

Differentiation of Deboned Fresh Chicken Thigh Meat from the Frozen-Thawed One Processed with Different Deboning Conditions

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Abstract

This study was performed to evaluate the quality characteristics of three deboned categories of chicken thigh meat: one which was slaughtered and deboned in the same plant (fresh); one which was slaughtered, deboned, frozen, and thawed in the same plant (frozen-thawed); and the last which was slaughtered in a plant, deboned in a different plant, but then transferred to the original plant (fresh-outside). Surface color, drip loss, 2-thiobarbituric acid reactive substances (TBARS) value, sensory evaluation, and total aerobic bacterial counts of the chicken samples were determined. Moreover, the torrymeter was used to measure the differences in freshness of the chicken meat. The surface color and the TBARS values did not show significant differences among the three categories. However, the total aerobic bacterial counts of fresh-outside and frozen-thawed chicken meat were significantly higher than the fresh chicken meat on the first storage day, and the drip loss of frozen-thawed chicken meat was significantly higher than the fresh-outside and fresh chicken meat. In addition, the sensory evaluation of frozen-thawed chicken meat was significantly lower than the fresh-outside and fresh chicken meat. Torrymeter values were higher in fresh chicken meat than fresh-outside and frozen-thawed chicken meat during the storage period. These results indicate that the quality of frozen-thawed chicken meat is comparatively lower than the fresh chicken meat, and the torrymeter values can accurately differentiate the fresh-outside and frozen-thawed chicken meat from the fresh ones.

Key words: chicken thigh, fresh, frozen-thawed, deboning, torrymeter, differentiation

Introduction

Chicken meat is generally considered as the healthiest animal food because it is low in fat and cholesterol, but rich in protein (Choe *et al.*, 2010). In addition, chicken is cheap and its consumption is not forbidden by any religion. The per capita consumption of chicken, both whole (Han *et al.*, 2009) and deboned (Lee *et al.*, 2012), is steadily increasing in Korea. With the increasing demand, the amount of chicken meat imported into Korea has increased by approximately two folds, from 58,000 tons in 2009 to 108,000 tons in 2011 (Korea Chicken Council, 2011).

Imported chicken meat in Korea is usually frozen and

much cheaper than fresh refrigerated ones. Freezing is an excellent method to preserve the quality of meat and fish for a long time (Sung *et al.*, 2013). However, deterioration of meat quality, indicated by factors such as high drip loss, decreases in tenderness and water-holding capacity, is triggered by the freezing and thawing process (Jeong *et al.*, 2011; Turhan *et al.*, 2006). In addition, various enzymes such as lysozymes, lipases, and proteases are released by damaged cells (Ballin and Lametsch, 2008). Despite the fact that frozen-thawed meat is of low quality, some domestic vendors deceive customers by mixing it with fresh meat. This practice is illegal. The rule imposed by government to label the meat and indicate its origin does not dissuade these illegal vendors.

It is difficult to visually differentiate fresh meat or fish from frozen-thawed one. However, studies on different meat species reported that torrymeter measurement could distinguish fresh meat or fish from frozen-thawed one (Duflos *et al.*, 2002; Jung *et al.*, 2011; Sung *et al.*, 2013). Harvesting physically damaged frozen-thawed meat or

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fish, makes its torrymeter value different from that of the fresh one (Lougovois *et al.*, 2003). They also reported that the torrymeter is easy to use, highly sensitive, and portable.

The animal product grading system has had a good impact on the production, and processing sectors and on the consumers since its introduction in Korea (KREI, 2008). In Korea, the grading of chicken meat is not compulsory. Recently, however, the consumer demand for chicken meat quality grading has been increased dramatically. To obtain the quality grade, chicken meat must be fresh (not frozen before) and it should not pass 48 h after slaughter (Notification from MIFAFF, 2011-175). In case of chicken meat cuts, chicken must be slaughtered and deboned at the same plant to obtain the quality grade because quality change of chicken meat is expected while transported. Recently, some companies have requested the permit to grade meat that is slaughtered and deboned in different plants (fresh-outside) when a single plant is unable to run both processes.

It is difficult to differentiate fresh chicken meat cuts with frozen-thawed or fresh but deboned at a different plant (fresh-outside). Therefore, the objective of this study was to evaluate the reliability of torrymeter measurement in differentiating among the deboned fresh chicken thigh meat that was slaughtered and deboned in the same plant without freezing (fresh), chicken meat that was slaughtered, deboned, frozen, and thawed in the same plant (frozen-thawed), and fresh one that was slaughtered in one plant, transferred to another plant for deboning, and returned to original plant without freezing (fresh-outside). The quality parameters were also assessed.

