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Effect of different thawing techniques on certain quality parameters of different cut-up parts of broiler chicken

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ABSTRACT
The freezing and thawing processes used in food preparation have significantly affected the quality of the meat. Broiler chicken cut-up parts vary in quality parameters depending on the location of the carcass. The uniform-sized cut-up parts were separately frozen overnight in an ultra-low temperature freezer (-40±2°C). The frozen broiler cut-up parts were thawed using household refrigerator (4±1°C), cool room condition (20±3°C), hot air oven (60±3°C), tap water (27±5°C), and hot water (40±1°C) conditions separately, up to the internal temperature reached to 10°C excluding the household refrigerator technique, where the internal temperature was remained at 4°C. In this study, moisture content, water holding capacity, drip loss, cooking loss, and pH were investigated. The method of thawing technique and the cut-up portions of frozen broiler meat had significant effects (p<0.01) in terms of moisture content, pH, cooking loss, water holding capacity and drip loss. Comparatively, the minimal quality reductions were observed in the low-temperature thawing techniques, whereas the oven technique showed the higher quality reductions in the cut-up parts.
Keywords: Broiler chicken, Cut-up parts, Meat quality, Thawing techniques, Ultra-low temperature freezer.

INTRODUCTION
Freezing is a common practice used to store the broiler chicken for a more extended period. The frozen meat has to be undergone thawing before the processing. The aim of thawing meat is to bring back its original quality to the greatest extent feasible (Xia *et al*., 2012). Freezing and thawing of meat involve a heat transfer process, which has an impact on it's both the physical and chemical quality (Gambuteanu *et al*., 2013; Li and Sun, 2002). Meat thawing needs external heating, and it is a time-consuming process, therefore the meat quality is changed with the thawing process (Kang *et al*., 2007). The most common thawing techniques practiced include room temperature thawing, cold water thawing, steam thawing and contact thawing (Kim *et al*., 2013). However, the appropriate thawing technique must be selected to ensure the end product's quality (Olivera *et al.*, 2015).

During the thawing process, the meat quality parameters include microbial load, drip loss (DL), and color (Kondratowicz *et al*., 2008), water holding capacity (WHC) (Zhuang and Savage, 2012), rancidity, denaturation of protein and softening of tissues (Kim *et al*., 1990) could be affected. The industries are practicing different portioning methods of whole chicken into many parts of combinations (Hudspeth *et al*., 1973). According to the available literature review, there is a void in the literature describing studies on the changes in quality characteristics of different broiler cut-up portions due to the different freezing and thawing processes.

The DL is a vital meat quality parameter from the industries' financial point view (Gambuteanu *et al*., 2013). The moisture loss and exudate formation of meat correlates with the thawing methods and thawing rates (Gonzalez-Sanguinetti *et al.*, 1985; Leygonie *et al*., 2012). The pH level of the meat is higher before it is frozen and then thawed (Leygonie *et al.*, 2012). The texture and juiciness are the sensorial properties, which affect the consumer preferences towards meat quality (Gambuteanu *et al*., 2013). The water-holding capacity (WHC) is a crucial carcass property that impacts the color and texture of meat (Mir *et al*., 2017).

Further, other factors are also influencing the quality of thawed meat, including the relative air humidity, thawing process and duration (Kondratowicz *et al*., 2006). As a result, the various thawing approaches such as high-pressure thawing, microwave thawing, ohmic thawing, and acoustic thawing are being investigated to address the quality reduction and time consumption of thawing process (Li and Sun, 2002). Furthermore, changes in the quality parameters in broiler chicken cut-up portions during different thawing methods have not been explored extensively. Therefore, the goal of this study is to analyse various meat quality parameters of different broiler chicken cut-up sections based on different thawing processes.

MATERIAL AND METHODS
The samples :
The broiler chickens were commercially available in Kalmunai, Sri Lanka was slaughtered, and four-piece cuts including thigh, wing, breast, and drumstick of the carcass were obtained. Approximately, 250g of broiler chicken cut-up parts with the absence of additional muscle fats and connective tissues were used for the study.

