ALTERNATIVE PROCESSING STEP TO REDUCE SALT AND MAINTAIN QUALITY WHEN PROCESSING LOW-FAT PORK BOLOGNA

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Abstract. The effectiveness of delaying the thermal step as a simple strategy in manufacturing low-fat, low-salt bologna was investigated. Pork bologna with various concentrations of sodium chloride (0.75%, 1.00%, 1.25%, 2.00%) was prepared and either cooked immediately (CI) or delayed cook (DC) by holding for 20 hr at 1oC before cooking. Results showed that the DC step significantly improved instrumental hardness and sensory firmness of bologna with extremely low-sodium concentration (0.75% NaCl) and showed minor improvements on sensory firmness of bologna with 1.0% salt. DC had no effect on meat batters with 1.25% and 2.0% NaCl. This research shows that the texture problem associated in reduction of salt in processing may be overcome by the simple step of delaying the thermal process to allow for protein extraction at lower ionic strength.
Key Words –holding, protein solubility, sodium

Background.

The link between high sodium intake and development of high blood pressure is the major reason for reducing salt in the food supply (CDC, 2012). Since more than 70% of sodium intake is from processed foods (9% from processed meats), the role and participation of food processors by increasing availability of low-sodium products in the market will help consumers to control their sodium intake (CDC, 2012). However, because of the important functionalities of salt in processing (i.e., saltiness, flavor-enhancing effect and extraction of myofibrillar proteins for water holding capacity (WHC) and desired textural properties of cooked products), sodium reduction is beset with challenges.

The good news is there are ingredients and potential processing strategies that may allow some reduction of salt in meat processing. These include use of salt replacers (i.e., potassium chloride, but not more than 50% replacement due to metallic flavours), use of phosphates and inclusion of a preblending process (Ruusunen and Poulanne, 2005). During preblending, a portion of the meat block (lean tissues) is treated with salt, cure and a portion of the water for several hours or days before completion of sausage processing (Hand et al., 1990). The lean tissue is initially exposed to high ionic strength favoring extraction of myofibrillar proteins before dilution with water and other ingredients. However, results of preblending on product texture are conflicting probably due to a number of factors affecting quality of emulsified meat products (i.e., duration and temperature of chopping). A study on the interaction effect of degree of chopping and preblending time on water holding capacity showed that preblending is advantageous in coarse type sausage only when presalted meat was subjected to a short period of chopping (Hermansson, 1982). However, as the period of chopping time increased (exceeding 10-15 min at low chopper speed) in emulsion type sausage, no positive effect on texture was observed. The prolonged chopping time was enough to complete swelling of myofibrils and extraction of proteins, even in the presence of reduced salt (Gumpen and Sorheim, 1987).

At that time, Gumpen and Sorheim (1987) considered "reduced" salt to be 1.8% salt (~710 mg sodium/100 g product) in the formulation. However, this salt level could be high enough to induce instant solubilization in finely chopped sausages. The extent to which preblending affects extremely low salt formulations (1% salt or less) is not known.

In the current study, we modified the preblending procedure by completing the chopping process and then holding the stuffed batter for 20 hr before cooking (delayed cooking) and investigated its effect in bologna formulated to contain different salt concentrations (from 0.75 - 2.0% salt). Favorable conditions as reported from previous studies (e.g. use of tetrapotassium pyrophosphate as superior in solubilizing myofibrillar proteins (Knipe et al., 1985) and slow heating during cooking to produce better gel strength (Foegeding et al., 1986) were also utilized in processing of bologna. We hypothesized that holding time before cooking would maximize functionality of salt and phosphate, therefore enhance protein solubility in the emulsion and stabilize protein-water-fat interaction prior to cooking leading to better product texture in extremely low-salt bologna.

Methodology.

