EFFECT OF SODIUM TRIPOLYPHOSPHATE ON GELATION PROPERTIES OF LOW-SALT BEEF GELS

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Abstract – Dynamic rheological properties, cooking loss and water holding capacity were investigated in reduced NaCl (2.5, 2.0, 1.5, 1.0 and 0%) salt soluble myofibrillar beef protein gels with the addition of 0.3% sodium tripolyphosphate (STPP). STPP addition to the reduced-NaCl gels resulted in higher storage modulus (G') values. With STPP addition, there were no significant differences in cooking loss and water holding capacity of the gels containing reduced amount of NaCl as compared to control with only 2.5% NaCl content. Based on the data obtained from the present study, it could be suggested that STPP would be a sound alternative salt replacer in meat systems.

Key Words - Dynamic rheological properties, Meat proteins, Salt reduction

I. INTRODUCTION

Epidemiological studies have shown that there is a direct relationship between dietary sodium intake, and hypertension and cardiovascular diseases [1]. Daily consumption of sodium chloride higher than 6g/day/person has an increasing effect on blood pressure [2]. Therefore, limiting dietary sodium chloride intake has been recommended in Western diet [3], in most cases, particularly for individuals possessing hypertensive risk genetically, salt intake needs to be reduced 1-3g/day [4]. In a typical Western diet, approximately 20-30% of NaCl comes from meat products, which leads to a rising demand for reduced sodium or low salt meat products [5].

In meat products, NaCl contributes to flavor and shelf life stability in addition to its role in improving textural and water binding properties. Reducing NaCl content not only causes sensory problems but also decreases extractability of salt soluble myofibrillar proteins (SSMP), thus, negatively affects functional properties of the meat systems [6]. One of the strategies to overcome problems due to NaCl reduction in meat systems is to substitute NaCl with sodium tripolyphosphate (STPP) to enhance water binding and texture of the ultimate product. STPP is a commonly used compound in meat systems for reduction of cooking and cooling losses and improvement of binding capacity as well as for its role as partial salt replacer [7]. The objective of the present study was to evaluate rheological properties, cooking loss and water holding capacity of beef salt soluble myofibrillar protein (SSMP) gels as a function of reduction in NaCl ratio and addition of STTP.

II. MATERIALS AND METHODS

Beef *semimembranosus* muscles were purchased from a local market in Oxford (UK) for the three replications. Beef muscles trimmed of visible fat and connective tissue and cut into (5x10 mm^2) small pieces were vacuum-packed with polyethylene bags, transferred to the lab, kept at -18°C for further analyses no more than a week.

Extraction of salt soluble myofibrillar proteins (SSMP): Salt soluble muscle protein was extracted according to the method described by Chen *et al*. [8] with slight modifications. All preparation conditions were carried out approximately at 10°C. Beef thawed at 4°C over night and three volumes of isolation buffer (0.5 M KCl, 17.8 mM $Na_5P_3O_{10}$, pH 8.7) were blended using a laboratory blender at high speed for 60s. The slurry was kept at 4°C for 1h followed by centrifugation at 10.000 rpm for 30 min using Beckman model J2-21centrifuge. The protein extract was filtered with three layers of cheese cloth and distilled water was used to dilute the filtrate for precipitation of proteins. To collect the proteins, the mixture was centrifuged at 4°C for 15 min at 10.000 rpm. Protein content was determined by the micro Kjeldahl method. Nitrogen content was converted to protein by multiplying by 6.25. Protein concentration of the extract was adjusted to 8% using the same isolation buffer.

The SSMP obtained were divided into five equal parts. NaCl at 2.5% used as blind control (2.5-NaCl) as generally used in regular comminuted meat products. To other four groups, NaCl at 2, 1.5, 1.0, and 0% with 0.3%STPP was added (group 2.0-NaCl, 1.5-NaCl, 1.0-NaCl, and 0-NaCl, respectively). SSMP from each treatment group kept at 4°C overnight was stuffed into the plastic tubes (19 mm in diameter) followed by gelation at 80°C for 30 min in a water bath. The gels were removed from water bath and cooled in cold water for 15 min, then, stored at 4°C overnight. These gels were used for water holding capacity and cooking loss measurements.

