its functional and sensory contributions to a processed meat product.

I. INTRODUCTION

Consumers, now more than ever before, are aware of the relationship between sodium (Na) intake and hypertension. This situation in part, is responsible for the increase in demand for meat products with reduced Na content. In recent decades the increased consumption of processed foods containing high levels of salt has changed the public's perception of dietary salt. It is now considered a potential health threat (1). In terms of the human diet, it is widely accepted that table salt i.e. sodium chloride (NaCl), is the main source of Na (2). There is a progressive increase in the blood pressure levels of individuals and increasing prevalence of age-associated hypertension across populations which appear to be directly correlated to Na intake (3). As many as 1 in 4 adults worldwide is thought to suffer from hypertension (4) and the average South African urinary sodium (Na) excretion was found to be in excess of 2400 mg Na/day (5). In sharp contrast to these findings, the physiological need for sodium was found to be approximately 90 mg Na/day and the latest recommendation of the World Health organization (WHO) is that no more than 2000 mg Na/day should be consumed (6). Discretionary salt use is a bigger problem in South Africa than in other, more affluent Westernized countries (7). The South African Government through the Department of Health (DoH) published a draft of regulations on the 20th of March 2013 limiting the use of Na in food products. Under this new draft "raw-processed meat sausages (all types) and similar products" may not contain more than 800 mg Na/100 g by the 30th of June 2016 and no more than 600 mg Na/100 g by the 30th of June 2019 (8). These regulations may contribute to improving the health of the average South African and may possibly help to lighten the strain on an already overburdened public health system.

The aim of this study was to evaluate the possible effects of decreasing NaCl levels on the microbial, chemical and sensory quality of a typical South African fresh pork sausage.

II. MATERIALS AND METHODS

Preparation of sausage models

Four batches of pork sausages were formulated and manufactured to each contain one of four possible final Na levels (Table 1). The first batch contained 0% added NaCl as the negative control, the second batch contained 1% added NaCl to comply with the 2019 Na target level, the third batch contained 1.5% added NaCl to comply with the 2016 Na target level and the fourth batch contained 2% NaCl as the current usage level. Henceforth the treatment groups were respectively only referred to as 0% NaCl added, 1% NaCl added, 1.5% NaCl added and 2% NaCl added. After manufacturing the sausages were individually placed in expanded polystyrene (EPS) trays, over-wrapped with polyvinyl chloride (PVC) film and stored either at 4°C under retail refrigeration-type fluorescent lighting for fresh product shelf-life determination, or at -18°C for frozen product

Table 1 The formulation, Na and NaCl content of the four batches of pork sausages.

Contents	Treatment Group			
	0% NaCl Negative control	**1% NaCl** 2019 target (< 600 mg Na/100 g)	**1.5% NaCl** 2016 target (< 800 mg Na/100 g)	**2% NaCl** Positive control
Pork 90/10 (g)	1420.22	1395.22	1382.72	1370.22
Backfat (g)	562.50	562.50	562.50	562.50
Ice water (g)	375.00	375.00	375.00	375.00
Rusk (g)	87.50	87.50	87.50	87.50
Starch (g)	20.00	20.00	20.00	20.00
Spices (g)	34.78	34.78	34.78	34.78
NaCl (g)	0.00	25.00	34.78	50.00
Total (g)	2500.00	2500.00	2500.00	2500.00
% Ash*	1.23^{a}	2.35^{b}	3.03^{c}	3.51^{d}
% NaCl/100 g (Volhard)*	0.36^{a}	1.26^{b}	1.70^{c}	2.17^{d}
mg Na/100 g (AAS)*	316.82^{a}	619.85^{b}	748.35^{c}	927.07^{d}

*Significance level = $p < 0.001$

lipid stability determination.

The sausages were manufactured in three separate rounds with an interval of one month between rounds during which the sausages from the previous round were analysed. The intervals were used as a way of negating any possible effect from raw material variation, especially the highest mass raw materials, the meat and backfat. A fourth round of sausages was prepared to be used for sensory evaluation exclusively.

Sausage sampling

The fresh product shelf-life sampling was done on days 0, 3, 6 and 9 and the frozen product lipid stability sampling was done on days 0, 90 and 180. For microbial and chemical analyses, four sausages for each one of the four treatment groups were sampled on the above mentioned days, while those destined for sensory evaluation were sampled directly after manufacturing.

Analytical procedures

Microbial analyses for total bacterial counts (TBC) were performed according to Harrigan (9). The NaCl content was determined by the Volhard method of titration (10) and Na content was determined using Atomic Absorption Spectrometry (AAS) (Varian Spectra 3000 spectrometer). Thiobarbituric acid reactive substances (TBARS) were determined quantitatively as indicator of the level of secondary oxidation product formation (11). Sensory evaluation was carried out using a 75-member consumer panel. A nine-point hedonic scale ranging from 1 for dislike extremely up to 9 for like extremely was used to score taste, texture, saltiness and overall liking as attributes. Samples were encoded with a randomized, 3-digit code unique to each sample to prevent the development of bias by the consumers. Diluted apple juice was used as a palate cleanser between each sample.

