



## The Quality Determination of Broiler Chicken Thawed Using Different Techniques

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### ABSTRACT

The freezing technique has been used for thousands of years for the preservation of meat. The frozen meat has to be thawed before further processing. Quality deterioration occurs during the thawing process. The uniform-sized broiler chicken samples were individually frozen using an ultra-low temperature freezer (-40°C) for an overnight. The frozen meat samples were thawed in the refrigerator (4°C), cool room (20°C), hot air oven (60°C), tap water (27±5°C), and hot water conditions (40°C) until core temperature of the meat reaches 10°C in all method except refrigeration method where the core allowed to reach 4°C. Moisture content (MC), water holding capacity (WHC), drip loss (DL), cooking loss (CL), and pH were determined. There were significant differences ( $p < 0.05$ ) observed among the quality parameters of the samples, including MC, DL and CL based on the different thawing methods. However, there were no significant deviations in the pH and WHC. The sensory evaluation was also carried to evaluate color, taste, flavor, chewiness, juiciness and overall rating of the uniformly cooked samples by using nine hedonic scale techniques. There were no significant differences among sensory parameters of the samples ( $p < 0.05$ ). Of which, the highest rating was obtained for the cool room and tap water method, while the poor rating was for the refrigeration method. Therefore, the different thawing methods impact on the quality parameters of the frozen broiler chicken rather than influencing the sensory qualities. However, the cool room thawing method had minimized reductions in the qualities of the thawed broiler chicken followed by the tap water method.

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### Introduction

Freezing of meat has been practiced for several years to extend the shelf life since it is a perishable food. Freezing techniques preserve the meat quality until it reaches the consumers (Xia *et al.*, 2009). The quality of meat depends on the type of freezing and thawing techniques (Li and Sun, 2002). The freezing rate affects the meat quality by the size of ice crystals formed during the freezing process (Li and Sun, 2002). Based on the speed of processing, the freezing methods can be classified into slow and fast freezing techniques. The slow freezing process cools down at 0.05 °C/min; meanwhile, the fast freezing cools down at the rate of 0.5 °C/min (Oliveira *et al.*, 2015). The fast freezing has many positive results in meat quality attributes (Kim *et al.*, 2018) compared to the slow freezing. The temperature below -18°C considered as deep freezing and temperature below -30°C considered as ultra-low temperature freezing (Tolstorebrov *et al.*, 2016). The ultra-low temperature freezers are mainly reducing the temperature approximately -40°C to -90°C (Kelly and Steinhoff, 2002).

The broiler chicken plays an important role in alleviating animal protein deficiency (Rokonuzzaman, 2018). According to the World Health Organization (WHO), 55g/day animal protein need for individual, but only 15.6g has been consumed as daily basis (Rokonuzzaman, 2018). The broiler meat stored in frozen condition to extend the shelf life. The frozen meat has to be thaw before further processing like unit operations and thermal processing. The meat thawing at low temperatures within a shorter period avoids excess temperature rise and dehydration of the product (Kim *et al.*, 2013). The standard thawing methods of frozen foods include room temperature thawing (normally at 27±5°C), cold water thawing (4°C - 20°C), steam thawing (100°C), and contact thawing (above 27±5°C) (Kim *et al.*, 2013). Other than that, high-pressure thawing, microwave thawing, ohmic thawing and acoustic thawing are also being studied to overcome the quality losses and thawing timing (Li and Sun, 2002). Water thawing and low-temperature thawing have been widely used in the meat industry (Zhang *et al.*, 2017). The water thawing at ambient temperature (27±5°C) is

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economically feasible, shorter thawing time, a lower degree of lipid oxidation, and lesser microbial contamination due to reduced thawing time than low-temperature thawing (4°C- 20°C), but a higher amount of thawing loss has occurred (Chandirasekaran and Thulasi, 2010; Ersoy *et al.*, 2008). The low-temperature thawing improves meat color and decreases DL compared with water thawing; but the thawing time is longer, and the degree of microbial contamination is higher in low-temperature thawing (Ersoy *et al.*, 2008; Xia *et al.*, 2012).