The freezing and thawing:
The cut-up portions were separately frozen at -40±2°C in an ultra-low temperature freezer (Innova C585, United Kingdom). The frozen meat was thawed in a household refrigerator (4±1°C), cool room (20±3°C), hot air oven (60±3°C), tap water (27±5°C), and hot water (40±1°C) conditions until the internal temperature (Point probe thermometer; WRNM-102A, China) of the meat reaches 10°C other than the household refrigerator technique where the internal temperature was allowed to meet 4°C. The preliminary investigations were conducted to identify the thawing timeframes of each technique as well as the thawing temperature of the oven to avoid excess heating and burning of the meat's surface.

The determination of meat quality parameters:
The WHC, DL, cooking loss, moisture content, and pH were determined for the broiler cut-up portion samples.

WHC:
Broiler cut-up portion samples were initially minced with a beef mincer (Brice TC12, Australia). Then, the WHC was determined using of 5g of the ground samples at 70°C in a water bath (D3024R, USA) for 30 minutes and centrifuged for 67 G force (RCF) for 10 minutes in a high-speed micro-centrifuge (1730R, Germany). After that, meat weight reduction was obtained after the centrifuge (Kristensen and Purslow, 2001).

WHC (%) = {(M1− M2) × 0. 951* / M1} × 100
Where,
M1= Amount of total water
M2= Amount of removed water
*0.951: pure water amount for meat moisture that is removed under 70°C

The drip loss (DL):
The bag method was used to determine the DL (Barton-Gade *et al*., 1993). The cut-up portions were measured and placed in a cotton net. Then both meat and net were hanged in a polyethene (PE) bag and closed, without contacting the inner surface of the polyethene bag. Further, the setup was chilled in a 4°C chilling room for 24 hours. Following that, the specimens was gently wiped with a wiping paper towel and the weight were determined (Kim *et al*., 2013).

DL (%) = {(M1- M2) / M1} × 100
Where,
M1= Initial meat weight before thawing
M2= Weight of thawed meat

Cooking loss (CL):
The broiler cut-up meat samples were heated in a water bath (RSTI140, India) at 75°C until the core temperature (Point probe thermometer; WRNM-102A, China) reached to 65°C and then cooled. The weight differences were computed (Abd-Elhak, 2017; Kim *et al.,* 2013).

CL (%) = {(M1− M2) / M1} × 100
Where,
M1= weight prior to cooking
M2= weight after cooking

Moisture content (MC):
The MC is determined at 105°C by an oven-dry method (Hot air oven method), according to AOAC (1990).

pH:
The 15g of the cut-up part sample was ground with 150ml of distilled water for 5 minutes on high speed in a meat mixer (Brice TC12, Australia). Afterwards, the pH of the solution was evaluated with the pH meter (PHS-3C, China) (Kim *et al.,* 2013).

Statistical analysis:
The values were analyzed using two-way ANOVA and mean separation was done using Tukey's post hoc test at $p = 0.05$ using the SPSS software (SPSS 20.0, New York, USA).

RESULTS

The two-way ANOVA results of the main effects and interaction are shown in Table 1. The interaction of thawing technique and the cut-up portions had a significant effect on the moisture content, pH, CL, WHC, and DL($p<0.01$).

Table 1. Results of two-way ANOVA

Parameter	Thawing technique		Cut-up parts		Thawing technique × Cut-up parts	
	F value	P value	F value	P value	F value	P value
MC (%)	20.079	0.000	1.218	0.316	14.791	0.000
pH	8.314	0.000	16.587	0.000	24.523	0.000
CL (%)	129.719	0.000	17.672	0.000	92.643	0.000
WHC (%)	4.651	0.001	1.110	0.361	4.094	0.000
DL (%)	55.954	0.000	65.201	0.000	31.605	0.000

Moisture Content (%)

Based on data of the current study (Table 2), hot water, cool room, oven and tap water thawing method were shown significant differences in the moisture content with respect to the different portions of the broiler carcass (p<0.05). The thigh, wing and breast had a significant difference in the moisture content with respect to different thawing techniques (p<0.05). The cool room technique shows the higher moisture content, whereas the tap water technique shows the lower moisture content for the different broiler parts except for the wing portion.