Statistical analyses

The research was carried out as a 4 x 3 factorial design representing four salt level treatments with three replicates per treatment. An analysis of variance (ANOVA) procedure was used for the determination of differences between the different treatments. The Tukey-Kramer multiple comparison test was used to identify differences between the treatment means.

III. RESULTS AND DISCUSSION

A stepwise increase in the percentage of NaCl/100 g product as determined by the Volhard method was found (Table 1). This was reflected in both the increase in percentage ash as well as the increase in the actual amount of Na/100 g as determined by AAS. The actual amount of Na/100 g product of the 1% NaCl added group and 1.5% NaCl added group were close to the 2019 target of 600 mg Na/100 g product and the 2016 target of 800 mg Na/100 g product, respectively. At 316.82 mg Na/100 g product, the 0% NaCl added group contained almost half the amount of Na of the 2019 target and at 927.07 mg Na/100 g product the 2% NaCl added group (current usage level) contained significantly ($p < 0.001$) more Na than the first reduction target of 2016.

No immediate effect of different NaCl contents on the TBC were seen as illustrated by the results of Day 0 (Fig. 1). A significant difference ($p < 0.05$) was found after Day 3 between the 2% NaCl added group and the 0% NaCl added group. This difference remained constant even as the TBC of all four treatment groups increased. After Day 9 the significance ($p < 0.001$) was more pronounced as the 2% NaCl added group experienced a slight decline in TBC compared to the slight increase in TBC experienced by the three other treatment groups. Although the amount of Na needed to inhibit microbial growth varies according to a number of factors (12), it is clear that NaCl

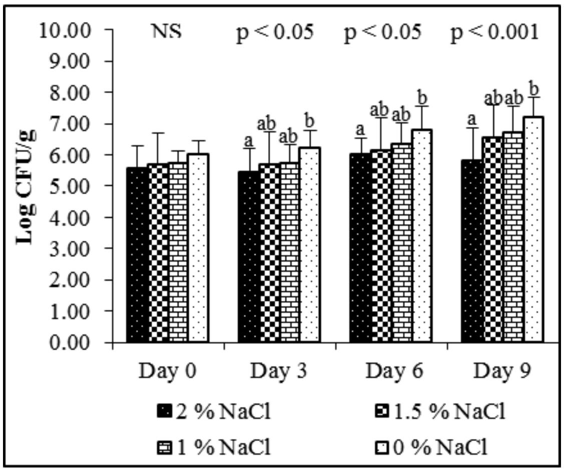

Figure 1 Total bacterial counts after 9 days storage at 4°C.

concentration plays a major role in microbial control.

The 75-member consumer panel consistently scored the 0% NaCl added group significantly ($p < 0.001$) lower than the other three treatment groups for all four of the chosen sensory attributes (Fig. 2). Consumers were able to detect and indicate the negative effect that low NaCl content has on the texture of a meat product. Furthermore, they were able to distinguish between the 2%, 1% and 0% NaCl added groups in terms of saltiness with a preference for the highest NaCl containing sausage compared to the lowest NaCl containing sausage.

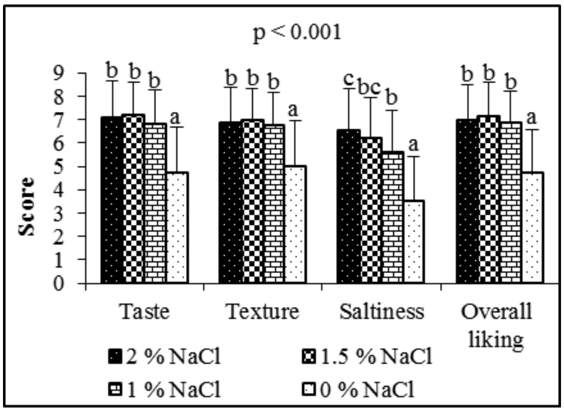

Figure 2 Scores of the four treatment groups for each of the four selected sensory attributes.

Salt has been reported as being pro-oxidative at inclusion levels of between 0.5-2.5% (13) causing damage to lipids which in turn negatively affects food quality (14).The TBARS of all four treatment groups were below the sensory threshold of 1 mg malonaldehyde/kg of sample (15) on day 0 (Fig. 3). From the results after 90 and 180 days it became clear that secondary oxidation could be correlated to different levels of added NaCl or the absence of added NaCl. After 90 days, the 2% NaCl added group had a TBARS value that was significantly ($p < 0.001$) higher than that of the 0% NaCl added group and somewhat lower than that of the 1.5% NaCl added group. After 180 days storage, all four treatment groups had increased TBARS values with only the 1.5% and 1% NaCl added groups having significantly ($p < 0.01$) higher TBARS values than the 0% added NaCl group.