However, the quality deterioration such as lipid and protein oxidation, protein denaturation, moisture loss, color deterioration, flavor loss, textural changes and microbial spoilage occurs during the thawing process (Benjakul and Bauer, 2000). The shelf life of the meat is mainly determined by appearance, texture, flavor, color, microbial activity and nutritive value (Leygonie *et al.*, 2012). The texture of the meat is an important quality parameter of meat associated with eating characteristics of the consumers (Allen *et al.*, 1998). The appearance of meat is related to the freshness and determining the tendency of buying products by the consumer, whereas flavor is associated with the acceptability of the product (Allen *et al.*, 1998). The immediate environment of the muscle fiber due to the subsequent freezing and thawing process leads to the quality alteration in the meat (Leygonie *et al.*, 2012). The drip loss (DL), water-holding capacity (WHC) and cooking loss (CL) were analyzed to have an overall assessment of the water-binding properties of the meat (Allen *et al.*, 1998). This study aims to assess the meat quality of the frozen broiler chicken characterized using an ultra-low temperature freezer by using different thawing methods.

## Materials and Methods

### Raw materials

The commercially available raw carcass of broiler chicken was used for this study. Approximately 250g of broiler chicken carcass pieces within 12 hours after slaughter without excess muscle fat and connective tissue were used as samples.

### The freezing and thawing

The samples were individually frozen using an ultra-low temperature freezer (Innova C585, Canada) at -40°C. The frozen carcass was thawed in refrigerator (4°C), cool room (20°C), hot air oven (60°C), tap water (27±5°C), and hot water (40°C) conditions until core temperature of the meat reaches 10°C in all method except refrigerator method where the core allowed to reach 4°C. The core temperature of the meat was measured using probe thermometer (THM-010-2MX-p, China). Preliminary studies were done to determine the thawing times of each method and to determine the thawing temperature

of the hot air oven conditions to prevent overheating of the surface of the meat.

### The determination of meat quality parameters

After thawing, the meat samples were determined for WHC, DL, CL, MC, pH and sensory evaluation.

### The drip loss (DL)

The DL was determined by the bag method (Barton-Gade *et al.*, 1993). Each meat sample was weighed and they were put into a net made of cotton. The setup was hanged out into a polyethylene (PE) bag without touching the interior surface of the bag and then which was closed. The prepared samples were placed in a chilling room at 4°C for 24 hours. Afterwards, the sample was gently dabbed with soft tissue and weight was measured (Barton-Gade *et al.*, 1993; Kim *et al.*, 2013).

$$\text{Drip loss}(\%) = \left[ \frac{(W_1 - W_2)}{W_1} \right] \times 100$$

Where,  $W_1$  = weight before thawing;  $W_2$  = weight after thawing

### Cooking loss (CL)

The sample was heated at 75°C in a water bath (Memmert w350, Germany) until the core temperature reaches 65°C and then cooled (Kim *et al.*, 2013). The weight differences were calculated.

$$\text{Cooking loss}(\%) = \left[ \frac{(W_1 - W_2)}{W_1} \right] \times 100$$

Where,  $W_1$  = weight before cook;  $W_2$  = weight after cook

### Water holding capacity (WHC)

Initially, the meat samples were placed in a water bath (Memmert w350, Germany) at 70°C for 30 minutes. Afterwards, the samples were minced using meat mincer (Brice TC12, Australia). The 5g of minced meat centrifuged for 1000 rpm for 10 minutes in high-speed micro-centrifuge (SCILOGEX SCI24). The centrifugation loss of the meat was calculated as the difference in weight before and after centrifugation (Kristensen and Purslow, 2001).

$$\text{WHC}(\%) = \left[ \frac{[M - N] \times 0.951^*}{M} \right] \times 100$$

Where, M = Total water content; N = separated water content; \*0.951: pure water amount for meat moisture that is separated under 70°C