Materials and Methods

Sample preparation

Chickens (Ross), which were reared in the same farm, and were fed the same feed, with an average weight of 1.5 kg (33 d of age, 10 chickens per treatment) were slaughtered at a local slaughter house (Cheonan, Korea). One day after slaughtering, fresh chickens were manually deboned in the same plant; and skinless thigh samples were packaged in low-density polyethylene material and stored in a refrigerator (4°C). These were the fresh samples. To prepare the fresh-outside samples, after slaughtering, whole chickens were transferred to a different plant (Jincheon, Korea) for manual deboning. For transfer, the chickens were put in an ice-filled container that was driven by a refrigerated truck. The deboned skinless chicken thighs

(fresh-outside) were aerobically packaged with the same low-density polyethylene material, returned to the original plant the next day, and stored in a refrigerator at 4°C. Frozen-thawed samples were prepared by storing the skinless thigh meat packaged with low-density polyethylene in a deep freezer (-40°C) for 29 d. These samples were then individually thawed in cool water (<10°C) for 2 d and transferred into a refrigerator (4°C). This process is a typical practice in industry.

Surface color, lipid oxidation, and total aerobic bacterial count of the skinless thigh samples were determined on the first (the next day of deboning), third, and seventh day of storage at 4°C. Torrymeter value was measured daily for 7 d and drip loss was measured after 7 d of storage.

Surface color

The color values of the chicken thigh samples were measured on the surface of samples by using a colorimeter (Spectrophotometer, CR-300, Minolta Inc., Japan). This instrument was calibrated with a black and a white reference tile. The values of lightness (CIE L*), redness (CIE a*), and yellowness (CIE b*) were obtained. For each color, three measurements were taken from different locations on the surface of skinless thigh, and their average was determined. Each color value was analyzed by Spectra Magic Software (Minolta Inc., Japan).

2-Thiobarbituric acid reactive substances (TBARS) value

Lipid oxidation was determined as the TBARS value by using the method described by Jung *et al.* (2012). For this test, 3 g of meat was added to 9 mL of distilled water. This was followed by the addition of 50 µL of butylated hydroxyanisole (7.2%). The whole mixture was homogenized for 30 s. One milliliter of the homogenate was transferred to a test tube, and 2 mL of TBA-TCA solution (20 mM TBA in 15% trichloroacetic acid) was added to it. The tubes were heated at 90°C in a boiling water bath for 30 min, cooled, and centrifuged for 10 min at 2,090×g (Hanil Science Industrial Co., Korea). The absorbance of the supernatant was measured at 532 nm with a spectrophotometer (DU530, Beckman Instruments Inc., USA). TBARS value was reported as milligram of malondialdehyde per kilogram of meat.

Total aerobic bacterial counts

Five grams of the meat sample were mixed with sterile saline solution (0.85% NaCl, 45 mL) for 30 min, using a

bag mixer (Model 400, Interscience, France). The mixture was then serially diluted. A series of decimal dilutions was prepared with sterile saline. Three agar plates were inoculated with 100 μ L of each of the serially diluted solution. These plates were prepared in triplicate, the dilutions were spread, and the plates were incubated at 37°C for 48 h. After incubation, the microbial counts were determined and expressed as Log CFU/g.

Drip loss

The packaged chicken thighs were stored for 7 d at 4°C, following which the drip loss was measured. This was done by weighing the samples and comparing their actual weights with the weight (original sample weight) measured on the first day of storage. The loss during thawing for frozen-thawed meat in cool water (<10°C) for 2 d was not included in drip loss calculation. Drip loss was expressed as percentage, and it was calculated as follows:

$$\text{Drip loss (\%)} = \{(\text{original thigh sample weight} - \text{measured thigh sample weight}) / \text{original thigh sample weight}\} \times 100$$

Sensory evaluation

Sensory evaluation was conducted by seven panelists. The panelists have experience on the sensory test of chicken meat at least six months. The meat samples (40×20×10 mm) were electrically grilled until the internal temperature reached to 72°C. Preliminary testing was done on the fresh samples. Each meat samples were placed on coded white dishes and served to panelists with water for rinsing the oral cavity. The samples were labeled with random 3-digit numbers and provided to panelists in random order. The sensory parameters, namely, color, flavor, taste, tenderness, juiciness, and overall acceptability, were measured using a 9-point hedonic scale (1=extremely disliked, 5=moderately liked, 9=extremely liked). Each sensory parameter was measured three times on the third day of storage.