Table 2: Moisture content (%) of the cut-up portions of thawed broiler chicken

Thawing Techniques	Cut-up Parts			
	Thigh	Wing	Breast	Drumstick
Refrigerator	76.470±0.312^{Aab}	77.529±837^{Aab}	77.320±1.160^{Aab}	76.708±0.269^{Aa}
Hot water	74.191±0.70^{Aab}	69.271±2.938^{Aa}	83.500±1.299^{Babc}	74.621±0.34^{Aa}
Cool room	84.052±1.628^{Aa}	67.631±2.148^{Ba}	88.520±2.211^{Abc}	86.951±2.754^{Ab}
Oven	83.139±2.182^{Aab}	75.950±1.057^{Bab}	78.421±0.612^{ABab}	76.629±0.358^{Ba}
Tap water	63.860±0.479^{ABc}	83.821±1.381^{Cab}	62.650±1.155^{Ad}	65.477±1.471^{BCa}

Means ± standard error among a row, attached to distinct A-C alphabet are significantly different at p=0.05.
Means ± standard error among a column, attached to distinct a-c alphabet are significantly different at p=0.05

pH

The hot water, cool room and tap water thawing techniques were shown a significant difference (p<0.05) whereas, the household refrigerator technique and oven thawing techniques did not show any significance in the pH values of the cut-up parts (p>0.05). The drumstick portion of broiler meat had a significant difference with respect to the various thawing techniques (p<0.05). According to a current study, the oven thawing technique shows a lower pH value for broiler portions except for the wing portion. Meanwhile, the tap water technique shows a relatively higher pH value than the other techniques (Table 3).

Table 3: pH content of the cut-up portions of thawed broiler chicken

Thawing Techniques	Cut-up Parts			
	Thigh	Wing	Breast	Drumstick
Refrigerator	6.00±0.13^{Aa}	5.84±0.09^{Aa}	5.91±0.03^{Aa}	6.19±0.14^{Aab}
Hot water	5.88±0.08^{Aa}	5.95±0.06^{Aa}	5.97±0.08^{Aa}	6.44±0.14^{Ba}
Cool room	5.47±0.14^{Aa}	5.87±0.05^{Aba}	5.68±0.10^{Aba}	6.28±0.26^{Bab}
Oven	5.47±0.13^{Aa}	5.98±0.98^{Aa}	5.58±0.19^{Aa}	6.06±0.14^{Aab}
Tap water	5.86±0.05^{Aa}	6.02±0.02^{Aa}	6.00±0.03^{Aa}	6.22±0.06^{Bab}

Means ± standard error among a row, attached to distinct A-B alphabet are significantly different at p=0.05.
Means ± standard error among a column, attached to distinct a-b alphabet are significantly different at p=0.05

Cooking loss (%)

The thigh, wing, breast and drumstick cut-up portions were shown a significant difference (p<0.05) for the CL with different thawing techniques. Household refrigerator and tap water thawing method were shown significant difference (p<0.05) in the CL with different cut-up portions. According to this study, the oven thawing technique shows the highest looking loss, while cool room thawing techniques had the lowest CL value for all broiler cut-up pieces than the other techniques (Figure 1).

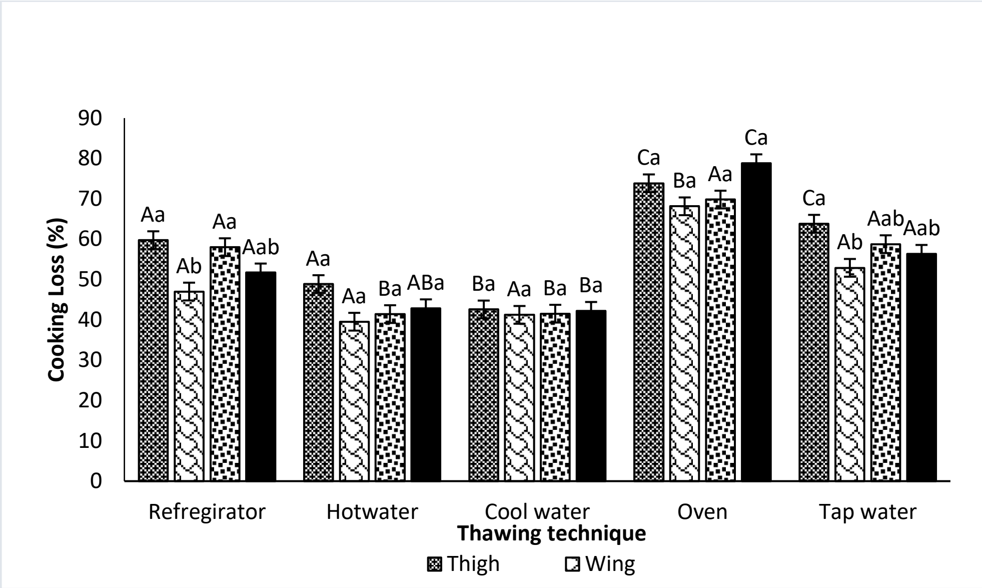

Figure 1: CL (%) of the thawed broiler Cut-up portions

The Means ± standard error attached with same A-B alphabet in a similar pattern are not significantly different at 0.05.
The Means ± standard error attached with same a-b alphabet in the similar group are not significantly different at 0.05.

