A new processing method to reduce sodium in sausages without potassium chloride and phosphates

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Abstract — **High sodium intake can promote hypertension, which increases the risk of cardiovascular disease. As meat products typically contain high levels of sodium, reducing sodium concentrations is an important challenge. Chlorides such as potassium chloride (KCl) are commonly used instead of sodium chloride (NaCl), but these agents have an astringent flavor, while the phosphates added to sausage to give elasticity have been reported to promote osteoporosis. This study investigated methods of improving the physical properties and enhancing saltiness of reduced sodium sausages, without using KCl or phosphates. The addition of basic amino acid and the partial replacement of pork with chicken were performed in order to give an appropriate texture. Furthermore, granular gelatin and soy sauce were added to enhance the saltiness. To examine the effects of these changes on the physical properties and saltiness of reduced sodium sausages, shear force values were investigated, and scanning electron microscopy and sensory evaluation were performed. Physical and histological analysis suggested that the sausages had an appropriate texture and exhibited a dense microstructure similar to that in the positive control (2.0% NaCl). On sensory evaluation, subjects reported that the saltiness of reduced sodium sausage (1.0% NaCl) was equivalent to 1.4% NaCl, which matched the preference of the panelists. Based on these findings, sodium can apparently be reduced by almost half, while producing sausages with acceptable texture and saltiness.**

Keywords — **reduced sodium sausage, improvement of texture, saltiness enhancement**

I. INTRODUCTION

Meat and meat products are important protein sources. Although the sodium content of the meat itself is less than 100 mg Na per 100 g [1] [2], meat products usually contain much higher sodium levels due to the salt content, which can be as high as 2% in cooked products and as high as 6% in uncooked cured products [2]. NaCl is an essential ingredient in processed meat products, contributing to the water-holding capacity, fat binding properties, antimicrobial properties and sensory properties. In addition, sodium is present in both the salt and various other additives, including monosodium glutamate, sodium phosphate and soy protein.

Excess intake of sodium is known to be linked with hypertension [3], which increases the risk of coronary heart disease [4]. Consumers have thus become more interested in reduced sodium meat products, and there is now greater demand for such products [1].

In reduced sodium products, it is necessary to complement the role of NaCl. The commonly used approaches are to replace all or part of the NaCl with other chloride salts, such as KCl, and to add phosphates in order to give elasticity to meat products [5]. It has been reported that the salt normally present in meat products can be reduced by as much as 50% with phosphates [2], and that reducing sodium can be achieved with blends of NaCl and KCl [6]. However, phosphates are now thought to contribute to osteoporosis [7] [8]. Although potassium phosphates can be used, the taste of potassium is unfavorable. Similarly, KCl has an astringent and bitter taste [6], which is unacceptable to most Japanese.

This study was conducted with a focus on physical properties and flavor. The aim was to improve the physical properties and to enhance the saltiness of reduced sodium sausage without using phosphates or KCl. We attempted to add sodium by using only NaCl and sodium nitrite, and did not add monosodium glutamate, soy protein or other sodium-containing compounds.

II. MATERIALS AND METHODS

Shear force measurement and scanning electron microscopy were performed in order to investigate whether the addition of basic amino acid and the changes in raw material composition resulted in the appropriate texture and microstructure (test A). Sensory evaluation was performed in order to investigate whether saltiness perception is enhanced by coarse-ground processing and addition of granular gelatin and soy sauce, and to investigate the preference of saltiness (test B).

Sausage preparation

In test A, after mincing the meat, emulsification of the meat mixture was performed in a vacuum bowl cutter. Meat samples were then stuffed into ϕ40-mm casings and cooked in a water bath for 60 min at 75°C.

The experimental conditions for test A were as follows (each sample contained 12% water and 0.01% sodium nitrite):

A-1. 2.0% NaCl, pork
A-2. 1.0% NaCl, pork
A-3. 1.0% NaCl, pork, 0.5% basic amino acid
A-4. 1.0% NaCl, pork and chicken (2:1), 0.5% basic amino acid
A-5. 1.0% NaCl, pork and chicken (1:1), 0.5% basic amino acid
A-6. 1.0% NaCl, pork and chicken (1:2), 0.5% basic amino acid

In test B, minced meat was mixed in a mixer for coarse-ground sausages. The other processes for coarse-ground sausage and emulsified sausages were performed as described for test A.

