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Research Article

Effect of different thawing methods on the quality of goat liver

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Abstract

The experiment was conducted to find out the effect of different thawing methods like ambient temperature thawing, refrigerator thawing and tap water thawing on the quality of goat liver. Sensory evaluation, proximate components, physico-chemical quality, biochemical properties and microbiological tests. Six goat livers were collected from a local slaughterhouse. Liver samples were preserved under freezing condition (-20°C) for 3 months after fresh evaluation. After evaluation of thawed liver, color, odor, juiciness, and tenderness were significantly ($P<0.05$) different with maximum values of color and odor found in refrigerator thawing while maximum juiciness and tenderness value found in ambient temperature thawing. DM and Ash contents were not significantly differed ($P>0.05$); however, the highest value found in refrigerator thawing within the three thawing methods. CP content was significant ($P<0.05$) different among the different thawing methods. EE content differed significantly ($P<0.05$), although less amount of EE content was found in refrigerator thawing. There was no significant ($P>0.05$) variation of pH value on studied thawing methods. Thawing loss, WHC and colour measurement significantly ($P<0.05$) differed with the different thawing methods, while thawing loss of tap water thawing, WHC value of ambient temperature thawing and colour value of refrigerator thawing were found in maximum level. TBARS value was significantly varied among the different thawing methods where the minimum result found in tap water thawing but maximum result found in ambient temperature thawing. TVC, TCC and TYMC comparatively more number found in ambient temperature thawing but less number found in refrigerator thawing. The lowest number of microbial counts found in refrigerator thawing. It may conclude that refrigerator thawing is the best thawing method to determine the quality of goat liver than others in this experimental condition.

Introduction

Liver is a most valuable delicious edible meat by product which contains high amount of protein, vitamins, minerals and essential dietary fatty acids with high biological value (Akhter et al., 2022; Fernandez-Lopez et al., 2006; Yasmin et al., 2022). In terms of nutritional value, raw goat liver is comprised about 18-20% protein, 2-5% fat (Tomovic et al., 2017). In addition, it consists different types of vitamins like B12, niacin, riboflavin, thiamin and minerals like iron, potassium, magnesium, sodium and folate are available in liver (Alam et al., 2024; Kawsar et al., 2006; Sarker et al., 2008; Tomovic et al., 2017). Although liver is more nutritious meat by product, it is generally considered that liver has poor hygienic quality. It is prone to rapid spoilage, and has a high incidence of pathogenic organisms, mostly a high content of water, protein, and fat that undergoes oxidation and rancidification (Hashem et al., 2021, 2023 and 2024; Vierira et al., 2009), which leads to undesirable changes in the sensory properties and nutritional value.

For preservation, freezing is one of the best options but it cannot strictly inhibit the processes accountable for quality deterioration of liver during frozen storage (Alam et al., 2023; Rahman et al., 2023; Xiong, 2000). The rate of freezing and thawing, the manner of thawing, the specific storage temperature, and temperature changes are most significant variables that affect the frozen meat (Mia et al., 2023, Son et al., 2024). Before any further food processing or cooking, frozen food must first be thawed. To the greatest extent possible, food quality should be restored during thawing. There are many variables that affect how thawing affects the liver quality, including relative air humidity, effective thawing time, and thawing techniques (Kondratowicz et al., 2006). Large lipid oxidation, protein oxidation, protein denaturation, and microbiological development occur throughout the thawing process, which contributes to this deterioration (Ambrosiadis et al., 1994). Slower thawing rates almost invariably result in more damage than faster thawing rates. There are numerous thawing methods for defrosting frozen products, including cold water thawing and refrigerator thawing (Anderson and Singh, 2006).

Thawing significantly reduces the quality of the frozen product (Alam et al., 2024; Sharker et al., 2024). A poor thawing process will cause the liver hibernating micro flora to multiply and become active (Xu et al., 2021). However, the effect of different thawing methods on the quality of goat liver is not determined yet. Therefore, the present study was undertaken to investigate the effects of different thawing methods such as ambient temperature thawing, refrigerator thawing and tap water thawing on the quality of goat liver.

