



Effect of various temperature and storage time during process on physical quality and water-holding capacity of broiler breast meat ผลของอุณหภูมิและระยะเวลาระหว่างกระบวนการผลิตต่อคุณภาพด้านกายภาพและความสามารถในการอุ้มน้ำของเนื้ออกไก่กระທ

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Abstract

Water holding capacity of chicken meat is very important for meat quality and meat production yield. Various conditions in product line might affect on quality and water holding capacity of chicken meat. The objective of this study was to determine the effect of process temperature, storage temperature and time and freeze-thaw process on quality of broiler breast meat. Higher process temperature influenced on more lightness (L^*), redness (a^*), yellowness (b^*) and drip loss in breast meat. However, no difference in cooking loss was observed among processing temperature ($0-4^{\circ}\text{C}$, $8-10^{\circ}\text{C}$ and $12-15^{\circ}\text{C}$ for 8 hr). Broiler breast meat chilled at $12-15^{\circ}\text{C}$ for 72 hr had higher ($P < 0.05$) in L^* , b^* and drip loss than those chilled at $0-4^{\circ}\text{C}$. Longer chilling storage time induced lower L^* , a^* , shear force value and greater b^* , drip and cooking losses. Quality of broiler breast meat after delay time process at $0-4^{\circ}\text{C}$ and $12-15^{\circ}\text{C}$ for 24 h were studied comparatively between freeze-thawed and chilled sample. Freeze-thaw broiler meat had lower ($P < 0.05$) in L^* and a^* than those of chilled meat. Freeze-thaw process provided the greater drip loss and lower shear force in broiler breast meat.

Keyword: water holding capacity, broiler breast meat, color, shear force value

1. Introduction

The water holding capacity is the ability of fresh meat to retain moisture. The majority of water in muscle is held either within the myofibrils, between the myofibrils and between the myofibrils and the cell membrane (sarcolemma), between muscle cells and between muscle bundles (groups of muscle cells) (1). The water holding capacity is an important property of poultry meat to determine quality and consumer acceptability. Poor in water holding capacity of meat could be performed by high drip and cooking losses. Many factors could affect the water holding capacity of broiler breast meat especially, process conditions such as carcass temperature, delay time, storage temperature and time. Hence, all those factors must be controlled during chicken meat production. However, variation of temperature and time during process was normally observed depending on production capacity and production management. In broiler meat production, reduction temperature of carcass by chilling tank has to be controlled within 0-4°C. However, for slow speed process, the carcass temperature might be increased high up to 10-12°C for some carcass. This might be contributed to variation of internal temperature of breast meat during production within 4-8 hr. High carcass temperature might cause to microbial problem and rapid rate of proteolysis leading to low water holding capacity of muscle protein. This will be related to high drip loss during process and high weight loss after storage of broiler meat product.

Higher postmortem carcass temperature influenced to lighter, tougher turkey meat with increased drip and cooking losses (2). In broiler meat, greater drip loss was observed at 12°C, whereas chilling at 0°C less water losses (3). Alvarado and Sams, 2004 (4) reported that turkey carcass which was chilled at 30°C

had higher in lightness (L^*) and cooking loss than that carcass chilled at 0°C. Ali et al., 2008 (5) reported that the lightness (L^*) increased, whereas redness (a^*) of duck meat decreased as the chilling temperature increased. During storage, longer storage time induced greater drip loss in turkey breast (6). Lee et al., 2009 (7) also found that the color, texture and water holding capacity of broiler meat affected by storage time. Freeze-thaw process affected to redness and yellowness broiler meat (8). Yu et al., 2005 (9) reported that frozen broiler meat had higher thawing loss and shear force value than chilled broiler meat. In commercial broiler meat production plant had observed an increasing in weight loss of broiler meat with some process variations. Therefore, the objective of this study was to determine the effect of various process conditions on quality and water holding capacity of broiler breast meat.