### Moisture content (MC)

The meat samples were kept in a hot air oven (TLPL 131, India) at 105°C overnight. The samples were placed in the oven until constant weight was achieved. The samples were placed in a desiccator before measuring the weight difference. (AOAC, 2000).

$$MC (\%) = \left[ \frac{W_1 - W_2}{W_1} \right] \times 100$$

Where,  $W_1$  = Initial weight;  $W_2$  = Weight after oven drying

### pH

The pH was measured by grinding 15g of the meat sample with 150ml of deionized water for 5 minutes using a meat mixer (Brice TC12, Australia) at high speed (Trout, 1989). The pH of the solution measured using the benchtop pH meter (Bp3001, Singapore).

### Sensory Evaluation

The samples were cut into a cube with 1 cm thickness and heated using a microwave oven until the core temperature of the meat reaches 75°C. The sensory evaluation was carried out based on color, flavor, chewiness, juiciness, taste and overall acceptability of the cooked samples. The degree of difference test on the 9-point scale was used for the screened consumer panel.

### Statistical analysis

The results were submitted to analysis of variance (ANOVA) and means were compared by the test of Tukey's HSD at  $p = 0.05$  using SPSS statistical package (SPSS 20.0, IBM, New York, NY, USA).

## Results and Discussion

### Moisture content (MC)

The meat MC and the moisture distribution changed by the freezing and thawing processes (Leygonie *et al.*, 2011). According to the results (Figure 1), the MC of thawed broiler meat was varying from 59% to 82%, whereas the average MC of raw broiler carcass varies from 52% to 64% (Pesti and Bakalli, 1997). The highest MC was retained in the broiler chicken, which was obtained using the cool room thawing method while the lowest MC was obtained using the tap water thawing techniques. The MC showed significant differences depending on the thawing methods ( $p < 0.05$ ). Gonzalez-Sanguinetti *et al.* (1985) reported a significant difference in MC for the refrigerator and tap water thawing methods. The reduction of thawing time exudate formation in the muscles reduces, which favors an increase in water activity (Sanguinetti *et al.* 1985). The MC depends on the WHC of the meat and it affects the ultimate pH of the meat because of rigor mortis (Owens and Meullenet, 2010). Tenderness, juiciness, firmness,

appearance and economic value of meat enhanced by the increment of the moisture in the meat (Mir *et al.*, 2017).

### Cooking loss (CL)

The CL is defined as loss of fluid and soluble matter during the cooking process, which leads to textural changes and loss in cooking yield in meat (Aaslyng *et al.*, 2003; Purslow *et al.*, 2016). According to this study (Figure 2), the CL of thawed meat using different techniques was varying from 43.185% to 60.838%. The highest CL was measured in the broiler chicken, which was obtained by the oven methods, while the lowest CL was expressed by the cool room thawing method and there were significant differences observed depending on the thawing methods ( $p < 0.05$ ) at this study. However, Vieira *et al.* (2009) did not observe any significant difference for CL, between different thawing methods for beef samples. The CL is an indicator of the meat moisture and yield reduction (Demirok *et al.*, 2013). The CL affects the WHC, protein and fat content of the meat (Aaslyng *et al.*, 2003). The chemically bound water is released from meat during the cooking process due to the denaturation of protein and melting of fat (Vieira *et al.*, 2009).

