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Effect of Frozen and Re-frozen Storage on Chemical Composition of Broiler Chicken Meats

Research Project

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ABSTRACT

Broiler chicken meat is one of the most consumed products in the meat industry. One of the most commonly used processes to extend its shelf-life is freezing. However, prolonged freezing period or refreening process may lead to a decrease in the nutritional value of the meat, as the following research shows. This study aimed to better understand the consequences of freezing and refreezing broiler chickens, including how the nutritional value changes. Samples of fresh, frozen, and refrozen broiler chicken meat were analyzed, and the results were compared. The thawing loss, moisture, protein, fat, and ash content of the samples were observed by various methods, including weight loss before and after thawing for thawing loss, burning for ash, the Kjeldahl method for proteins, the Soxhlet extraction method for fat, and weighing the samples before and after drying using oven for moisture content. The results showed considerable differences between fresh, frozen and refrozen broiler chicken meat samples. Thawing loss was 5.4% and 7.9% for frozen and refrozen meat samples. Such losses were attributed to factors such as lipid oxidation, denaturation and the restructuring of ice crystals during refrozen storage. The moisture content was significantly higher in the frozen and refrozen samples than in the fresh ones. Protein, fat and ash content were found to be highest in the fresh and frozen meat samples compared to that in refrozen meat samples. In accordance to such results, it is suggested that broiler chicken meat should be served fresh, and to avoid freezing and refreezing for the best nutritional value.

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ACKNOWLEDGEMENTS

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1. INTRODUCTION

Broiler meat is gaining preference by many meat consumers, thanks to its low fat content, mainly saturated fatty acid and cholesterol level when compared to similar cuts of red meat including mutton and beef. In spite of its low in lipid content, broiler chicken meat has a high proportion of unsaturated fatty acids in addition to being a source of conjugated linoleic acid, which have such beneficial effects on human health as anti-inflammatory, anti-thrombotic and atherosclerotic preventatives (Marangoni et al., 2015). Broiler meat has also protein of high biological value constituting all essential amino acids that covering human requirement. In addition, broiler is an important source of vitamins especially vitamin A, E and D and minerals such as potassium, sodium, calcium, magnesium, iron, copper, zinc and manganese (Angelovičová et al., 2016).

Although broiler meat is highly nutritious, yet it is one of the most rapid perishable foods because of its short shelf life (Mir et al., 2017). The extension of shelf life can be achieved by chilling, freezing, salting, drying, caning, curing and smoking. Freezing techniques at a continuous temperature of -20°C are a common practice to prolong shelf life of poultry meat and meat products based industry due to the fact that freezing is characterized with easy application and storage conditions, neither adding nor removing any ingredients from meat. Additionally, consumers usually buy broiler chicken in bulk and store in freezer (Soglia et al., 2019).

Deterioration of meat quality in freezer and thawing rate collectively may have influence on the nutritious value of broiler meat. Considering the importance of consumer and industry viewpoint, the present study aimed to assess the effects of frozen and refrozen storage on the chemical composition of broiler chicken meats.

Specific Objectives

- To investigate the influence of frozen and refrozen storage on thawing loss of broiler chickens meats.
- To assess the effects of frozen and refrozen storage on the chemical composition (moisture, protein, fat and ash) of broiler chicken meats.

2. LTERATURE REVIEW

2.1. Freezing and Refreezing of Meat

Freezing is a commonly used preservation method in the meat industry. The understanding of the product behavior during the freezing process can assist in a better process management and quality control (Marini et al., 2014). Freezing storage of meat at a continuous temperature of -20°C is reported to contribute to the safety and shelf life by cooling fresh meat for weeks or months, the shelf-life of meat could be substantially extended to longer periods (Hhm et al., 2019). However, meat refreezing could be defined as meat that is thawed in the refrigerator then refroze in order to keep it safe without cooking. Multiple freeze-thaw cycles increase the loss of muscle moisture, as the damage to the ultrastructure of the meat fibers does not allow uptake of moisture into the intracellular spaces, leading to thawing loss (Ali et al., 2016).

