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Research Article

Quality of cattle, buffalo & goat meat keema at different storage temperature

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Abstract

The aim of the study was to compare the quality and safety of meat keema during storage at spot and refrigeration (4±1°C) temperature for a specific storage period. Six samples of Buffalo, Beef and Goat meat were collected from Kamal Ronjit-market ("K.R. Market") of Bangladesh Agricultural University, Mymensingh and processed into meat keema. The keema was prepared by standardized formulations, processed and were stored at ambient (37±1°C) and refrigeration (4±1°C) temperature and the quality was compared. In case of the hot-boned keema, the MDA (Melondialdehyde) of meat keema was significantly ($p< 0.05$) higher in goat meat than others. Water activity was higher in buffalo meat than others although the values did not differ significantly ($p> 0.05$). Ash content was significantly ($p< 0.05$) higher in buffalo meat than others. WHC (Water holding capacity) was significantly ($p< 0.05$) higher in goat meat than buffalo meat. Cooking loss was significantly ($p< 0.05$) higher in beef and goat meat than buffalo meat. Color (yellowness) was significantly ($p< 0.05$) higher in beef than buffalo meat. Meat pH, Keema pH, Color (lightness), Color (redness) values did not differ significantly ($p> 0.05$) within the three species. In case of chilled-boned keema of Buffalo, Beef and Goat meat, the MDA and water activity were higher in goat meat than others although the values did not differ significantly ($p> 0.05$). It is revealed from the study that the Buffalo meat keema (hot-boned and chilled-boned) showed better in meat quality attributes compared to the others. Beef, buffalo and goat meat keema stored in ambient temperature stored resulted in significant deterioration of quality parameters compared to the refrigeration storage.

Introduction

Meat is a primary dietary component and forms an important part of a balanced and varied diet (Azad et al., 2021; Rahman et al., 2023; Saba et al., 2018; Whitney and Rolfes 2008). Meat is the edible part of the skeletal muscle of an animal and is a highly perishable product due to its biological composition (Lambert et al., 1991). Beef is defined as the meat of cattle used as food. The nutritional attributes of meat, which provide a major proportion of consumer requirements for protein, some vitamins and certain minerals, are highlighted in work on the nutritional value of meat in other countries (Mobin et al. 2022; Hossain, 2023). Meat is one of the most widely used delicious and versatile meats in the world largely because its protein is of excellent quality and contains all the essential amino acids needed by man. Since there is a considerable deficiency among population, this is of animal protein in developing countries can play role in mitigation the protein gap of Bangladesh. It plays a very vital role in keeping the human body strong in order to provide energy, health and vigor (Azad, 2022; Hasan et al., 2022). Meat is the most concentrated and easily assimilable nitrogenous food and is a good source of high-quality protein that contains these amino acids, essential for human life. Polyunsaturated fatty acids of meat are important for development of brain especially in the fetus. Meat can be regarded as an important source of dietary vitamins and minerals. A vegetable diet compared with a meat diet is usually incomplete in respect of essential amino acids. Moreover, the vegetable proteins are less easily digested and remain in the stomach for a shorter period than meat protein with the result that a feeling of hunger recurs more readily (Sadakuzzaman, 2021).

A common component in several Bangladesh dishes is keema - a simple or complex meat dish, depending on the chef. Also spelled qeema or kheema, this is a customary method of surrounding ground meats like mutton, from the meat of an older lamb, with vegetables like peas and potatoes as well as a medley of characteristic Indian spices called garam masala, creating a flavor that is widely known as curry. In the end, this concoction can be spread on naan, eaten as-is, or pulled piece by piece from a flame-hot skewer. Keema derives its name from the ancient Turkish word for minced meat. It has been prepared in India for several generations, though its precise origination is unclear. The dish is one of dozens of traditional Indian curry dishes still widely enjoyed in 2011, with different regions of the country preparing curry dishes in a slightly different way. Most of the regional cuisines, however, will offer some form of keema. One of the chief benefits of keema is that it can be made in one pan or pot in no more than 15 minutes. It starts with salted ground mutton, sizzled in a pan until just browned. Then the mutton is set aside, and into the pan go chopped vegetables like onion, garlic, peas, tomatoes and even chilies. Some also cook up some diced potatoes at this point. When it is all slightly caramelized, the meat and dry spices go in too. The chemical compositions of meat keema includes following ingredients such as Coriander powder (Dhania) 25%, Coriander powder (Dhania) 12%, Dried ginger (Sont) 10%, Aniseed (Soanf) 10%, Black pepper (Kali mirch) 10%, Capsicum (Mirch powder) 5%, Degi mirch 5%, Degi mirch 5%, Caraway seed (Ajowain) 2.5%, Cardamom (Bada elaichi) 2.5%, Cinnamom (Daru chini) 2.5%, Cloves (Laung) 2.5%, Nutmeg (Jaiphal) 2.5%, Split bengal gram (Channa dal) 1.5%, Mace (Javithri) 1.0%, Curry leaves 1.0%, Bay leaf (Tej pata) 1.0%, Poppy seeds (Kaskas) 1.0% (Kandeepan, 2013).

The processing of meat keema can be followed by several steps. First, Precook the minced meat along with required quantity of water in a pressure cooker for 10 min and keep ready, then Fry the onion, ginger, garlic and green chilly pastes and spice mix in oil as in order in a kettle and Add the precooked minced meat and fry for 5 min. After that Add tomato puree, meat extract, and salt and mix all the ingredients well and Cook on a medium heat for 25 min till the minced meat become tender. Cool to the room temperature and record the cooking yield. Vacuum package in laminated pouches (Nylon / LDPE). Reheat by steam cooking in a water boiler to an internal temperature of 90°C. Finally, Cool to room temperature and store at 37±1°C and 4±1°C (Kandeepan et al., 2010).