Frozen coarsely ground pork muscle was thawed 2 d at 1°C before processing, reground using a 3.9 mm hole grinder plate and processed into bologna. Each batch of bologna was formulated to produce meat batters with 11.0% protein (in compliance with Canadian regulations for minimum protein content) and 10.0% fat. The levels of meat, back fat, TKPP, curing salt, and sodium erythorbate of all batches were held at 48.95, 11.10, 0.50, 0.28 and 0.05%, respectively. Salt levels were varied according to treatment (0.75, 1.0, 1.25, or 2.0%) and water was adjusted based on changes in salt levels. Bologna was processed following the procedure described by Sanjeewa (2010) and Shand (2000).

The stuffed bologna chubs were portioned and assigned into holding treatments either as cooked immediately (CI) or delayed cook (DC, chubs were held for 20 h at 1°C before cooking). Cooking of bologna was done by immersing the stuffed batter chubs in an agitated water bath (~200 L) and cooked using a four-stage process schedule: 30 min at 50°C (initial water temperature), 30 min at 60°C, 30 min at 70°C and followed by cooking at 75°C to a final internal temperature of 71°C. The total cooking time was approximately 2 h. Samples were cooled in an ice and water mixture for one h and stored at 4°C until analyses. Effectiveness of DC was determined by measuring the texture, WHC and sensory characteristics of bologna following procedures described by Sanjeewa (2010) and Shand (2000).

Results.

Water holding capacity. The effects of DC on WHC were evaluated by measuring cook loss (CL) and expressible moisture (EM). DC was effective (p<0.05) in improving WHC based on EM but had no effect when using CL or PL measurements. Although not statistically significant, DC had the tendency (p=0.09) to reduce cook loss of the products (2.28% CI vs. 1.89% DC). The CL was significantly affected (p<0.05) by NaCl level (**Figure 1**). Interestingly, samples with 1.00% NaCl had the same cook loss as samples with 1.25% and 2.00% NaCl.

The EM of cooked bologna samples was affected by the interaction between salt level and holding before cooking (p<0.05) **(Figure 2).** However, the interaction effect was confined only to bologna with 0.75% NaCl. The DC was effective in reducing EM at this extremely low NaCl (0.75% NaCl) and had no effect on samples with 1.0-2.0% NaCl (CI and DC) (**Figure 2**).

There were two consistent observations on how the treatments affected WHC in this study. First, it was observed that 0.75% NaCl was too low to form a stable emulsion matrix resulting in a very poor WHC. Second, the WHC of samples with 1.00% NaCl was not statistically different with samples containing 1.25% or 2.00% NaCl, showing that with a strong meat block (pork leg meat in this case), 1.0% salt (400 mg sodium per 100 g) in finely comminuted sausage is technologically feasible.

Texture profile analysis. TPA hardness of bologna was significant affected by the interaction effect between NaCl and holding (Figure 3). However, similar to water holding capacity the interaction effect was confined only at 0.75% NaCl level wherein there was a significant increase in TPA hardness as a result of delayed cooking of the meat batter. Although not statistically different, the numerical TPA value for 0.75% NaCl DC was slightly higher compared to the rest of the samples. This observation could be related to the effect of two factors: higher cook loss of DC samples with 0.75% NaCl compared to treatments with higher NaCl levels, and structure formation as a result of delayed cooking. TPA hardness of samples with 1.0% NaCl CI or DC was not statistically different from samples containing higher NaCl levels (1.25% and 2.00%).

Sensory evaluation. Sensory firmness results were similar to instrumental texture results except that panelists perceived improvements contributed by holding (delayed cooking) in bologna samples with 0.75 and 1.00% salt (**Figure 4**).

Panelists commented that the samples with 0.75% salt (CI) did not have a perceived dryness but rather had rapid free water release on mastication and were considered to be "wet" while samples with 1.0 to 2.0% NaCl had similar juiciness scores. This wetness could be due to emulsion matrix breakdown or poor matrix formation and 0.75% seemed to be below the critical level for protein extraction when cooked immediately resulting in product texture failure. The pH and ionic strength (IS) of the mixture are important parameters for maximum protein extraction which occur at pH >6.0 and when IS > 0.6µ (Yasui et al., 1980). Although the pH of the raw batter with 0.75% salt was 6.41, the total calculated IS was below 0.6µ, which helps to explain the poor texture of this sample.

