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QUALITY CHANGES OF BROILER MEAT FROZEN USING HOUSEHOLD REFRIGERATOR AT -18°C AND THAWED USING DIFFERENT TECHNIQUES

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ABSTRACT

The physico-chemical quality parameters are altered during the freezing and thawing process. The uniform-sized whole broiler chicken samples and cut-up parts samples were individually frozen in the household refrigerator (-18°C) 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 the core temperature of the meat reaches 10°C in all method except refrigerator method. The refrigerator method thawing allowed to reach 4°C core temperature. In this study, the moisture content, water holding capacity, drip loss, cooking loss, and pH were investigated for both the whole and the cut-up parts samples. The moisture content and the drip loss were shown a significant difference ($p<0.05$) between different thawing methods for a whole chicken sample. Since the pH, water holding capacity, and cooking loss were not shown any significant differences ($p>0.05$) between different thawing methods for a whole chicken sample. The overall best quality retention was observed in the cool room thawing method. In cut-up part analysis, pH was shown a significant difference($p<0.05$) between portions in the cool room thawing method but moisture content, water holding capacity, drip loss, and cooking loss were not shown any significant difference ($p>0.05$) between cut-up parts for cool room thawing method. According to this study, the different thawing methods affect the quality parameters such as moisture content and drip loss. The cut-up part analysis results, the cool room thawing method affects the pH of different cut-up parts of the broiler meat.

1.Introduction

Freezing is the most widely used approach in preserving surplus agricultural production. A large proportion of poultry meat sold for cooking purposes in markets is offered as frozen meat. Freezing changes in the quality of meat are direct outcomes of freezing and frozen storage processes. Usually, freezer compartments in household refrigerators are below -18°C (Anderson et al., 2004). The freezing rate influences the meat quality by the size of ice crystals formed during the freezing process (Li and Sun, 2002). According to the rate of freezing, the freezing methods can be classified into slow and fast freezing techniques (Oliveira et al., 2015). The freezer compartment of the refrigerators is categorized under the slow freezing technique, which produces typically larger ice crystals.

Broiler chicken plays a significant part in mitigating the shortage of animal protein (Rokonuzzaman, 2018). According to the World Health Organization, the human required 55g/day of animal protein, but only 15.6 was eaten daily (Rokonuzzaman, 2018). To prolong the shelf life, the broiler meat was kept in freezing conditions. Before further preparation, such as cutting and heat processing, the frozen meat must be thawed.

The thawing mechanism is slower rather than freezing (Akhtar *et al*., 2013). Quick thawing at low temperatures is desirable in order to ensure food safety by preventing noticeable temperature increases and food dehydration (Akhtar *et al*., 2013). Food is prone to damage by chemical and physical alterations and microbial attacks during the thawing period (Fennema *et al*., 1973). Quality degradation, such as lipid and protein oxidation, protein denaturation, moisture loss, color deterioration, flavor loss, textural changes, and microbial spoilage, occur during the thawing period. (Benjakul and Bauer, 2000). The drawbacks of traditional thawing include food quality loss due to the leaching of soluble proteins, heavy energy consumption, and significant volumes of filled wastewater (Roberts *et al*., 1998).

Room temperature thawing, cold water thawing, steam thawing, and contact thawing are common thawing techniques for frozen foods. High-pressure thawing, microwave thawing, ohmic thawing, and acoustic thawing are now being researched to resolve losses in efficiency and duration of thawing (Li and Sun, 2002). The objective of this study is to evaluate the quality changes of thawed broiler meat using different techniques, which are frozen in the household refrigerator.

2. Materials and methods

2.1. Location

This study was done in the Food Science Laboratory of the Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka.

2.2. The samples

The commercially available raw carcass of broiler chicken was used for this study. Approximately 250g of whole broiler chicken carcass within 12 hours after slaughter without excess muscle fat and connective tissue were used as samples. For the cut-up parts study, 150g of each broiler meat part was used.