For perishable commodities like meat, accurate control of temperature in supply chain is necessary to maintain the product quality and safety. Any fluctuation in temperature at any point during transport and subsequent storage will create great economic burden to the producer and health hazards to the consumer. In this perspective a reliable mechanism that can monitor any temperature abuse is necessary to check meat spoilage in supply chain. Therefore, research was undertaken to develop a time-temperature integrator (TTI) based on enzyme substrate complex for monitoring safety of meat during temperature abuse conditions. Accordingly, an enzyme-based time-temperature responsive system using a color changing reaction by the action of enzyme -amylase on iodine-starch clathrate complex was developed to monitor temperature abuse of meat in supply chain. Different levels of substrate and enzyme were optimized for developing the TTI. The suitability of the integrator to monitor temperature fluctuation was studied using simulated temperature abuse model in laboratory condition using an incubator. It was observed that the color of the integrator packed along with frozen fresh meat was found to be changing when exposed to temperature abuse conditions. The results indicated that the color changing response of the integrator can be efficiently utilized to reveal complete time-temperature exposure history of the product. It is concluded that the level of enzyme can be successfully altered to develop integrators suitable for different storage temperatures. Papadima and Bloukas (1999) indicated that storage conditions affected the microflora, pH, weight losses and water activity but had no effect on composition, color and sensory attributes of traditionally processed Greek sausages. Karthikeyan et al. (2000) analyzed physicochemical, microbiological and sensory attributes of hurdle treated chevon keema and indicated that it was fairly acceptable for up to 5 days at ambient temperature. Boles and Swan (2002) found that age/gender often significantly influenced the processing characteristics but storage regime affected the sensory attributes of beef roasts. Investigation by Diana and Iciar (2004) proved that vacuum packaging of the dry fermented sausages was the best method to prevent formation of lipid oxidation volatile compounds. The storage temperature affected microbial development and production of biogenic amines. Thomas et al. (2007) found that changes in pH, TBARS, tyrosine value and microbial counts influenced the quality of hurdle treated pork sausages stored at ambient temperature. Under these situations, people process the cattle, buffalo & goat meat keema and eat it fresh. Some people store the surplus, reheat and consume on the next day or within 24 h of preparation. Scientific processing, accompanied by good manufacturing practices and suitable packaging would improve the shelf life of the cattle, buffalo & goat meat keema without refrigerator storage. But the quality of keema stored at ambient temperature till an acceptable storage period would definitely differ with the quality of keema stored at refrigerator for the same period. But there is no scientific evidence on this hypothesis. Moreover, the scientific information on processing and quality of traditional cattle, buffalo & goat meat keema from different groups of buffaloes is not available. Considering the above points, a study was undertaken to develop processed keema from different buffalo groups and to compare their quality during storage at ambient (37±1°C) and refrigeration (4±1°C) temperature for a specific storage period.

Earlier studies found that meat qualities are closely related with muscle type and storage conditions such as storage temperature or packaging methods. Bruce and Ball (1990) reported that a high muscle temperature postmortem accelerates the rate of pH decline in muscle, presumably because such physiological temperature conditions permit enzymatic activity to continue. A more rapid decrease in pH at higher temperatures may rupture the lysosome membrane in which some catharsis could hydrolyze specific myofibrillar proteins. High-temperature conditioning of muscles and carcasses also affected meat tenderness adversely. Higher carcass temperatures early in the postmortem period speed the aging process and result ultimately in increased tenderness (Whipple et al., 1990). Kirchofer et al. (2002) reported that not only do individual muscles differ in fiber-type composition but muscle fiber type within a specific muscle may be affected by breed, sex, feeding time and maturity. A number of studies have been conducted to investigate the effect of storage conditions on meat qualities. However, the effect of storage conditions on beef quality in different muscle types of Han woo during storage is still largely unknown. Thus, the purpose of this study is to investigate the effect of storage temperatures on meat qualities in muscle with different fiber-type composition from Han woo cattle. Refrigerators are not commonly available in every household and fact is interrupted power Supply is day to day problem in Bangladesh. Under these situations, preserve the meat keema and its freshness. Some people store the surplus. Reheat and keep on the next day or within 24 of Scientific processing, accompanied by good manufacturing practices and packaging would improve the shelf life of the different meat keema without refrigerator storage, the quality of keema stored at ambient temperature till an acceptable storage period would definitely differ with the quality of keema stored at refrigerator for the same period. But there is no scientific evidence. Moreover, the scientific information on processing and quality of traditional meat keema from different species is not available.

In the present culinary system of Bangladesh, supply of quality and safe keema remains a challenge for the growing food-cooking industry. Moreover, still, no reports have yet been produced on the quality of keema from different meat species. The proposed research has been aimed to compare the quality and safety of keema during storage at spot and refrigeration temperature for a specific storage period.

Materials and Methods

Place of Experiment

The experiment was conducted at the laboratory of the Department of Animal Science.

Collection of Raw materials

The samples of beef were collected from Kamal Ronjit-market of Bangladesh Agricultural University, Mymensingh. The samples were taken only the muscle part, avoiding bone part. After that, the meat sample was immediately transferred to the

"Animal Science Laboratory".

Raw materials

Meat from young male, aged male and aged female were procured from nearby meat market to use in the experiments of keema. The meat samples were collected from the longissimus dorsi muscle of the carcasses of almost similar conformation from each group of animals slaughtered according to the traditional halal method. The meat was obtained within 1 h of slaughter for hot boned keema and 6 h of slaughter, packed in low density polyethylene (LDPE) bags and conditioned at 4^{o}C in a refrigerator for about 24 h. Later, the separable fat and connective tissue was removed.

Processing of meat keema

About 500 g of meat each from different groups of animals was grounded in a meat mincer with 4 m plate. The following standardized formulation and procedure were used for the processing meat keema from different groups. The keema along with all the required quantity of water was precooked in a pressure cooker for 10 min. The precooked minced meat was kept ready. Onion paste, ginger paste, garlic paste, green chili paste and spice mix were fried in oil as in order in a kettle. The precooked minced meat was added and fried for 5 min. Tomato puree was added followed by meat extract and salt. All the ingredients were mixed well. Then cooking was done on a medium heat for 25 min to reach an internal core temperature of 90° C in the keema. The meat keema was cooled to the room temperature and the cooking yield was recorded. The experiment was repeated three times.

