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ARTICLE

Quality Characteristics of Marinated Chicken Breast as Influenced by the Methods of Mechanical Processing

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Abstract

The aim of this study was to investigate the effects of various marination processes on the quality characteristics of chicken breast prepared with chicken feet gelatin and wheat fiber. The chicken feet gelatin was swollen with hydrochloric solution (0.1 N HCl, pH 1.31±0.02) and dehydrated by freeze-drying. The composition (w/w) of the marinade was water (10%), soy sauce (12%), phosphate (0.3%), wheat fiber (1.5%), and chicken feet gelatin (1.5%). Three samples of chicken breast were manufactured with Tumbler (only tumbler), Tenderizer (tenderizer and tumbler), and Injector (injector and tumbler). The water content of the Injector sample was significantly higher than those of the Tumbler and Tenderizer samples ($p<0.05$). During heating, the lightness of all chicken breasts increased and the redness decreased. The tumbling and cooking yield of the Injector sample were significantly higher than those of the Tumbler and Tenderizer samples ($p<0.05$). The shear force of the Tenderizer sample was significantly lower than that of the Tumbler and Injector samples ($p<0.05$). No significant differences, except for color, were observed in the sensory analysis of the samples. Thus, the proper selection of mechanical processing is important to improve the quality characteristics of marinated chicken breast, considering the types of final products.

Key words: chicken breast, tumbler, tenderizer, injector, gelatin, fiber

Introduction

Tenderness of chicken breast is the most important factor related to overall sensory attributes (Cavitt *et al*., 2005), the several ways to improve the tenderness has been extensively examined. Typical tenderizing method can be largely categorized as chemical and physical tenderization. The chemical tenderization has been carried out with endogenous or exogenous enzymes and the addition of additives, whereas the physical tenderization has been conducted through mechanical equipment such as a meat tenderizer, an injector, and a tumbler (Ashie *et al*., 2002).

Marination of chicken breast meat has become an important part of the poultry industry because of increased consumer market, institutional food service, and restaurant demand for ready-to-cook and convenience foods. Marination has also been used as a method for tenderizing meat (Young and Lyon, 1997). Palladino and Ball (1979) found that sodium ions in marinades yield a tenderizing effect. Hamm (1960) postulated that dispersion of ions into muscle had a tenderizing effect owing to the repulsion caused by association of the ions with the proteins. This repulsion allowed increased water uptake and, therefore, increased moisture content and tenderness of the cooked meat.

Meat products such as beef, pork, and poultry are commonly marinated using a tumbler (to accelerate the extraction of the muscle proteins), tenderizer (to increase muscle tenderness) or injector (to easily disperse the brine into muscle). All three methods could reduce marination cost and time required to manufacture meat products. Recently, the availability of commercial marination process using the mechanical equipment has increased with

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increasing consumer demand for ready-to-cook marinated chicken breast products (Wong and Kitts, 2002). In the modern food industry, gelatin is utilized in the manufacture of confections, low-fat spreads, dairy, baked goods, and meat products, to help improve the texture and mouthfeel of products (Johnston-Banks, 1990; Schrieber and Gareis, 2007). Dietary fiber is also desirable for its high nutritive value and functional and technological properties.

Therefore, the objective of this study was to evaluate the effect of various mechanical marination processes on the quality characteristics of chicken breast prepared with chicken feet gelatin and wheat fiber.

Materials and Methods

Materials

Chicken breasts (*Pectoralis major*) and feet were provided by local meat processing factory (Maniker F&G Co., Korea). All subcutaneous fat and visible connective tissue were removed from the chicken breasts. They were then placed in polyethylene bags and vacuum-packaged using a vacuum packaging system (FJ-500XL, Fujee Tech, Korea) and stored at -21°C until required for product manufacturing. Chicken feet were skinned, washed using tap water, and immediately frozen and stored at -21°C until use. The wheat fiber used was WF400 (500 μm long particles; 74% cellulose, 26% hemicellulose, and <0.5 of lignin) of Vitacel® (J. Rettenmaier and Söhne GmbH, Germany). All reagents used were of analytical grade.

Preparation of chicken feet gelatins

The cleaned chicken feet were soaked in 10 volumes (v/w) of hydrochloric solution (0.1 N HCl) at 18°C for 24 h to swell them. After the acid treatment, the feet were neutralized with flowing tap water. For hot-water extraction, the feet were placed in polyethylene bags and vacuum packaged using a vacuum packaging system (FJ-500XL, Fujee Tech, Korea) before being heated at a temperature of 75°C for 2 h in a boiling water bath. The extracted gelatin was frozen at -70±1°C and dried at -40°C under 80×10^{-3} torr pressure using a freeze-dryer (PVTFD 20R, Ilshinlab, Korea). The gelatin was dehydrated until it reached a constant weight (<3% final moisture) for 48 h in the freeze-dryer.

