EXTENDED HOLDING OF STUFFED BATTER BEFORE COOKING AS A SIMPLE SALT REDUCTION STRATEGY WHEN PROCESSING LOW SODIUM, LOW FAT BOLOGNA

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Abstract – The effects of NaCl levels (0.75%, 1.00%, 1.25%, 2.00%) and holding stuffed batter at 1°C for 20 h before cooking on the quality of low sodium, low fat bologna were investigated. Results showed that water holding capacity (WHC), instrumental texture, and sensory characteristics of samples with 0.75% salt cooked immediately were lowest (*p*<0.05) among treatments but was improved (*p*<0.05) after holding prior to cooking. Slight texture improvement after holding was also observed in samples with 1.00% with no additional benefit at 1.25 and 2.00% salt levels. Panelists detected differences in texture of samples subjected to holding at NaCl levels of 0.75% and 1.00% (*p*<0.05). This study shows that holding the stuffed batter can be a potential strategy for processing extremely low sodium (0.75% NaCl) low fat emulsified-type products.

Key Words –holding, protein solubility, sodium

I. INTRODUCTION

Since consumption of processed foods is a major source of sodium in the diet in the form of sodium chloride, sodium reduction remains a challenging area in product development [1]. Consumption of processed meats accounts for 9.0% of the total sodium intake of the Canadian population [2]. Thus the strategy to achieve the interim intake goal of 2.3 g of sodium per day by 2016 includes sodium reduction in processed meats. Although studies have shown some promising salt substitutes none can deliver equally superb functionalities as the sodium chloride in meat processing considering product taste and texture. Currently, meat processors commonly use potassium chloride [3, 4]. However, limitations with the use of KCl include metallic taste and its restriction for individuals with kidney problems whose potassium intake is strictly controlled [4]. The use of a preblending process, which involves subjecting a portion of meat materials with salt, cure and a portion of the water for several hours or days prior to actual sausage processing [5, 6], is one potential way to produce low sodium processed products. However, some results on the advantage of preblending in terms of product texture are conflicting [5, 7] 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 [8]. However, as period of chopping time increased (exceeding 10-15 min at low chopper speed), in emulsion type sausage, no positive effect on texture was observed. They hypothesized that prolonged chopping time was enough to complete swelling of myofibrils and extraction of proteins, even in the presence of reduced salt.

In this study, we investigated the effect of holding stuffed batter at 1°C (considered as a modified version of blending) prior to cooking in bologna with different levels of salt. We hypothesized that increasing the holding time before cooking would enhance protein solubility in the emulsion and stabilize protein-water-fat interaction prior to cooking leading to better product texture.

II. MATERIALS AND METHODS

A. Materials

For each replication, chilled fresh lean (<7 d post-mortem) pork leg muscles (22.5% protein, 3.2% fat, 1.9% ash, and 71.6% moisture, and pH 5.71±0.01) were obtained from a commercial meat packing company through a local meat purveyor. The meat was cut into cubes, minced through a 6.5 mm hole plate, vacuum packaged, and kept frozen at -30°C prior to use. Non-meat ingredients such as salt, tetra potassium pyrophosphate (TKPP), sodium nitrite, and sodium erythorbate were obtained from Cargill Salt (Minneapolis, MN, USA), Windsor® Salt (Quebec, CA), Innophos (Ontario, CA), Griffith Laboratories (Quebec, CA), and from Unipac Packaging Products Ltd (Alberta, CA), respectively.

B. Sausage manufacture

Frozen meat was thawed 2 d at 1°C before processing and reground using a 3.9 mm hole grinder plate. Each bologna treatment 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 and water was adjusted based on changes in salt levels. No spices/seasonings were added in the formulation to eliminate flavour complexity in the matrix and potential interference in saltiness perception during sensory evaluation.