Comparison of quality of meat keema

The meat keema processed as per the standardized formulation was stored at ambient temperatures (37 ± 1° C) in an incubator and refrigerator. To evaluate the effect of different groups meat samples on the quality of keema, product yield, pH, water activity, MDA, protein content was determined on the day of processed in the same batch, having same quality characteristics on day one in each group. The comparison of quality changes in meat keema stored at ambient (37 ± 1° C) and refrigeration (4 ± 1° C) temperature was evaluated on the alternate day (day 3). The product was compared for its various physicochemical, and sensory quality attributes.

Physicochemical properties of Keema

pH measurement

A digital pH meter (Seven Easy pH, Mettler-Toledo GmbH, Switzerland) was used to determine the pH. For this, a vortex machine was used to homogenize 10 g of ground material with 50 mL of distilled water for 1 minute, and the electrode was dipped into the suspension to record the pH.

Reheating of packaged buffalo meat keema

The ready to eat buffalo meat keema were vacuum packaged in Gallenkamp ballistic bomb calorimeter (Haque and Lal, 1999). The samples were ignited and burnt in excess oxygen in the to bomb measure the rise in temperature by the thermocouple and galvanometer system. This was compared by burning a standard sample (benzoic acid) of known calorific value and the energy value were determined. The calorific value of the sample was calculated and expressed as Kcal/100 g. The distillation method of Tarladgis et al. (1960) was followed to estimate TBARS value. 2- Thiobarbituric acid mixed in glacial acetic acid was used to develop a pink colour in the distillate of buffalo meat keema. The absorbance of the colour developed was recorded at 538 nm using a spectrophotometer (Scanning mini-SPEC, model SL 177, Elico Ltd, Hyderabad). The absorbance was multiplied by a factor 7.8 and TBARS value was expressed as mg malonaldehyde/kg of sample.

Water Holding Capacity

WHC was measured according to Choi et al. (2011). Thawed samples (1 g each) were wrapped in absorbent cotton and placed in a centrifugal tube (SpinwinTM, Tarsons, Kolkata, India). The tubes with samples were centrifuged in a centrifuge separator (1730R, Lynge, Denmark) at 3,000×g for 10 min at 4°C, following which the samples were weighed. The WHC of the sample is expressed as the ratio of the sample weight after centrifugation to the initial sample weight, using the following formula: Water holding capacity (%) = Sample weight after centrifugation (g)/Sample weight before centrifugation (g) ×100

Color value estimation

Color values like lightness (CIE L*), redness (CIE a*), and yellowness (CIE b*) for several patties were determined utilizing a colorimeter (Konica Minolta CR-400, Tokyo, Japan). The standard white plate (Y=81.2; x=0.3191; y=0.3263) was employed for calibrating the colorimeter, and each sample was measured thrice. The measurement for chroma (C*) value and hue angle (h°) value was carried out utilizing two equations of {(a* + b*) 1/2} and {tan−1 (b*/a*)}, respectively.

Ash

Weighed samples were taken in porcelain crucibles and pre-ashed at 100°C in an electric oven. The crucibles were then placed in a muffle furnace and heated at 550°C for 6 hours. The crucibles were then cooled in desiccators. The average weight in percentage of each sample of the remaining material was taken as ash. The formula is mentioned below:

$$\% \text{ of ash content} = \frac{C}{E} \times 100$$

Where, E = Weight of ash C = Weight of sample

Cooking Loss

To determine cooking loss, weighed 5 g sample and wrapped in a heat-stable foil paper and kept in water bath at 80°C for 30 min. The internal temperature was not measured, but from a previous study (Sultana et al.2008). It was estimated that the optimum internal meat temperature (75-80°C) would be gained by 30 min. Samples surface was dried and weighed. Cook loss was calculated after draining the drip coming from the cooked meat as follows: Cook loss (%) = $[(w_2 - w_3) / w_2] \times 100$ Where,

w_2 = meat weight before cooking (g) and w_3 = meat weight after cooking (g).

Sensory evaluation

Each meat sample was evaluated by a trained 3-member panel. Panelists were chosen from among department personnel and students and trained under the American Meat Science Association standards (AMSA, 1995). Individual booth with controlled, humidity, temperature, and lighting were used for sensory evaluation. The sensory questionnaires measured intensity on a 5-point balanced semantic scale (weak to strong) for the following attributes color, flavor, tenderness, juiciness, and overall acceptability. The judges evaluated the samples based on the above criterions. Panelists were selected among department staff and students and Earned according to the American Meat Science Association guidelines (AMSA, 1995). 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, flavor, juiciness, tenderness, overall acceptability) of beef using an intensity scale. Panelists were chosen from among department personnel and students and trained under the American Meat Science Association standards. Individual booth with controlled, humidity, temperature, and lighting were used for sensory evaluation.

Statistical analysis

All values were expressed as the mean ± SE (Standard Error). All data were subjected to one-way ANOVA, and the significance of difference among means was determined by the Duncan's Multiple Range Test (DMRT). A probability of less than 0.05 was considered statistically significant. All statistical analyses were conducted using IBM SPSS Statistics 20 software.

Results and Discussion

MDA and water activity for hot-boned keema

Table 1 shows the MDA and water activity for hot-boned keema meat of Buffalo, Beef and Goat. MDA of meat keema was significantly ($p< 0.05$) higher in goat meat than others. Water activity was higher in buffalo meat than others although the values did not differ significantly ($p> 0.05$). MDA of meat keema was significantly ($p< 0.05$) higher in goat meat than others. Water activity was higher in buffalo meat than others although the values did not differ significantly ($p> 0.05$). MDA is a well-known product of lipid oxidation (Esterbauer and Cheeseman 1990). MDA in foods exists as free or combined with protein and fat by means of aldol condensation. Therefore, the extraction procedures of MDA from foods are involved with MDA detection. Nevertheless, nitrites react with MDA under acidic conditions (condensation reaction) and cause underestimation of MDA. Table 2 shows the MDA value and water activity for chilled-boned keema of Buffalo, Beef and Goat meat. MDA and water activity were higher in goat meat than others although the values did not differ significantly ($p> 0.05$). The MDA values of Buffalo, Beef and Goat for chilled-boned keema meat were 0.17±0.04, 0.16±0.04, 0.19±0.04 respectively. The water activity for chilled-boned keema meat of Buffalo, Beef and Goat values were 0.96±0.08, 0.95±0.08, 0.97±0.12. MDA and water activity were higher in goat meat than others although the values did not differ significantly ($p> 0.05$).

