PE4.40 Effects of starch, soy protein isolates and phosphate on improving lean chicken meat batters

140.00

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Abstract—Lean minced chicken meat batters were prepared with modified starch, soy proteins or phosphate as well as their combinations; all evaluated in a high water added meat system. Both starch and soy reduced cook loss by about 50%. When combined, an 85% reduction was observed. The latter was similar to phosphate addition by itself. When all three added, cook loos was virtually eliminated. Starch did not affect product's hardness, whereas soy increased it by 50% and phosphate doubled it. Cohesiveness, showed a similar trend. Employing a controlled stress rheometer to continuously monitor the heating and cooling processes, also revealed that the treatment with soy, phosphate and starch produced the highest storage modulus values. The microstructure of the soy added treatment showed soy protein islands which most probably helped to re-enforce the structure. In the starch added treatment, the swelled gelatinized granules which helped retain the moisture were clearly visible. The phosphate added treatment produced the most dense microstructure compared to all the other treatments including the control.

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Index Terms—meat, microstructure, poultry, protein, soy, texture.

I. INTRODUCTION

THE meat industry is employing various non-meat additives, such as vegetable proteins and starches to improve texture, moisture retention, and control cost. (1). Current changes include consumer demand for low fat meat products that taste good. In most cases extra moisture is part of the formulation, and therefore it is important to find ingredients that would contribute to moisture retention. Overall, water is a major constituent of lean meat (~ 70 %) and the ability of a meat product to retain its own and additional moisture is very important. This is especially true when the product is heated and the moisture retention of meat proteins is significantly reduced. The additives must be compatible with the meat proteins otherwise they disrupt the structure and can also lower yield. Beuschel et al. (2) indicated that the contribution of whey protein concentrate to a meat system depends on the meat pH, solubility of the whey protein, and heating temperature.

They reported that gel hardness increased as whey protein solubility decreased at pH 6.0, 7.0 and 8.0, when heated to 65°C; however the opposite trend was observed when heated to 90°C. These authors and others have indicated that in order to optimize the contribution of non-meat ingredients, and balance benefit vs. cost, it is essential to understand the interactions within the meat system. Soy proteins are composed of the two major proteins, β-conglycinin (7S) and glycinin (11S) (3). It has been reported that the 7S and 11S denatured around 75 °C and 90°C, respectively, thus preventing regular soy proteins from undergoing sufficient structural changes under common meat processing conditions. Therefore, commercially manufactured soy proteins are often subject to certain denaturing conditions during preparation (e.g., high temperature and severe alkaline conditions) which influence their functional properties . These proteins are usually modified to allow them to interact with other ingredients (4). Parks and Carpenter (5) and Lin and Mei (2000) indicated that soy proteins can improve emulsifying capacity and emulsion stability in meat products. Emulsifying properties of soy proteins varying in fiber content, positively correlated with protein and negatively with fibre content. The objective of this study was to evaluate the combined effects of using starch, soy protein and phosphate on enhancing yield, texture, color and microstructure of lean chicken breast meat batters.

II. MATERIALS AND METHODS

A. Meat and Meat Batter Preparation

Chicken breast meat was used after removing all connective tissue. The meat was chopped in a bowl chopper, packed under vacuum and frozen. Each treatment consisted of lean meat and one or a few of the following non meat ingredients: high functionality / high gelling soy protein isolate (SPI), modified waxy maize starch, salt, tripolyphosphate (TPP) and water. The SPI was added at a 2% protein level. Starch was added at a 1% level and TPP at 0.25%. Salt was added (2.5%) to all treatments to duplicate the common level used by the industry. Water (50%) was added to bring the meat protein level to 14%.

B. Cooking and Cook Loss

Three 35 g portions were cooked in test tubes and centrifuged to remove small air bubbles. Tubes were heated (30 to 72°C) in a water bath within 1.25 h, followed by cooling. Cook loss was determined as the amount of liquid released.

C. Texture Analysis

Texture profile analysis (TPA) parameters were determined using six center cores per treatment, which were compressed twice to 75% of their original height by a texture analyser (TA.XT2, Stable Micro Systems, Texture Technologies Corp., Scarsdale, NY) employing a moving flat plate descending at 1.5 mm/s. The TPA parameters of fracturability, hardness, springiness, cohesiveness, and chewiness were determined .

D. Rheology

A controlled stress rheometer (Bohlin Inst. Model CS50, Cranbury, NJ, USA) was used. Samples were loaded into the cup, covered with a thin layer of mineral oil to prevent dehydration. Temperature was increased from 30 to 75°C, and then cooled back to 30°C. Changes of storage modulus (G) were recorded. The storage modulus is directly proportional to the amount of structure in a material since the greater the structure the greater its ability to store energy, and it is, therefore, related also to the elastic behaviour of the material.

E. Microstructure

Samples were cut from the centers of cooked meat batters and fixed in 10% formalin for 10 h, dehydrated with a series of increasing alcohol solutions. Samples were later embedded in paraffin, cut into 4-6 –µm thick sections, stained with Hematoxylin/Eosin for proteins, and Periodic Acid Schiff for carbohydrates.