Marination processes of chicken breast

The composition (w/w) of marinate solution was water (10%), soy sauce (12%), phosphate (0.3%), wheat fiber (1.5%) and chicken feet gelatin (1.5%). The tumbling treatment was only marinated by tumbling for 1 h at 0±1°C (MKR150, RÜHLE GmbH, Germany). The tenderizer samples were tenderized by tenderizer (DK-9003, DONGKANG Co., Korea) and then marinated by tumbling for 1 h at 0±1°C. The injection treatments were injected by an injector (PR8; RÜHLE GmbH, Germany) and then marinated by tumbling for 1 h at 0±1°C. All samples were heated at 75±1°C for 30 min by using a smoke chamber. The cooked samples then were cooled with cold water and stored at 4°C until further analysis.

Proximate composition

Compositional properties of the marinated chicken breast were determined using AOAC (2000). Moisture content was determined by weight loss after 12 h of drying at 105°C in a drying oven (SW-90D, Sang Woo Scientific Co., Korea). Fat content was estimated by Soxhlet method with a solvent extraction system (Soxtec® Avanti 2050 Auto System, Foss Tecator AB, Sweden), and protein content was estimated by Kjeldahl method with an automatic Kjeldahl nitrogen analyzer (Kjeltec® 2300 Analyzer Unit, Foss Tecator AB, Sweden). Ash was determined according to AOAC method 923.03.

pH

Following grinding and homogenization of 5 g of sample in 20 mL of distilled water for 60 s (Ultra-Turrax® T25, Janke & Kunkel, Germany), the pH was measured using a pH meter (Model 340, Mettler-Toledo GmbH Analytical, Switzerland). All measurements were performed in triplicate.

Color evaluation

Samples were evaluated on the basis of their surface color. Color measurements were recorded with a colorimeter (Chroma meter CR-210; Minolta, Japan; illuminate C, calibrated with white standard plate CIE L*=97.83, CIE a*=-0.43, CIE b*=+1.98) and consisted of an 8-mm diameter measurement area and a 50-mm diameter illumination area. Color values (CIE L*, a*, and b*) were measured on the sample surfaces. Results were obtained in triplicate for each sample.

Marinating yield

The initial sample was raw chicken breast (initial weight). The marinated samples were weighed (marinating weight), and the percentage marination yield was calculated from the recorded weights as follows;

marinating yield (%) = [marinating weight (g) / initial weight (g)] × 100

Cooking yield

Raw chicken breast samples (initial weight) were heat processed at 75±1°C water bath (Model 10-101, Daehan Co., Korea) for 30 min until the core temperature of the samples reached at 71±1°C. After cooling for 1 h, the cooked samples were weighed (cooking weight), and the percentage cooking yield was calculated from the recorded weights as follows;

cooking yield (%) = [cooking weight (g) / initial weight (g)] × 100

Shear force measurement

For the determination of shear force, each sample was cooked individually polyethylene bags immersed in a 75°C water bath (Model 10-101, Daehan Co., Korea) for 30 min. After cooking, the cooked samples were cooled at room temperature for 3 h. Shear force values were determined with a Warner-Bratzler shear attachment on a texture analyzer (TA-XT2*i*; Stable Micro System Ltd., UK). Test speeds were set at 2 mm/s. Data were collected and analyzed from the shear force values (kg) to obtain the maximum force required to shear through each sample.

Sensory evaluation

A trained 30-member panel consisting of researchers from the Department of Food Sciences and Biotechnology of Animal Resources at Konkuk University in Korea participated in the study. Each sample was evaluated in terms of color, flavor, juiciness, tenderness, and overall acceptability. Panelists were presented with randomly coded samples. The color (1 = extremely undesirable, 10 = extremely desirable), flavor (1 = extremely undesirable, 10 = extremely desirable), tenderness (1 = extremely tough, 10 = extremely tender), juiciness (1 = extremely dry, 10 = extremely juicy), and overall acceptability (1 = extremely undesirable, 10 = extremely desirable) of the samples were evaluated using 10-point descriptive. Panelists were required to cleanse their palate with water between samples (Keeton, 1983).

