



Quality Characteristics of Chicken Breast Surimi as Affected by Water Washing Time and pH Adjustment

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ABSTRACT : This study was carried out to compare the quality properties of chicken breast surimi manufactured by four different procedures/methods. Surimi was made from chicken breast by washing two (T1) or four times (T2) with water as well as by pH adjustments at 3.0 (T3) or 11.0 (T4). The contents of moisture and crude fat were significantly higher in the surimi manufactured from pH-adjusted material than after washing. Again, collagen and yield were significantly higher in chicken breast surimi manufactured from washed than pH-adjusted samples, whereas crude protein was higher in the pH-adjusted than washed surimi samples. There was no significant difference in myofibrillar protein content among the surimi manufactured after different washing times and differences following pH adjustments were found. T4 showed highest myofibrillar protein content rating among the surimi samples. All physical characteristics were higher in pH-adjusted chicken breast surimi than in T1 and T2 washed surimi samples. The pH-adjusted surimi had higher hardness, gumminess and chewiness than washed surimi samples ($p < 0.05$). The chicken breast surimi made by pH adjustments had higher lightness (L^*) than when made by washing times, whereas pH 3.0-adjusted surimi samples had lower whiteness (W) than the other surimi samples. Myoglobin content was significantly higher in the surimi manufactured from pH-adjusted chicken breast samples. (**Key Words :** Surimi, Chicken Breast, Washing Time, pH Adjustment, Gel Properties)

INTRODUCTION

Surimi is a Japanese term that defines a concentrate of myofibrillar protein obtained after mincing and water washing of fresh flesh (Hastings et al., 1990). It is light in color, bland in odor, low in fat, high in myofibrillar protein, and extremely functional due to the unique gelling properties of the myofibrillar proteins. These texture qualities make surimi an ideal functional ingredient for fabricating new meat products (Lanier, 2000) due to its gel forming capacity to assume almost any desired texture. The success of surimi-based products is mainly due to their low cost and good taste, relative to using meat (Park, 1994). Normally, surimi is prepared from fish protein by two-three times washing of mechanically deboned fish to remove blood, lipids, enzymes, and sarcoplasmic proteins (Vilhelmsson, 1997).

Numerous studies have been conducted on surimi using fish meat. As for studies on animal meats, those using chicken breast, lamb, animal heart, mechanically deboned meats (MDM), etc. make up the majority (Yang and Froning, 1992; Smyth and Oneill, 1997; Lee et al., 1999). For pork, it has been reported that the hind leg area, which is often regarded as unfavorable, has high myofibrillar protein content, and could therefore be used as a substitute for fish meat surimi. Also, by appropriately adjusting the ratio of recovered protein, chicken breast and the hind leg of pork could be used to produce diverse refined products like fish protein with different textures (Jung et al., 2004). However, chicken meat has lower functional properties of protein, including binding and water holding capacity, than red meat. It deteriorates more readily by chemical reactions which reduce its consumer appeal due primarily to color changes (Baker and Bruce, 1989).

Recently, protein recovered by a pH adjustment method has been developed (Choi and Park, 2000) and defined as "recovered proteins" to distinguish them from surimi. Compared with surimi produced by aqueous washing, recovering proteins by pH adjustment with acidic (pH 2.5) and alkaline (pH 10.5) methods (Underland et al., 2002) reduces the water soluble protein loss that occurs during

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washing, and thus, not only the yield becomes high (Lin and Park, 1996), but also the cost of waste treatment could be substantially reduced (Park et al., 2003).

Again, this material can then be used for further processing with better textural attributes (Kristinsson and Hultin, 2003). Surimi is light in color, bland in odor, low in fat, high in myofibrillar protein and extremely functional due to the unique gelling properties of the myofibrillar proteins; these qualities make surimi an ideal functional ingredient for fabricating new food products (Han-Chung and Leinot, 1993; Lanier, 2000). The gel forming capacity of surimi enables it to assume almost any desired texture. Therefore, the most important characteristics of surimi products are their elastic texture and appearance.