Dynamic rheological properties: Dynamic rheological measurement was performed using Bohlin Gemini200 rheometer. A parallel plate, 55 mm in diameter was used with the 1 mm gap size. Single frequency at 1 hz was used for heating the samples from 25 to 75°C at 2°C /min heating speed. The data were collected by the Bohlin software and monitored during analysis at each temperature. Viscoelastic and gelation properties (storage modulus G', and loss modulus G") of duplicate SSMP mixtures were determined within the linear viscoelastic region.

Cooking loss (CL): Duplicate cooled gels stored at 4°C for 1 day were dried with filter paper and CL was determined by the method reported by Cong-Gui *et al.*[9], and was calculated as a percentage based on the raw stuffed weight.

Water holding capacity (WHC): Gel samples (19 mm in diameter, 10 mm in height) were weighed into the centrifuge tubes with absorbent cotton on the bottom, and centrifuged at 3000 rpm at 4°C for 10 min) to determine WHC [10]. WHC was expressed as the ratio of centrifuged gel weight to the initial gel weight.

Data from three replications were analyzed with analysis of variance and Duncan's test using SAS system 9.

III. RESULTS AND DISCUSSION

Dynamic rheological properties of heat induced gelation of SSMP were described by both storage modules G' (shows the elasticity of material) and loss modules G" (indicates the viscosity of material). During heating, SSMP shows three dimensional viscoelastic behavior [8, 11]. STPP addition to the reduced-NaCl gels resulted in higher G' values with increases depending on the reduction in NaCl concentrations (Fig. 1). Barbut *et al.* [12] reported that poultry meat batters with lower NaCl ratio had greater G' value, however, this was not the case for beef batters. STPP addition at 0.3% into the gels, resulted in higher G' values, probably due to its pH increasing effect.

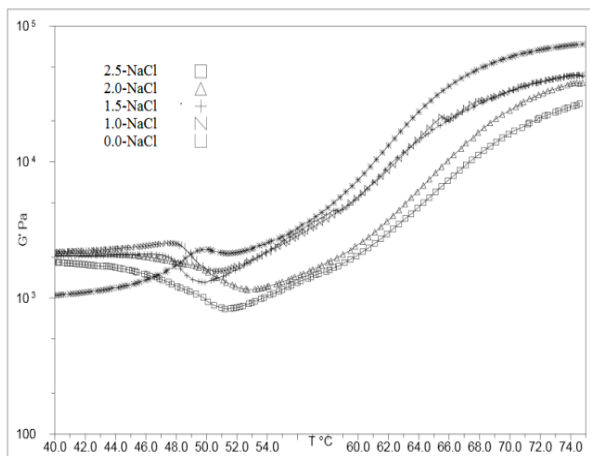

Fig. 1. Effect of NaCl reduction with STPP addition on changes in storage modulus (G') of beef gels

Reduction in NaCl concentration up to 1.0% did not exhibit significant change ($p>0.05$) in cooking loss (CL) due to addition of STTP (Fig. 2). Only STPP addition without NaCl resulted in the highest CL as compared to the other groups ($p<0.05$). NaCl with STPP synergistically improves texture of meat batters and reduces the cooking loss [13].

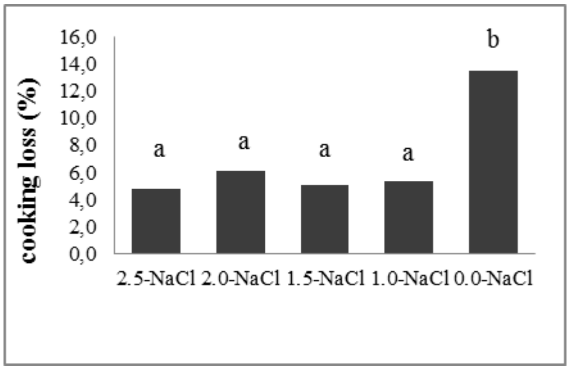

Fig. 2.Effect of NaCl reduction with STPP addition on changes in CL. Bars having different letters are significantly different (p<0.05).

There was no significant difference (p>0.05) in water holding capacity (WHC) values between reduced-NaCl groups with STPP and the control (2.5-NaCl) without addition of STPP (Fig. 3).