Materials and methods

Place of experiment

The experiment was conducted at the Department of Animal Science in Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh.

Sample Collection

Six goat livers weighing around 500g to 600g were collected from local slaughterhouse at Mymensingh Sadar at the early in the morning (7.00 A.M.) where all the goats were same age (around 1.5 to 2 years) and same sex (male). Fresh goat livers were immediately kept in the air tied plastic bag with ice and rapidly transferred to the "Animal Science Laboratory."

Preparation of jar and other instruments

All necessary instruments and jars or containers were cleaned with hot water and detergent powder and then dried properly before starting the experimental activities.

Preparation of fresh liver sample

All visible fat and connective tissue were trimmed off as far as possible with the help of knife from fresh livers. At first, six samples were prepared from six livers for freshly evaluation such as sensory, proximate, physico-chemical, biochemical and microbial analysis in the "animal Science Laboratory" under the hygienic condition. Replication number of each parameter was three times.

Preservation of liver sample for thawing evaluation

Every three samples were prepared from each liver and a total of eighteen samples were prepared from six livers then every sample was packaged in sterile plastic zipper bags with the date and labeling then stored in freeze (-20ºC) for further study by three different thawing methods. The livers were sampled and preserved in the "Animal Science laboratory" under the hygienic condition. The storage duration was three months.

Thawing

Three different thawing methods such as ambient temperature thaws (ATT, 25ºC), refrigerator thawing (RT, 4ºC) and tap water thawing (TWT, 20ºC) were applied to compare their effects on goat liver after three months of freezing. From eighteen samples, six frozen samples were thawed by refrigerator thawing, six samples were thawed by ambient temperature thawing and six samples were thawed by tap water thawing. Time of ambient temperature thawing was two hours under room temperature, time of refrigerator thawing was 2.5 hours and temperature of refrigerator was 4ºC, time of tap water thawing was 45 minutes & water temperature was 20ºC to bring normal condition. Evaluation of all samples such as sensory, proximate, physio-chemical, biochemical and microbial analysis were performed in the "Animal Science Laboratory". Replication number of each parameter was three.

Sensory evaluation

Sensory evaluation was carried out in individual booths under controlled conditions of light, temperature and humidity. Prior to sample evaluation, all panelists participated in orientation sessions to familiarize with the scale attributes (color, odor, juiciness, and tenderness) of goat liver using a 5-point balanced semantic scale (weak to strong). Sensory scores were 5 for excellent, 4 for very good, 3 for good, 2 for fair and 1 for poor (Disha et al., 2020). Panelists were selected among department member and students and trained according to the American Meat Science Association guidelines (AMSA, 1995).

Proximate Composition

Proximate composition such as Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), and Ash were carried out as per the standard procedures of AOAC (1995).

Measurement of Physicochemical properties of goat liver

Thawing loss

Thawing loss of the thawed sample chops was determined from the known weights of sample before and after thawing (Xia et al., 2012) of goat livers were determined by subtracting the final weight of liver sample from its initial weight and expressed as a percentage of the initial weight. Thawing loss was calculated with the three different thawing methods such as ambient temperature thawing, refrigerator thawing and tap water thawing.

Formula of thawing loss

Thawing loss (%) = $[(w_1\text{-}w_2) \div w_1] \times 100$

Where, w_1 = Weight of sample before thawing, w_2 = Weight of sample after thawing

Water holding capacity (WHC)

Water holding capacity of liver depending on each thawing method, using the modified method, is calculated by heating 5 g of minced liver at 70°C in a water bath for 30 minutes and then cooling it, and then centrifuging at 1,000 rpm for 10 minutes and measuring total moisture, after which is calculated by the following formula.

$$\%\ \text{of WHC} = \frac{(\text{wt of sample before centrifuge} - \text{wt of smple after centrifuge}) \times 0.951 *}{\text{wt of sample before centrifuge}} \times 100$$

*0.951: pure water amount for liver moisture which is separated under 70°C

Colour measurement

Using a Color Difference Meter (WSC-S, Shanghai Physics and Optics Instrument), the surface color of porcine chop was measured. Using a white standard plate (L* = 19.23, a* = 5.64, b* = 6.92), the instrument was calibrated. Values were taken from four separate regions on the surface of each chop and were expressed as L* (lightness), a* (redness), and b* (yellowness) units. A minimum of three chops per treatment block were evaluated to derive an average value.