Table 1. MDA and water activity for hot-boned keema

	Buffalo	Beef	Goat	Level of Significance
MDA (mg/kg)	0.25^{b}±0.06	0.31^{b}±0.04	0.42^{a}±0.05	*
Water activity	0.95±0.08	0.94±0.08	0.92±0.06	NS

[a, b] Mean in the same row with different superscripts differ significantly (P<0.05), NS means not significant

Table 2. MDA value and water activity for chilled-boned keema

	Buffalo	Beef	Goat	Level of Significance
MDA (mg/kg)	0.17±0.04	0.16±0.04	0.19±0.04	*
Water activity	0.96±0.08	0.95±0.08	0.97±0.12	NS

[a, b] Mean in the same row with different superscripts differ significantly (P<0.05), NS means not significant

Kolodziejska et al. (1990) found that over 99.9% of MDA reacts with nitrite at pH < 3, and no MDA reacts with the nitrite at pH 6 when the molar ratio of MDA to nitrite is 1:5. Other studies showed that the reactive form of a nitrite for formation of the MDA-nitrite adduct is probably nitrous acid, whose pKa is 3.4; therefore, less than 1% of the nitrite is in the form of nitrous acid at pH > 5.5 (Kolodziejska et al., 1990). The lower MDA content in groups Nitrite and Mix may be explained by the antioxidant activity of the nitrite in the Nitrite samples and the nitrite and phosphate in the Mix samples (Sebranek and Fox, 1985). Lipid oxidation is a consequence of oxy- and/or lipid free radical generation and leads to the formation of toxic compounds such as MDA and cholesterol oxidation products (Morrissey et al. 1998). Sabow et al. (2016) found significant differences in malondialdehyde (MDA) content at day 7 of storage of goat meat.

Chemical characteristics of hot-boned keema

Table 3 shows the chemical characteristics of hot-boned keema of Buffalo, Beef and Goat meat. Ash content was significantly ($p< 0.05$) higher in buffalo meat than others. On the other hand, moisture content, protein content and fat content did not differ significantly ($p> 0.05$) within the three species. The Chemical characteristics of hot-boned keema of Buffalo, Beef and Goat meat were measured. The Moisture content of hot-boned keema of Buffalo, Beef and Goat meat were 67.67, 59.83, 64.83%, respectively. The Protein content of hot-boned keema of Buffalo, Beef and Goat meat were 19.66, 20.0, 19.33. Young male Murrah buffaloes showed a moisture percentage of 74.04- 77.75. The meat obtained from high protein diet fed young male buffaloes showed moisture content of 76.36% (Syed Ziauddin et al., 1994). Whereas, spent female Murrah buffaloes showed a moisture percentage of 76.51-79.69 (Syed Ziauddin et al., 1994; Naveena et al., 2004). Some authors did not find any significant difference in the moisture content between young and old animals (Jokismovic and Ognjanovic, 1977).

Table 3. Chemical characteristics of hot-boned keema

	Buffalo	Beef	Goat	Level of Significance
Moisture content%	67.67±7.69	59.83±8.28	64.83±6.89	NS
Protein content%	19.66±5.77	20.0±7.11	19.33±7.47	NS
Fat content%	9.83±3.12	10.66±2.82	11.0±4.09	NS
Ash content%	1.35^{a}±0.55	0.9^{b}±0.46	1.08^{b}±0.67	*

[a, b] Mean in the same row with different superscripts differ significantly (P<0.05), NS means not significant

The fat content of hot-boned keema of Buffalo, Beef and Goat meat were 9.83±3.12, 10.66±2.82, 11.0±4.09. The ash content of hot-boned keema of Buffalo, Beef and Goat meat were 1.35±0.55, 0.9±0.46, 1.08±0.67. Lapital et al. (2004) estimated the ash content of beef was 1.17% which was similar to the results of the present study. Akhter and Rahman (2009) found that the ash content of beef increased from 16.15% to 21% at 120 days for cooked meat and 16.80% to 22% at 120 days for cooked meat and 16.80% to 22.00% at 120 days for non-cooked meat. They also found that the ash content of block, flat and minced meat increased from 16.19% to 21.63%, 16.25% to 20.43% and 16.99% to 22.74%, respectively at the end. Rahman et al. (2012) found that the ash content in meat of Tapri goat averaged 1.19 ± 0.06%, while in Pateri meat it was slightly higher than Tapri i.e., 1.39 ± 0.056% and remarkably higher i.e. 1.63 ± 0.07% in Kamori goat meat. The ash content in meat of all three breeds of goat varied in a range of 0.87 and 1.97% (mean 1.40 ± 0.049). In their study, statistically analysis revealed highly significant differences (P< 0.001) in ash content in meat of different breeds of goat i.e. Kamori, Pateri and Tapri. LSD (T) comparison of means at rejection level of 0.05 revealed that the average ash content in meat of Kamori, Pateri and Tapri was significantly different at the level of P< 0.05. A study also was conducted and analyzed by Laskar et al., (2013) on the moisture and ash content in different breeds and sexes and claimed that there were significant differences present in mineral (ash) and moisture content among different breeds but not between sexes. In this experiment ash content was significantly (p< 0.05) higher in buffalo meat than others. On the other hand, moisture content, protein content and fat content did not differ significantly (p> 0.05) within the three species.