2.2. Thawing Loss

Thawing is the process of taking a frozen product from frozen to a refrigeration temperature (usually above 0°C) where there is no residual ice. Thawing is often considered as simply the reversal of the freezing process (Kalla and Devaraju, 2017).Thawing cause meat discoloration, thawing and cooking loss, and lipid oxidation. However, the main threat to the quality of frozen meat is the decrease of water holding capacity, which is manifested as a loss of exudate (drip) upon thawing. Drip loss has a direct impact on meat weight and reduces its tenderness and the overall eating quality, and all these factors seriously affect its commercial value (Hhm et al., 2019).

2.3. Chemical Composition of Meat

Poultry, especially chicken broilers, is one of the most widely consumed muscle foods in the world. It is an important source of dietary energy and nutrients, such as high quality proteins, essential fatty acids, vitamins and highly bio-available minerals. The muscle of most broiler chichens contains 75% water, 22% protein, 4% fat and 1% minerals (Listrat et al., 2016).

Moisture is the major component and plays an important role in the sensory aspects of the meat. The moisture influences the quality parameters of meat such as the tenderness, juiciness, and processing quality of the meat. From an economic point of view moisture contributes to the weight of the meat, if its content in the meat is less then it will affect the weight of meat (Warner et al., 2017).

Meat contains about 20% protein of which 12% is structural proteins - actin and myosin (myofibrillar), 6% is the soluble sarcoplasmic proteins found in the muscle juice, and 2% is the connective tissues - collagen and elastin, encasing the structural protein. Collagen differs from most other proteins in containing the amino acids hydroxylysine and hydroxyproline but no cysteine or tryptophan. Elastin, also present in connective tissue, has less hydroxylysine and hydroxyproline. Thus the protein content of meat rich in connective tissue is lower than that of connective tissue free meat. The content of connective tissue in these cuts makes them tough and lowers their economic and eating quality values (Petracci et al., 2014).

Fat is an important energy source because of the amount of energy produced can be doubled from that generated by proteins and carbohydrates. Generally, fat is in triglycerides form. The composition of triglycerides significantly determines meat tenderness and roughness. Additionally, lipid in poultry meat meat has a high proportion of unsaturated fatty acids in addition to being a source of conjugated linoleic acid which have such beneficial effects on human health as anti-inflammatory, anti-thrombotic and atherosclerotic preventatives (Jiang et al., 2014). In addition to moisture, protein, and fat, meat contains a wide variety of minerals such as iron, zinc, and copper.

Chemical composition of meat could be affected by a number of factors such as freezing, refreezing and thawing. Hhm et al. (2019) investigated the effect of freeze and re-freeze on chemical composition of poultry meat at storage period 4.5 months. They reported large compositional changes were observed during the storage periods for the crude fat, crude protein, moisture, and ash contents of poultry meats. Crude fat, crude protein and ash content of poultry meats decreased at half-shelf life. Poultry meat showed a decrease in crude fat content from 7.63% to 6.90%, protein from 17.63% to 16.67%, and ash content from 0.77% to 0.60%, while increased moisture contents from 71.77% to 73.60% were noted at 2 and 4.5 months storage.

3. MATERIALS AND METHODS

3.1. Animals and Muscle Sampling

A five male broiler chickens (35 days old; average body weight of 2.000 ± 0.103 kg) reared under similar management system were used in this study. Before slaughtering, broilers were subjected to a total feed withdrawal of 12 h along with a 3 h lairage time at the processing plant. Birds were subsequently slaughtered by severing the jugular vein and carotid artery and allowed bleeding for 180 s. After evisceration and carcass dressing, the whole breast muscle samples were vacuum-packaged and assigned randomly into three groups. In the first group, breast samples were kept at 4°C for 24 h (fresh). In the second group, samples were frozen at -20°C for 5 days (frozen)while the third group of breast samples was frozen at -20°C, thawed overnight at 4°C in their original packages and then refrozen at -20°C for other 5 days (refrozen).

