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Research Article

Assessment of quality and shelf life of goat liver stored at refrigerated temperature

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Abstract

The objective of this study was to assess the quality and shelf life of goat liver storage at refrigerated temperature (4º C). For this purpose, raw goat liver samples were divided into five treatment groups in relevant of five days storage, treated as T_1 (day 1or control), T_2 (day 2), T_3 (day 3), T_4 (day 4) and T_5 (day 5). Sensory attributes (color, flavor, juiciness and tenderness), proximate composition, pH value, cooking loss, biochemical properties such as free fatty acids (FFA), peroxide value (POV), thiobarbituricacid value (TBA), and microbial load such as total viable count (TVC), total coliform count (TCC) and total yeast mould count (TYMC) were carried out in each day of storage. The results show that color, flavor, juiciness, and tenderness were significantly decreased with increase the days of storage. Dry matter (DM) content significantly ($p<0.05$) increased, while crude protein, ether extract and ash contents were significantly ($p<0.05$) decreased with increase the days of storage. A significant ($P<0.05$) decrease of pH from 6.85 to 5.68 was observed during 5 days of storage. The percentage of cooking loss of 13.37 ml on day1 gradually increased to 33.84 mL on the fifth day of storage. In addition, the biochemical and microbial analysis also showed that FFA, POV, TBA, TVC, TCC and TYMC values were significantly ($p<0.05$) increased with increase the days of storage. Therefore, based on these results of shelf life evaluation, it may be concluded that goat liver will acceptable microbiologically and organoleptically up to the third day of storage at 4º C.

Introduction

There are various methods for meat and meat by-products preservation such as refrigeration (Akhter et al., 2022; Rahman et al., 2017), curing (Woods et al., 2019), Drying (Akhter et al., 2009), irradiation (Sadakuzzaman et al., 2021; Haque et al., 2017; Rima et al., 2019; Islam et al., 2018, 2019 and 2021), through adding electrolyzed water (Azad et al., 2021) and by adding natural antioxidants (Ali et al., 2022; Boby et al. 2021; Hossain et al., 2021a; Bithi et al., 2020; Disha et al., 2020; Saba et al., 2018; Jahan et al, 2018; Siddiqua et al., 2018). Refrigeration is a common method of storage meat and meat products to retard the growth of microorganisms and widely used by the sales man in Bangladesh. Meat and meat by-products such as liver, heart, tongue, kidneys, blood, skin, bone, etc. are a major source of complete protein, containing all essential amino acids in sufficient amounts for human use (Lawrie et al., 2006, Hossain et al., 2021b). Generally, the non-carcass components of goat viscera such as the heart, lungs, liver, kidneys, intestines and stomach as well as the brain and blood account for 15–20% of the live weight of the animal (Costa et al., 2005, Santos et al., 2007, Kakimov et al., 2017). Such percentages would have great economic impact for slaughterhouses if part of these by-products were utilized as a raw material to produce new ingredients or to obtain a processed product. The nutritive value of these by-products is equal to that of normal meat; however, vitamin and mineral content is higher (Kovaleva et al., 2014). Numerous studies reported that the livers are a good source of protein including globulin, albumen, glycoproteins, ferritin and ferrin (Lai et al., 2012; Nunes et al., 2013). However, meat and meat products are considered a high-risk food as these are serve as an ideal medium for growth of different microorganisms (bacteria, yeasts and molds), some of which are pathogens (Jay et al., 2005). Indeed, livers are necessarily of poor hygienic quality, are prone to rapid spoilage, and have a high incidence of pathogenic organisms (Gill et al., 1988). During storage, microbial growth can lead to the production of slime and/or off-odors and off-flavors (Gram et al. 2002). Lipid oxidation can change color, odor and flavor of food products and can reduce the shelf life (Faustman and Cassens, 1990). The term “shelf life” can be defined as the time period in which the food is safe and acceptable for consumers from a microbiological, nutritional and sensory point of view (Labuza, 1996). Microbial growth and lipid oxidation are the main problems causing shortening of the shelf life of meat and meat products (Shanet al., 2009). Microbial growth can lead to the production of slime and/or off-odors and off-flavors (Gramet al., 2002). Previous study reported that lipid oxidation products increased the rate of oxidation of oxymyoglobin to metmyoglobin (MetMb) and discoloration (Chanet al., 1997). In addition, malondialdehyde (MDA) is a potent mutagenic and/or carcinogenic compound which is a major product of lipid oxidation (Ames, 1983; Frankel, 1991). Nevertheless, storage periods and temperature alter the shelf life and quality of meat and meat products. There is a lack of

information regarding their shelf life and quality deteriorated by the storage periods and temperature. Therefore, the present study was undertaken to investigate the effect of storage periods and refrigerated temperature (4° C) on the shelf life and quality of goat livers, based on sensory attributes, nutritional values, physicochemical and biochemical properties as well as microbial load.