Surimi produced by washing is commonly used, while surimi making by pH adjustment is a new method. Therefore, our aim was to compare washing methods with pH adjustment. Again, surimi preparation with pH adjustment in acidic or alkaline condition was also of interest. Although, all segments of the meat industry are attempting to market low-saturated or zero fat products, the beef, pork and poultry industries offer a wider variety of products.

Therefore, the objective of this study was to investigate the quality characteristics of surimi from muscles of the chicken breast extracted by different washing times and pH adjustment. Subsequent products will be manufactured to evaluate the functional characteristics of the surimi.

MATERIALS AND METHODS

Preparation of surimi samples

The chicken breast meat surimi was manufactured using 4 different methods (T1: washing two times, T2: washing four times, T3: pH adjustment of 3.0, and T4: pH adjustment of 11.0). The 45 days-old Ross broiler breast meat was purchased from a local processing plant. The birds were slaughtered at 45 days of age and stored for 2 days in a chilled refrigerator. The external fat tissue, bone and skin were removed from the muscles, and the lean muscle was cut into approximately $3.0 \times 3.0 \times 2.0$ cm³ cubes and ground through a 3 mm diameter orifice using a mincer. The minced samples were combined with six times volume of distilled water and homogenized with a Polytron homogenizer (T25-B, IKA Sdn. Bhd., Malaysia) at 8,000 rpm for 30 s. The slurry was filtered through a 1 mm-mesh metal screen to remove the connective tissue, the filtrate centrifuged (two or four times) at $10,000 \times g$ for 25 min, and the supernatant containing fat and water-soluble proteins discarded.

Similar to a previous study (Jung et al., 2004), in the pH adjustment method the minced meat was filtered through a standard sieve (1 mm-mesh metal screen) using 1 N HCl or

NaOH solutions. For the extraction of protein, the filtrates were adjusted to acidic or alkaline conditions of pH 3.0 or pH 11.0, and then centrifuged at $10,000 \times g$ for 25 min, discarding the highest and lowest layers and recovering the middle layer. The recovered samples were adjusted to pH 5 using 1 N NaOH and HCl solutions, incubated for 30 min and centrifuged at $10,000 \times g$ for 25 min collecting the low layer precipitate, which was then adjusted to pH 7 using 1 N NaOH. The resulting sediments of both methods were stuffed into PVDC casings (diam 18 mm) and cooked in a cooking chamber at 78°C for 40 min.

Proximate composition

Moisture (AOAC 950.46), crude protein (AOAC 992.15), and crude fat (AOAC 985.15) contents were determined according to AOAC methods (AOAC, 2000). The moisture, protein, and fat parameters of minced surimi samples were determined in triplicate.

Myofibrillar protein extraction

The procedure used to determine the myofibrillar proteins was similar to that of Kuo and Chu (2003). The myofibrillar proteins were isolated from samples by homogenizing 4 g of minced sample in a homogenizer (T25-B, IKA Sdn. Bhd., Malaysia) for 10 s in 10 vol. (v/w) of a 2°C isolating medium containing 100 mM KCl, 20 mM potassium phosphate (pH 7.0), 1 mM EDTA and 1 mM sodium azide. The homogenate was sedimented at $1,000 \times g$ for 15 min and the supernatant decanted. The sediment was resuspended at $1,000 \times g$ for 15 min, and again the supernatant decanted. Next, the sediment was resuspended in 5 vol. (v/w) of the original isolating medium and passed through a polyethylene strainer to remove connective tissue and debris. Five more volumes, resulting in 10 vol. (v/w) total of the original isolating medium, were used to further facilitate passage of the myofibrillar protein through a strainer. Again, the supernatant was sedimented at $1,000 \times g$ for 15 min and the supernatants decanted. The sediments were washed three more times by suspension in 5 vol. (v/w) of the original isolating medium, and were sedimented at $1,000 \times g$ for 15 min. Finally, the sedimented myofibrillar proteins were resuspended in 5 vol. (v/w) of the original isolating medium. The protein concentration was determined by the biuret procedure as described by Clark and Switzer (1977).

