EFFECT OF THAWING CYCLES ON PROXIMATE COMPOSITION AND PHYSICAL QUALITIES OF RAW MUTTON

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ABSTRACT
This research was designed to investigate the effect of repeated thawing on the physicochemical qualities of fresh mutton. Samples of mutton were subjected to a two weeks freeze-thaw cycles taking samples for physical, and proximate analysis at day 1, 7 and 14. Results indicated that thawing cycles significantly affected (P<0.05) all proximate parameters of fresh mutton. Results shows a trend in decreasing moisture content, increasing ash, lipid and protein content with increase thawing period. Similarly, results of physical properties indicated that thawing cycles had significantly affected (P<0.05) all physical parameters measured from fresh mutton, except pH. It was concluded that multiple freeze-thawing can lead to decreasing drip loss, water holding capacity and cooking loss, moisture content, while protein content, lipid content and ash content of fresh mutton increased in a two cycle freeze thawing.
Keywords: thawing, physical qualities, proximate composition, mutton.

INTRODUCTION

Freezing is an excellent method to maintain the quality of meat and to keep it fresh for a period of time (Sung *et al.*, 2013). Furthermore, this preservation method provides a great logistical advantage required for the export of meat (Wang, *et al*., 2020). Frozen storage is chosen to be the preferred method in meat preservation. However, multiple freeze-thaw (F-T) cycles will occur during the transfers or distribution processes under poor cold-chain conditions (Hu and Xie, 2021; Daria *et al.,* 2022). Frozen preservation is a widely used storage method for meat and meat products. Hansen *et al*. (2004) suggested that –55°C is an ideal preservation condition for frozen meat to prevent storage conditions from affecting meat quality. At –55°C microbial activity, enzymic reactions and oxidative deterioration are minimized, and there is almost no deterioration in meat quality during storage (Zhou *et al.,* 2010). However, –18°C is a commonly used commercial storage condition. At this temperature, some chemical and biochemical processes in the meat may still occur. Such reactions mainly involving lipid oxidation and discoloration are responsible for the deterioration of meat quality during frozen storage (Kim *et al*., 2017). The freezing process can affect meat properties due to mechanical damage from ice crystal formation in extracellular locations, as well as volume alternations in cellular structures (Dalvi-Isfahan *et al.,* 2016; Tippala *et al,* 2021). In general, the quality of frozen meat is closely associated with the freezing and thawing processes. Freezing and thawing rate collectively have a vital role in tissue damage and water loss due to the small ice crystals formation and drip loss. Multiple freeze-thaw cycles increase the loss of muscle moisture, as the damage to the ultra-structure of the meat fibers does not allow uptake of moisture into the intracellular spaces, leading to thawing loss, while freezing deteriorates meat quality due to osmotic removal of water, mechanical damage due to ice crystal formation, and lipid and protein oxidation (Benjakul *et al*., 2001), thawing cause meat discoloration, thawing and cooking loss, and lipid oxidation (Xia *et al*., 2009). However, the main threat to the quality of frozen meat is the decrease of water holding capacity (WHC), which is manifested as a loss of exudates (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 have been reported to seriously affect its commercial value (Jeremiah, 2006).When thawing to food once more, quality changes occur and can affect people's health seriously (Kim *et al.,* 2017). Erratic nature of power supply in developing countries like Nigeria leads to great losses in food that are stored in cooling systems due to temperature fluctuations. Fluctuation may result in ice recrystallization and microstructural changes in frozen food products. It possibly causes irreversible damage to cells and tissues and lowers frozen food quality in the logistics. The main purposes of this study is to point out the quality changes of fresh mutton that is subjected to multiple freeze and thaw cycles.

MATERIALS AND METHODS

Preparation of Sample by Thawing

The study was conducted at the Animal Science Laboratory, Kebbi State University of Science and Technology, Aliero. Samples of fresh mutton from semi memranosus muscle were collected from Birnin Kebbi Central Abattoir. All visible fat and connective tissues were removed prior to the experiment. Mutton of about 250g per replicate, was randomly selected and cut into $10\times7.5\times2.5cm^3$ pieces. These pieces were packed in moisture impermeable polyethylene bags, sealed and stored at -20ºC for each cycle. For each period, a set of frozen samples were thawed at 4ºC for 4 hours. The frozen samples were subjected 0–2 freeze–thaw cycles. A weekly analysis of the samples was performed over three weeks.

Determination of Physical Qualities

pH

The pH was evaluated according to the method described by Lan *et al*. (2016). One gram of minced mutton sample was homogenized in 10 mL potassium chloride (0.1 M, pH 7.0) using a high-speed disperser (XHF-D, Ningbo Xingzhi Biotechnology Co., Ltd., Zhejiang, China). A digital pH meter (UB-7, Sartorius AG, Goettingen, Germany) was used to measure pH.