Water holding capacity (%)

The cool room and oven thawing techniques had a significant difference in the WHC (p<0.05) with respect to cut-up portions (p<0.05) (Figure 2). Whereas, the breast and wing portions were shown a significant difference in terms of WHC with respect to the various thawing techniques (p<0.05). the cool room thawing technique had the lowest WHC of portions except for the drumstick compared to the other thawing techniques.

Drip loss (%)

Based on the current study (Table 4), the cool room and tap water techniques were shown a significant difference (p<0.05) whereas, the hot water, cool room and oven thawing techniques did not show any significant difference in terms of the DL(p>0.05). Further, the thigh, wing, breast and drumstick portions had a significant difference in the DL regarding to different thawing techniques. The tap water shows the least DL value for all broiler chicken parts whereas the oven technique, hot water technique and household refrigerator techniques show a higher DL percentage.

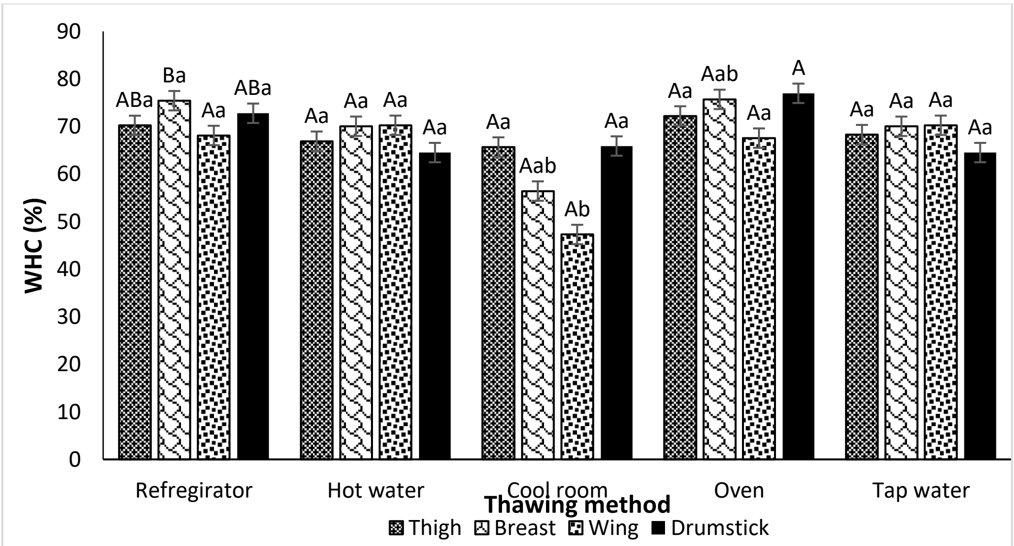

Figure 2: WHC (%) of the cut-up portions of thawed broiler chicken

The Means ± standard error attached with same A-B alphabet in a similar pattern are not significantly different at 0.05.
The Means ± standard error attached with same a-b alphabet in the similar group are not significantly different at 0.05.

Table 4: DL (%) of cut-up portions of thawed broiler chicken

Thawing Techniques	Cut-up Parts			
	Thigh	Wing	Breast	Drumstick
Refrigerator	10.699±0.382^{Aa}	14.196±0.12^{Aa}	10.312±0.674^{Aa}	7.754±0.283^{Aa}
Hot water	9.890±0.370^{Aa}	9.363±0.221^{Aa}	8.060±0.987^{Aa}	8.642±0.461^{Aa}
Cool room	9.89±0.217^{Aa}	4.586±1.00^{Bb}	5.522±0.116^{Bb}	3.194±1.031^{Bb}
Oven	13.291±0.601^{Aa}	11.323±0.339^{Aa}	8.620±0.167^{Ac}	8.620±0.159^{Aa}
Tap water	3.846±0.233^{Ab}	3.048±0.039^{ABb}	4.287±0.734^{Ab}	2.849±0.236^{Bb}