Torrymeter value measurement

The torrymeter (GR The Torry Freshness Meter, Distell Industries Ltd., UK) was used to evaluate the degree of freshness of chicken thigh meat stored at 4°C. The torrymeter sends low electric current under 1 mA to the sample, which helps determine changes in the dielectric properties of the tissues (Duflos *et al.*, 2002). The torrymeter gives a response ranging from 0 (advanced decomposition)

to 16 (very fresh). A single measurement was obtained for each sample by applying the probe of the torrymeter on the sample surface. Electrodes were cleaned between measurements.

Statistical analysis

The whole experiment was performed in triplicates. Analysis of variance was calculated via the procedure of the General Linear Model by using SAS version 9.2 software. Duncan's multiple range test was conducted to determine the significant differences among the mean values of treatments ($p < 0.05$). The mean values and their standard errors (SEM) were also calculated.

$$y_{ij} = \mu_i + \alpha_i + \varepsilon_{ij} \quad (i = 1, 2, 3; j = 1, 2, 3)$$

y_{ij} = the j observation on the i treatment

μ_i = grand mean

α_i = effect of i treatment

ε_{ij} = random error

Results and Discussion

Surface color

When consumers buy meat, surface color is the most important factor considered by them (Fletcher, 1999). Bright red meat is highly preferred over the brown one, because the bright red color indicates that the meat is fresh. Meat color is dependent on pH, temperature, pre-mortem stress, age, and sex (Renner and Labadie, 1993). During the freezing-thawing process, myofibrils shrink and exudates leak from them. These exudates may cause light scattering; however, there was no significant difference in L* value over the storage period (Table 1). The a* (redness) value of fresh chicken meat increased significantly over the storage period. Livingston and Brown (1981) reported that metmyoglobin reducing activity is very active and is quickly reduced to deoxymyoglobin. When this happens, the meat obtains a bloom color in fresh muscle. During storage, oxymyoglobin is converted into metmyoglobin by autoxidation, making the meat appear darker (Ledward and MacFarlane, 1971). On the first day of storage, the b* value of frozen-thawed chicken meat was significantly higher than that of fresh and fresh-outside meat. This observation is in agreement with the findings of Sung *et al.* (2013) and is explained by the fact that the freeze-thaw cycle causes lipid oxidation and color instability (Dias *et al.*, 1994).

Table 1. Surface color, 2-tiobarbituric acid reactive substances (TBARS), total aerobic bacterial (TAB) count of chicken thigh meat processed with different deboning conditions

	Treatment ¹	Storage (d)			SEM ²
		1	3	7	
L*	Fresh	54.95	55.26	53.34	0.711
	Fresh-outside	54.90	54.86	54.88	1.813
	Frozen-thawed	56.26	58.41	56.59	1.128
	SEM ³	1.132	1.500	1.239	
a*	Fresh	5.91 ^y	7.03 ^{xy}	8.11 ^x	0.465
	Fresh-outside	5.69	8.61	8.25	0.826
	Frozen-thawed	8.14	7.93	7.71	0.996
	SEM ³	0.800	0.756	0.824	
b*	Fresh	17.24 ^b	17.83	17.88	0.511
	Fresh-outside	16.60 ^b	18.43	17.59	0.535
	Frozen-thawed	18.63 ^a	18.21	18.42	0.524
	SEM ³	0.340	0.476	0.693	
TBARS	Fresh	0.36	0.35	0.37	0.023
	Fresh-outside	0.37 ^y	0.39 ^y	0.45 ^x	0.016
	Frozen-thawed	0.46	0.47	0.48	0.057
	SEM ³	0.035	0.042	0.034	
TAB	Fresh	2.52 ^{by}	3.62 ^y	7.03 ^x	0.374
	Fresh-outside	4.22 ^{ay}	4.91 ^y	7.17 ^x	0.254
	Frozen-thawed	3.61 ^{az}	5.11 ^y	7.36 ^x	0.241
	SEM ³	0.207	0.351	0.310	

¹Fresh, chicken thigh meat slaughtered and deboned in the same plant and stored at 4°C; Fresh-outside, chicken thigh meat slaughtered in a plant, deboned in a different plant, but transferred to the original plant and stored at 4°C; Frozen-thawed, chicken thigh meat slaughtered, deboned, frozen at -40°C for 29 d, thawed with cool water, and stored at 4°C.