Bologna with 0.75% salt and 1.00% salt had sodium contents of 320 mg and 400 mg Na/100 g serving, respectively, which was considerably less than the target average of 654 mg Na/100 g serving for ready-to-eat processed meats (Health Canada, 2010). Samples with 0.75% salt had the lowest flavour intensity and panelists commented that the CI sample had an "unpleasant flavour" and mushy texture. Samples with 2.00% salt levels had the highest flavor score but had higher sodium content (760 mg/100 g) than the desired sodium level in processed meat set by Heart and Stroke Foundation (maximum of 650 mg/100 g serving). While intermediate in flavour intensity, bologna with 1% NaCl (cooked after holding) had similar texture to others with higher salt.

Conclusion.

This study revealed the usefulness of holding stuffed batter at 1°C for 20 h prior to cooking in formulating extremely low salt (0.75% or 1.00% NaCl) low fat bologna (11% protein, 10% fat). In addition, this study generally shows that texture is not a major issue in producing low sodium processed meats as 1.00% salt in the formulation resulted in a similar texture profile as bologna with 1.25% and 2.00% salt. The biggest challenge may be in meeting the desired flavour when reducing salt in low-fat processed meats, as seasoning alone may not be able to correct for the negative flavour profile resulting when very low sodium levels are used.

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References

1. CDC (Center for Disease Control and Prevention. 2012. Americans consume too much sodium (Salt). Retrieved on May 30, 2012 from http://www.cdc.gov/Features/dsSodium/
2. Foegeding, E. A., Allen, C. E., & Dayton, W. R. (1986). Effect of heating rate on thermally formed myosin, fibrinogen, and albumin gels. Journal of Food Science, 51, 104-108, 112.
3. Hand, L. W., Mandigo, R. W., & Calkins, C. R. (1990). The effects of preblending time on physical and textural properties of coarse ground sausages. Meat Science 31: 13-24.
4. Health Canada. (2012). Guidance for the Food Industry on Reducing Sodium in Processed Foods. Retrieved on June 10, 2012 from http://www.hc-sc.gc.ca/fn-an/alt_formats/pdf/legislation/guide-ld/2012-sodium-reduction-indust-eng.pdf.
5. Hermansson, A. M. (1982). The effect of presalting of meat on the properties of finely comminuted meat products. In: Gumpen, A. A. and Sorheim, O. (1987). Presalting effects on water retention of pork and beef batters. Food Chemistry 23: 235-243.
6. Gumpen, A. A. and Sorheim, O. (1987). Presalting effects on water retention of pork and beef batters. Food Chemistry 23, 235-243.
7. Knipe, C. L., Rust, R. E., and Olson, D. G. 1990. Some physical parameters involved in the addition of inorganic phosphates to reduced-sodium meat emulsions. Journal of Food Science 55: 23-25.
8. Ruusunen, M. & Puolanne, E. (2005). Reducing sodium intake from meat products. Meat Science 70: 531-541.
9. Shand, P.J. (2000). Textural, water holding, and sensory properties of low-fat pork bologna with normal or waxy starch hull-less barley. Journal of Food Science 65: 101-107.
10. Sanjeewa, W. G. T., Wanasundara, J. D. J., Pietrasik, Z., & Shand, P. J. (2010). Characterization of chickpea (*Cicer arietinum* L.) flours and application in low-fat pork bologna as a model system. Food Research International, 43, 617-626.
11. Yasui, T., Ishioroshi, M., & Samejima, K. (1980). Heat-induced gelation of myosin in the presence of actin. Journal of Food Biochemistry 4: 61.