Collagen content

Using a modified method cited by Palka (1999), the collagen content was determined after 24 h hydrolysis of 300 mg of sample with 25 ml of 6 M HCl at 100°C. The hydrolysates were clarified with active carbon, neutralized with 10 M and 1 M NaOH and diluted with distilled water to 250 ml. Four ml of hydrolysate and 2 ml of chloramines

T solution (1.41 g of chloramines T, 10 ml of distilled water, 10 ml of *n*-propanol and 80 ml of citric buffer at pH 6.8) were mixed in a test tube and left for 20 min at room temperature. Next, 2 ml of 4-dimethyl-aminobenzaldehyde (*p*-DABA) solution (10 g of *p*-DABA, 35 ml of HClO₄-60% and 65 ml of isopropanol) was added. The solution was shaken and heated at 60°C for 20 min. The samples were cooled for 5 min in tap water and the absorbance measured at 588 nm. The amount of hydroxyproline was determined from a standard curve. The collagen content was calculated from the hydroxyproline content using the coefficient 7.25.

Yield

The yield was calculated from the difference between the whole muscle weight and the final mass of the surimi. Yield (%) = ((whole muscle weight-surimi weight)/(whole muscle weight))×100.

pH

The pH was measured using a digital pH meter (Model 420A, Orion, NA, USA). Approximately 5 g of sample was cut into small pieces and 45 ml of distilled water added. Slurry was then made using an homogenizer and the pH was recorded using a pH meter.

Cooking loss

Cooking loss was determined for each treatment-replication combination from the recorded weights of the uncooked and cooked surimi (Yang et al., 2006). Cooking loss (%) = ((uncooked weight-cooked weight)/uncooked weight)×100.

Shear force

The samples were sheared through the center using an Instron 3343 machine (US/MX50, A&D Co., MA, USA) equipped with a Warner Bratzler shearing device (load cell: 10 kg, crosshead speed: 200 mm/min).

Gel characteristics (breaking force, deformation, and gel strength)

The gel characteristics were determined according to the method described by Phatcharat et al. (2006). Here, the gels were equilibrated and evaluated at room temperature. Five cylindrical pieces of 3.5 cm wide and 3 cm thick were tempered at 20°C prior to measuring. The breaking force, deformation and gel strength were measured using a texture analyzer (EZ-test, Shimadzu, Tokyo, Japan) equipped with a cylindrical plunger (diam. 5 mm, depression speed 66 mm/min).

Color

Color (CIE *L** (lightness), *a** (redness), *b** (yellowness)) was measured using a Minolta color meter (CR-400, Tokyo,

Japan), with measurements standardized with respect to the white calibration plate. Five readings were made from the surface of the samples. Whiteness (*W*) was determined using the following formula: $L^* - 3b^*$ (Park et al., 1996).

Myoglobin content

The myoglobin content (Mb) was determined by direct spectrophotometric measurement (Chaijan et al., 2004). Two grams of chopped sample were weighed into a 50 ml polypropylene centrifuge tube and 20 ml of 40 mM phosphate buffer pH 6.8 were added. The mixture was homogenized at 13,500 rpm for 10 s, followed by centrifuging at 3,000 g for 30 min at 4°C. The supernatant was filtered with Whatman No. 1 (diam. 150 mm) filter paper. The supernatant was combined with 0.2 ml of 1% (w/v) sodium dithionite to reduce the myoglobin. The myoglobin content was determined by direct spectrophotometric measurement at 555 nm and then calculated from the millimolar extinction coefficient of 7.6 and a molecular weight of 16,111 (Gomez-Basauri and Regenstein, 1992).

Texture profile analysis (TPA)

Texture profile analysis was performed in an Instron Universal Testing Machine (Model 3343). Five surimi cores (diam 2.0 cm, height 2.0 cm) per replication were axially compressed to 70% of their original height. Force versus time curves were obtained with a 10 kg load cell applied at a crosshead speed of 200 mm/min. The textural attributes of hardness, cohesiveness, springiness, gumminess, and chewiness were then calculated from the curve (Bourne, 1978). Five specimens from each treatment were measured.

