EFFECT OF HIGH HYDROSTATIC PRESSURE ON REDUCING OF SODIUM CHLORIDE AND SODIUM PHOSPHATE OF BEEF GELS

Anastasiia Maksimenko*, Ryo Kikuchi, Satomi Tsutsuura and Tadayuki Nishiumi

Division of Life and Food Science, Graduate School of Science and Technology, Niigata University, Niigata 950-2181, Japan

*Corresponding author email: anastasia.2603@mail.ru

Abstract – The effect of high hydrostatic pressure treatment on the physical and chemical properties of beef gels was investigated. In this study, we applied combined medium high hydrostatic pressure (HHP) (conditions 100 – 200 MPa, 20 °C, 10 min) /thermal (T) (70 °C, 30 min) treatment. The raw and thermal beef gels were assessed for appearance, color, cooking losses (CL), water content (WC), SDS-PAGE analysis and physical consistency by textural profile analysis (TPA) and gel strength (GS). Under combination use of 1% salt + HHP (150 MPa) /T (70 °C) treatment we observed the synergistic effect of increased WC and decreased CL, improving juiciness and yield of beef gels. In SDS-PAGE analysis, the staining intensity of the α-actinin band was decreased at HHP treatment 100-200 MPa. The TPA and GS of thermal beef gels showed that hardness, cohesiveness, adhesiveness and breaking stress under combination of 1% salt + HHP (150 MPa) /T (70 °C) treatment were increased (increase of protein solubility, densification of network, improvement of binding ability), we can get the gel with modifying-improved texture. This type of technology could be used for the production of gel-type meat products with a reduced content of food additives.

Key Words – food additives, high pressure, gel-type meat products

I. INTRODUCTION

In 2010, global mean sodium chloride (NaCl) intake was 10.06 g/day [1]. As is known, excess NaCl intake raises a blood pressure, a major risk factor for cardiovascular disease. WHO recommended limit of 5 g/day NaCl. Also, excess inorganic phosphate intake raises a hyperphosphatemia [2]. Since the 1990s, intake of inorganic phosphate increased from 500 mg/day to 1000 mg/day [3]. Processed meat products are one of the main sources of sodium chloride and sodium phosphate. The salt and phosphate are the main ingredients for the extraction of myofibrillar proteins (MP) (solubilization) and formation of a stable meat gel that holds water and fat in a less mobile state. Gel-forming abilities, emulsifying properties and water-holding abilities of MP depend on adding salt and phosphate, and identifying the quality of gel-type meat product (yield, appearance, texture, juiciness and organoleptic properties). One of the approaches to enhancing of functional properties of MP and reducing of the salt and phosphate additives in processed meat is applying of high hydrostatic pressure (HHP) treatment. The objective of this study was to investigate the effect of HHP treatment on the physical and chemical properties of beef gels, in order to further the development of comminuted meat products for healthy diet, functionally improved, with reduced content of food additives.

II. MATERIALS AND METHODS

Silverside Australian frozen beef was used as the meat sample. The meat was purchased from Itoham Foods Inc. and was stored at – 20 °C. The meat was thawed overnight at 4 °C, cut into pieces and minced through a 5–mm plate using mincer machine. Raw beef gels were prepared by comminuting beef mince (97.5–100%) together with NaCl (0–2%) and sodium pyrophosphate (SPP) (0–0.5%), using a kitchen cutter. Beef samples were placed in the metal case and then individually vacuum-sealed polyethylene bags. Beef gels were pressurized at 0.1, 100, 150 and 200 MPa at 20 °C for 10 min using a high-pressure food processor (Dr. CHEF, Kobe Steel, Japan). After pressurization, each beef gel was heated for 30 min at 80 °C and cooled down with ice-cold water.

The L*, a* and b* color values were determined using a chroma meter (CR-400, Konica Minolta, Japan). Water content (WC) was measured using a halogen moisture analyzer (HG63, Mettler Toledo, Switzerland). Cooking losses (CL) of beef gel were determined by calculating the weight difference before and after heating. The protein composition of the supernatant fraction was determined by sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). Gel strength (GS) and texture profile analysis (TPA) of thermal beef gels were measured using a rheometer (Creep Meter RE2-33005B, Yamaden, Japan). For the GS, determination of breaking stress, the samples were cut into pieces 20 × 20 × 10 mm in size and punctured by using a plunger (spherical plunger, 5 mm diameter) at 1 mm/s, compression ratio 100%. For the TPA, determination of hardness, cohesiveness, adhesiveness, the samples were cut into pieces 15 × 15 × 10 mm in size and compressed by using a plunger (disk plunger, 40 mm diameter) at 10 mm/s, compression ratio 60% (double compression).