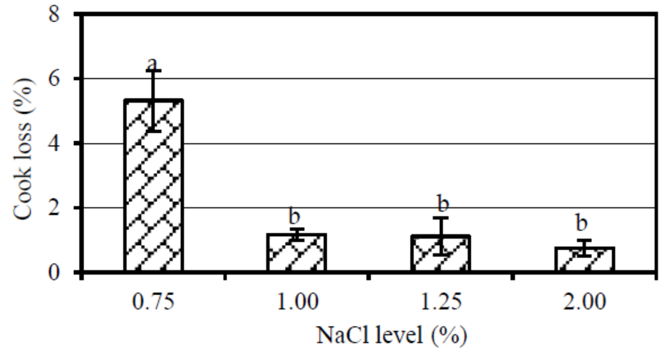

Figure 1 Effect of NaCl level on cook loss of bologna
[a-b]Means with different letters are significantly different (p<0.05)

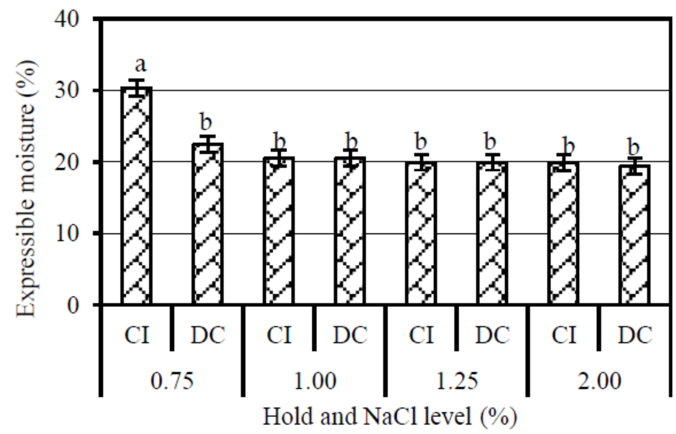

Figure 2 Interaction effect between NaCl level x holding on expressible moisture
(CI-cooked immediately, DC-delayed cooking).
[a-b]Means with different letters are significantly different (p<0.05)

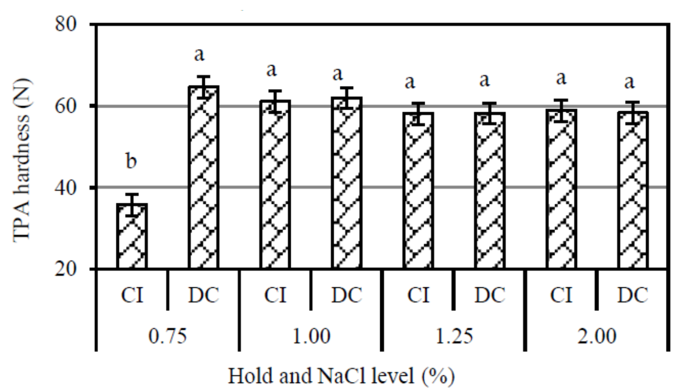

Figure 3 NaCl level x hold interaction effects on the TPA hardness
(CI-cooked immediately; DC-delayed cooking).
[a-b] Means with different letters are significantly different (p<0.05)

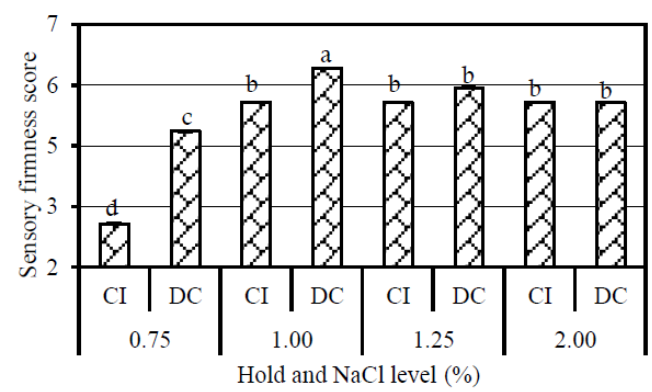

Figure 4 NaCl level x hold interaction effects on sensory firmness of bologna samples (CI-cooked immediately; DC-delayed cooking).
[a-d] Means with different letters are significantly different (p<0.05).
Scores: 8- extremely firm; 1-extremely soft