Statistical analysis

All experiments were performed in duplicate with at least three replicates. The experimental results are expressed as means and standard deviations. An analysis of variance was performed on all variables measured using the general linear model procedure of the SAS statistical package (SAS Institute, 2010). The Duncan's multiple range test (p<0.05) was used to determine whether differences between treatment means were significant.

Results and Discussion

Proximate composition of marinated chicken breast

The proximate composition values of marinated chicken breast manufactured with tumbler, tenderizer, and injector are given in Table 1. Each marination process caused the different changes in proximate composition of chicken breast. The protein and fat content of the injected chicken breast was the lowest among all the samples. In contrast, the water content (73.77%) of the injected chicken breast was significantly higher than that of the tumbled and tenderized chicken breast samples (p<0.05). The water content was expected to be highest in injected that have lower protein and fat content. Boles and Shand (2001) reported an increase in water content when injected roasts were compared with non-injected roast beef. Furthermore, dispersion of dietary fiber and gelatin into the muscle by injection could obviously improve the dispersion of dietary fiber and gelatin in the brine which resulted in an increase in water holding capacity (WHC) of chicken breast. Kim *et al*. (2012) reported that the water content of the meat product increased with an increase in the chicken feet gelatin content. Choi *et al*. (2009) and Lee *et al*. (2008) reported that dietary fiber provides high water retention. A similar trend has been reported previously for several types of meat products manufactured with dietary fiber, such as frankfurters (Choi *et al*., 2009), bologna (Osburn *et al*., 1998), beef steak (Jiménez-Colmenero *et al*., 2003), and breakfast sausages (Mittal and

Table 1. Proximate composition of marinated chicken breast manufactured with Tumbler, Tenderizer, and Injector

Properties	Treatment		
	Tumbler	Tenderizer	Injector
Water content (%)	71.54 ± 0.11^{b}	70.88 ± 0.12^{c}	73.77 ± 0.48^{a}
Protein content (%)	26.85 ± 0.08^{a}	26.60 ± 0.13^{b}	22.86 ± 0.09^{c}
Fat content (%)	1.11 ± 0.18^{ab}	1.46 ± 0.22^{a}	0.98 ± 0.17^{b}
Ash content (%)	1.77 ± 0.03^{b}	1.99 ± 0.07^{a}	2.04 ± 0.01^{a}

All values are mean ± standard deviation of three replicates.
$^{a-c}$Means within a row with different letters are significantly different (p<0.05).

Barbut, 1994). The ash content was higher in the tenderized and injected chicken breast samples ($p<0.05$) than in the tumbled chicken breast, and this result is associated with the minerals contained in wheat fiber (Kim *et al*., 2012; Lee *et al*., 2008). Choe *et al*. (2009) observed that the ash content of liver sausage was increased by the addition of kimchi powder, which contains a high amount of dietary fiber. Consequently, our results shows the proximate composition of chicken breast was differently affected by the marination method due to different dispersibility of components contained in the brine.

pH value and color characteristics of marinated chicken breast

The pH values and color characteristics of marinated chicken breast manufactured with tumbling, injecting, and tenderizing processes are given in Table 2. The pH values of marinated and uncooked chicken breast ranged from 6.00 to 6.09, after cooking, the marinated chicken breast samples ranged from 6.16 to 6.31. No significant differences were observed in the pH values of both cooked and uncooked marinated chicken breast among all treatments ($p>0.05$). For all samples, the pH of marinated and uncooked chicken breast was lower than that of all marinated and cooked chicken breast. These results were probably due to the exposure to imidazolium, the basic R group of the amino acid such as histidine, during heating, increased the pH of the marinated chicken breast (Choi *et al*., 2009). Kim *et al*. (2010) reported similar results that pH of cooked meat batter was higher than uncooked meat batter. Numerous studies also reported that the increase in pH value of several meat products after thermal processing (Morin *et al*., 2002).

In terms of uncooked chicken breast, the tumbled chicken breast had significantly higher lightness, redness, and yellowness than the injected chicken breast ($p<0.05$). After cooking, however, there was only difference in yellowness among treatments. Also, the lightness and yellowness values of marinated and cooked chicken breast samples were higher than those for uncooked samples. However, the redness of all cooked samples was lower than that of uncooked samples. In general, cooking increases the lightness values and decreases the redness values of meat products (Jiménez-Colmenero *et al*., 2003). Choi *et al*. (2011) noted that the lightness of heat-induced gel prepared with pork-soluble meat protein increased and the redness of heat-induced gel decreased during the heating process.