2. Material and Method

2.1 Preparation of broiler breast meat

Boneless, skinless, breast fillets weight 160-190 g of each were collected from commercial deboning production plant, which obtained from broiler chicken aged 38-42 days, weighed 2.16-2.56 kg. All breasts (*Pectoralis major* muscle) were collected random immediately after chilling in ice water and fillets. Three groups of 120 fillets for each were chilled to equilibrium internal temperature at 0-4, 8-10 and 12-15°C and kept individually at the maintain temperature for 8 hr before analysis to determine the effect of internal temperature during process. Breast meat for 120 fillets were packed in two polyethylene plastic bags (60 fillets for approximately 10 kg for each bag) were prepared for each treatment of storage temperature and time at 0-4°C and 12-15°C for 0, 24, 48, 72 and 96 h. Breast meat for three packs of each treatment (60 fillets for approximately 10

kg for each bag) were prepared for freeze-thawed and chilled samples. The freeze-thaw process was prepared by freezing the bag of fillet samples at -20°C for 24 hr and then thawing at $9-10^{\circ}\text{C}$ for 9 hr before the samples were subjected to chilled storage at $0-4^{\circ}\text{C}$ or $12-15^{\circ}\text{C}$ for 24 h. The chilled breast was used as the control sample.

2.2 pH

Approximately 5 g of broiler breast meat was minced by blender (Panasonic, Malaysia). The minced sample was homogenized in 25 mL distilled water for 1 minute. The pH of the homogenate was determined using a pH meter (Mettler Toledo, SevenGo SG2-FK2, Switzerland) calibrated at 4.0 and 7.0.

2.3 Color

Surface color was measured on raw intact fillet (thirty fillets for each treatment). Color parameters (L^* , a^* and b^*) were evaluated for three replicates for each fillet using Hunterlab colorimeter (Color Flex, U.S.A.). The replication applied on the surface of upper, middle and lower of fillet.

2.4 Shear force value

Shear force value of raw intact fillet was determined using texture analyzer (Stable Micro System, TA-XT2i, U.S.A.). Thirty fillets were obtained from each treatment. Each fillet was sheared with the Warner Brazler shear blade (WB-blade), cross head speed 2 mm/s and 25 kg load cell.

2.5 Drip loss

Three strips (1.0 cm wide, 3.0 cm long and 0.5 cm thick) from each of 30 fillets were individually weighed, placed in sealed polyethylene bag and stored for 24 h at chilling temperature (1 to 5°C). Samples were again weighed and drip loss was determined as percentage of weight loss by initial weight of sample (10).

2.6 Cooking loss

Approximately 2 kg of fillets were placed on stainless steel screen and cooked in steam oven at

100°C for 17 min. The internal temperature applied on this analysis was to 85°C as recommended method by Honikel, 1998 (10). The fillets were then allowed to equilibrate to room temperature, reweighed, and cooking loss was determined as percentage of weight loss by initial weight of sample.

2.7 Statistical analysis

The differences between quality broiler breast meat data were analyzed by analysis of variance (ANOVA) and significant differences between treatment were analyzed by Duncan's multiple range test using the Statistical Package for Social Science (SPSS 10.0 for windows, SPSS Inc., Chicago, IL, USA).

3. Results and Discussion

3.1 Effect of internal temperature on quality of broiler breast meat

The quality characteristics of broiler breast meat with different internal temperature are presented in Table 1. The results obtained no difference ($P \geq 0.05$) in pH, shear force value and cooking loss existed among the treatments. Alvarado and Sams, 2004 (4) reported that cooking loss was not different when turkey carcasses were chilled at 0, 10, 20 and 30°C before deboning. The broiler breast meat with high internal temperature at $12-15^{\circ}\text{C}$ had higher ($P < 0.05$) in lightness (L^*), redness (a^*) and yellowness (b^*) than those of broiler breast meat with lower internal temperature at $0-4$ and $8-10^{\circ}\text{C}$. However, no significant difference in L^* and b^* were found between the breast meat samples treated at $0-4$ and $8-10^{\circ}\text{C}$, and at $8-10$ and $12-15^{\circ}\text{C}$ ($P \geq 0.05$). The L^* value has been reported to be related with scattering of light due to denaturation of protein and an increasing in the amount of extracellular water (4). McKee and Sams, 1998 (2) reported that increased L^* value for turkey meat held at 40°C as compared with samples held at lower