Means ± standard error among a row, attached to distinct A-B alphabet are significantly different at *p*=0.05.
Means ± standard error among a column, attached to distinct a-c alphabet are significantly different at *p*=0.05

DISCUSSION

During the thawing process, both physical and chemical parameters of meat were altered (Rifath and Jemziya, 2021). The freezing and thawing processes could modify the moisture content of meat (Leygonie *et al*., 2012). According to Rokonuzzaman in 2018, the moisture content of the broiler breast on summer season varies between 67.46-70.76%, thigh varies around 73.49-74.49%, drumstick varies around 71.35-73.33%, and wing varies around 67.14-71.83% depends on the strains. During the thawing process, the water relocates at a slow pace to its original position prior to freezing (Olivera *et al*., 2015). The relocation of water to its origin is affected by the rate of thawing. Whereas, the slow thawing process at the low temperature facilitates this phenomenon (Olivera *et al*., 2015). The findings of this study also obtained the similar result as, the cool room thawing method had the higher moisture content of the thawed broiler meat compared to the other methods.

According to the findings of this study, the thawing techniques had an impact on pH of the thawed broiler cut-up portions. The drumstick portion of the thawed meat was observed with the significant variation in the pH values of the various thawing technique. The pH value of the thawed meat generally lower than before freezing. The pH of meat depends on the glycogen storage in the muscles before slaughtering, and the glycogen conversion rate from glycogen to lactic acid (Mir *et al*., 2017). During thawing process, meat produces subsequent exudates that denature the buffer proteins and release more hydrogen ions (Leygonie *et al*., 2012). Further, the thawing techniques and the cut-up portions of the broiler meat had an impact on the CL of the thawed broiler meat. It may be due to the further denaturing of buffer protein ions (Leygonie *et al*., 2012) of broiler meat because of the higher temperature. The CL is a direct relationship to the reduction of moisture and the cooking yield and its impact on WHC, protein and fat content of the meat (Aaslyng *et al*., 2003, Demirok *et al*., 2013). As protein and fat are denatured during cooking, the chemically bonded water is released from the meat (Vieira *et al*., 2009).

Furthermore, the outcomes of this research showed that the thawing techniques and the cut-up portions of the broiler meat affected the WHC of the thawed broiler meat. The WHC is a key functional property, as it impacts on the color and texture of meat (Mir *et al*., 2017). The WHC of the meat affects the pH, sarcomere distance, ionic strength, osmotic pressure, and development of rigor mortis. (Offer *et al.,* 1988). Hence, fast-thawing techniques induce myofibril degradation, which impacts on the quality of the thawed meat (Yu *et al*., 2010). The freeze-thaw cycle also affects the meat quality, and the lowering of WHC levels (Ali *et al*., 2015). But in this study, the oven thawing technique obtained the higher WHC. Further, the DL of thawed meat also had a changing pattern by the methods of thawing techniques and the cut-up portions. The freezing and thawing processes ultimately separate exudate from the meat (Leygonie *et al*., 2012). It induces the ultrastructure damage in the muscle cells, allowing mitochondrial and lysosomal enzymes, haem iron, and other pro-oxidants to be released (Leygonie *et al*., 2012). Further, faster rate of thawing resulted in less exudate formation. Moreover, faster thawing rate lowers the DL (Eastridge and Bowker, 1994). The finding of this study also supports the literature as the tap water showed the least DL value for all broiler chicken parts whereas the oven technique and the hot water techniques were shown a higher DL percentage.

CONCLUSION

The quality characteristic of broiler cut-up parts is significantly affected by the different thawing techniques and cut-up portions. The method of thawing technique and cut-up portions had a significant effect on moisture content, water holding capacity, CL , pH and drip loss of cut-up parts of frozen broiler chicken. However, comparatively high losses in quality were observed in oven thawing technique. Eventually, it is concluded to the broiler chicken's thawing techniques using at lower temperature involving techniques, which is most appropriate with the minimal quality changes in the meat cut-up parts. Therefore, thawing broiler cut-up parts at lower temperatures could improve the quality parameters during thawing of household and industrial processing. Whereas, rapid thawing techniques at higher temperatures negatively affected the quality parameters of broiler meat cut-up parts.

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