Thiobarbituric Acid Value (TBA) (mg-MDA/kg)

Lipid oxidation was assessed in triplicate using the 2-thiobarbituric acid (TBA) method described by (Schmedes and Holmer,

1989). Goat liver samples (5 g) were blended with 25 ml of 20% trichloro acetic acid solution (200 g/L of tricholoro acetic acid in 135 ml/L phosphoric acid solution) in a homogenizer for 30 s. The homogenized sample was filtered with Whatman filter paper number 4, and 2 ml of the filtrate was added to 2 ml of 0.02 M aqueous TBA solution (3 g/l) in a test tube. The test tubes were incubated at 100°C for 30 min and cooled with tap water. The absorbance was measured at 532 nm using a UV-VIS spectrophotometer (UV-1200, Shimadzu, Japan). The TBA value was expressed as mg malondealdehyde per kg of liver sample.

Microbial assessment

For microbial assessment, total viable count (TVC), total coliform count (TCC) and total yeast mould count were undertaken according to the procedure described by Bithi et al. (2020).

Statistical analysis

Data were analyzed statistically by using MSTATC package in one way analysis of variance test as per Completely Randomized Design (CRD). Means were considered significantly different for ($p < 0.05$). Data presented are shown as means ± SD.

Results and discussion

Effect of different thawing methods on the sensory evaluation of goat liver

The parameters for sensory evaluation have been shown in Table 1. All parameters color, odor, juices and tenderness scores were significantly increased ($P<0.05$) in fresh liver and decreased in different thawing methods. However, among these last three treatments (three thawing methods), the most preferable color and odor were observed in refrigerator thawing (RT), whereas the highest juiciness and tenderness score were observed from ambient temperature thawing (ATT). The result indicates that the maximum value found in ambient temperature thawing for liver juiciness. The result of this experiment is also related to (Lui et al., 2010) findings. Diminution in juiciness occurs because LDPE has a high permeability to moisture. The lower odor scores may be related to the increased malonaldehyde formation due to oxidation of fat, which has detrimental effect on the flavor and firmness of the product (Kondraratowiez et al., 2006). Deterioration of odor during storage might be due to microbial growth, formation of FFA and oxidative rancidity (Hossain et al., 2024; Vieira et al., 2009). The tenderness of meat with the breakdown of myofibrillar proteins affected by the presence of calcium-dependent proteases or calpains.

Table 1. Effect of different thawing methods on the sensory evaluation of goat liver

Parameters	FL	ATT	RT	TWT	Level of significance
Color	4.97 ± 0.08^{a}	3.10 ± 0.14^{c}	3.31 ± 0.17^{b}	2.84 ± 0.15^{d}	P<0.05
Odor	5.0 ± 0.59^{a}	3.12 ± 0.33^{b}	3.23 ± 0.18^{b}	3.01 ± 0.25^{b}	P<0.05
Juiciness	4.77 ± 0.08^{a}	3.23 ± 0.31^{b}	3.06 ± 0.08^{b}	3.05 ± 0.14^{b}	P<0.05
Tenderness	4.97 ± 0.08^{a}	3.24 ± 0.28^{b}	3.09 ± 0.21^{b}	3.22 ± 0.27^{b}	P<0.05

FL= Fresh liver, ATT= Ambient temperature thawing (25ºC), RT= Refrigerator thawing (4ºC), TWT= Tap water thawing (20ºC). Means in each row having different superscripts vary significantly at values p<0.05. Values are presented as mean ±SD.