Materials and methods

Place of Experiment

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

Sample Collection and Preparation

Goat livers (500 g) were collected from local market at 9.00 a.m. and immediately transferred to the Animal Science Laboratory, BAU. All visible fat and connective tissue were trimmed off as far as possible with the help of sharp knife and the samples were sliced and individual slices were packaged in sterile plastic bags. One sample bags was analyzed immediately after preparation and remaining bags were stored at refrigeration temperature (4° C) followed by analyzed on 2nd, 3rd, 4th, and 5th day of storage. In each day, samples were used for sensory, proximate, physicochemical, biochemical and microbial analysis.

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 (Rahman et al., 2012). 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

Physicochemical properties in terms of pH value and cooking loss (%) were determined in fresh and preserved samples. A pH meter was used to measure the pH value of goat liver homogenate. The homogenate was prepared by blending 5 g of goat liver with 10 ml distilled water. For measuring the cooking loss, the fresh goat liver samples were weighted (initial weight) followed by boiled at 100° C in at water bath. After completed boiling, samples were removed from the water bath and covered with foiled paper to remove the surface water properly and final weight taken of boiled liver.

The formula of cooking loss is

$$\text{Cook loss (\%)} = \frac{(\text{Weight before cooking of sample} - \text{weight after cooking})}{\text{Weight before cooking of sample}} \times 100$$

Analysis of Free Fatty Acid (FFA)

FFA value was determined according to Rukunudin et al. (1998). Five grams of sample was dissolved with 30 ml chloroform using a homogenizer (IKA T25 digital Ultra-Turrax, Germany) at 10.000 rpm for 1 min. The sample was filtered under vacuum through Whatman filter paper number 1 to remove particles. After five drops of 1% ethanolic phenolphthalein were added as indicator to filtrate, the solution was titrated with 0.01 N ethanolic potassium hydroxide.

The formula is mentioned below:

FFA (%) = ml titration × Normality of KOH × 28.2/g of sample

Analysis of Peroxide Value (POV) (meq/kg)

The POV was determined according to the procedure described by Sallam et al. (2004). The sample (3 g) was weighed in a 250-ml glass stopper Erlenmeyer flask and heated in a water bath at 60° C for 3 min to melt the fat, then thoroughly agitated for 3 min with 30 ml acetic acid-chloroform solution (3:2 v/v) to dissolve the fat. The sample was filtered under vacuum through Whatman filter paper number 1 to remove particles. Saturated potassium iodide solution (0.5 ml) was added to filtrate and continue with addition of starch solution. The titration was allowed to run against standard solution of sodium thiosulfate (25/1).

The formula is mentioned below:

The POV was calculated and expressed as milliequivalent peroxide per kilogram of sample:

$$\text{POV (meq/kg)} = \frac{S \times N}{W} \times 100$$

Where S is the volume of titration (mL), N the normality of sodium thiosulfate solution (n = 0.01) and W the sample weight (g).

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 Parvin et al. (2017).

Experimental designs

In this study, total five treatments were undertaken to find out the effect of storage duration on quality of goat liver stored at refrigeration temperature (4° C). These five treatments were considered based on the storage day such as - T_1 = fresh goat liver (control) at day 1; T_2 = stored goat liver at day 2; T_3 = stored goat liver at day 3; T_4 = stored goat liver at day 4; T_5 = stored goat liver at day 5.

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 storage periods on sensory evaluation of goat liver

The parameters for sensory evaluation have been shown in Table 1. The ranges of overall observed color score at different treatments were 5 to 3. All parameters color, odor, juices and tenderness scores were significantly decreased ($P<0.05$) with the increase of storage life. Most preferable color and odor were observed in T_1 whereas less preferable were found in T_5 group. Gradual decline in appearance and color scores of goat liver stored at refrigeration conditions might be due to pigment and lipid oxidation resulting in non-enzymatic browning between lipids and amino acids. Tenderness is interrelated with DM content of the goat liver. In addition, decreasing tenderness also supported by the increasing of DM content of goat liver in this study (Table 2). A similar result was reported by Juana et al., (2006) conducted an experiment on shelf life of ostrich (*Struthio camelus*) liver stored under different packaging conditions. Changes in color of the muscle and blood pigments decrease the attractiveness of fresh red meat, which in turn influences the consumers' acceptance of meat products (Pearson, 1994). The lower odor scores may be related to the increased malonde aldehyde formation due to oxidation of fat, which has detrimental effect on the flavor and firmness of the product (Miller et al., 1981). Deterioration of odor during storage might be due to microbial growth, formation of FFA and oxidative rancidity (Devatkal et al., 2007). Several researchers have associated tenderness of meat with the breakdown of myofibrillar proteins affected by the presence of calcium-dependent proteases or calpains (Muchenje et al., 2008).