### pH

The pH is the indicator of the glycogen content before slaughtering and the rate of glycogen conversion from glycogen to lactic acid (Mir *et al.*, 2017). The average pH of broiler carcass falls between 5.4 and 6.0 (Ristic and Damme, 2013) whereas, that thawed meat pH varying from 5.77 to 6.06 using different methods based on this study (Table 1). The highest pH was measured in the thawed broiler chicken, which was obtained by hot water thawing methods, while the lowest pH was expressed by the oven thawing method. However, there was no significant difference in the pH content of the thawed broiler chicken ( $p > 0.05$ ). The pH of thawed meat is lower than frozen meat (Leygonie *et al.*, 2011). It is due to the production of exudate, which could denaturize buffer proteins causes the release of hydrogen ions and also released exudate increases the concentration causes reduction of pH (Leygonie *et al.*, 2012). The pH of the raw carcass has a direct effect on meat quality such as tenderness, WHC, color, juiciness and shelf life (Anadon 2002; Mir *et al.*, 2017). The broiler meat with higher WHC showing higher pH and vice versa (Mir *et al.*, 2017).

### Water Holding Capacity (WHC)

The ability of fresh meat to retain the moisture is termed as WHC (Huff-Lonergan and Lonergan, 2005). The muscle holds moisture either within the myofibrils between myofibrils and sarcolemma or between muscle cells or between muscle bundles (Huff-Lonergan and Lonergan,

2005). The freeze-thaw cycle plays a major contributor to meat quality, which is influencing in the reduction of WHC of meat (Añón and Cavelo, 1980; Ngapo *et al.*, 1999; Vieira *et al.*, 2009; (Ali *et al.*, 2015). Kim *et al.* (2013) reported that the average WHC of broiler meat was around 60% to 63%, whereas this study showed that the WHC of thawed meat varying from 58.095% to 75.161%. Based on this study (Table 1), the highest WHC was measured in the broiler chicken, which was obtained by the oven thawing methods while the lowest WHC was expressed by using tap water method. The reduction of WHC is due to the disruption of muscle fiber and the denaturation of proteins (Leygonie *et al.*, 2012). However, there was no significant difference in the WHC of the thawed broiler chicken ( $p>0.05$ ).

Table 1. The pH and water holding capacity (WHC) of the thawed broiler chicken

Thawing Techniques	pH	WHC (%)
Refrigerator	5.99±0.08	71.636±1.582
Hot water	6.06±0.13	72.767±5.727
Cool room	5.78±0.13	60.322±5.381
Oven	5.77±0.15	75.161±3.731
Tap water	6.02±0.07	58.095±3.790

The values are means of triplicates ± standard error mean (SEM); Within a column, means followed by the same letter are not significantly different by the Tukey's HSD at  $p=0.05$ .

Further, the WHC is the most important functional property, which has direct effects on color and the tenderness of the raw carcass (Mir *et al.*, 2017). The WHC has an effect on cellular and extracellular components of meat, which alters the pH, sarcomere length, ionic strength, osmotic pressure and development of rigor mortis (Offer and Knight, 1988). However, the rapid thawing of frozen meat causes deterioration of myofibril, which influences the thawed meat quality (Yu *et al.*, 2010).

#### Drip loss (DL)

The DL refers to the fluid that is expelled from meat without mechanical force other than gravity (Fischer, 2007). The freezing and thawing techniques are influencing in exudate release (Leygonie *et al.*, 2012). It causes damage to the ultrastructure of the muscle cells to release the mitochondrial and lysosomal enzymes, haem iron, and other pro-oxidants (Leygonie *et al.*, 2012). Furthermore, the DL is an indicator of the meat moisture and yield reduction (Demirok *et al.*, 2013) and

it is closely associated with the meat quality parameters such as MC, thawing loss and nutrient content (Leygonie *et al.*, 2012). Based on this study (Figure 3), the highest DL was measured in the thawed broiler chicken, which was obtained using the refrigerator thawing method while the lowest DL was measured using tap water thawing techniques and there were significant differences observed between the thawing methods ( $p<0.05$ ). The refrigerator method has significantly deviated from the cool room, tap water and oven methods in terms of DL. The increased rate of thawing caused less exudate to form. Meanwhile, the rapid thawing of meat decreased DL (Ambrosiadis *et al.*, 1994).