Tumbling and cooking yield of marinade chicken breast

The tumbling and cooking yields of marinated chicken breast manufactured with tumbling, injecting, and tenderizing processes are given in Fig. 1. Cooking and tumbling yield are important measurements related to WHC of meat product. The tumbling and cooking yields of marinated chicken breast samples ranged from 109.57% to 125.56%, and from 88.67% to 100.11%, respectively. The tumbling and cooking yields of the injected chicken breast was significantly higher than those of the tumbled and tenderized chicken breast samples ($p<0.05$). Boles and Shand (2001) previously reported that the cooking yield of injected beef was higher than that of non-injected roast beef. Boles and Swan (1997) also observed that cooking yields of pre-rigor injected beef was increased compared with that of non-injected pre-rigor cooked beef. Furthermore, the result of marinating and cooking yields could be associated with the high WHC and water absorbed ability (Choi *et al*., 2009; Osburn and Mandigo, 1998). Choe *et al*. (2013) reported that the cooking yield of frankfurters increased as dietary fiber and gelatin content increased. Further, dietary fiber and gelatin could be

Table 2. pH value and CIE L*, a*, b* value of marinated chicken breast manufactured with Tumbler, Tenderizer, and Injector

Condition	Traits	Treatment		
		Tumbler	Tenderizer	Injector
Uncooked	pH	6.09 ± 0.03	6.06 ± 0.03	6.00 ± 0.03
	CIE L*	48.29 ± 1.29^{a}	46.81 ± 1.12^{b}	46.23 ± 1.53^{b}
	CIE a*	10.46 ± 0.65^{a}	10.32 ± 1.12^{a}	9.22 ± 0.40^{b}
	CIE b*	16.09 ± 1.00^{a}	15.31 ± 0.30^{b}	15.42 ± 0.37^{b}
Cooked	pH	6.30 ± 0.04	6.16 ± 0.09	6.31 ± 0.05
	CIE L*	71.71 ± 1.40	70.45 ± 2.81	70.59 ± 2.66
	CIE a*	4.52 ± 0.49	4.48 ± 0.75	4.83 ± 0.72
	CIE b*	21.87 ± 1.41^{b}	22.80 ± 1.50^{ab}	23.56 ± 0.93^{a}

All values are mean ± standard deviation of three replicates.

^{a,b}Means within a row with different letters are significantly different ($p<0.05$).

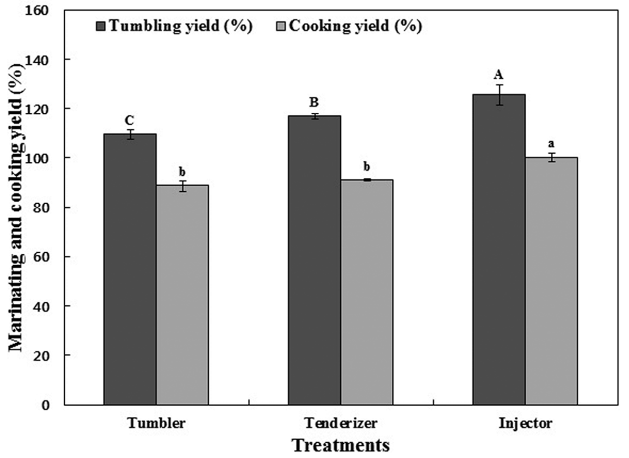

Fig. 1. The marinating and cooking yields of marinated chicken breast manufactured with Tumbler, Tenderizer, and Injector. [A-C]Means values with different letters among the marinating yield of treatment are significantly different ($p<0.05$). [a-c]Means values with different letters among the cooking yield of treatment are significantly different ($p<0.05$).

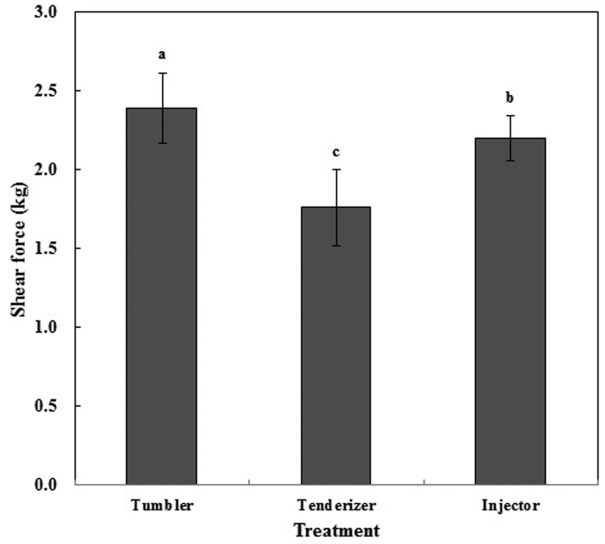

Fig. 2. The shear force of marinated chicken breast manufactured with Tumbler, Tenderizer, and Injector. [a-c]Means values with different letters among the treatment are significantly different ($p<0.05$).

used to increase cooking and tumbling yield due to their water- and fat-binding properties, as well as to improve texture (Choi *et al*., 2009; Kim *et al*., 2012). Thus, the marinating and cooking yields of chicken breast could be related to the components in the brine, and the injecting process is considered as the most effective method for improving the dispersion of the brine.