² Standard error of the means (n=9).

³(n= 9).

^{a,b}Different letters within the same column with the same parameter differ significantly ($p<0.05$).

^{x,y}Different letters within the same row differ significantly ($p<0.05$).

2-Thiobarbituric acid reactive substances (TBARS) value

Lipid oxidation products cause the following effects: development of rancid flavor, discoloration, and acceleration of myoglobin oxidation. The aldehydic compounds, malondialdehyde and hydroxynonenal, are the major final products of lipid oxidation (Philippe *et al.*, 2007). The TBARS value of frozen-thawed meat was significantly higher than that of fresh and fresh-outside meat (Table 1). During freezing, the cell membranes are damaged by ice crystals; these membranes then release pro-oxidants such as free iron (Benjakul and Bauer, 2001). The TBARS-value of fresh and frozen-thawed chicken meat did not increase significantly on the seventh day of storage (Table 1). These results concord with the findings of Filgueras *et al.* (2010) who reported that the TBARS value of leg muscle of rhea was not significantly increased during air-packaged storage. On the other hand, the TBARS value of fresh-outside sample had increased significantly on the seventh day of storage. This may be attributed to the inevitable fluctuation in temperature during transportation

and handling.

Total aerobic bacterial (TAB) count

On the first day of storage, fresh chicken meat showed significantly lower TAB counts than fresh-outside and frozen-thawed meat (Table 1). The TAB counts of frozen-thawed meat significantly increased during the storage period, whereas those of fresh and fresh-outside samples increased only after the third day of storage ($p<0.05$). Moisture leaked out of the meat during thawing. This moisture contained proteins, vitamins, and minerals, which are conducive to microbial growth (Leygonie *et al.*, 2012). In this study, we considered meat as spoilt when the TAB counts was greater than 7 Log CFU/g on the seventh day of storage.

Drip loss and sensory evaluation

The drip loss of frozen-thawed chicken meat (6.36%) was significantly higher than that of fresh-outside (3.7%) and fresh (4.59%) samples (Fig. 1). Drip loss of meat is inevitable due to the isoelectric point of muscle proteins,

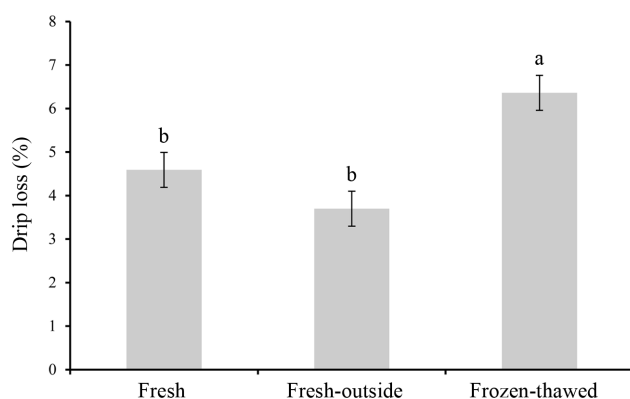


Fig. 1. Drip loss of chicken thigh meat processed with different deboning conditions after 7 d of storage. ^{a,b}Different letters among treatments differ significantly ($p < 0.05$).

the loss of adenosine triphosphate (ATP), proteolysis, and shrinking of the myofibrils during rigor mortis (Huff-Lonergan and Lonergan, 2005). In case of frozen-thawed chicken thigh meat, ice crystals can cause physical damage, cell destruction, and body fluid separation. After microscopic observation, Jung *et al.* (2011) reported that frozen-thawed breast fillets had larger spaces between their muscle fibers and their myofibrils had collapsed. Decreased water holding capacity of meat can be attributed to frozen storage and thawing (Vieira *et al.*, 2009). Therefore, as expected, the drip loss of frozen-thawed chicken meat was more than that of fresh-outside and fresh samples.