#### Sensory evaluation

The output of the sensory evaluation of the thawed broiler chicken was illustrated in Table 2. The meat undergoes for different freezing and thawing methods may have an impact on sensory parameters in relation to the color, texture (including juiciness) and flavor (rancidity) characteristics (Muela *et al.*, 2012). Consumers perceive quality in terms of appearance, which significantly influences the purchasing behavior of consumers (Resurreccion, 2004). The texture is an important parameter assessing the quality of poultry (Mir *et al.*, 2017). The texture and the firmness of the meat expressed by the amount of the water tightly bound to the intra muscles (Anadon, 2002). The juiciness of meat is directly related to moisture and fat retained intramuscularly (Cross *et al.*, 1986). The flavor and aroma of meat are complex meat sensory attributes affected by species, age, fatness, and type of tissue, locality, gender, diet, and method of cooking (Webb *et al.*, 2005).

Based on this study, the highest scores of the color, flavor, chewiness and juiciness were obtained by the cool room thawing method, but the good taste was determined by the hot water and oven method. In contrast, the least scores of the sensory parameters were obtained by the refrigeration method. Eventually, the cool room and tap water thawing methods were obtained at the highest rate of overall acceptability. However, there were no significant differences observed between the sensory quality parameters and the different thawing methods ( $p>0.05$ ). Kim *et al.* (2013) evidenced also that there is no significant difference observed for meat sensory characteristics depending on different freezing and thawing methods.

Table 2. Sensory evaluation of the thawed broiler chicken

Thawing techniques	Color	Taste	Flavor	Chewiness	Juiciness	Overall rating
Refrigerator	5.1±0.7	5.4±0.7	5.1±0.5	5.9±0.3	5.6±0.5	6.0±0.6
Hot water	5.6±0.5	6.7±0.4	5.4±0.4	6.6±0.3	6.0±0.4	6.5±0.4
Cool room	6.0±0.7	6.3±0.6	6.6±0.4	6.6±0.4	6.4±0.4	6.7±0.6
Oven	5.2±0.6	6.7±0.8	6.4±0.2	6.5±0.4	6.0±0.5	6.5±0.2
Tap water	5.7±0.8	5.8±0.5	6.3±0.5	6.4±0.5	5.9±0.5	6.7±0.2

The values are means of triplicates ± standard error mean (SEM); Within a column, means followed by the same letter are not significantly different by the Tukey's HSD at  $p=0.05$ .

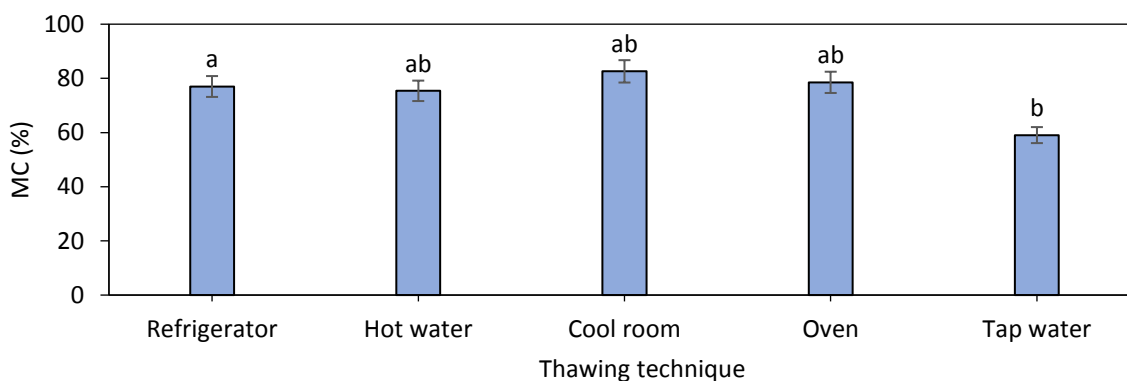


Figure 1. The moisture content (MC) of the thawed broiler chicken. The values are means of triplicates ± standard error mean (SEM); Within a column, means followed by the same letter are not significantly different by the Tukey's HSD at  $p=0.05$ .