Effect of different thawing methods on proximate composition of goat liver

The values of proximate components have been shown in Table 2. Among the groups, DM content was not significantly ($p > 0.05$) changed and the value indicates that the highest dry matter content found in refrigerator thawing (29.80%) and the lowest value observed in ambient temperature thawing (28.83%). The same trend was also observed by Kim et al. (2013) and reported that DM content increased during frozen storage and thawing. In contrast, the CP content was significantly ($P < 0.05$) changed among the groups and highest values was found in Refrigerator thawing (4ºC), whereas the lowest values were obtained in fresh liver. These findings are consistence with previous studies (Boonsumrej et al., 2007; Akhter et al., 2013) revealed that CP content decreased during thawing period. On the other hand, among these last three treatments (three thawing methods), the amount of EE content was significantly increased in tap water thawing (3.83); while lowest values observed in refrigerator thawing (2.29%); indicating that the most acceptable result obtained in refrigerator thawing. It has been disclosed that deterioration lipids took place due to intermediary activities of endogenous liver enzymes leading to hydrolysis of fat (Serdaroglu et al., 2005). There was no significant variation was found for the ash content among the groups. A non-significant ($p > 0.05$) decrease in ash percentage was reported (Tomovic et al., 2017) which coincided with this study.

Table 2. Effect of different thawing methods on proximate composition of goat liver

Parameters	FL	ATT	RT	TWT	Level of significance
CP (%)	24.84 ± 1.00^{b}	26.81 ± 0.95^{a}	27.77 ± 2.56^{a}	25.99 ± 1.02^{ab}	P<0.05
DM (%)	29.47 ± 3.65^{a}	29.72 ± 1.24^{a}	29.80 ± 0.70^{a}	28.83 ± 0.52^{a}	P>0.05
Ash (%)	1.27 ± 0.12^{a}	1.15 ± 0.30^{a}	1.20 ± 0.19^{a}	1.05 ± 0.13^{a}	P>0.05
EE (%)	2.27 ± 0.23^{b}	2.92 ± 0.78^{b}	2.29 ± 0.53^{b}	3.83 ± 0.75^{a}	P<0.05

FL= Fresh liver, ATT= Ambient temperature thawing (25ºC), RT= Refrigerator thawing (4ºC), TWT= Tap water thawing (20ºC). Means in each row having different superscripts vary significantly at values p<0.05. Values are presented as mean±-SD. DM = Dry Matter, CP = Crude Protein, EE = Ether Extract.

Effect of different thawing methods on physicochemical properties of goat liver

The physicochemical properties such as pH, thawing loss and water holding capacity (WHC) and colour were determined and the results obtained are shown in Table 3. The results show that for pH value, no significant ($p > 0.05$) differences were found among the groups. Among these last three treatments (three thawing methods), the value of pH was 6.68 to 6.70. The highest pH value was observed from tap water thawing (6.7). The decreasing pH was probably due to the secretions of microorganisms in the goat liver. The pH of fresh livers is 6.72 to 6.94. pH values lower than 6.15 may be considered as indicative of goat liver spoilage (Leygonie et al., 2011). The findings of this study also stated that thawing loss was significantly ($p < 0.05$) varied among the groups **(**Table 3). The highest value found in tap water thawing (5.99%) and the lowest value found in ambient temperature thawing (3.52). Thawing loss refers to the loss of fluid resulting from the formation of exudates following freezing and thawing (Alam et al., 2023); Chandirase and Thulasi, 2010). Thereby, losses are lower following a rapid thawing compared with slow thawing. Major components of thawing losses are occurred during thawing time, dripping and evaporation.

In the present study, the range of overall observed water holding capacity at different treatments was 89.22% to 93.57% (Table 3). Water holding capacity was significantly (P<0.05) varied among the observations. Within the last three treatments (three thawing methods), the lowest WHC value found in refrigerator thawing (86.73%) and the highest WHC value found in ambient temperature thawing (89.95%). The WHC is the ability of the liver to retain its own water or water added during the application of any force (Honikel, 1997). Protein and lipid oxidation are commonly linked to decreases in muscle protein functionalities, such as reduced water-holding capacity and weakened gels strength (Xia et al., 2012).