3.2. Thawing Loss

After hanged samples in chiller vertically for 12 h, thawing loss was calculated as a percentage of weight loss before and after thawing following the procedure described by Ali et al. (2016).

Thawing loss % = (frozen sample weight – thawed sample weight) / frozen sample weight × 100

3.3. Proximate Composition

Proximate composition of broiler breast muscle samples was determined in triplicates per sample following the procedures of AOAC (1990).

3.3.1. Moisture determination in meat

The meat samples were individually weighed (approximately 5g) and recorded as initial weight (W1). The weighed samples were dried in an oven at 105 °C for 24 h. After a constant weight obtained, the samples were immediately weighed and recorded as W2. The percentage of moisture was calculated and expressed as the percentage of differences of sample initial weight and sample weight after 24h drying divided by sample initial weight.

$$\text{Moisture (\%)} = [(W1 - W2) \div W1] \times 100$$

3.3.2. Protein determination in meat

The samples used for moisture determination were collected, prepared and used for determining the concentration of protein. Crude protein was determined by the Kjeldahl method. The method was conveniently divided into three steps which are digestion, neutralization and titration. Briefly, the organic component in meat sample (0.1 g) was digested with strong sulfuric acid in the presence of catalyst in order to convert total nitrogen to ammonia sulphate (digestion stage). In the neutralize or distillation stage, the nitrogen in digested solution was converted to ammonia hydroxide by ammonium hydroxide then being distillated into a boric acid solution and converted to ammonia borate which was titrated with strong hydrochloride acid (titration stage). Because the Kjeldahl method does not measure the protein content directly, the following equation was used to determine the nitrogen (N) concentration of flesh sample that weighs m grams using xM HCl acid solution for the titration:

$$\% N = \frac{\text{x moles } \times (\mathrm{V_s} - \mathrm{V_b})\, cm^3 \times 14\, g}{1000\, cm^3 \times \text{m g}} \times 100$$

Where:

V_s and V_b are the titration volumes of the sample and blank, and 14g is the molecular weight of nitrogen N. Once the nitrogen content was determined, it was converted to a protein content using the following equation:

$$\text{Protein (\%)} = N \times 6.25 \text{ (equivalent to 0.16 g nitrogen per gram of protein)}$$

3.3.3. Fat determination in meat

Fat content of dried meat samples was determined by Soxhlet extraction method using petroleum nine. The dried meat sample was individually weighed (approximately 1 g) and recorded as initial weight (W1) and placed into a dried and pre-weighed filter paper (W2). The sample was then put in a distillation path or extraction tube. The cleaned distillation flask was filled up to ¾ with nine then tidily attached with other parts of soxlat device and put the device on a head source after the water passing through the condenser was opened. After nine was started to evaporate to the condenser then dripped into the meat sample which was placed in to the distillation path, the fat extracted from sample and the hexane filled with fat backed to the distillation flask when it was reached at the end of the side tube of the distillation path (siphon). The process of siphon is repeated at a rate of 7 to 10 siphon per hour and continued for 1:30 hours. After extraction, the meat sample was dried from the nine and cooled then re-weighed (W3). The percentage of fat is calculated using the following equation:

$$\text{Fat (\%)} = [(W2 - W3) \div W1] \times 100$$

3.3.4. Ash determination in meat

For ash determination, the samples of Third chilling and frozen and refrozen meat were individually weighed and recorded as initial weight (W1) and placed into a dried and pre-weighed porcelain crucible (W2). The samples were then burned in a in a muffle furnace at temperatures of 550°C for 24 h. The burned samples were removed from the muffle furnace, equilibrated to room temperature in a desiccator and reweighed (W3). The ash percentages were calculated using the following equation:

$$\text{Ash (\%)} = [(W3 - W2) \div W1] \times 100$$

3.4. Data Analysis

The experiment followed a completely randomized design. Data obtained proximate composition were analyzed using the GLM procedure of Statistical Analysis System (SAS) package version 9.2 software (SAS, 2007). T-test was used to test the significance of variance between the means of the studied parameters at significant level of $p<0.05$. All values are reported as the means ± standard errors**.**