Chemical characteristics of chilled-boned keema

Table 4 shows the Chemical characteristics of chilled-boned keema of buffalo, beef and goat meat. Moisture, protein, fat and ash content did not differ significantly (p> 0.05) within the three species. The Chemical characteristics of chilled-boned keema of Buffalo, Beef and Goat meat were measured. The Moisture content of chilled-boned keema of Buffalo, Beef and Goat meat were 46.33±8.40, 49.13±8.63, 45.66±7.75. The Protein content of chilled-boned keema of Buffalo, Beef and Goat meat were 19.85±6.67, 20.88±5.17, 19.89±5.78. A higher protein content of 20.53% was recorded in meat obtained from young male buffaloes fed with high protein diet (Anjaneyulu et al., 1985). Young male buffaloes showed a protein percentage of 17.33-23.3 (Kesava Rao et al., 1985). Whereas, spent female Murrah buffaloes showed a protein percentage of 17.81-20.08 (Syed Ziauddin et al., 1994; Naveena et al., 2004). Meat from males had markedly higher protein content than females (Mohan et al., 1987). Rotua et al., 2017 states that the average muscle protein content of longissimus dorsi aceh cattle is 15.94% with fat content of 5.63%.

Table 4. Chemical characteristics of chilled-boned keema

	Buffalo	Beef	Goat	Level of Significance
Moisture content%	46.33±8.40	49.13±8.63	45.66±7.75	NS
Protein content%	19.85±6.67	20.88±5.17	19.89±5.78	NS
Fat content%	8.63±3.50	9.78±4.21	9.68±2.89	NS
Ash content%	0.67^{b}±0.22	0.78^{b}±0.27	1.50^{a}±0.65	*

[a, b] Mean in the same row with different superscripts differ significantly (P<0.05), NS means not significant

Dewi et al. (2016) reported the content of Bali beef nutrient i.e., ash content, protein content and carbohydrate levels of active muscle is higher when compared with passive muscle value (P < 0.05). Nuraini et al. (2019) found that while fat and water content of active muscle was low when compared with passive muscle. Ash content, protein and carbohydrate content of active muscle (0.99, 16.60, and 5.99%) and the content of passive muscle respectively (0.90, 14.60, 4.32%). Fat and water content of active muscle (6.30, 70.08%) and for passive muscle (6.54, 72.99%). Pal and Agnihotri (1999) found that carcass fat decreased with increasing age in Barbari male goat. In this study the fat content of chilled-boned keema of Buffalo, Beef and Goat meat were 8.63±3.50, 9.78±4.21, 9.68±2.89. The energy level of the meat increased with age and fat content of the animal (Mohan et al., 1987).

Intact males contained less fat (Stoikov and Dragoeva, 2002). Palmitic, stearic, oleic and linoleic acids were the four predominant fatty acids in the phospholipids of buffalo meat. High protein feeding in young male buffaloes recorded a fat content of 1.50% in the meat. Buffalo meat from 2 years old male calves showed a fat percentage of 1-3.5 (Kesava Rao et al., 1985). The ash content of chilled-boned keema of buffalo, beef and goat meat were 0.67±0.22, 0.78±0.27, 1.50±0.65. Moisture, protein, fat and ash content did not differ significantly (p> 0.05) within the three species.

Physical characteristics of hot-boned keema

Physical characteristics of hot-boned keema of buffalo, beef and goat meat are shown in Table 5. WHC was significantly (p< 0.05) higher in goat meat than buffalo meat. Cooking loss was significantly (p< 0.05) higher in beef and goat meat than buffalo meat. Color (yellowness) was significantly (p< 0.05) higher in beef than buffalo meat. Meat pH, Keema pH, Color (lightness), Color (redness) values did not differ significantly (p> 0.05) within the three species. The decline in color scores during ambient storage was due to lipid oxidation and subsequent oxidized compounds reacting with amino acids during non-enzymatic

browning of the product. Flavor changes were more in case of room temperature stored mutton curry compared to refrigerated product (Himanish and Radhakrishna, 2001). The steep decline in flavor scores was attributed to the liberation of fatty acids, oxidation of fat and increased microbial load (Sahoo and Anjaneyulu, 2000). The significant decrease in texture during ambient storage was due to changes in the disulphide bond and contents of amino acid. An abrupt reduction in overall acceptability during ambient storage was mainly attributed to decline in flavor in chevon keema (Karthikeyan et al., 2000) in chevon keema.

Table 5. Physical characteristics of hot-boned keema

	Buffalo	**Beef**	**Goat**	**Level of Significance**
Meat pH	6.57±1.82	6.71±1.06	6.61±1.53	NS
Keema pH	6.44±1.57	6.87±0.95	6.76±1.16	*
WHC%	83.31^{b}±8.41	92.16^{ab}±8.24	94.21^{a}±7.58	*
Cooking loss%	24.31^{b}±5.36	37.21^{a}±4.93	32.20^{a}±5.89	*
Color (lightness)	46.13±5.79	47.31±4.90	46.63±4.90	NS
Color (Redness)	6.57±1.82	6.71±1.06	6.61±1.53	NS
Color (Yellowness)	12.31^{b}±2.58	19.95^{a}±5.80	14.83^{ab}±6.95	*

[a, b] Mean in the same row with different superscripts differ significantly (P<0.05), NS means not significant

The physical characteristics of hot-boned keema of buffalo, beef and goat meat were also measured in this study. The meat pH of Buffalo, Beef and Goat meat were 6.57±1.82, 6.71±1.06, 6.61±1.53. The keema pH of buffalo, beef and goat meat were 6.44±1.57, 6.87±0.95, 6.76±1.16. The lower and higher ultimate pH values might be attributed to the degree of stress exposed in each group of animals. The pH of goat meat increased during frozen storage at -10°C for 16 weeks. pH of the beef increased during frozen storage at -17.8°C for 37 weeks (Miller et al., 1980). Simela et al. (2004) reported that sex and age had non-significant effect on pH. Slaughter weight and sex did not affect meat pH. Frozen storage treatments at -10°C and -25°C for 90 days to goat meat showed a significant improvement in bound water (Al-Dualaimy et al., 1985). Zhang et al. (2005) while investigating the functional stability of normal and high pH frozen beef reported that high pH (6.10 – 6.79) frozen minced beef stored for 0,1,2,3 or 7 months showed decrease in protein solubility with increasing frozen storage time and had significantly lower values of myofibrillar proteins (SSP).