F. Color

A color-meter (Minolta Spectrophotometer with a window diameter of 10mm (illumination D65, observer 10°) was used to evaluate three freshly cut surfaces from each cooked sample, to obtain the CIE L* (lightness), a* (redness) and b* (yellowness) values.

G. Statistical Analysis

The experiment was designed as a complete randomized block, with three separate replications. Statistical analysis was performed using a software package (sas version 8.02, sas institute, Cary, NC, USA)..

III. RESULTS AND DISCUSSION

Adding soy protein or modified starch to the lean meat batter reduced cook loss by about one half (Table 1). However, when used together, an 85% reduction in cook loss was observed. The main reason was that both ingredients contribute to water holding. The modified starch is designed to bind water at low temperature. This is unlike regular starch which does not get to gelatinize prior to the final cooking temperature of about 70°C (i.e., a common temperature for sausage processing). Actually, this is the reason for using modified starches in various further processed meat products (additional discussion on the microstructure to follow). Phosphate addition by itself reduced cook loss by about 80% (Table 1).

This is due to phosphate ability to extract myofibrular proteins and act synergistically with sodium chloride (7,8). The combination with regular starch and SPI basically eliminated cook loss. Overall, this combined effect is what the industry is looking for since there are several regulatory and economic restrictions concerning the use of different non-meat ingredients (e.g., maximum of 0.5% phosphate regulation where allowed; cost of modified starch). The textural characteristics of the cooked meat batters were evaluated by texture profile analysis (TPA) tests. The results show that adding SPI increased hardness by 50%. Using modified starch resulted in significantly lower hardness and cohesiveness values. Examining the microstructure of this treatment helped to shed some light on the effect of the modified starch in the cooked batter. Overall, the presence of swollen gelatinized “starch islands” appears to be the reason for the lower hardness value, as these “starch islands” form soft spots within the gel structure. When starch and SPI were added together, hardness and cohesiveness values stayed similar to the SPI treatment (i.e. unlike the effect on cook loss previously discussed). Phosphate addition significantly increased hardness and cohesiveness values above the SPI. This phosphate effect (resulting from extracting additional myofibrular proteins and acting synergistically with sodium chloride) has been previously reported by Whiting (8). Using phosphate, starch and SPI together showed the same overall trend as using phosphate by itself.

The hardness value was actually twice as high as the control or the starch treatment by itself. This is an indication that even though the gelatinized "starch islands" were present, the protein matrix was much firmer due to phosphate addition. Overall, phosphate addition consistently improved all textural parameters and as in the case of reducing cook loss, phosphate use is recommended in this meat system. The microstructure of the control finely chopped lean meat batter showed a typical structure of minced muscle fibers embedded in a protein matrix (9).

The matrix was composed of the salt soluble proteins, which forms a fairly rigid gel upon heat induced gelation. The treatment with modified starch showed starch granules dispersed within the protein matrix. The size (25-50μm) and shape were typical of gelatinized starch granules.

As discussed earlier, these granules are helpful in trapping water and this was reflected in the low cook loss result. When phosphate was added, a denser meat protein matrix was formed. Cook loss was also lowered by TPP addition; more than by starch or SPI (Table 1). Adding phosphate with starch and SPI showed a dense structure in which small soy protein particles and gelatinized starch granules were distributed. Following the changes in the storage modulus (G) provided more insight into the contribution of the different ingredients to texture development (Fig. 1).

The control treatment showed a typical structure development curve once the myofibrular proteins started to denature at around 48°C (10). With further temperature increase, more proteins started to gel, at about 60°C, and continued to do so up to 72°C. Similar curves have been published by (11). The use of starch caused an upward shift in the G values starting at 30°C and going all the way to 75°C. Adding phosphate increased the storage modulus values above 40°C. This was a distinct phosphate effect, where G increased much faster than in the other treatments (Fig. 1). This was most probably due to more protein extracted and consequently contributing to higher G. The higher G values continued up to the end of cooking. The color was not much affected by the treatments (Table 1).

IV. CONCLUSION

The information presented points out the importance of using a combination of non-meat ingredients to optimize yield and texture of a lean poultry meat batter prepared with salt, phosphate, starch and soy proteins.

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Table 1. Effect of soy protein isolate (SPI), modified starch and tripolyphosphate (TPP) on cook loss, color and texture of poultry meat batters.

Treatment	Cook Loss (%)	Color	Hardness (N)	Cohesiveness (ratio)	Lightness (L*)	Redness (a*)	Yellowness (b*)	1. Control
5.9 a	81 a	0.7 b	11 a	41 c	.36 c 2. SPI	2.9 b	79 c	0.3 a
11 a	66 b	.43 b 3. SPI + starch	0.9 c	77 d	0.3 a	11 a	65 b	.42 b 4. SPI + starch + TPP
0.1 c	76 e	1.0 c	9 b	88 a	.58 a 5. Starch	2.6 b	80 b	0.7 b
11 a	40 c	.33 d 6. TPP	0.8 c	78 cd	1.8 d	9 c	80 a	.58 a

a-d Means in the same column followed by different letters are significantly different ($p<0.05$).