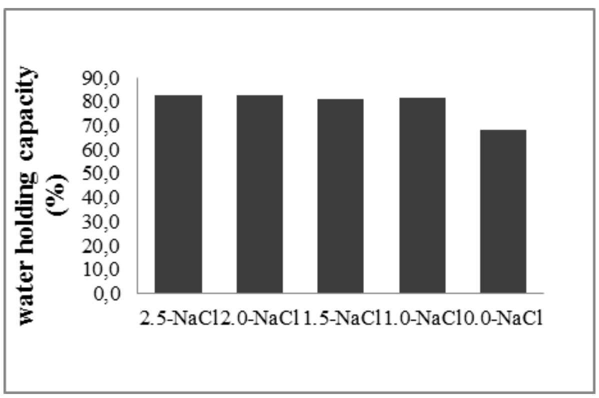

Fig. 3. Effect of NaCl reduction with STPP addition on changes in WHC.

IV. CONCLUSION

The effect of salt reduction with the addition of STPP was investigated in beef protein gels. STPP addition to reduced-NaCl beef gels (at all NaCl concentrations tested) was effective in improving rheological and physical properties. STTP addition into reduced-salt meat systems as an alternative strategy would be beneficial when it is used in combination with the other ingredients contributing salty flavor. Future research should focus on combined effects of different salt substitutes on the rheological and textural characteristics of meat gel systems.

REFERENCES

1. Antonios, T.F.T. & MacGregor, G.A. (1997). Production and processing of healthy meat, poultry and fish products. Blackie Academic & Professional 84-100.

2. Ruusunen, M., Vainionpaa, J., Lyly, M., Lahteenmaki, L., Niemisto, M., Ahvenainen, R. & Puolanne, E. (2005). Reducing the sodium content in meat products: The effect of the formulation in low-sodium ground meat patties. Meat Science 69(1): 53-60.

3. Barbut, S. & Mittal, G.S. (1989). Effects of salt reduction on the rheological and gelation properties of beef, pork and poultry meat batters. Meat Science 26(3): 177-191.

4. Alino, M., Grau, R., Baigts, D. & Barat, J. M. (2009). Influence of sodium replacement on the salting kinetics of pork loin. Journal of Food Engineering 95(4): 551-557.

5. Verma, A.K. & Banerjee, R. (2012). Low-sodium meat products: retaining salty taste for sweet health. Critical Review in Food Science and Nutrition 52(1): 72-84.

6. Totosaus, A. & Perez-Chabela, M.L. (2009). Textural properties and microstructure of low-fat and sodium-reduced meat batters formulated with gellan gum and dicationic salts. Lwt-Food Science and Technology 42(2): 563-569.

7. Robe, G.H. & Xiong, Y.L. (1992). Phosphates and muscle-fiber type influence thermal transitions in porcine salt-soluble protein aggregation. Journal of Food Science 57(6): 1304-&.

8. Chen, H.H., Xu, S.Y. & Wang, Z. (2007). Interaction between flaxseed gum and meat protein. Journal of Food Engineering 80(4): 1051-1059.

9. Cong-Gui, C., Gerelt, B., Shao-Tong, J., Nishiumi, T. & Suzuki, A. (2006). Effects of high pressure on pH, water-binding capacity

and textural properties of pork muscle gels containing various levels of sodium alginate. Asian-Australasian Journal of Animal Sciences 19(11): 1658-1664.

10. Ma, F., Chen, C. G., Sun, G. J., Wang, W., Fang, H. M. & Han, Z. (2012). Effects of high pressure and CaCl2 on properties of salt-soluble meat protein gels containing locust bean gum. Innovative Food Science & Emerging Technologies 14: 31-37.

11. Li, X. (2008). Effects of Protein Modification on Textural Properties and Water Holding Capacity of Heat Induced Turkey Breast Meat Gels, in Head of the Department of Food and Bioproduct Sciences University of Saskatchewan, University of Saskatchewan: Canada. p. 111.

12. Barbut, S. & Mittal, G.S. (1989). Effects of Salt Reduction on the Rheological and Gelation Properties of Beef, Pork and Poultry Meat Batters Meat Science 26: 177-191.

13. Lampila, L.E. & Godber, J.P. (2002). Food Phosphates, in Food Additives, A.L. Branen, et al., Editors. Marcel Dekker: New York. p. 809-896.