Statistical analysis

The effects of washing time and pH adjustments were analyzed by analysis of variance using the SAS statistical program (SAS, 1997). Each treatment group was prepared in triplicate and for each measurement three samples were used. Treatment differences were analyzed using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Proximate analysis, myofibrillar, collagen content, and yield

The proximate composition, myofibrillar protein, collagen content and surimi yield are shown in Table 1. The moisture and crude fat content were significantly higher in the pH adjusted surimi than washed surimi samples ($p < 0.05$). Again, there was significant difference in protein content among the surimi manufactured by different washing times and different pH adjustments. T3 showed highest protein content rating among the surimi samples

Table 1. Mean values for proximate composition, myofibrillar protein, collagen and yield of chicken breast surimi manufactured by washing time and pH adjustment

Treatments ¹	Moisture (%)	Crude protein (%)	Crude fat (%)	Myofibrillar protein (mg/g)	Collagen (mg/g)	Yield (%)
T1	77.95 ^{BC}	14.71 ^C	1.14 ^B	5.02 ^B	1.49 ^A	51.11 ^A
T2	76.72 ^C	14.55 ^C	1.14 ^B	5.01 ^B	1.38 ^{AB}	43.88 ^A
T3	79.83 ^{AB}	20.11 ^A	1.19 ^A	5.01 ^B	1.15 ^C	43.08 ^A
T4	82.25 ^A	18.64 ^B	1.17 ^A	5.08 ^A	1.24 ^{BC}	33.33 ^B
Pooled SE	0.80	0.18	0.01	0.01	0.06	2.48
Washing time	77.34 ^B	14.63 ^B	1.14 ^B	5.02	1.43 ^A	47.49 ^A
pH adjustment	81.04 ^A	19.38 ^A	1.18 ^A	5.04	1.20 ^B	38.21 ^B
Pooled SE	0.66	0.26	0.00	0.01	0.05	2.48

^{A-C} Means with different superscripts in the same column significantly differ at $p < 0.05$.

¹ T1: washing two times, T2: washing four times, T3: pH adjustment of 3.0 and T4: pH adjustment of 11.0.

Table 2. Mean values for physical characteristics of chicken breast surimi manufactured by washing time and pH adjustment

Treatments ¹	pH	Cooking loss (%)	Shear force (kg/cm ²)	Breaking force (g)	Deformation (mm)	Gel strength (g/cm ²)
T1	7.29 ^B	34.96 ^B	1.90 ^B	213.00 ^C	5.83 ^B	1241.30 ^C
T2	7.28 ^B	33.94 ^B	1.84 ^B	213.00 ^C	5.83 ^B	1241.65 ^C
T3	7.66 ^A	38.36 ^A	2.55 ^A	274.00 ^A	6.81 ^A	1865.39 ^A
T4	7.48 ^{AB}	38.22 ^A	2.39 ^A	263.67 ^B	6.79 ^A	1790.08 ^B
Pooled SE	0.06	0.67	0.05	1.83	0.07	18.12
Washing time	7.29 ^B	34.45 ^B	1.87 ^B	213.00 ^B	5.83 ^B	1241.48 ^B
pH adjustment	7.57 ^A	38.29 ^A	2.47 ^A	268.83 ^A	6.80 ^A	1827.74 ^A
Pooled SE	0.05	0.45	0.04	2.00	0.05	16.53

^{A-C} Means with different superscripts in the same column significantly differ at $p < 0.05$.

¹ Treatments are the same as Table 1.

($p < 0.05$). The content of moisture and fat are a critical factor in surimi products (Uddin et al., 2006). The lipids in surimi products may cause an adverse effect on quality, because oxidized lipids interact with proteins, causing denaturation and changes in their functional properties (Smith, 1987). This was expected with both water washing and pH adjustments, the effect causing the fat to float off and be removed was the same during chicken breast surimi preparation; and, in particular, protein concentration greatly affects the gel properties of surimi (Luo et al., 2004). Higher protein contents were noted from sodium phosphate and sodium hydroxide adjusted pork leg, which indicated small losses of muscle proteins due to acidic or alkaline conditions (Yang and Froning, 1990). The myofibrillar protein content was significantly higher in the T4 than the other surimi samples ($p < 0.05$), but there was no significant difference in myofibrillar protein content among the surimi manufactured by different washing times and pH adjustments. The collagen content and yield, however, were significantly higher in the chicken breast surimi made by two separate washing times than the surimi samples from pH adjustment ($p < 0.05$). Collagen content and yield were significantly higher in the chicken breast surimi made by different washing times than pH-adjusted surimi samples. Collagen and connective tissue may also play important roles in the textural development of processed foods such as surimi-based products (Mizuta et al., 2007). In general, high protein, high myofibrillar protein, high collagen, low crude