temperatures (0 and 20°C). Ali et al., 2008 (5) reported that the duck breast chilled at 20°C had higher L^* than duck breast chilled at 0 and 10°C. High temperature was also affected on a^* value, that caused an oxidation of myoglobin to metmyoglobin (11).

Higher drip loss was observed in breast meat samples with high internal temperature at 12-15°C than those at 0-4°C and 8-10°C ($P < 0.05$). The proteolytic activity might increase at high temperature, that caused

to destruct fibre and cell membrane and induce water transfer from intracellular space to the extracellular fluid (11) leading to leaching of water. Lesiak et al., 1996 (6) reported that drip loss of turkey meat chilled at 0°C was lower than those of turkey meat chilled at 12°C and 30°C. McKee and Sams, 1998 (2) found that turkey meat was held at 40°C had higher ($P < 0.05$) in drip loss than turkey meat was held at 0 and 20°C.

Table 1 The characteristics of broiler breast meat at different internal temperature 0-4, 8-10, 12-15°C for 8 hr process condition

Characteristics	Temperature (oC)		
	0-4	8-10	12-15
pH	5.77±2.45a	5.93±0.15a	5.89±0.13a
L^*	52.35±2.45a	52.69±2.12a,b	53.73±2.06b
a^*	3.18±0.71a	3.40±0.71a,b	3.75±0.81b
b^*	8.57±0.96a	9.16±0.72b	10.27±1.09c
Shear force (kg/s)	109.8±18.6a	111.5±24.7a	101.5±19.5a
Drip loss (%)	2.46±0.51a	2.64±0.64a,b	2.88±0.55b
Cooking loss (%)	19.49±0.78a	19.58±1.87a	20.49±1.52a

^{a-c} Means within a row with different superscripts are significantly different ($P < 0.05$).

3.2 Effect of storage temperature and time on quality of broiler breast meat

Figure 1 presents the pH change of broiler breast meat during storage at 0-4°C for 96 h and at 12-15°C for 72 h. Change in pH value of broiler breast meat during storage was not different between chilled at 0-4°C and 12-15°C. Broiler breast meat stored at both temperatures exhibited significantly increase ($P < 0.05$) in pH value with the storage time. The pH value of muscle increased when the storage time increased. This might be due to microbial excretes diaminease to attack free amino acid and then produced ammonia (11, 12). Allen et al., 1997 (13) found the high positive correlation between pH and psychrotrophic bacteria. In

beef roast, Boles and Swan, 2002 (14) reported that the pH of muscle increased with storage time.

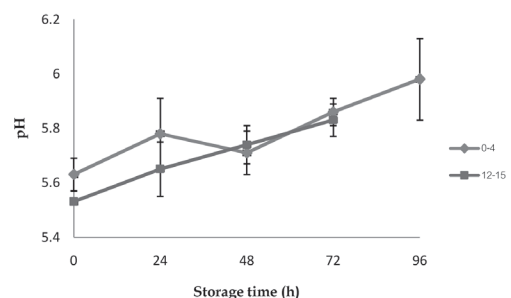


Figure 1 Mean pH values of broiler breast meat during storage at 0-4°C for 96 h and 12-15°C for 72 h.