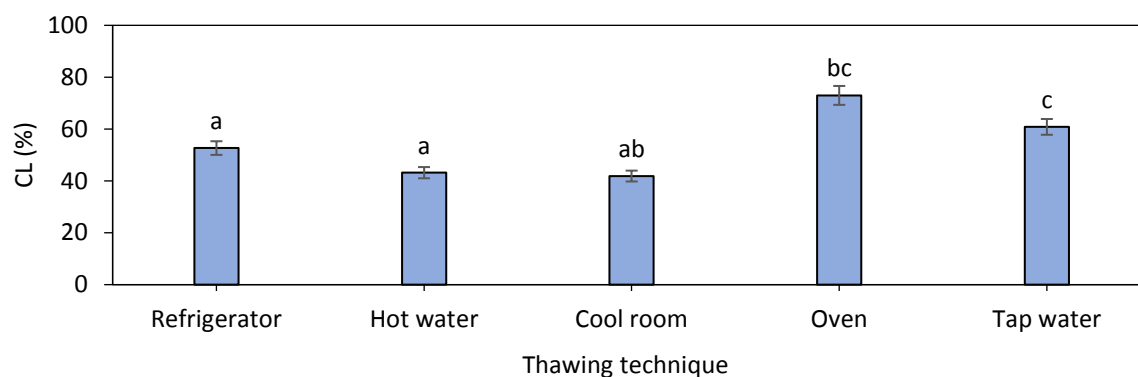


Figure 2. The cooking loss (CL) of the thawed broiler chicken. The values are means of triplicates ± standard error mean (SEM); Within a column, means followed by the same letter are not significantly different by the Tukey's HSD at  $p=0.05$ .

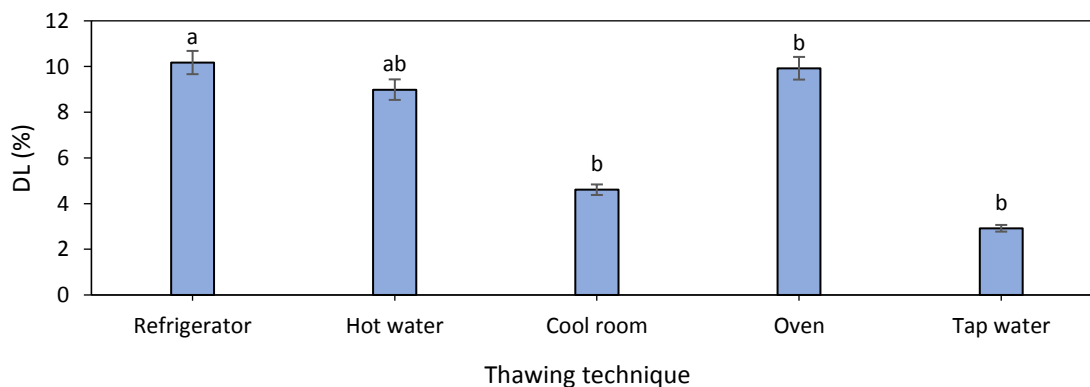


Figure 3. The drip loss (DL) of the thawed broiler chicken. The values are means of triplicates ± standard error mean (SEM); Within a column, means followed by the same letter are not significantly different by the Tukey's HSD at  $p=0.05$ .



## Conclusion

This study showed that the cool room thawing method expressed the highest MC and lowest CL, while the tap water method had the lowest DL compared to other methods as optimum physico-chemical quality characteristics of the thawed broiler chicken. Along with, the highest scores for the sensory qualities including the color, flavor, chewiness and juiciness were obtained by the cool room thawing method. However, the cool room and tap water method obtained the best overall ratings as well. Eventually, it is concluded that the cool room thawing method had minimized reductions of the physico-chemical qualities and achieved good sensory perceptions of the thawed broiler chicken followed by the tap water method compare to other methods.

## Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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