Experimental conditions for test B were as follows (each sample contained 12% water and 0.01% sodium nitrite):

B-1. 0.8% NaCl, emulsified
B-2. 1.0% NaCl, emulsified
B-3. 1.2% NaCl, emulsified
B-4. 1.4% NaCl, emulsified
B-5. 1.6% NaCl, emulsified
B-6. 1.8% NaCl, emulsified
B-7. 2.0% NaCl, emulsified
B-8. 1.0% NaCl in total, including 1.5% granular gelatin, 2.5% soy sauce, coarse-ground
B-9. 1.2% NaCl in total, including 1.5% granular gelatin, 2.5% soy sauce, coarse-ground

NaCl contents of B-8 and B-9 were calculated to include sodium present in the soy sauce (15% NaCl).

Shear force measurement

Sausages (A-1 ~ A-6) were cut into small pieces (1 × 1 × 2 cm), and the shear force values for more than 10 pieces from each sample were measured using a Rheometer with a wedge-shaped plunger.

Scanning electron microscopy (SEM)

Specimens were prepared for SEM. Samples were fixed in 2.5% glutaraldehyde in phosphate buffer, pH 7.4, for 4 days. Samples were cut into small pieces (5 × 5 × 10 mm), and were rinsed in distilled water for 3 days at room temperature. Pieces were then placed in 1% tannic acid for 3 hours, rinsed in distilled water (15 min × 3 times), and post-fixed in 1% OsO_4 for 1 hour. After dehydration through a graded ethanol series, samples were frozen in ethanol and fractured using a razor blade and hammer. Specimens were freeze-dried in *t*-butyl alcohol [9]. Dried specimens were coated with osmium and platinum, and observed under an SEM with an accelerating voltage of 5 kV.

Sensory evaluation

Examination of perception and preference of saltiness was performed with 70 panelists (30 panelists in 20's, 4 in 30's, 6 in 40's, 4 in 50's and 2 in 60's). Evaluations were performed with sausage (B-1 ~ B-9) sliced to 1-cm in thickness. The saltiness test evaluated which samples from B-1 ~ B-7 corresponded to the saltiness of B-8 and B-9. Higher points were given to more favorable sausage samples, 0 (unfavorable) ~ 5 (favorable), and total scores were calculated.

Statistical analysis

Data for shear force measurement are expressed as means ± standard deviation, and the statistical significance of differences was evaluated using Tukey-Kramer's multiple range test.

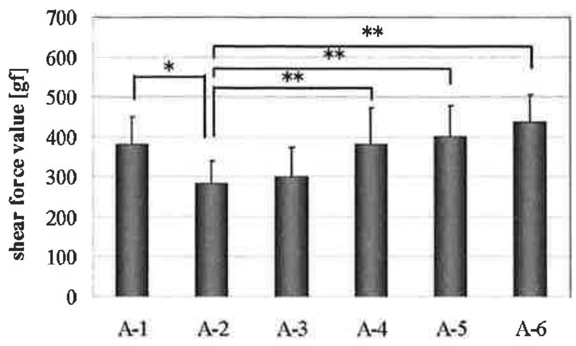

Fig. 1 Shear force values for A-1 ~ A-6.
Asterisk indicates significant differences ($p < 0.05$, ** $p < 0.01$).*

III. RESULTS AND DISCUSSION

Figure 1 shows the results for shear force measurement of various samples with different salt contents and raw material compositions (test A). Shear force values for sausage consisting of 1.0% NaCl and pork (A-2) were significantly lower when compared with sausage consisting of 2.0% NaCl and pork (A-1). The physical properties of A-3, which contained basic amino acid, tended to be better, but there were no significant differences in shear force value. Furthermore, partial replacement of pork with chicken improved the physical properties to a comparable level as A-1. There were significant differences ($p < 0.01$) in the sausages containing chicken and basic amino acid (A-4 ~ A-6) when compared to A-2.