Table1: Effects of storage periods and refrigerated temperature (4°C) on sensory parameters of goat liver

Parameters	Treatments				
	T_1	T_2	T_3	T_4	T_5
Color	5.0^{a}±0.12	4.3^{ab}±0.26	3.9^{bc}±0.17	3.2^{cd}±0.26	3.0^{d}±0.0
Odor	5.0^{a}±0.05	4.77^{ab}±0.55	4.43^{bc}±0.51	3.83^{cd}±0.29	3.17^{d}±0.29
Juiciness	4.8^{a}±0.35	4.3^{ab}±0.26	3.87^{bc}±0.23	3.27^{cd}±0.25	3.0^{d}±0.0
Tenderness	5.0^{a}±0.12	4.63^{ab}±0.32	4.0^{b}±0.03	3.5^{cd}±0.03	3.0^{d}±0.0

T_1 = Day 1, T_2 = day 2, T_3 = Day 3, T_4 = Day 4, T_5 = Day 5. Means in each row having different superscripts vary significantly at values $P<0.05$. Values are presented as mean ± SD.

Table2: Effects of storage periods and refrigerated temperature (4°C) on proximate compositions of goat liver

Parameters (%)	Treatments				
	T_1	T_2	T_3	T_4	T_5
DM	34.99^{b}±0.56	35.11^{b}±0.63	35.85^{ab}±0.29	35.89^{ab}±0.72	36.011^{a}±0.93
CP	17.21^{a}±0.27	16.51^{a}±0.27	15.81^{ab}±0.27	15.46^{bc}±0.27	14.76^{c}±0.27
EE	1.08^{a}±0.08	0.95^{ab}±0.05	0.9^{ab}±0.05	0.85^{bc}±0.05	0.8^{c}±0.05
ASH	2.18^{bc}±0.82	2.16^{bc}±0.14	1.72^{ab}±0.11	1.71^{ab}±0.11	1.7^{a}±0.11

T_1 = Day 1, T_2 = day 2, T_3 = Day 3, T_4 = Day 4, T_5 = Day 5. 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 storage periods on proximate composition of goat liver

The values of proximate components have been shown in Table 2. Among the treatments, the DM content was significantly ($P<0.05$) increased whereas CP, EE and ash contents were decreased with the increased of storage days. The same trend was also observed by Konieczny et al. (2007), reported that DM and CP content increased and decreased during frozen storage respectively. Agnihotri (1988) reported deterioration in meat lipids took place due to intermediary activities of endogenous meat enzymes leading to hydrolysis of fat. A non-significant decrease in ash percentage was reported by Ziauddin et al. (1993) which coincided with this study.

Effect of storage periods on pH value and cooking loss (%) in goat liver

The values of pH and cooking loss (%) have been shown in Table 3. The findings show that pH value and cooking loss were significantly ($P<0.05$) decreased and increased with increase of storage days respectively. The ranges of pH value at different treatments were 6.85 to 5.68 whereas the percentages of cooking loss were 13.37 to 33.84. The highest amount of pH indicates this product is most preferable for consumers' health. The decreasing pH was probably due to the secretions of microorganisms in the goat liver. Generally, the pH of fresh liver is 6.72 to 6.94. Previous study reported that pH values lower than 6.15 may be considered as indicator of beef liver spoilage (Hernandez-Herrero et al., 1999). In addition, Elsaaid et al. (1993) found that pH

of fresh beef liver 6.26 to 6.91. Cooking loss refers to the reduction in weight of liver during the cooking process (Jama et al., 2008). Major components of cooking losses are thawing, dripping and evaporation. Cooking loss in liver is important for maintaining an attractive retail display of liver. For example, meat and their products are a rich source of proteins, essential minerals and vitamins. The increased loss of such nutrients of meat decreases the nutritional quality and consumer demands (Jama et al., 2008). The meat also tended to shrink during the cooking process due to the denaturation of meat protein; the loss of water and fat also contributed to the shrinking process (Serdaroglu et al., 2005).