Shear force of marinated chicken breast

The shear force values of marinated chicken breast manufactured with tumbling, injecting, and tenderizing processes are given in Fig. 2. A shear force value between 6.0 and 8.8 kg/g would be considered as "slightly tender" to "moderately tender", in terms of consumer consumption (Lyon and Lyon, 1990). The shear force of marinated chicken breast ranged from 1.76 to 2.39 kg. All treatments were classified as "very tender" by the consumer. Shear force value of the tenderized chicken breast was a significantly lower than those for the tumbled and injected chicken breast samples ($p<0.05$). This result is probably due to the many knives of a tenderizer effectively breaks muscle fiber. The shear force value is a useful indicator related to the meat tenderness, and lower shear force values indicate a more tender meat (Herring *et al*., 1967). Pietrasik and Shand (2004) reported that shear force values of beef was reduced by the blade or needle tenderization. The injected chicken breast was significantly more tender ($p<0.05$) than the tumbled chicken breast, possibly due to greater muscle fiber and gelatin disruption from fluid pressure, and the injector needles disrupting the density of the muscle fiber network. Alvarado and Sams (2004) found that the shear force of broiler breast prepared using the tumbler and injector was lower than that of the broiler breast prepared using the tumbler alone. Boles and Shand (2001) showed that hardness of roast beef decreases with an increasing injection level.

Sensory evaluation of marinade chicken breast

The sensory properties of marinated chicken breast manufactured with tumbling, injecting, and tenderizing processes are shown in Table 3. The tenderness score of tenderized chicken breast samples was higher than that of both tumbled and injected chicken breast samples. The tenderized chicken breast showed the highest score for tenderness when compared to tumbled and injected chicken breast treatments. The result of tenderness is supported by the result of shear force which showed more tender for tenderized chicken breast than tumbled sample ($p<0.05$). Sensory evaluation of color, flavor, juiciness, and overall acceptability for all treatments fell within a high score of range of 7-8 points; thus, the panel members showed no differences in their individual preferences. These results agree with those reported by Kim *et al*. (2012) who noted significantly high scores in semi-dried jerky on the addition of wheat fiber and chicken feet gelatin. According to Turhan *et al*. (2005) and Choe

Table 3. Sensory evaluation value of marinated chicken breast treated with Tumbler, Tenderizer, and Injector

Properties	Treatment		
	Tumbler	Tenderizer	Injector
Color	8.38 ± 0.74	8.38 ± 0.52	8.38 ± 0.52
Flavor	8.38 ± 0.52	8.50 ± 0.53	8.63 ± 0.52
Tenderness	7.75 ± 0.71[b]	8.63 ± 0.52[a]	8.13 ± 0.35[ab]
Juiciness	8.13 ± 0.64	7.94 ± 0.94	8.38 ± 0.52
Overall acceptability	8.13 ± 0.64	8.25 ± 0.46	8.50 ± 0.53

All values are mean ± standard deviation of three replicates.
[a,b]Means within a row with different letters are significantly different (p<0.05).

et al. (2013), the presence of dietary fiber and gelatin enhanced the consistency of the meat products through the formation of a three-dimensional network capable of modifying rheological properties, thus leading to higher overall acceptability scores. Many researchers have also shown that dietary fiber improves sensory properties of meat products (Fernández-Ginés *et al*., 2004; Turhan *et al*., 2005). Sadler and Young (1993) reported that for any collagen content, sausages containing preheated tendon had a more desirable sensory texture, flavor, and overall acceptability than did sausage containing raw tendon. Consequently, the method of mechanical processing differently influenced the quality characteristics of marinated chicken breast, and the result could related to the dispersibility of the brine and physical impact on the muscle fiber. In the view of the water retention and holding abilities, injecting processes greatly improves the marinating and cooking yields of chicken breast, whereas the tenderizing process is more effective in enhancement of the tenderness of chicken breast when compared to tumbling and injecting processes.

Thus, this study suggests that proper selection of mechanical processing is important to improve the quality characteristics of marinated chicken breast, considering the types of final products.

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