4. RESULTS AND DISCUSSION

4.1. Effect of Frozen and Refrozen on Thawing Loss of Chicken Meats

The thawing loss content of fresh, frozen, and refrozen breast broiler chickens is presented in Figure 1. The thawing loss percentage was found to be 5.408 and 7.875% in frozen and refrozen breast broiler chicken meats, respectively. The persentage of thawing loss of refrozen breast broiler chickens was significantly higher than that of frozen breast broiler chickens The frequent melting during thawing and restructuring of ice crystals during freezing in a number of freeze-thaw conditions was evidently harmful to muscle tissues by mechanically damaging the cell membranes and the loss of the water holding capacity (Ali et al., 2015).

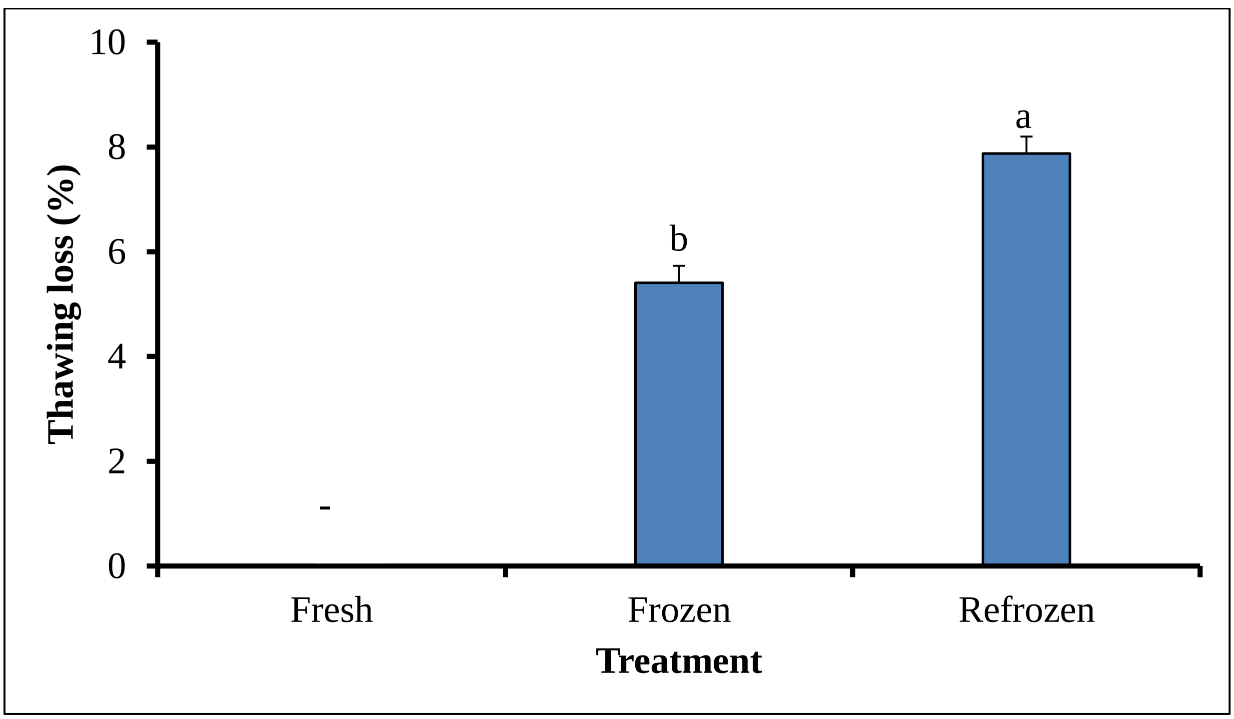

Figure 1 The effect of frozen and refrozen storage on the thawing loss of chicken breast meats

[ab]Means with different letters are significantly different ($p<0.05$).