fat and adequate water are required to make a high quality product (Jin et al., 2007). In this study, yield and collagen content were higher in the chicken breast surimi made by washing, and the proximate composition and myofibrillar content were higher in the chicken breast surimi made by pH adjustment.

Physical characteristics

The physical characteristics of the surimi are shown in Table 2. All physical characteristics were significantly higher in the chicken breast surimi made by pH adjustment than by different washing times ($p < 0.05$). Comparing chicken breast surimi made by different washing times, no significant differences in all physical characteristics were observed. The chicken breast surimi made by a pH adjustment of 3.0 had significantly higher breaking force and gel strength than the pH 11.0-adjusted surimi samples. Kristinsson and Hultin (2003) reported that an increase in gel pH led to dramatic increases in water-holding capacity and water uptake of manufactured washed chicken breast muscle. Again, thermal transitions of myofibrillar tissues including myosin and actomyosin are dramatically influenced by pH (Xiong and Brekke, 1990). The pH values of mince varied greatly, depending on the washing time and pH adjustment. Despite the same portion of muscle of chicken breast being used, the deformation and gel strength of its surimi products clearly increased with increase in pH and ionic strength. Therefore, alkaline and acid solution

Table 3. Mean values for color and myoglobin (Mb) content of chicken breast surimi manufactured by washing time and pH adjustment

Treatments ¹	Lightness (<i>L</i> *)	Redness (<i>a</i> *)	Yellowness (<i>b</i> *)	Whiteness (<i>W</i>)	Mb (mg/g)
T1	75.34 ^B	2.45 ^A	9.03 ^C	48.24 ^A	3.20 ^C
T2	75.23 ^B	2.56 ^A	9.38 ^C	47.08 ^{AB}	2.53 ^D
T3	79.26 ^A	0.49 ^B	12.03 ^A	43.17 ^B	6.62 ^A
T4	79.31 ^A	1.97 ^A	10.40 ^B	48.12 ^A	5.87 ^B
Pooled SE	0.74	0.30	0.23	1.21	0.15
Washing time	75.29 ^B	2.50 ^A	9.21 ^B	47.66	2.87 ^B
pH adjustment	79.29 ^A	1.23 ^B	11.21 ^A	45.65	6.24 ^A
Pooled SE	0.47	0.30	0.30	1.11	0.18

^{A-D} Means with different superscripts in the same column significantly differ at $p < 0.05$.

¹ Treatments are the same as Table 1.

Table 4. Mean values for textural attributes of chicken breast surimi manufactured by washing time and pH adjustment

Treatments ¹	Hardness (kg)	Cohesiveness (%)	Springiness (mm)	Gumminess (kg)	Chewiness (kg-mm)
T1	0.20 ^{BC}	48.69 ^A	12.51 ^A	9.57 ^C	116.56 ^B
T2	0.18 ^C	45.75 ^{AB}	12.37 ^A	9.47 ^C	116.31 ^B
T3	0.30 ^{AB}	40.28 ^B	11.88 ^{AB}	11.95 ^B	142.81 ^B
T4	0.38 ^A	50.73 ^A	11.14 ^B	16.58 ^A	185.82 ^A
Pooled SE	0.03	1.91	0.33	0.72	10.06
Washing time	0.19 ^B	47.22	12.44 ^A	9.52 ^B	116.44 ^B
pH adjustment	0.34 ^A	45.51	11.51 ^B	14.27 ^A	164.32 ^A
Pooled SE	0.02	2.10	0.24	0.86	9.31

^{A-C} Means with different superscripts in the same column significantly differ at $p < 0.05$.