Table 3: Effects of storage periods and refrigerated temperature (4^0C) on physicochemical properties of goat liver

Parameters	Treatments				
	T_1	T_2	T_3	T_4	T_5
PH	$6.85^{a}\pm0.02$	$6.79^{ab}\pm0.11$	$6.13^{bc}\pm0.02$	$6.03^{bc}\pm0.03$	$5.68^{c}\pm0.3$
CookingLoss (%)	$13.37^{b}\pm0.41$	$20.2^{c}\pm0.29$	$33.4^{bc}\pm0.28$	$36.15^{ab}\pm0.32$	$33.84^{ab}\pm0.72$

T_1 = Day 1, T_2 = day 2, T_3 = Day 3, T_4 = Day 4, T_5 = Day 5. Means in each row having different superscripts vary significantly at values $P<0.05$. Values are presented as mean ± SD.

Effect of storage periods on biochemical properties in goat liver

The value of biochemical components such as FFA (%), POV (meq/kg) and TBA(mg-MA/kg) have been shown in Table 4. These values were increased with increase of storage days. The most preferable FFA was observed from 1st day and less preferable FFA was found from 5th days samples. Biochemical properties indicate the good or bad quality of goat liver. The lowest amount peroxide value indicates this product is most preferable for consumes health. Polyunsaturated fatty acids increase sensitivity to peroxidation, leading to unpleasant odors (Coulon and Priolo, 2002). Changes in proportions between saturated and unsaturated acids are also an adverse phenomenon from the dietary point of view.

Table 4: Effects of storage periods and refrigerated temperature (4° C) on biochemical properties of goat liver

Parameters	Treatments				
	T_1	T_2	T_3	T_4	T_5
FFA(%)	$1.14^{c}\pm0.0$	$1.34^{bc}\pm0.0$	$1.91^{bc}\pm0.05$	$2.03^{ab}\pm0.04$	$2.44^{a}\pm0.04$
POV(meq/kg)	$1.18^{c}\pm0.02$	$1.4^{bc}\pm0.03$	$1.82^{bc}\pm0.05$	$2.84^{bc}\pm0.05$	$3.07^{ab}\pm0.04$
TBA(mg-MA/kg)	$0.13^{c}\pm0.0$	$0.14^{bc}\pm0.0$	$0.15^{bc}\pm0.0$	$0.19^{a}\pm0.0$	$0.24^{a}\pm0.0$

T_1 = Day 1, T_2 = day 2, T_3 = Day 3, T_4 = Day 4, T_5 = Day 5. Means in each row having different superscripts vary significantly at values $P<0.05$. Values are presented as mean ± SD. FFA=Free Fatty Acid, POV=Peroxide Value; TBA = Thiobarbituric Acid Value

Effect of storage periods on microbial load of goat liver

In the present study, we also observed the presence of micro-flora (TVC), and TYMC on fresh and preserved samples. According to the table 5, the initial value of TVC, TCC and TYMC for fresh goat liver were significantly lower compared to storage samples, indicating that all these value were increased with increase the storage days. The lower value indicates the freshness of product which is most preferable for consumers' health. Similarly, a study in beef stated that the mean value of TVC, TCC and TYMC for fresh sample is lower than preserved samples (Haider, 2018).

Table 5: Effects of storage periods and refrigerated temperature (4° C) on microbial load of goat liver

Parameters	Treatments				
	T_1	T_2	T_3	T_4	T_5
TCC(logCFU/g)	$2.02^{c}\pm0.04$	$2.29^{bc}\pm0.02$	$2.43^{bc}\pm0.02$	$4.45^{b}\pm0.01$	$4.47^{a}\pm0.01$
TYMC(logCFU/g)	$1.09^{c}\pm0.02$	$1.47^{bc}\pm0.02$	$1.71^{bc}\pm0.02$	$2.26^{b}\pm0.01$	$3.28^{a}\pm0.02$
TVC (logCFU/g)	$4.33^{c}\pm0.05$	$4.84^{b}\pm0.03$	$4.57^{bc}\pm0.02$	$6.02^{b}\pm0.02$	$7.03^{a}\pm0.01$

T_1 = Day 1, T_2 = day 2, T_3 = Day 3, T_4 = Day 4, T_5 = Day 5. 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 that shelf life of raw goat liver at refrigerated temperature (4° C) is maximum three days. Therefore, the findings of the current study will contribute for further research in preservation of meat and meat products.

Conflicts of Interest

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

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