Drip Loss

Drip loss (%) was measured for frozen mutton until the temperature in center of mutton reaches at 0□.

$$\text{Drip loss (\%)} = \frac{\{(\text{weight before thaw} - \text{weight after thaw})\}}{\text{Weight before thaw}} \times 100$$

Thawing Loss

Thawing loss was measured by the method from Barbin *et al.* (2013) was used to evaluate thawing loss, (Wf is the weight of fresh meat before freezing, and Wt is the weight of repeated freeze-thaw cycles samples after thawing).

Water holding capacity (WHC)

WHC of samples was measured using the modified Kim *et al*. (2017) method. It was determined by heating 5g of minced meat at 70□ in a water bath for 30 min and then cooling it, and then centrifuging at 1,000 rpm for 10 min and measuring total moisture, after which is calculated by the following formula.

$$\text{WHC (\%)} = \frac{(\text{total water content} - \text{separated water content})}{\text{Total water contents}} \times 0.951^{*} / \times 100$$

*0.951: pure water amount for meat moisture which is separated under 70□

Determination of Proximate Composition

Proximate composition was determined using the procedure of Association of Analytical Chemists (AOAC, 2007) standard procedures.

Data Analysis

Both data on physical qualities and proximate composition were analyzed using general linear model (GLM) multivariate analysis. Significant means were separated using Games-Howell test at 5% level SPSS statistical package was used for the data analysis (SPSS, 2007).

RESULTS AND DISCUSSION

Proximate Composition and Physical Characteristics of Fresh Mutton Subjected to Freeze-Thaw cycles

Results for Proximate Composition of Fresh Mutton Subjected to repeated freeze-Thaw cycles is shown in Table 1. Results indicated that thawing cycles had significantly affected ($P<0.05$) all proximate parameters. Moisture content decreased with repeated thawing. Ash and lipid and protein contents increased with repeated thawing. Result for physical characteristics shows that thawing cycles had significantly affected ($P<0.05$) water holding capacity and drip loss of fresh mutton. However, pH was not significantly affected ($P>0.05$).

Table 1 Proximate Composition of Fresh Mutton Subjected to freeze-Thaw cycles

Thawing Cycles	Parameters								
	MC (%)	Ash (%)	Lipid (%)	Nit. (%)	CP (%)	NFE (%)	pH	WHC (%)	DL (%)
CYCLE 1 (0 days)	64.5[a]	2.0[c]	3.5[c]	3.25[b]	18.30[c]	2.70[a]	7.61	0.6[c]	22.0[a]
CYCLE 2 (7 days)	58.5[b]	3.5[b]	7.5[b]	3.50[a]	21.88[b]	1.10[c]	7.75	0.83[b]	13.3[b]
CYCLE 3 (14 days)	55.0[c]	7.0[a]	10.5[a]	3.08[c]	22.25[a]	2.20[b]	7.73	1.68[a]	13.67[b]
SE (±)	0.337	0.058	0.058	0.034	0.034	0.058	0.577	0.022	0.981

abc= means that bears different superscripts along columns differ significantly (P<0.05)
MC= moisture content Nit.= Nitrogen CP= crude protein NFE= nitrogen free extracts
WHC= water holding capacity DL= drip loss

DISCUSSION

Measurement of moisture loss

The initial moisture content of mutton was 64.5%, but after two thawing cycles, the moisture content decreased progressively to 58.5% and 55.0%, respectively. The amount of moisture loss may be a measure of damage to muscular tissue structure in the freezing process, reflecting the effectiveness of different thawing methods (Kondratowicz *et al*., 2008). This finding agrees with Muela *et al*. (2010) and Soyer *et al*. (2010) reported that an increase in freeze-thaw cycles or a reduction in the rate of freezing results in increased moisture loss. According to Xia *et al.* (2009), thawing loss is conditioned by the number of freezing-thawing cycles. In case of drip loss all treatments showed a significant change over the course of the trial. Drip loss tend to be decreasing as the number of freeze-thaw cycles increased which agreed to Ali *et al.,* (2016); Hu and Xie (2021); Daria *et al* (2022) who reported that rapid thawing of meat by submergence in water decreased the drip loss and in case of refrigerated thawing, which resulted in the highest drip loss. In this study, drip loss was within 14.05% to 4.54%. In general, drip loss was decreased with the number of repeated freeze-thaw cycles. In cycle one and two WHC was higher than the control but in cycle 3 WHC was decreased than the control. An initial increase and a subsequent decrease in WHC have been reported (Mohammad *et al*., 2014). In general freezing, frozen storage and thawing all contribute to a decrease in the water-holding capacity of meat (Vieira *et al.*, 2009). WHC was also affected by thawing methods and the combined effect of thawing methods and freeze-thawing cycles. The result of WHC in this study was satisfactory which agreed to Nasreen *et al*. (2012). The pH of the samples remained almost similar up to 21 days of frozen storage at (−20±1□).

CONCLUSION

It has been concluded that multiple freeze-thawing had significantly affected physical qualities of raw and cooked mutton by decreasing drip loss, water holding capacity and cooking loss. Multiple freeze-thawing had significantly affected proximate composition of raw and cooked mutton by reducing moisture content, increasing protein content, lipid content and ash content of both fresh and cooked mutton.

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