During storage, broiler breast meat chilled at 12-15°C had higher ($P < 0.05$) L^* and b^* value than those of broiler breast meat chilled at 0-4°C. This might be related to more protein was denatured at higher temperature resulting to an increase in the amount of extracellular water and influence to light scattering (4). However, no significant difference was found in a^* value between 0-4 and 12-15°C chilled breast meat samples ($P \geq 0.05$). With storage time, broiler breast meat tended to be less lightness, redness and more yellowness (Fig. 2). However, broiler breast meat stored over 24 h had lower ($P < 0.05$) in L^* value with storage time. This was probably due to the structure of meat with high pH was not open and scatter light (11). Allen et al. 1998 (15) found the high negative correlation between L^* and pH value. Boles and Swan, 2002 (14) reported that the lightness would be increased with storage. The b^* value was increased highest in the broiler breast meat stored up to 48 h and then after b^* value would be decreased with storage time. The redness (a^*) weakening of the broiler meat with storage time might be due to the pigment decreased with water loss increased. Consequently, the decreased of redness might influence the increased in yellowness during storage (7).

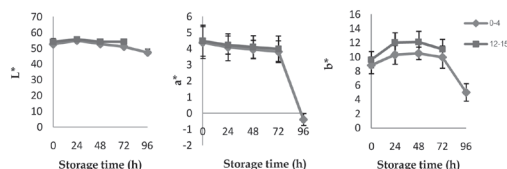


Figure 2 Color values (L^* , a^* and b^*) of broiler breast meat during storage at 0-4°C for 96 h and 12-15°C for 72 h.

The effect of temperature and storage time on shear force value of the broiler breast meat are shown in Figure 3. No difference ($P \geq 0.05$) in shear force value existed among broiler breast samples for different chill-

ing temperatures. Shear force value of broiler breast meat chilled at 0-4°C for 96 h (70.84 kg/s) was the lowest among others. At longer storage time, the proteolytic enzymes could degrade myofibrillar proteins and tenderness increased (15). These data were in agreement with Lee et al., 2009 (7), who observed broiler breast fillets aged for 6 days had lower values in meullenet-Owens razor shear than fillets aged for 1 day.

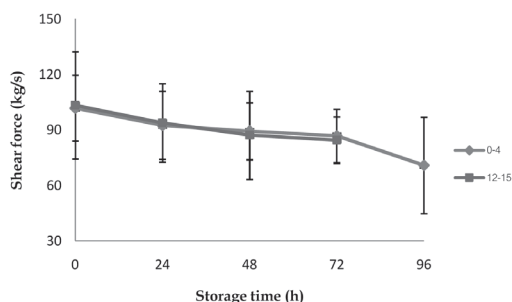


Figure 3 Shear force values of broiler breast meat during storage at 0-4°C for 96 h and 12-15°C for 72 h.

No difference ($P \geq 0.05$) in cooking loss existed among broiler breast meats chilled at different temperatures and storage time (Fig. 5). In broiler breast meat, 12-15°C chilling resulted in greater drip loss than chilling at 0-4°C and drip loss of broiler breast sample tended to be increased with storage time (Fig. 4). The high drip loss of broiler breast meat caused by higher chilling temperature was described previously. During storage, degradation of protein due to proteolysis would certainly allow water that is expelled from intramyofibrillar spaces to drip production (1). Lee et al., 2009 (7) reported that drip and cooking losses of broiler meat aged for 6 day had higher than broiler meat aged for 1 day. This result was in agreement with Lesiak et al., 1996 (6) who found that longer storage time was induced greater drip loss. Boles and Swan, 2002 (14) found that purge of beef roast tended to increase with

storage time. The decrease of drip loss at 72 hr in breast meat stored at 12-15°C might be due to high water loss happened on the earlier storage period and resulted in less remaining water when analyze drip loss. In additional, broiler breast sample chilled at 12-15°C for 96 h had off-odor and green color due to microbial growth and resulted in unacceptable quality.