4.2. Effect of Frozen and Refrozen on Chemical Composition of Meats

Moisture content of fresh, frozen and refrozen of breast broiler chickens is presented in Figure 2. The moisture percentage was found to be 65.871, 65.169 and 69.411% in fresh, frozen and refrozen of breast broiler chickens, respectively. According to statistical findings, the water content of refrozen of breast broiler chickens was significantly higher than the fresh and frozen of breast broiler chickens. In agreement with the results of this study, Hhm et al. (2019) have similarly reported an increase moisture contents from 71.77% to 73.60% in poultry chicken at 2 months storage, with further increases at 4.5 months.

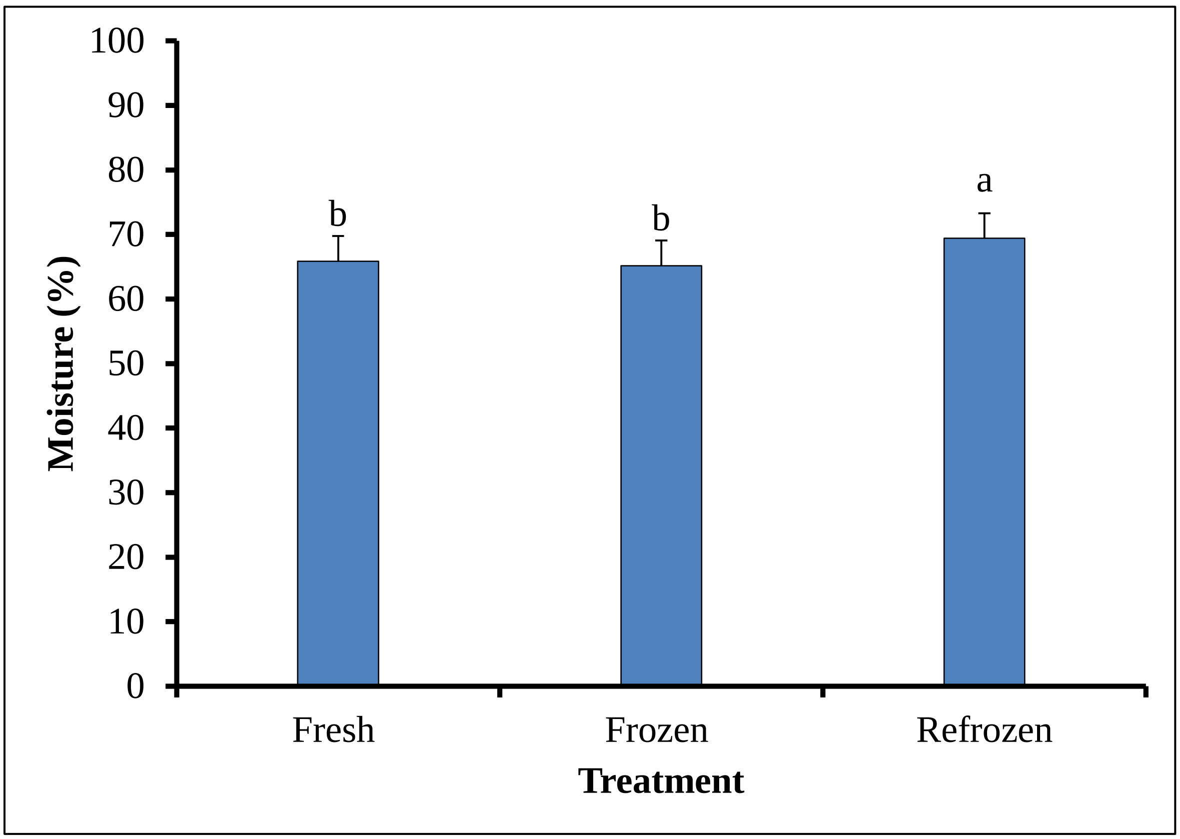

Figure 2 The effect of frozen and refrozen storage on moisture content of breast broiler chickens

[ab]Means with different letters are significantly different ($p<0.05$).