2.3. The freezing and thawing

The samples were individually frozen in the freezer compartment of the household refrigerator (Eco 251 NF, Sri Lanka) at -18°C. The frozen carcass was thawed in the lower compartment of the refrigerator(4°C), cool room (20°C), hot air oven (60°C), tap water (27±5°C), and hot water (40°C) conditions. The samples were thawed until the core temperature of the meat reaches 10°C in all methods except the refrigerator lower compartment method, where the core was allowed to reach 4°C. The core temperature of the broiler meat measured using a 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 hot air oven conditions to prevent overheating of the surface of the meat. After thawing, the meat samples were determined for water holding capacity, drip loss, cooking loss, moisture content, pH, and sensory evaluation.

2.4. The drip loss (DL)

The DL was determined by the bag method (Barton-Gade *et al*., 1993). Each meat sample was weighed and put into a net made of cotton, and both meat and net were put into a polyethylene (PE) bag and closed without touching the interior surface of the bag. 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).

$$\text{Drip loss (\%)} = [(W_1 - W_2)/W_1] \times 100 \quad (1)$$

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

2.5. 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, and the weight differences were calculated (Kim *et al*., 2013).

Cooking loss (%) = $[(W_1-W_2)/W_1] \times 100$ (2)

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

2.6. Water holding capacity (WHC)

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

WHC (%) = $[(M-N) \times 0.951^{*}/M] \times 100$ (3)

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

2.7. Moisture content (MC)

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

MC (%) = $[(W_1-W_2)/W_1] \times 100$ (4)

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

2.8. 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).

2.9. 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).

3. Results and discussions

The freezing and thawing cycles affect the MC of the meat (Leygonie *et al.*, 2012). According to this study, MC has shown a significant difference ($p<0.05$) for different thawing methods (Table 1).

Table 1. Moisture content (MC) and Drip loss (DL) values of thawed broiler chicken

	Cool room	Hot water	Oven	Refrigerator	Tap water
MC (%)	76.392 ± 0.957^{a}	76.586 ± 0.446^{a}	77.086 ± 0.261^{a}	77.590 ± 0.838^{ab}	79.641 ± 0.679^{b}
DL (%)	11.051 ± 1.780^{a}	8.455 ± 2.431^{a}	26.207 ± 3.409^{b}	10.107 ± 2.052^{a}	11.917 ± 2.608^{a}

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

The tap water thawing method has shown higher MC, whereas the cool room thawing method shown lower MC. Gonzalez-Sanguinetti *et al*. (1985) reported a significant difference in MC with different thawing techniques. The MC, determined by the WHC of the meat, ultimately affects the final pH of the meat (Rifath and jemziya, 2021). Tenderness, juiciness, firmness, appearance, quality, and economic values are increased with the moisture content of the meat (Mir *et al*., 2017). Meanwhile, DL has shown a significant difference ($p<0.05$) among different thawing methods (Table 1). The minimum DL was observed in the hot water thawing method, whereas the highest DL was observed in the oven thawing method. Exudate release is influenced by freezing and thawing methods (Leygonie *et al*., 2012). It causes damage to the muscle cells' ultrastructure to release the mitochondrial and lysosomal enzymes, haem iron, and other pro-oxidants (Leygonie *et al*., 2012). The increased rate of thawing contributed to decreased exudate forming (Ambrosiadis *et al*., 1994).