Results are expressed as the mean ± SEM. The statistical significance of differences among means was evaluated using Student's t-test at the 1% level.

III. RESULTS AND DISCUSSION

Color and visual appearance of beef gels: The L*, b* color values of raw HHP-treated gels did not change. The a* color value of HHP-treated samples significantly decreased ($p < 0.01$). After heat treatment, the L*, a*, b* color values of HHP-treated gels did not significantly change, but improved visual appearance, the surface of thermal samples was smoother and more moist (improving gelation under HHP treatment). The specific color changes in beef upon HHP treatment depend on the physical state and chemical conditions of the meat, myoglobin and changes during pressurization [4].

Water content (WC) and cooking losses (CL): Under HHP treatment, particularly at 150 MPa, WC of thermal gels tended to increase while CL decreased ($p < 0.01$). Optimal WC was observed in the samples 1% NaCl, 2% NaCl, 1% NaCl + 0.5% SPP at 150 MPa and 2% NaCl + 0.5% SPP at 0.1 MPa. Control (unpressurised) gel containing 2% NaCl had similar CL to HHP-treated gel containing 1% NaCl at 150 MPa ($p < 0.01$). The combined use of 1% NaCl + 150 MPa HHP treatment has a synergistic effect on improved water holding capacity (WHC) of beef gels. These results could be explained as the influence of HHP treatment to the increased protein solubility and improved protein-water interactions as a result of changes of protein conformation.

SDS-PAGE Analysis: There was a decrease in the concentration of α-actinin under HHP treatment 100 – 200 MPa, that suggests the disruption of Z-line and the dissociation of thick and thin filaments. This disposition of thin and thick filaments within the myofibrils is mainly responsible for the WHC in muscle. It is suggested that the space for holding water within the myofibril increased, because the myofibril structure was ruptured by HHP treatment.

Texture profile analysis (TPA) and gel strength (GS): Hardness, cohesiveness, adhesiveness and breaking stress of thermal HHP-treated gels increased compared with control 0.1 MPa ($p < 0.01$), that contributed to the enhanced binding ability due to increased MP solubilization and improved gelation through partial MP unfolding under HHP treatment.

IV. CONCLUSION

This type of technology (1% NaCl + HHP (150 MPa) /T (70 °C) treatment) would be beneficial for the manufacturing of traditional gel-type meat products such as low/free additives products, with the modified and improved texture. This is supported by the finding that pressure induced the solubilization of MP and modified of the protein structure without the need for food additives.

REFERENCES

1. Powles, J., Fahimi, S., Micha, R., Khatibzadeh, S., Shi, P., Ezzati, M., Engell, R. E., Lim, S. S., Danaei, G. & Mozaffarian, D. (2013). Global, regional and national sodium intakes in 1990 and 2010: a systematic analysis of 24 h urinary sodium excretion and dietary surveys worldwide. BMJ Open 3: e003733.
2. Ritz, E., Hahn, K., Ketteler, M., Kuhlmann, M. K. & Mann, J. (2012). Phosphate additives in food—a health risk. Dtsch. Arztebl. Int. 109: 49-55.
3. Kalantar-Zadeh, K., Gutekunst, L., Mehrotra, R., Kovesdy, C. P., Bross, R., Shinaberger, C. S., Noori, N., Hirschberg, R., Benner, D., Nissenson, A. R. & Kopple, J. D. (2010). Understanding sources of dietary phosphorus in the treatment of patients with chronic kidney disease. Clin. J. Am. Soc. Nephrol. 5: 519-30.
4. Bak, K. H., Bolumar, T., Karlsson, A. H., Lindahl, G. & Orlien V. (2017). Effect of high pressure treatment on the color of fresh and processed meats: A review. Crit. Rev. Food Sci. Nutr. 28: 1-25.