The bologna processing procedure was carried out in a refrigerated pilot plant (<4.0°C). The finely ground meat was chopped with salt, TKPP, curing salt, and a portion of water for 1 min. Thereafter the pork back fat and remaining water were added and chopped for another 2 min. The emulsification process was completed by passing the chopped mixture through an emulsion mill (Type 1E-75F, Alexanderwerk, Remscheid, Germany) twice. The emulsion final temperature did not exceed 14°C. To remove air trapped in the emulsion matrix, the batter was vacuum tumbled (Model VSM-150H, Glass, Frankfurt, Germany) for 3 min (then repeated twice). The batter was then stuffed (~1 kg) into 63 mm diameter, moisture-proof plastic casings using a hydraulic stuffer (Model EL-20, Mianca Equipamientos Carnicos, S.L., Barcelona, Spain). The stuffed chubs were twisted by hand, clipped with aluminum clips, and washed to clean the outside of the casings. Half of the stuffed chubs were cooked immediately (representing CI) and half were kept at 1°C for 20 h (corresponding to PS samples) prior to cooking.

Cooking of bologna was done by immersing the stuffed batter 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. Immediately after cooking, samples were cooled in an ice and water mixture for one h and stored at 4°C until analyses.

C. Analyses

Protein solubility. The amount of salt soluble protein in the raw meat batter was determined using a modified stirring method [10]. Briefly, 3 g of batter was diluted with 30 mL soluble protein extraction solutions (made up to match salt/phosphate concentrations found in aqueous phase of each treatment), stirred for 30 sec using a magnetic stir bar and vortex mixer (full speed, Fisher vortex, N.Y., USA), and centrifuged for 15 min at 32,000 x g at 2°C. The protein content of the supernatant was then evaluated using the biuret method with bovine serum albumin (BSA) as a standard. Soluble protein was expressed as % soluble protein in the lean meat.

Water holding capacity. The effect of treatment factors on WHC of the products were determined using cook loss, expressible moisture and vacuum purge (during 2-week storage at 4°C) which were all expressed as percentage weight lost during cooking, or centrifugation or 14 days storage at 4°C in comparison to the initial sample weight [11].

Texture profile analysis (TPA). This was determined using TMS-Pro Texture Press (Food Technology Corp., Rockville, MD, USA). Eight cores (35 mm in diameter and 25 mm height) from each treatment were pressed twice to 50% of their original height at a crosshead speed of 50 mm/min using a 250 N capacity load cell. The following parameters were obtained using Texture Lab pro software: hardness, and springiness [11].

Sensory evaluation. This was conducted using a 12-member semi-trained panel (composed of 9 males and 3 females, ages 21-40 yrs). Panelists first participated in eight days of training. The panel were asked to evaluate the coded samples (12.5 mm x 12.5 mm cubes) for firmness (8 as extremely firm---1 as extremely soft), juiciness (8 as extremely juicy ----1 as extremely dry), flavour (8 as extremely intense --- 1 as extremely bland), and saltiness (6 as no detectable saltiness ---- 1 as extremely salty). The sensory data are means of 12 panelists x 3 replications.

Statistical analysis. This study was repeated three times. Observed data were analyzed as a Randomized Complete Block Design using the Proc Mixed Procedure of SAS (SAS, Inst. Inc., Cary, NC). Variations contributed by meat materials used in each replicate were considered as block. Treatments and interaction were written in the model and considered as fixed effects while block as random effect. Means were analyzed and separated with the least significant difference (LSD) procedure of SAS and pdmix SAS macro was used to convert mean separation output to letter groupings (Saxton, 1998). Significance was declared at $p<0.05$.

III. RESULTS AND DISCUSSION

Protein solubility

The post-stuffing hold (PS) treatment significantly increased protein solubility of batters with 0.75-1.00% salt levels. However, samples with 1.00% salt subjected to holding did not differ in solubilized protein to treatments with 1.25% and 2.00% NaCl. Holding treatment had no effect on samples with 2.00% salt level (Fig. 1).