Figure 2 shows the microstructure of A-1, A-2 and A-6, as observed by SEM. Although the surface of A-2 was rougher than A-1, that of A-6 was as smooth as A-1. It was thought that chicken and basic amino acid give a dense structure to the sausage, thereby creating a surface smooth. It seemed that the tissue condition gradually improved as the content of chicken increased in A-4 ~ A-6, although observations of A-4 and A-5 were not performed. The results shown in Fig. 2 indicated the same trends as in Fig. 1.

Figure 3 shows the results of sensory evaluation of coarse-ground sausage with granular gelatin and soy sauce (test B). The saltiness of coarse-ground sausage with 1.0% NaCl, including 1.5% granular gelatin and 2.5% soy sauce (B-8), was similar to that of the emulsified sausage with 1.4% NaCl (B-4), while that of the coarse-ground sausage with 1.2% NaCl, including granular gelatin and soy sauce (B-9), was equivalent to the emulsified sausage with 1.6% NaCl (B-5). These results suggest that coarse-ground processing and addition of granular gelatin and soy

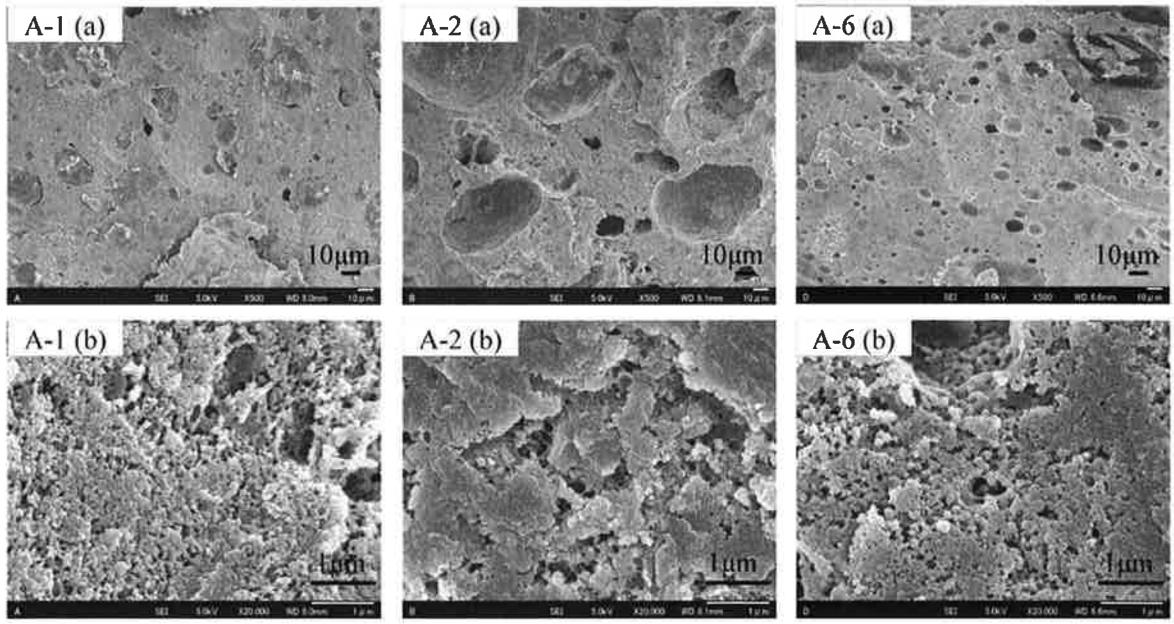

Fig. 2 Microstructure of sausages (A-1, A-2 and A-6) observed by SEM.
Upper images were obtained at 500-fold magnification (a), and lower images were obtained at 20000-fold magnification (b).