Protein content of fresh, frozen and refrozen of breast broiler chickens is presented in Figure 3. The Protein percentage was found to be 20.262, 20.332 and 19.948% in fresh frozen and refrozen of breast broiler chickens, respectively. The samples of fresh and frozen breast broiler chickens presented higher values of crude protein than that from the refrozen breast broiler chickens and the values were significant. The low value of crude protein in refrozen breast broiler chickens could be because denaturation and loss in gelatin caused by extended frozen storage and also due to proteolysis induced by enzymatic activities of psychotropic microbial growth. This finding is in tandem with those of Ali et al. (2015) who reported similar crude protein value for both fresh and frozen chicken breast meat.

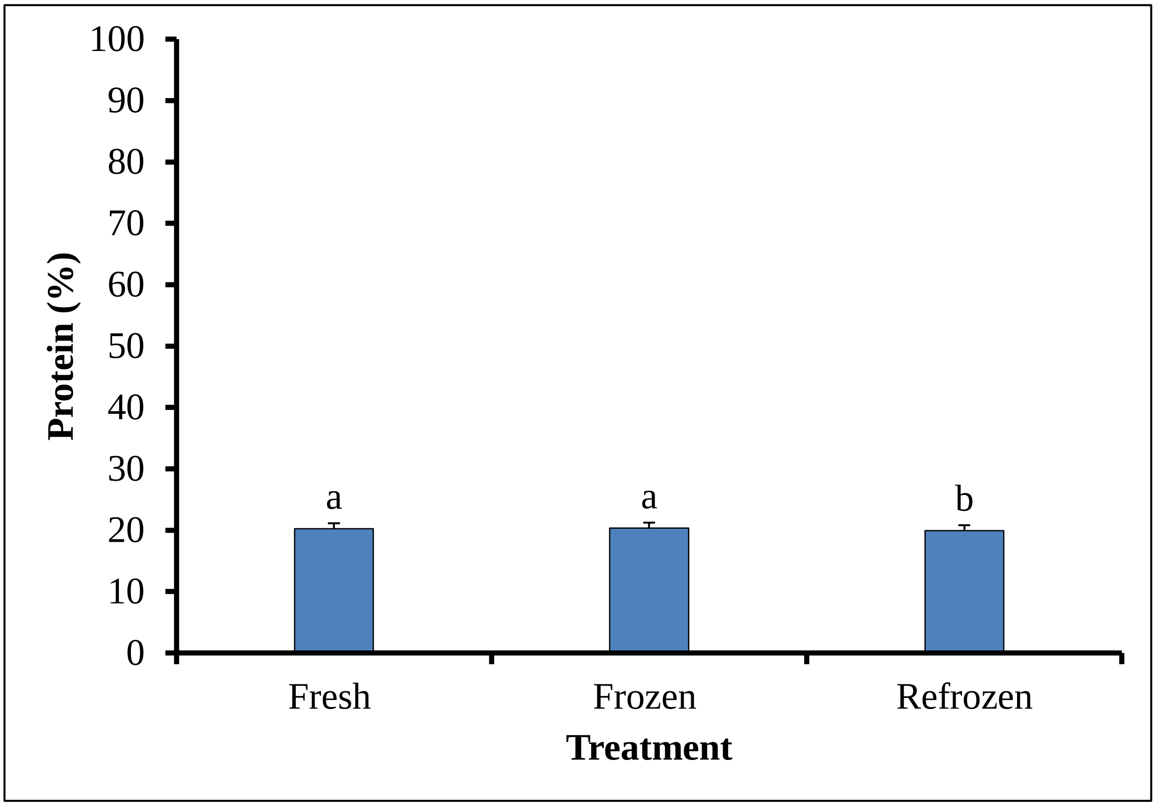

Figure 3 The effect of frozen and refrozen storage on protein content of breast broiler chickens

[ab]Means with different letters are significantly different ($p<0.05$).