As shown in Table 2, the color, flavor, taste, tenderness, juiciness, and overall acceptability values of fresh and fresh-outside samples were significantly higher ($p < 0.05$) than those of frozen-thawed samples, and the sensory panelists clearly noticed the differences between the frozen-thawed chicken thigh meat and other samples. During thawing, water is released as the muscle fibers shrink. The fibers, therefore, become flaccid and tough or less tender (Leygonie *et al.*, 2012). Therefore, frozen-thawed samples had low sensory scores. This is explained by the fact that tenderness plays an important role in the textural charac-

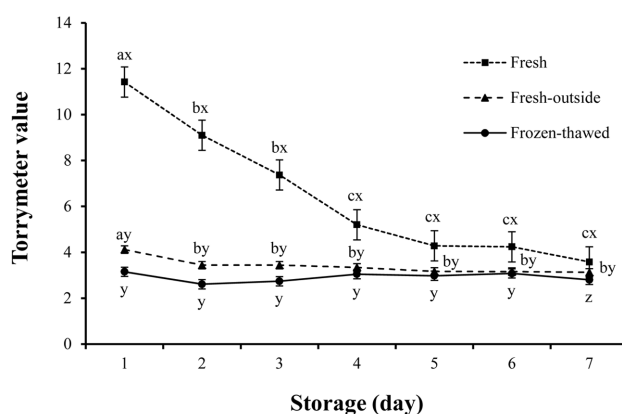


Fig. 2. Torrymeter value of chicken thigh meat processed with different deboning conditions and stored for 7 d. ^{a-c}Different letters among storage days differ significantly ($p < 0.05$). ^{x-z}Different letters among treatments differ significantly ($p < 0.05$).

teristic of meat (Kim and Lee, 2003), and the drip contains many nutrients (Fischer, 2007).

Torrymeter value

The torrymeter value of fresh chicken meat (7.69) was significantly higher than that of fresh-outside (3.44) and frozen-thawed samples (3.14) at the first storage day (Fig. 2). This value of fresh chicken meat decreased steeply from the first to the fourth day of storage; after the fourth day, the decrease was more gradual while those of the fresh-outside and the frozen-thawed chicken meat remained constant lower throughout the storage period. These findings concord with those of Jung *et al.* (2011); they reported that the torrymeter values of fresh chicken breast meat decreased significantly while those of the frozen-thawed one remained constantly lower throughout the storage period. The torrymeter has been used to determine the freshness of meat or fish by measuring modifications in the electrical properties of tissues (Duflos *et al.*, 2002). The permittivity and conductivity of meat were decreased with the increase of spoilage (Lougovois *et al.*, 2003). Sung *et al.* (2013) found that torrymeter value was negatively

Table 2. Sensory evaluation of chicken thigh meat processed with different deboning conditions

Treatment ¹	Sensory parameter					
	Color	Flavor	Taste	Tenderness	Juiciness	Overall acceptability
Fresh	5.08 ^x	5.25 ^x	5.08 ^x	5.71 ^x	5.45 ^x	5.41 ^x
Fresh-outside	5.04 ^x	5.71 ^x	5.63 ^x	5.38 ^x	5.25 ^x	5.63 ^x
Frozen-thawed	4.38 ^y	3.54 ^y	3.54 ^y	3.46 ^y	3.04 ^y	3.04 ^y
SEM ²	0.160	0.269	0.271	0.295	0.298	0.317

¹See the footnote of Table 1.

²Standard error of means (n=24).

^{x,y}Different letters within the same column differ significantly ($p < 0.05$).

correlated to the count of total aerobic bacteria in duck breast meat. Therefore, it seems that the low torrymeter value of fresh-outside chicken compared to that of fresh one is caused by the higher count of total aerobic bacteria. In addition, freezing decreased the permittivity and conductivity of meat because the generation of ice crystals during freezing damaged the membrane of meat, causing the efflux of intercellular electrolytes and the influx of extracellular ones (Jung *et al.*, 2011; Ghatass *et al.*, 2008). As well as torrymeter, K value was introduced as an indicator of the degree of meat freshness (Saito *et al.*, 2009). This value is obtained by measuring the proportion of inosine and hypoxanthine to the total amount of ATP and its degradation products. However, the K value is not reliable for differentiating between frozen-thawed and fresh meat because the amount of ATP and its degradation products depend on the storage conditions (Lougovois *et al.*, 2003). The study by Jung *et al.* (2011) confirmed that pH and K values did not provide satisfactory results for the differentiation of frozen-thawed breast fillets from fresh ones during storage.

Conclusions

Drip loss and sensory evaluation clearly differentiate the fresh chicken thigh meat from the frozen-thawed one. The torrymeter was found to be effective and simple to differentiate the fresh chicken thigh meat from frozen-thawed or fresh-outside samples, and can, therefore, be implemented in industry.

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