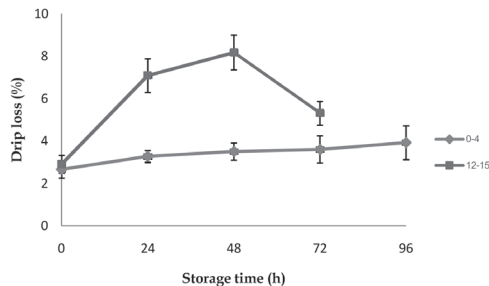


Figure 4 Drip loss values of broiler breast meat during storage at 0-4°C for 96 h and 12-15°C for 72 h.

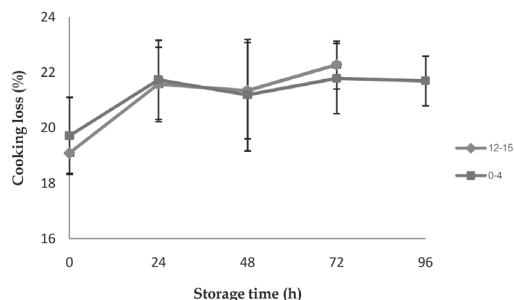


Figure 5 Cooking loss values of broiler breast meat during storage at 0-4°C for 96 h and 12-15°C for 72 h.

3.3 Effect of freeze-thaw process on quality of broiler breast meat

The effect of freeze-thaw process on quality of broiler breast meat is shown in Table 2. One cycle of freeze-thaw process caused no effect ($P \geq 0.05$) on pH, shear force value and cooking loss of breast meat. The L^* and a^* value was lower ($P < 0.05$) in the freeze-thawed broiler breast meat sample. The decrease in L^* value of freeze-thawed broiler meat could be due to the loss of water from muscle structure and reduction of scatter light (11). Carroll et al., 1981 (16) reported that the compaction of muscle fiber of frozen meat was observed more than in unfrozen meat. This data was agreed with the finding of Galobart and Moran, 2004 (8) who observed that freeze thaw process caused reduction in L^* values of pale broiler breast meat. Reduction in a^* and b^* of frozen meat was also due to myoglobin was a water soluble protein and might decrease with water loss (7, 17). This result was in concomitant with the higher drip loss ($P < 0.05$) was observed in freeze-thawed sample than that in chilled sample. The higher muscle compaction of thawed muscle results in a higher drip loss (9). This data was agreed with Yu et al., 2005 (9), who found the higher drip loss for the muscles thawed at 18°C than that at 2 and 0°C.

Table 2 Effect of freeze-thaw process before chilling at 0-4°C or 12-15°C for 24 hr on quality characteristics of broiler breast meat

Characteristics	0 - 4°C		P	12 – 15°C		P
	Chilled	1 cycle freeze-thaw		Chilled	1 cycle freeze-thaw	
pH	5.78±0.13	6.04±0.10	NS	5.65±0.10	5.93±0.09	NS
L*	54.82±2.10	52.28±2.59	**	55.82±1.65	53.06±2.57	**
a*	4.10±0.83	3.49±0.64	**	4.23±0.56	3.74±0.81	**
b*	10.30±1.33	10.15±1.22	NS	12.04±1.38	11.64±1.09	NS
Shear force (kg/s)	92.49±18.33	80.07±20.49	NS	93.84±21.17	86.53±16.99	NS
Drip loss (%)	3.27±0.28	5.44±0.84	**	7.08±0.80	7.49±0.73	**
Cooking loss (%)	21.73±1.43	20.88±0.88	NS	21.57±1.34	20.82±1.16	NS

NS = not significant

** significance $P < 0.05$

4. Conclusion

At higher internal temperature, broiler breast meat had higher in lightness (L*), redness (a*), yellowness (b*) and drip loss. The variation of internal temperature of broiler breast meat should be controlled not over than 10°C during process for 8 hr to minimize the drip loss and pale color. Storage broiler breast meat at higher temperature than 4°C caused significantly high in drip loss and slightly paler color. Three times higher in drip loss was obtained when broiler breast was stored at 12-15°C. Longer storage time induced to soft texture and darker yellowish breast meat, especially in high storage temperature. The storage temperature at 0-4°C for 72 hr could maintain quality and water holding capacity of broiler breast meat. Freeze-thaw process with storage temperature high up to 12-15°C should be avoided to prevent weight loss caused by low water holding capacity of broiler breast meat.