Fat content of fresh, frozen and refrozen of breast broiler chickens is presented in Figure 4. The fat percentage was found to be 11.151, 11.776 and 9.007% in fresh frozen and refrozen of breast broiler chickens, respectively. The fat content was significantly low for refrozen of breast broiler chickens than those from the frish and frozen breast broiler chickens. This could be attributable to the oxidation of the lipid which is involved in the deterioration of flavor, formation of rancid odors, discoloration and production of potentially toxic compounds which can affect consumers' health. A similar explanation was given by Ali et al. (2015) who attributed the lower lipid content of refrozen chicken breast meat samples to significantly higher the oxidation of fat. The obtained fat values agree with those obtained by Hhm et al. (2019), showing a decrease fat content of poultry meats after the refrozen storage.

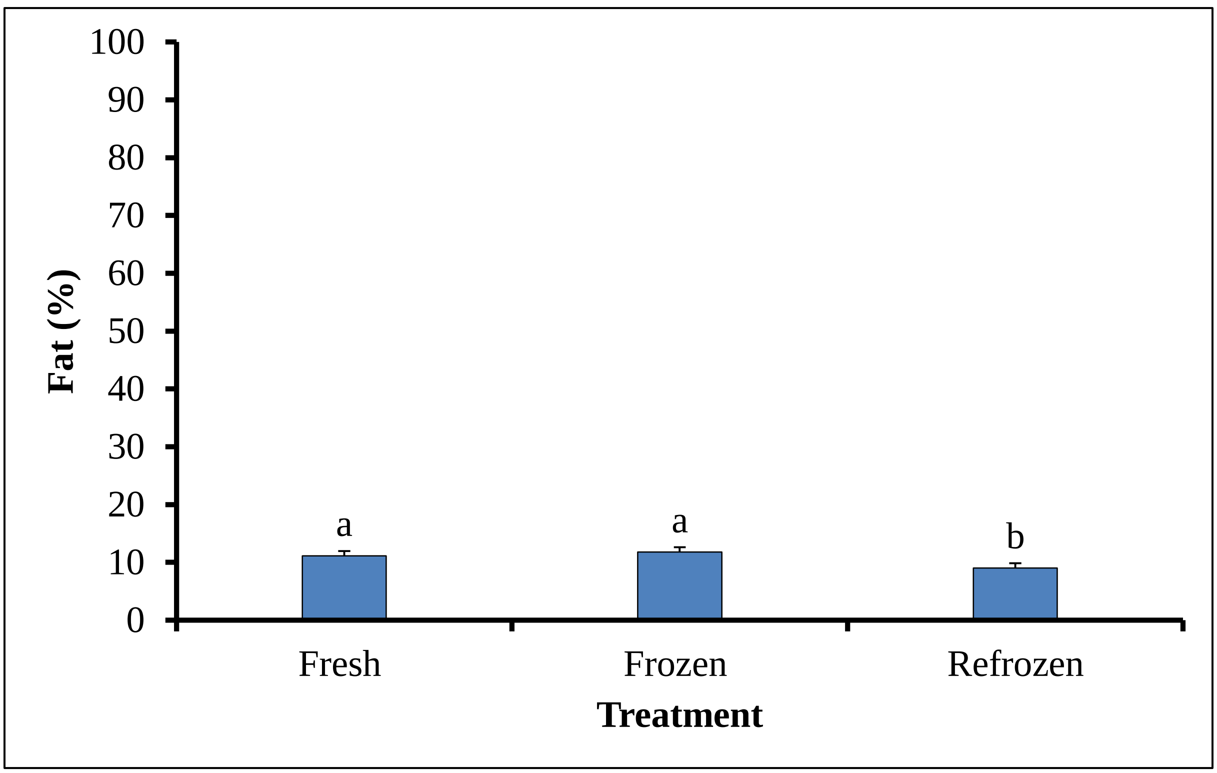

Figure 4 The effect of frozen and refrozen storage on fat content of breast broiler chickens

[ab]Means with different letters are significantly different ($p<0.05$).

Ash content of fresh, frozen and refrozen of breast broiler chickens is presented in Figure 4. The ash percentage was found to be 2.715, 2.722 and 1.633% in fresh, frozen and refrozen of breast broiler chickens, respectively. As shown in figure 4, ash content is significantly different ($p<0.05$). The ash contents were higher in fresh and frozen breast broiler chickens in comparison to that of refrozen breast broiler chickens. The result of the ash content of freeze-thaw in the current study was similar to those reported by Hhm et al. (2019) and Ali et al. (2015).