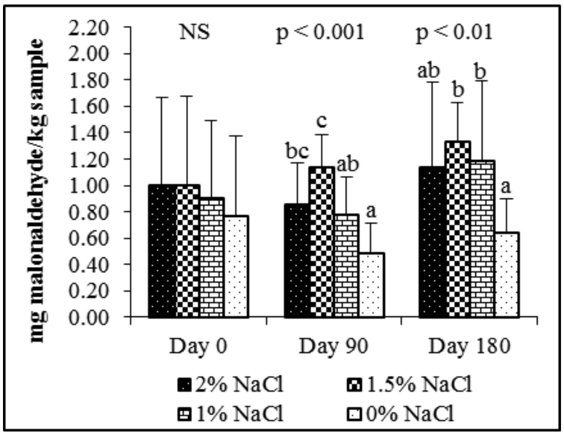

Figure 3 TBARS values after 180 days storage at -18°C.

IV. CONCLUSIONS

The major difference in NaCl content, especially between the highest and lowest inclusion levels, confirmed the negative effect NaCl reduction may have on a given product's microbial shelf-life. Consumers were acutely aware of drastic changes in NaCl content and disliked the effect of very low NaCl content on taste and texture. Consumers' affinity for a strong salty taste need to be addressed or satisfied by a sodium-reduced product in order to decrease high discretionary salt use. In contrast to these findings, drastic (0% NaCl added) and even mild (1% NaCl added) changes to NaCl content was shown to improve the lipid oxidative stability over long storage periods. Reducing the NaCl content of a meat product without adding other substances to fulfil the functions of the reduced NaCl content creates a number of challenges that may otherwise have been avoided.

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REFERENCES

1. Doyle, M.E. (2008). Sodium reduction and its effects on food safety, food quality, and human health. Food Research Institute Briefings. www.fri.wisc.edu/docs/pdf/FRIBriefSodiumReductFRI1108.pdf. Retrieved on 28 February 2013.
2. Reddy, K.A. & Marth, E.H. (1991). Reducing the sodium content of foods: A Review. Journal of Food Protection 54, 138-150.
3. Dickinson, B.D. & Havas, S. (2007). Reducing the population burden of cardiovascular disease by reducing sodium intake: a report of the Council on Science and Public Health. Archives of Internal Medicine 167, 1460-1468.
4. Kearney, P.M., Whelton, M., Reynolds, K., Muntner, P., Whelton, P.K. & He, J. (2005). Global burden of hypertension: analysis of worldwide data. Lancet 365, 217-223.
5. Charlton, K.E., Steyn, K., Levitt, N.S., Zulu, J.V., Jonathan, D., Veldman, F.J. & Nel, J.H. (2005). Diet and blood pressure in South Africa: intake of foods containing sodium, potassium, calcium and magnesium in three ethnic groups. Nutrition 21, 39-50.
6. WHO. (2007). Reducing salt intake in populations. Report of a WHO forum and technical meeting, 5-7 October 2006. Paris, France. www.who.intl/dietphysicalactivity/ redreducingsaltintak.pdf. Retrieved on 20 June 2013.
7. Charlton, K.E., Steyn, K., Levitt, N.S., Zulu, J.V., Jonathan, D., Veldman, F.J. & Nel, J.H. (2005). Diet and blood pressure in South Africa: intake of foods containing sodium, potassium, calcium, and magnesium in three ethnic groups. Nutrition 21, 39-50.
8. South African Department of Health. (2013). Regulations relating to the reduction of sodium in certain foodstuffs and related matters. The Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972). Government Gazette No. 36274, 20 March 2013. Government Notice No. R. 214.
9. Harrigan, W.F. (1998). Laboratory Methods in Food Microbiology. Academic Press. San Diego, California.
10. AOAC. 1990. Official Methods of Analysis, 15th Ed. Methods 32.034-32.039. Gaithersburg, MD.
11. Raharjo, S., Sofos, J.N. & Schmidt, G.R. (1993). Solid-phase extraction improves thiobarbituric acid method to determine lipid oxidation. Journal of Food Science 58, 921-924
12. Doyle, M.E. & Glass, K.A. (2010). Sodium reduction and its effects on food safety, food quality and human health. Comprehensive Reviews in Food Science and Food Safety 9, 44-56.
13. Rhee, K.S. & Ziprin, X.A. (1987). Lipid oxidation in retail beef, pork and chicken muscles as affected by concentrations of heme pigments and nonheme iron and microsomal enzymatic lipid peroxidation. Journal of Food Biochemistry 11, 1-15.
14. Decker, E.A. (1998). Strategies for manipulating the prooxidative/anti-oxidative balance of foods to maximise oxidative stability. Trends in Food Science and Technology 9, 241-248.
15. Gray, J.I. & Pearson, A.M. (1987). Rancidity and warmed-over flavour. In: A.M. Pearson & T.R. Dutson (Eds.) Advances in Meat Research, Vol 3. pp. 221-270. New York: Van Nostrand Keinhold Company