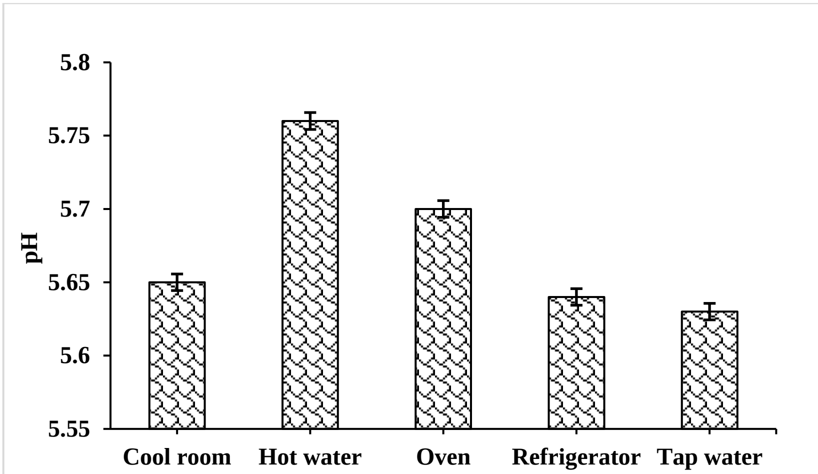

Figure 1. pH of the thawed broiler chicken
The values are means of triplicates ± standard error mean (SEM)

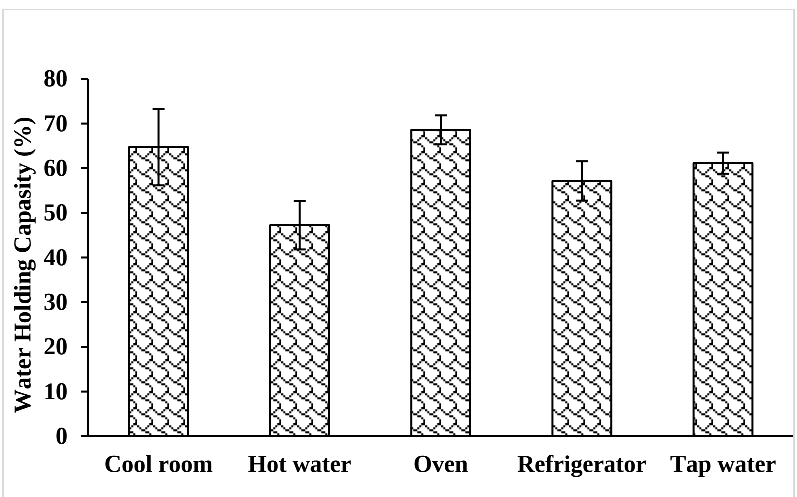

Figure 2. WHC (%) of the thawed broiler chicken
The values are means of triplicates ± standard error mean (SEM)

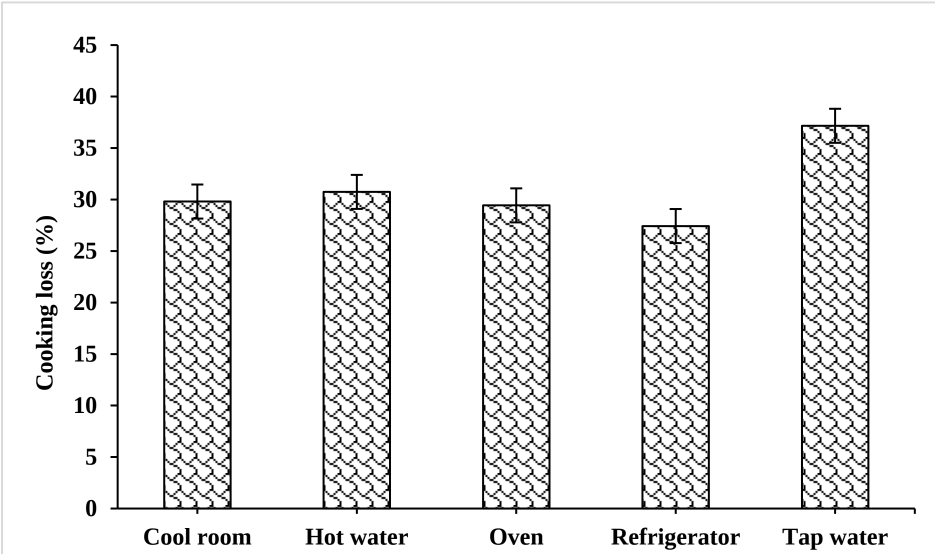

Figure 3. Cooking loss (%) of the thawed broiler chicken
The values are means of triplicates ± standard error mean (SEM)