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6. References

- (1) Huff-Lonergan E, Lonergan SM. Mechanisms of water-holding capacity of meat: The role of postmortem biochemical and structural changes. *Meat Sci.* 2005;71: 194-204.
- (2) Mckee SR, Sams AR. Rigor mortis development at elevated temperatures induces pale exudative turkey meat characteristics. *Poultry Sci.* 1998;77: 169-174.
- (3) Lesiak MT, Olson DG, Lesiak CA, Ahn DU. Effects of post-mortem time before chilling and chilling temperature on water-holding capacity and texture of turkey breast muscle. *Poultry Sci.*

- 1997;76: 552-556.
- (4) Alvarado CZ, Sams AR. Turkey carcass chilling and protein denaturation in the development of pale, soft, and exudative meat. *Poultry Sci.* 2004;83: 1039-1046.
 - (5) Ali MS, Yang HS, Jeong JY, Moon SH, Hwang YH, Park GB, et al. Effect of chilling temperature of carcass on breast meat quality of duck. *Poultry Sci.* 2008;87: 1860-1867.
 - (6) Lesiak MT, Olson DG, Lesiak CA, Ahn DU. Effects of postmortem temperature and time in the water-holding capacity of hot-boned turkey breast and thigh muscle. *Meat Sci.* 1996;43(1): 51-60.
 - (7) Lee YS, Owens CM, Meullenet JF. Changes in tenderness, color, and water holding capacity of broiler breast meat during postdeboning aging. *J Food Sci.* 2009;74(8): E449-E454.
 - (8) Galobart J, Moran Jr ET. Freeze-thaw and cooking effects on broiler breast fillets with extreme initial L^* values. *Poultry Sci.* 2004;83: 2093-2097.
 - (9) Yu LH, Lee ES, Jeong JY, Paik HD, Choi JH, Kim CJ. Effects of thawing temperature on the physicochemical properties of pre-rigor frozen chicken breast and leg muscles. *Meat Sci.* 2005;71(2): 375-382.
 - (10) Honikel KO, Reference method for the assessment of physical characteristics of meat. *Meat Sci.* 1998;49: 447-457.
 - (11) Lawrie RA, Ledward DA. *Lawrie's meat science.* 7th ed. Cambridge: England; 2006.
 - (12) Garcia-Lopez ML, Prieto M, Otero A. The physiological attributes of gram-negative bacteria associated with spoilage of meat and meat products. In: Davies A, Board R, editors. *The microbiology of meat and poultry.* 1st ed. London, UK: Blackie academic & professional; 1998. p. 1-28.
 - (13) Allen CD, Russell SM, Fletcher DL. The relationship of broiler breast meat color and pH to shelf-life and odor development. *Poultry Sci.* 1997;76: 1042-1046.
 - (14) Boles JA, Swan JE. Meat and storage effects on processing characteristics of beef roasts. *Meat Sci.* 2002;62(1): 121-127.
 - (15) Allen CD, Fletcher DL, Northcutt JK, Russell SM. The relationship of broiler breast color to meat quality and shelf-life. *Poultry Sci.* 1998;77: 361-366.
 - (16) Carroll RJ, Cavanaugh JR, Rorer FP. Effects of frozen storage on the ultrastructure of bovine muscle. *J Food Sci.* 1981;46: 1091-1094.
 - (17) Macini RA, Hunt MC. Current research in meat color. *Meat Sci.* 2005;71: 100-121.