According to the results of present study, the range of overall observed color score at different treatments report- L^* (lightness) value was 23.54 to 15.30, a^* (redness) value was 9.15 to 6.37 and b^* (yellowness) value was 845 to 3.68 (Table 4). The color scores were significantly changing (P< 0.05) with the different thawing methods. The highest color value was observed from fresh liver among four treatment groups and the lowest color value was observed from ambient temperature thawing method. Within the last three thawing methods, the range of color L^* (lightness) value was 15.30 to 22.64, a^*(redness) Value was 7.48 to 6.37 and b^* (yellowness) value was 8.45 to 3.98. Lightness, redness and yellowness values of refrigerator thawing were greater than the other thawing methods (AT, WT). The value indicates that the maximum result found in refrigerator thawing. Generally, color changes can occur during frozen storage and thawing due to lipid oxidation and pigment degradation processes (Dias et al., 1994).

Table 3. Effect of different thawing methods on physicochemical properties of goat liver

Parameter	FL	ATT	RT	TWT	Level of significance
pH value	6.75±0.06	6.68±0.07^a	6.68±0.05^a	6.70±0.04^a	P>0.05
Thawing loss		3.52±0.70b	4.92±1.77ab	5.99±0.77a	P <0.05
WHC	93.57±1.15c	89.95±1.38b	86.73±1.09a	89.22±1.12b	P <0.05

FL= Fresh liver, ATT= Ambient temperature thawing (25ºC), RT= Refrigerator thawing (4ºC), TWT= Tap water thawing (20ºC). Means in each row having different superscripts vary significantly at values p<0.05. Values are presented as mean±-SD.

Table 4. Effect of different thawing methods on the colour measurement of goat liver

Parameters		FL	ATT	RT	TWT	Level of significance
Color measurement	**L^***	23.54±0.97^a	15.30±1.09^a	22.64±1.18^a	17.47±1.44^a	P <0.05
	a^*	9.15±0.32^a	6.37±0.64^a	7.07±.06^a	7.48±0.43^a	P <0.05
	b^*	4.68±0.26^a	8.45±0.16^a	3.68±0.76^a	3.98±0.64^a	P <0.05

L^*= lightness, a^*= redness, b^*= yellowness, FL= Fresh liver, ATT= Ambient temperature thawing (25ºC), RT= Refrigerator thawing (4ºC), ATT= Tap water thawing (20ºC). Mean values having same superscript in each row differ significantly at p<0.05. Values are presented as mean±-SD.

Effect of different thawing methods on microbial load of goat liver

The present study observed the presence of micro-flora (TVC) and food borne pathogens (Coliform and Yeast-Mould) on controlled and different treatment groups. After 1st day observation other samples were preserved at -20ºC for the further study after 3 months. Table 5 has been shown that within three thawing methods, the value of TVC, TCC and TYMC were significantly higher in ambient temperature thawing method compared to the value obtained from refrigerator thawing and tap water thawing. TCC value was increased due to temperature fluctuation as well as deteriorating of fat and helped prevent the metabolism of fat by bacteria (Clarence et al., 2009). Low amount of TYMC value indicates that this method is most preferable for thawing. The TYM value was increased when increased the thawing period, fluctuate temperature and humidity (Stopforth et al., 2006). Cross-contamination from the environment (i.e., the air or food handlers) or from the survival of spores or resistant cells was possible in this study as well as in commercial operations. Some bacteria may be present in the sample, but their growth is controlled under thawing conditions (Kondraratowiez et al., 2006).

Table 5. Effect of different thawing methods on the microbial count of goat liver

Parameters		ATT	RT	TWT	Level of significance
Microb-al count (logCFU/g)	TCC	4.56±0.24^b	4.07±0.26^c	4.10±0.21^c	p<0.05
	TYMC	5.18±0.35^b	4.64±0.12^c	4.70±0.16^c	p<0.05
	TVC	6.63±0.39^b	5.87±0.79^c	6.28±0.20b^c	p<0.05

ATT= Ambient temperature thawing (25ºC), RT= Refrigerator thawing (4ºC), TWT= Tap water thawing (20ºC). Means in each row having different superscripts vary significantly at values p<0.05. Values are presented as mean±-SD.

Conclusions

The results obtained from sensory evaluation, nutritional composition, physicochemical properties, biochemical and microbial analyses suggest refrigerator thawing of goat liver is the best method. Therefore, the findings of the current study will contribute for further research in the processing of meat and meat products.

Conflicts of Interest

The authors declare that there is no potential conflict of interests.

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