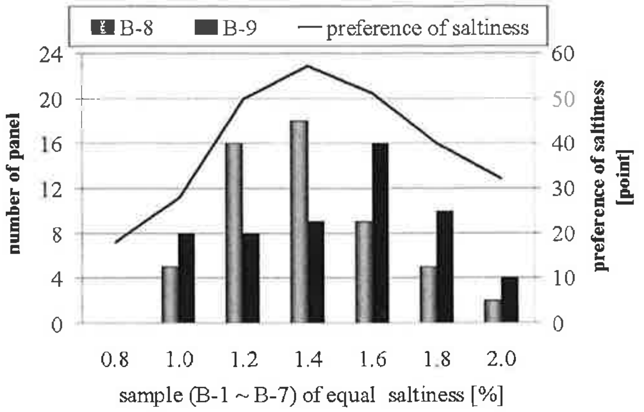

Fig. 3 Results of sensory evaluation of B-8 and B-9 and preference for saltiness perception.
Bar graphs indicate the number of panellists who felt that the saltiness of B-8 and B-9 was equal to that of B-1 ~ B-7. Line chart indicates the total points given for saltiness preference among B-1 ~ B-7 (0 ~ 5 points/panelist).

sauce enhance saltiness. Granular gelatin in sausage melts and spreads throughout the mouth, which may contribute to delivering NaCl and increasing the perception of saltiness. It has also been reported that the aroma of soy sauce strengthens saltiness [10]. These effects may therefore enable the panel to perceive the sausage as being more salty. The preference of saltiness for B-4 was the highest among B-1 ~ B-7. These findings indicate that the saltiness of B-8 matched the panel preference. Furthermore, B-8 was found to have a savory taste and a good total balance, which suggests that good flavor can be achieved without monosodium glutamate and sodium inosinate. We also obtained good physical properties in the coarse-ground processing as with emulsified processing.

It has been reported that when frankfurters were produced without phosphate, additional ingredients such as starch were needed when the salt content was lower than 1.5% [11]. In this study, sodium reduced to 1.0% NaCl using neither phosphates nor additional ingredients by partial replacement of pork with chicken and adding basic amino acid. Sodium in sausage can therefore be reduced to 1.0% NaCl while still providing a favorable flavor.

IV. CONCLUSIONS

This study suggested that the sodium content of sausages can be reduced by almost half (1.0% NaCl) without using KCl, phosphates and other additives, including monosodium glutamate, sodium inosinate and soy protein, while yielding sausage with favorable texture and taste. These results were achieved by replacement of pork with chicken, as well as addition of basic amino acid, granular gelatin and soy sauce, and the use of coarse-ground processing.

REFERENCES

1. Ruusunen, M. (2005) Reducing sodium intake from meat products. Meat Science, 70, 531-541.
2. Colmenero, J. F. (2001) Healthier meat and meat products: their role as functional foods. Meat Science 59, 5-13.
3. Fries, H. A. (1976) Salt volume and the prevention of hypertension. Circulation, 589-595.
4. Feng J. H. (2010) Reducing Population Salt Intake Worldwide: From Evidence to Implementation. Progress in Cardiovascular Diseases 52, 363-382.
5. Sofos, J. N. (1989) Phosphates in meat products. In S. Thorne (Ed.) Development in food preservation 5, 207-252, New York: Elsevier Applied Science.
6. Terrell, R. N. (1981) Chloride salts and processed meats: properties sources, mechanisms of action, labelling. In Proceedings of Meat Industry Research Conference, 67-94, Arlington, Va: American Meat Institute Foundation.
7. Remet, T. (1994) Estimation of the renal net acid excretion by adults consuming diets containing variable amounts of protein. The American Journal of Clinical Nutrition, 59, 1356-1361.
8. New, S. A. (2002) Nutrition Society Medal lecture. The role of the skeleton in acid-base homeostasis. Proceedings of the Nutrition Society, 61, 151-164.
9. Inoue, T. (1988) A new drying method of biological specimens of scanning electron microscopy: The t-butyl alcohol freeze-drying method. Archives Histology and Cytology 51, 53-59.
10. Mitsuya, S. (2007) Does shoyu odor strengthen salty flavour? The Japanese Journal of Taste and Smell Research 14, 1, 3-8.
11. Ruusunen, M. (2003) Physical and sensory properties of low-salt phosphate-free frankfurters composed with various ingredients. Meat Science 63, 9-16.