The cooking loss levels in steaks in the current study were slightly higher than 22.5% but lower than 30% (Razminowicz et al., 2006). The differences in cooking and thawing losses in the current study and those reported by other authors may be attributed to several factors such as differences in ageing, cooking method applied, cooking temperatures, duration of cooking temperatures, pH and Marbling (Boby et al., 2021). Saba et al. (2018) reported that beef cooked swiftly to a given internal temperature has a low cooking loss and is juicier than beef cooked at the same temperature slowly. This is because a high heat (70˚C) rapidly coagulates the proteins on the beef surface and so rapidly forming a layer that protects much cooking losses by evaporation and drip. Muscle of lower holding capacity is associated with higher drip and cooking losses hence lower juiciness and less tender muscle (Bruce et al., 2003). On the other end, long term stress depletes the muscle glycogen storage after slaughter. This depletion of glycogen leads to low acid production and high ultimate pH. This ultimate pH improves the space availability and thus more water is withheld within the myofibrillar proteins. In this experiment the WHC values of buffalo, beef and goat meat were 83.31, 92.16 and 94.21%, respectively. A water holding capacity of 20.61 ml/100g was recorded in meat obtained from young male buffaloes fed with high protein diet (Anjaneyulu et al., 1985). The meat from entire males had higher water holding capacity than castrates (Dessouki et al., 1981). Whereas, the meat samples from spent female Murrah buffaloes showed a WHC of 16.67 ml/100g in ground meat (Sahoo and Anjaneyulu, 2000). The minced meat of goat had lower WHC than the chunks during frozen storage because mincing promotes physicochemical changes (Rahman et al., 2023) and this might have affected the WHC. The cooking loss is a combination of liquid and soluble matters lost from the meat during cooking. At increasing centre temperatures the water content of the meat has been shown to decrease, and the fat and protein content to increase indicating that the main part of the cooking loss is water (Boby et al., 2021). It may have been expected that cooking loss would have been a useful predictor of juiciness (Disha et al., 2020).

After cooking at 80°C the effect of differences in pH on cooking loss would be small since the pH values of the cooked meat would be close to the isoelectric point of the cooked meat proteins (Bouton et al., 1976). They stated that the cooking losses are significantly ($P < 0.001$) lower in the stretched than in the contracted muscles at all of the raw muscle fiber lengths. Cooking losses increase ($P < 0.001$) with decrease in fiber length. The effect of myofibrillar contraction state on losses confirms earlier results (Bouton et al., 1976) while the effect of fiber length agrees with the work of Laskar et al. (2013). The color (Yellowness) of buffalo, beef and goat meat were 12.31, 19.95 and 14.83 respectively. WHC was significantly ($p< 0.05$) higher in goat meat than buffalo meat. Cooking loss was significantly ($p< 0.05$) higher in beef and goat meat than buffalo meat. Color (yellowness) was significantly ($p< 0.05$) higher in beef than buffalo meat. Meat pH, Keema pH, Color (lightness), Color (redness) values did not differ significantly ($p> 0.05$) within the three species.

Physical characteristics of chilled-boned keema

The physical characteristics of chilled-boned keema of buffalo, beef and goat meat were also measured in this study. The meat pH of Buffalo, Beef and Goat meat were 5.45, 5.77 and 5.62 respectively. The results resembled the pH of chevon keema (Karthikeya et al., 2000) the keema pH of Buffalo, Beef and Goat meat were 6.04, 6.13, and 6.25 respectively. The WHC values of Buffalo, Beef and Goat meat were 90.16, 85.15, and 88.93 respectively. The Cooking loss values of Buffalo, Beef and Goat meat were 26.30, 27.08, and 36.45. Nuraini et al. (2019) found that, the dark color of the meat is assessed as meat that has been stored for a long time and has been damaged. The color of the meat that has not been exposed to oxygen is a purplish red, then if it has been oxidized for several minutes it will be bright red. The bright red color may turn red or brown if there is oxidation or if the meat is stored long, or reddish-green if decay has occurred.

The meat obtained from intact males was lighter in color (Stoikov and Dragoeva, 2002). The myoglobin content varied from 2.7 to 9.4 mg/g depending upon the type of the muscle and age and meat becomes darker with increasing age. A slight variation in

myoglobin was observed in the meat from spent male and female buffaloes (Dransfield et al., 1990). The meat pigment concentration of spent male buffalo meat was significantly higher than young males, which was attributed to greater content of haeme pigment and myoglobin. The heme pigment concentration in meat samples of bulls was 3.59 to 3.99 mg/g (Mamino and Horn, 1996). The total meat pigment obtained from spent female buffalo was 0.25% (Sahoo and Anjaneyulu, 2000). The meat pigment content from younger buffaloes was significantly ($P<0.05$) lower than spent male and female buffaloes (Kandeepan et al., 2010).

The Color (lightness) of Buffalo, Beef and Goat meatF were 56.96, 57.15 and 56.50 respectively. The color (Redness) of Buffalo, Beef and Goat meat were 6.47, 7.13 and 6.25 respectively The color (Yellowness) of Buffalo, Beef and Goat meat were 17.178, 18.10 and 16.45 respectively. Cooking loss was significantly ($p< 0.05$) higher in goat meat than beef and buffalo meat. Table 6 shows the physical characteristics of chilled-boned keema of buffalo, beef and goat meat. Cooking loss was significantly ($p< 0.05$) higher in goat meat than beef and buffalo meat.

Table 6. Physical characteristics of chilled-boned keema

	Buffalo	**Beef**	**Goat**	**Level of Significance**
Meat pH	5.45±0.65	5.77±0.35	5.62±0.50	NS
Keema pH	6.04±0.60	6.13±0.62	6.25±0.67	NS
WHC%	90.16±6.96	85.15±6.54	88.93±6.03	NS
Cooking loss%	26.30^{b}±4.95	27.08^{b}±4.08	36.45^{a}±4.72	*
Color (lightness)	56.96±3.64	57.15±4.01	56.50±3.57	NS
Color (Redness)	6.47±.87	7.13±1.07	6.25±.61	NS
Color (Yellowness)	17.17±3.28	18.10±3.17	16.45±2.89	NS

[a, b] Mean in the same row with different superscripts differ significantly ($P<0.05$), NS means not significant

Conclusion

It is revealed from the study that the Buffalo meat keema (hot-boned and chilled-boned) showed better in meat quality attributes compared to the others. Scientific processing by adopting good manufacturing practices and suitable packaging helped greatly to improve the shelf life of the ambient temperature stored beef, buffalo and goat meat keema.