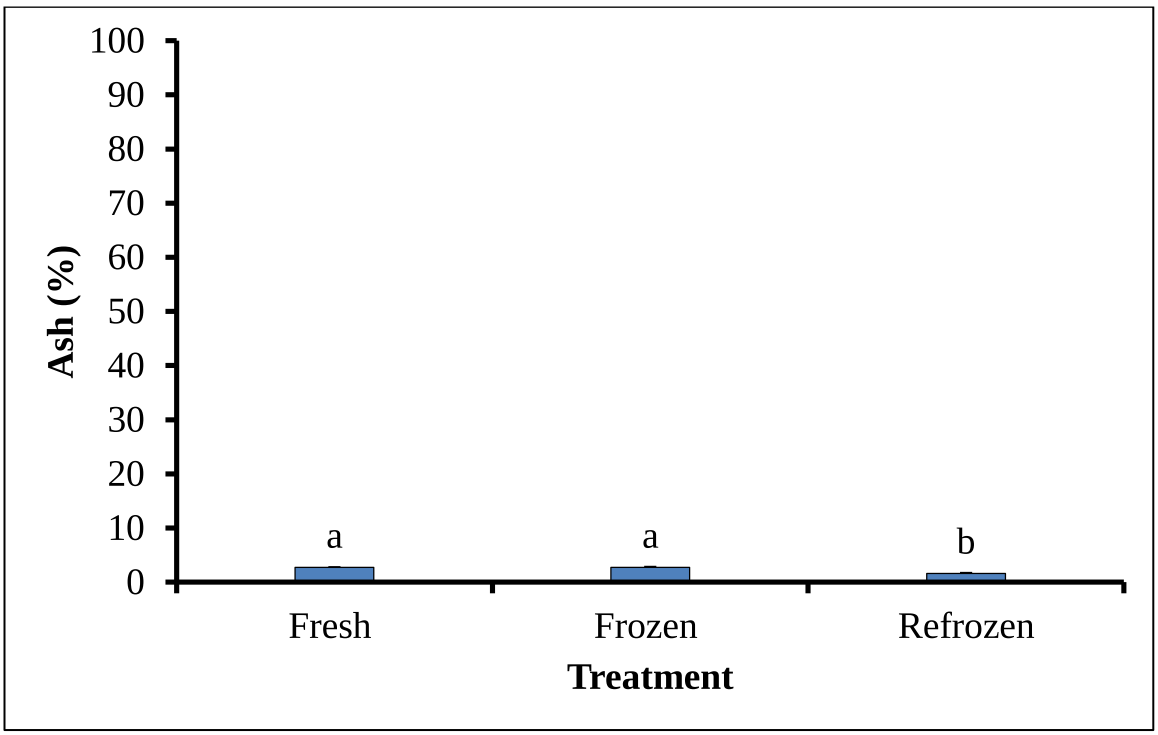

Figure 5 The effect of frozen and refrozen storage on ash content of breast broiler chickens

[ab]Means with different letters are significantly different ($p<0.05$).

5. CONCLUSION AND RECOMMENDATIONS

This research aimed to study the impact of frozen and refrozen broiler chicken on meat quality. Based on the series of tests that were conducted upon three groups of broiler chicken meat samples (fresh, frozen and refrozen), it can be concluded that the thawing loss was higher in refrozen meat samples than that of frozen meat samples, which were 7.9% and 5.4%, respectively. The results of chemical composition were shown that the moisture content of the refrozen chicken meat was higher than that of frozen and fresh samples while protein, fat, and ash were significantly lower in the refrozen chicken meats in comparison with fresh and frozen chicken meats. Based on these conclusions, practitioners in the poultry farming industry should consider offering their broiler chicken meat products in the freshest way possible, and also warn consumers that refreezing the chicken leads to loss of nutritional value in the meat.

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