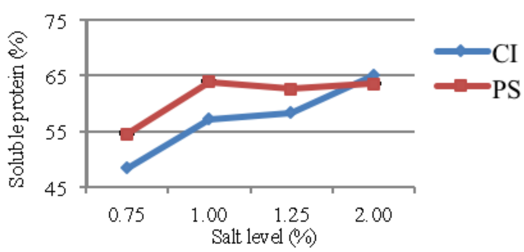

Fig 1. Protein solubility as affected by holding and salt levels

Water holding capacity

A significantly lower WHC was observed for treatments with 0.75% salt in the formulation but this was slightly overcome by holding the batter at 1°C prior to cooking as shown by reduction in % expressible moisture (p=0.006) and tendency to reduce % cook loss (p=0.096). However, holding did not have an effect on WHC of treatments with 1.00-2.00% salt ($p>0.05$) (Table 1).

Texture profile analysis

Holding of batter prior to cooking significantly improved ($p<0.001$) TPA hardness of samples formulated with 0.75% salt. However, this treatment was not as springy and as cohesive as those processed with higher salt levels (data not shown). Holding overnight did not improve hardness at higher salt level (1.00 - 2.00%) (Fig. 2).

Table 1. Effects of salt levels, and holding time of stuffed batter before cooking on water holding capacity parameters of low salt low fat bologna

NaCl level (%)	Holding	Cook loss (%)	Expressible moisture (%)	Purge loss (%)
0.75	CI	6.5 ± 0.8^{a}	34.1 ± 2.0^{a}	7.3 ± 1.6^{a}
	PS	4.8 ± 0.9^{a}	25.4 ± 1.8^{b}	7.4 ± 1.3^{a}
1.00	CI	1.2 ± 0.1^{b}	21.5 ± 1.6^{bc}	6.7 ± 2.0^{b}
	PS	1.2 ± 0.2^{b}	20.8 ± 0.7^{bc}	6.1 ± 1.0^{b}
1.25	CI	1.2 ± 0.8^{b}	22.1 ± 2.6^{bc}	6.5 ± 1.1^{b}
	PS	1.1 ± 0.5^{b}	21.9 ± 1.4^{bc}	6.1 ± 1.6^{b}
2.00	CI	0.9 ± 0.2^{b}	21.2 ± 1.6^{c}	6.0 ± 1.0^{b}
	PS	0.9 ± 0.1^{b}	22.0 ± 1.1^{bc}	6.3 ± 1.1^{b}

[a-c]Means in the same column with different superscripts are significantly different, $p<0.05$

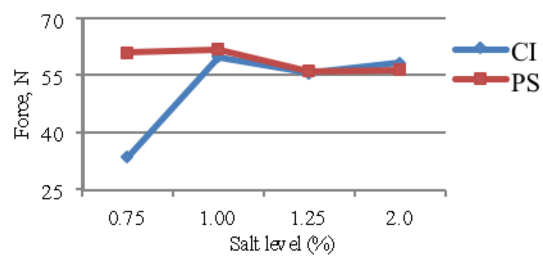

Fig 2. TPA hardness as affected by holding and salt levels

Sensory evaluation

Sensory firmness results were similar to instrumental texture results except that panelists perceived improvements contributed by holding in bologna samples with 0.75 and 1.00% salt (Fig 3).

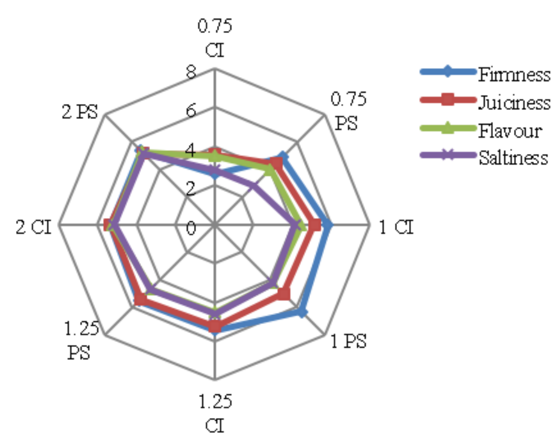

Fig 3. Sensory characteristics of bologna as affected by holding and salt levels

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 1.00 to 2.00 % 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 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 [13]. 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 [2]. 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. While intermediate in flavour intensity, bologna with 1% NaCl (cooked after holding) had similar texture to others with higher salt.

IV. 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 had similar texture profile with samples 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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