References

Akhter S, Rahman M. 2009. Effects of drying as a preservation technique on nutrient contents of beef. Journal of the Bangladesh Agricultural University, 7(1): 63-68.

Al-Dulaimy HHA, Goma MA, Al Aswad MB. 1985. Changes in pH and bound water of goat meat stored by cooling and freezing. Iraqi Journal of. Agricultural Science Zanco, 3: 59-67.

AMSA (American Medical Student Association). 1995. Research Guide Line for Cookery. Sensory Evaluation and Instrumental Tenderness Measurements of Beef. American Medical Student Association, Chicago.

Anjaneyulu ASR, Sengar SS, Lakshmanan V, Joshi BC. 1985. Meat quality of male buffalo calves maintained in different levels of protein. Buffalo Bulletin, 4: 44-47.

Azad MA, Sakib MN, Murshed HM, Hashem MA, Ali MS, Habib M, Billah MM. 2022. Indigenous transport methods: Hormonal responses and physicochemical properties of lamb meat. Meat Research, 2(2): 1-6.

Azad MAK, Kikusato M, Zulkifli I, Rahman MM, Ali MS, Hashem MA, Toyomizu M. 2021. Comparative study of certain antioxidants -electrolyzed reduced water, tocotrienol and vitamin E on heat-induced oxidative damage and performance in broilers. Meat Research, 1: 1, Article 7.

Boby F, Hossain MA, Hossain MM, Rahman MM, Azad MAK, Hashem MA. 2021. Effect of long coriander leaf (Eryngium foetidum) extract as a natural antioxidant on chicken meatballs during at freezing temperature. SAARC Journal of Agriculture, 19(2): 271-283.

Boles JA, Swan JE. 2002. Processing and sensory characteristics of cooked roast beef: effect of breed, age, gender and storage conditions. Meat Science 62 (4) 419-427.

Bouton PE, Harris PV, Shorthose WR. 1976. Factors influencing cooking losses from meat. Journal of Food Science, 41(5): 1092-1095.

Bruce HL, Stark JL, Beilken SL. 2003. The effect of finishing diet and post mortem ageing on the quality of M. longissimus thoracis of the electrically stimulated Brahman steer carcasses. Meat Science, 67(2): 261-268.

Bruce HL, Ball RO. 1990. Postmortem interaction of muscle temperature, pH and extension on beef quality. Journal of Animal Science, 68: 4167– 4175.

Choi YS, Park KS, Kim HY, Kim HW, Song DH, Chung HJ, Lee JW, Kim CJ. 2011. Interactions between chicken salt-soluble meat proteins and makgeolli lees fiber in heat-induced gels. Food Science of Animal Resources, 31(6): 817-26.

Dessouki TM, Saied SZ, Abo-Selim I and El-Kholi M. 1981. Effect of castration on the physical and chemical properties of buffalo meat. II. Influence of frozen storage. Agricultural Research Review, 56 (7): 69-77.

Dewi AM, Swacita IB, Suwiti NK. 2016. Pengaruh perbedaan jenis otot dan lama penyimpanan terhadap nilai nutrisi daging sapi bali. Buletin Veteriner Udayana, 8 (2): 135-144.

Diana A, Iciar A. 2004. Effect of storage and packaging on fatty acid composition and oxidation in dry fermented sausages made with added olive oil and antioxidants. Meat Science, 67 (2): 237-244.

Disha MNA, Hossain MA, Kamal MT, Rahman MM, Hashem MA. 2020. Effect of different levels of lemon extract on quality and shelf life of chicken meatballs during frozen storage. SAARC Journal of Agriculture, 18(2): 139-156.

Dransfield E, Nute GR, Hogg BW and Walters BR. 1990. Carcass and eating quality of ram, castrated ram and ewe lambs. Animal Production, 50(2): 291-299.

Esterbauer H, Cheeseman KH. 1990. Determination of aldehydic lipid oxidation products: malonaldehyde and 4-hydroxynonenal. Meth Enzymol, 186: 407-421.

Hasan M, Chakrabartty S, Rahman MA, Akter S, Murshed HM, Azad MAK. 2022. Regional effect on meat quality traits of