¹ Treatments are the same as Table 1.

washing effectively improved gel characteristics, and the physical structure of chicken breast surimi from pH-adjusted samples should be more stable than from two- and four-times washing samples.

Color and myoglobin content

The results of color and myoglobin content for different surimi samples are shown in Table 3. The chicken breast made by pH adjustments had significantly higher lightness (*L**) than that made by different washing times. Redness (*a**) was significantly lower in the adjusted pH samples than in different washing times samples, and yellowness (*b**) was significantly higher in the adjusted pH samples than in different washing times surimi samples ($p < 0.05$). In relation to the increased lightness, washing decreased redness of the mechanically deboned chicken meat (Yang and Froning, 1992). Decreasing redness varied when comparing individual washing solutions and times. Whiteness (*W*) was lower in adjusted pH 3.0 surimi sample, but there was no significant difference in whiteness among the surimi manufactured by different washing times and pH adjustments. Myoglobin content was higher in the adjusted-pH chicken breast surimi samples than for the two different washing times samples, whereas the two different washing times surimi had lower myoglobin content than pH-adjusted surimi. For surimi processing, myoglobin plays an essential role in the whiteness (Chen, 2002) and, therefore, whiteness is one of the most important factors in surimi quality. Since myoglobin contributes to the color of muscle (Pearson and Young, 1989), the higher whiteness of different washing

times surimi is related to increased transparency as well as loss of myoglobin. This result showed that the myoglobin content of surimi was more affected by washing method than pH adjustment. In this study, T3 showed lowest whiteness value, and highest myoglobin content. On the other hand, when comparisons were made between washing times and pH adjustments of the chicken breast surimi sample, color was better in the pH 3.0 and 11.0 adjusted surimi. Therefore, color was superior in surimi made by the pH process than by the washing process.

Texture profile analysis

The surimi hardness, cohesiveness, springiness, gumminess and chewiness attributes are shown in Table 4.

The pH adjusted surimi had higher hardness, gumminess and chewiness than washing time samples ($p < 0.05$), but the springiness was significantly higher in the different washing time than pH adjustment surimi samples. The chicken breast surimi made by pH 11.0 adjustment had significantly higher gumminess and chewiness than pH 3.0-adjusted surimi samples. Hanann (1988) reported that strain, as an indicator of protein interactions, was strongly affected by protein functionality. It is well known that myofibrillar protein plays the most critical role during meat processing because they are responsible for cohesiveness and the firm texture of meat products (Xiong, 1997; Kang et al., 2007). Again, Jin et al. (2007) reported that the texture attributes of different surimi meat types can be improved by increasing the pH adjustment. In this study, the chicken breast surimi made by an adjusted pH had significantly higher hardness,

gumminess and chewiness than the two- and four-washed surimi samples. Thus, we assume that the pH-adjusted chicken breast surimi samples had better texture than different washing time samples.

CONCLUSIONS

From the results of this study, we found that the content of moisture, crude fat collagen and yield were higher in the surimi manufactured from chicken breast by washing compared to pH adjustment, whereas crude protein was higher in the pH-adjusted than washing-time surimi. There was no significant difference in myofibrillar protein content among the surimi manufactured by different washing times and different pH adjustments, but T4 showed highest myofibrillar protein content among the surimi samples. Again, all physical characteristics were higher for pH-adjusted chicken breast surimi than two- and four-time washed samples. The pH-adjusted surimi had higher hardness, gumminess and chewiness than washing-times samples ($p < 0.05$). The chicken breast surimi made by pH 11.0 adjustment had significantly higher gumminess and chewiness than pH 3.0-adjusted surimi samples. The chicken breast surimi made by pH adjustment had higher lightness than when made by washing, whereas pH 3.0-adjusted surimi had lower whiteness than the other surimi samples. Myoglobin content was significantly higher in the surimi manufactured from pH-adjusted chicken breast. In conclusion, we found that white gel could not be obtained when a chicken breast muscle surimi is made by adjustment to pH 3.0, again bright, strength and firm gel can be obtained from chicken breast surimi made by pH adjustment.

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