The pH was not shown a significant difference ($p>0.05$) among different thawing methods (Figure 1). The lowest pH was recorded for the tap water thawing method, and the hot water method was observed with the highest pH value. The thawed meat shows a lower pH than frozen meat (Leygonie *et al*., 2012). It is due to the development of exudate that may denaturate buffer proteins, which triggers the release of hydrogen ions and also raises the concentration of released exudate, which causes pH reduction (Leygonie *et al*., 2012). The ultimate pH of meat depends on initial glycogen content prior to slaughtering and the rate of glycogen conversion (Mir *et al*., 2017).

The WHC was not shown a significant difference ($p>0.05$) among different thawing methods (Figure 2). The WHC for the oven thawing method is highest compared to other thawing methods, whereas the hot water thawing method was observed for a lower value. The WHC of the meat is reduced by the freezing and the thawing cycles (Añón and Cavelo, 1980; Ngapo *et al*., 1999; Vieira *et al*., 2009). The WHC has directly affected color and the tenderness of the raw carcass (Mir *et al*., 2017).

The CL was not shown a significant difference ($p>0.05$) among different thawing methods (Figure 2). The CL of the tap water-thawed broiler meat was considerably higher than other methods, and the refrigerator lower compartment thawing method was recorded with low value. The CL affects the WHC, protein, and fat content of the meat (Aaslyng *et al*., 2003). Protein denaturation and fat-melting during cooking release the chemically binding water from meat during cooking (Vieira *et al*., 2009). When comparing the overall results, the cool room thawing method quality degradation during the thawing period is minimum. The broiler meat thawed using a cool room shows lower values for DL and CL. Meanwhile, it shows higher WHC and moderate pH overall.

Table 2. Physico-chemical quality parameters of cool room thawed cut-up parts of broiler chicken

	MC (%)	pH	CL (%)	WHC (%)	DL (%)
Thigh	76.871±.462^{a}	5.61±0.06^{a}	29.273±1.722^{a}	60.455±2.867^{a}	13.844±1.620^{a}
Drumstick	76.990±0.497^{a}	5.87±0.07^{b}	31.432±1.263^{a}	58.116±3.008^{a}	11.861±2.160^{a}
Wing	77.641±0.621^{a}	5.60±0.05^{a}	32.747±1.607^{a}	58.637±4.295^{a}	14.544±1.908^{a}
Breast	77.655±0.447^{a}	5.64±0.06^{ab}	29.273±1.497^{a}	59.852±1.940^{a}	14.805±3.020^{a}

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.

The quality characteristics analyzed for cut-up parts thawed using the cool room method are given in Table 2. According to the results, pH showed a significant difference ($p<0.05$) between cut-up parts. Zhang *et al*., (2017) also reported that broiler breast cut-up parts thawed using different methods shown a difference in pH. Since MC, CL, WHC, and DL were not shown any significant difference ($p>0.05$) between cut-up parts. The moisture content for the breast part comparably higher than other parts, and the thigh recorded with lower moisture content than other parts. The lowest value for the pH is observed in the wing portion, and higher was observed in the drumstick portion. The wing portion lost a higher amount of exudate during the cooking process. Meanwhile, breast and thigh portions were loosed minimal amount of exudate during the cooking. The highest WHC was recorded in the thigh portion, and the lowest value was recorded in the drumstick. The drip loss was lower in the drumstick portion than other cut-up parts, and the highest DL was observed in the breast portion.

4. Conclusions

This study investigated the changes of quality parameters of broiler meat frozen in the household refrigerator and thawed using different techniques. The broiler meat quality parameters such as moisture content and drip loss depend on the thawing methods. The cool room thawing method shows an overall minimal quality reduction for quality parameters than other methods. The cut-up parts thawed using the cool room method are not showing any difference between portions except pH.

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