Buffaloes in Bangladesh. Meat Research. 2(6): 1-8.
Himanish Das, Radha Krishna K. 2001. Preservation of mutton as ready to eat curry by hurdle technology. Journal of Food Science and Technology. 28 (3): 287-289.
Haque N, Lal M.1999. Gross energy estimation. Laboratory manual of animal nutrition. Ind. Vet. Res. Inst. Izatnagar, India:71-6.
Hossain MA, Rahman MM, Rahman MW, Hossain MM, Hashem MA. 2023. Effect of supplementary feeding on the production traits, carcass and meat quality of Jamuna basin lambs. Journal of Animal Science and Technology. 65(1): 209-224.
Joksimovic J and Ognjanovic A. 1977. Comparison of carcass yield, carcass composition and quality characteristics of buffalo meat and beef. Meat Science, 1(2): 105-110.
Kandeepan G, Anjaneyulu ASR, Kondaiah N, Mendiratta SK. 2010. Quality of buffalo meat keema at different storage temperature. Afr J Food Science 4 (6) 410-417.
Kandeepan G, Anjaneyulu AS, Kondaiah N, Mendiratta SK, Rajkumar RS. 2013. Evaluation of quality and shelf life of buffalo meat keema at refrigerated storage. Journal of food science and technology, 50:1069-1078.
Karthikeyan J, Kumar S, Anjaneyulu ASR, Rao KH (2000). Application of hurdle technology for the development of Caprine keema and its stability at ambient temperature. Meat science, 54 (1): 9-15.
Kesava Rao V, Anjaneyulu ASR, Lakshmanan V, Sharma N, and Kondaiah N. 1985. Meat and fat characteristics of male buffalo calves. Indian Journal of Animal Sciences, 55 (7): 596-598.
Kirchofer, KS, Calkins CR, Gwartney BL. 2002. Fibertype composition of muscles of the beef chuck and round. Journal of Animal Science. 80: 2872–2878.
Kolodziejska I, skonieczny S, Rubin LJ. 1990. Malondialdehyde nitrite interactions in meat and model systems. Journal of Food Science, 55 (4): 926-928.
Lapital RM, Del Barrio AN, Katsube O, Orden EA, Robles AY, Fujihara T, Cru LC, Kanai Y. 2004. Proceeding's 7th World Buffalo Congress, Makati city, Philippines, PP. 202-211.
Laskar S, Saha D, Nath D, Hazarika M, Das A. 2013. Proximate composition and sensory qualities of fat reduced chevon salamis enriched with dietary fiber. Indian journal of animal production and management, 29(1-2):20-24.
Mamino EN, and Horn SP. 1996. Chemical, processing and sensory characteristics of carabeef ham from philmurrah x phil-murrah crossbred. Proceedings of the 2nd Asian Buffalo Association Congress, October, 9-12, 1996, Manila, Philippines 252-260.
Miller AJ, Acerman SA, Palumbo SA. 1980. Effect of frozen storage on functionality of meat for processing. Journal of Food Science, 45: 1466-1471.
Mobin MH, Hossain MA, Azad MA, Rahman MM, Hashem MA. 2022. Comparison of growth performance and carcass traits of native lambs in Bangladesh. Meat Research, 2 (4): 1-8.
Mohan B, Narahari D, Jaya Prasad. 1987. Studies on influence of age and sex on the chemical composition of Japanese quail (Coturnix coturnix japonica) meat. Indian Journal of Poultry Science, 22 (2): 182-184.
Morrissey PA, Sheehy PJ, Galvin K, Kerry JP, Buckley DJ. 1998. Lipid stability in meat and meat products. Meat science, 49:73-86.
Naveena BM, Mendiratta SK, and Anjaneyulu ASR. 2004. Tenderization of buffalo meat using plant proteases from Cucumis trigonus roxb (Kachri) and Zingiber officinale roscoe (Ginger rhizome). Meat Science, 68 (3): 363-369.
Nuraini H, Lesa Aditia E, Brahmantiyo B. 2019. Meat Quality of Indonesian Local Cattle and Buffalo. IntechOpen. doi: 10.5772/intechopen.79904
Papadima SN, Bloukas JG. 1999. Effect of fat level and storage conditions on quality characteristics of traditional Greek sausages.
Rahman A, Memon M, Khaskeli M. 2012. Studies on the Evaluation of Moisture and Ash Content in Kamori, Pateri and Tapri Goat Meat. International Journal for Agro Veterinary and Medical Sciences
Razminowicz RH, Kreuzer M, Scheeder MRL. 2006. Quality of retail beef from two grass-based production systems in comparison with conventional beef. Meat Science, 73: 351–361.
Saba NA, Hashem MA, Azad MAK, Hossain MA, Khan M. 2018. Effect of bottle gourd leaf (Lagenaria siceraria) extract on the quality of beef meatball. Bangladesh Journal of Animal Science, 47(2): 105-113.
Sabow AB, Sazili AQ, Aghwan ZA, Zulkifli I, Goh YM, Ab Kadir MZA, Adeyemi KD. 2016. Changes of microbial spoilage, lipid-protein oxidation and physicochemical properties during post mortem refrigerated storage of goat meat. Animal science journal, 87 (6): 816-826.
Sadakuzzaman M, Hossain MA, Rahman MM, Azad MA, Hossain MM, Ali MS, Hashem MA. 2021. Combined effect of irradiation and butylated hydroxyanisole on shelf life and quality of beef at ambient temperature. Meat Research. 1 (1): 1-9.
Sahoo J and Anjaneyulu ASR. 2000. Effect of sodium ascorbate, alpha-tocopherol acetate and sodium tripolyphosphate on the quality of pre-blended ground buffalo meat. Journal of Food Science and Technology, 37(4): 388-393.
Sebranek JG, Fox JB. 1985. A review of nitrite and chloride chemistry: interactions and implications for cured meats. Journal of the Science of Food and Agriculture, 36 (11): 1169-1182.
Simela L, Webb EC, Frylinck L. 2004. Effect of sex, age and pre-slaughter conditioning on pH, temperature, tenderness and colour of indigenous South African goats. South African Journal of Animal Science, 34(5): 208-11.
Stoikov A, Dragoeva A. 2002. Comparative study on meat quality of male non-castrated piglets of different breeds and pre-slaughter weight. Zhivotnov"dni-Nauki, 39: (2) 8-13.
Syed Ziauddin K, Mahendrakar NS, Rao DN, Ramesh BS, and Amla BL. 1994. Observations on some chemical and physical characteristics of buffalo meat. Meat Science, 37 (1): 103-113.
Tarladgis B, Watts BM and Yonathan M 1960. Distillation Method for Determination of Malonaldehyde in Rancid Food. Journal of American Oil Chemistry Society, 37: 44-48.
Thomas R, Anjaneyulu ASR, Kondaiah N. 2007. Development of shelf stable pork sausages using hurdle technology and their quality at ambient temperature (37±1°C) storage. Meat Science, 79 (1): 1-12.
Whipple G, Koohmaraie M, Dikeman ME, Crouse JD. 1990. Effects of high-temperature conditioning on enzymatic activity and

tenderness of Bos Indicus longissimus muscle. Journal of Animal Science, 68: 3654– 3662.
Whitney EN, Rolfes SR. 2008.Understanding nutrition (9th Ed.). Australia. Wadsworth.
Zhang SX, Farouk MM, Young OA, Weiliczko KJ, Podmore C, 2005. Functional stability of frozen normal and high pH beef. Meat Science, 69: 765-772.