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Effect of Domestic Refrigeration on Keeping Quality of Buffalo Meat

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Abstract: Buffalo meat is the only future remedy for nutritional security in India. If the quality gets deteriorated, the meat preserved in refrigerator would impact greatly on the health of consumers. Hence meat samples from five year old sixteen buffalo bulls were analyzed in the fresh state (0 day) and after 4 and 7 days in chiller (4±°C) and 4, 7, 14, 30, 60 and 75 days in freezer (–10±1°C) in a domestic refrigerator. The values of ERV, WHC and proximate composition decreased with increasing storage period. Whereas pH, TBA no., tyrosine value, chilling loss and drip loss showed an increasing trend. Thus it was concluded that a storage period upto 4 days in chiller and 30 days in freezer could satisfactorily maintain the buffalo meat quality.

Key words: Nutritional, domestic,analyzed, composition

INTRODUCTION

India has 96.9 million number of buffaloes, which accounts for 58% of the total buffalo population in the world. Presently, India credited 1.49 mMT of buffalo meat to its total meat pool (6.04 mMT) contributing 45.56% of world buffalo meat production (FAO, 2004). Only the buffalo meat has the export potential from our country. Major quantity of meat is exported in frozen form from India to Malaysia and Gulf countries with annual foreign exchange revenue to the tune of Rs. 1375.04 Crores (Apeda, 2003).

In India, consumers purchase meat in fresh or frozen form mostly. To adjust with the fast growing life style of urbanization, they hardly find time to purchase meat daily. Hence they purchase meat in bulk to meet their daily requirements. This meat is stored in refrigerator and consumed on definite intervals. Deterioration of meat quality in refrigerator storage may have great impact on the health of consumers. Considering the importance from consumer viewpoint, a program has been ascribed to study the effect of refrigerator storage on buffalo meat quality. The objective of this study was to determine the physicochemical and proximate changes of buffalo meat in domestic refrigerator. Thereby the shelf life of buffalo meat in Chiller and Freezer was established. This study has immense importance to satisfy consumer's query relating to how long buffalo meat can be stored without any deterioration in domestic refrigerator.

MATERIALS AND METHODS

Sample collection and preservation: Meat samples each weighing 2 kg from shoulder were removed from twenty buffalo bulls of five years old slaughtered at Municipal slaughter house, Tangra, Kolkata. The muscles were then utilized for the study. Five trials were conducted for each experiment with meat samples from different buffalo bulls of same age group. Age of the buffalo bull carcasses was estimated by observing dentition. The samples were wrapped in highly gas permeable low density polyethylene and transported to the laboratory within 1 hour postmortem.

The samples were kept in chiller (24 hrs at 4±1°C) for ageing (Ziauddin, 2003). The separable fat and connective tissue were removed. Then the samples were packaged in low-density polyethylene, each containing 250 g of meat sample and stored in chiller and freezer respectively for further study. One portion was analyzed in the fresh state (0 day) and the remaining portion after chiller storage (4±1°C) for 4 and 7 days and freezer storage (-10±1°C) for 4, 7, 14, 30, 60 and 75 days in a domestic refrigerator (Godrej Cold Gold Model). The stored samples were then analyzed for physicochemical changes, proximate composition.

Physicochemical parameters ph: pH of the finely minced meat sample was determined by the method of Gillespie, 1960. 10 g of meat sample was homogenized with 50 mL of

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distilled water using mortar and pestle. Then the pH of the suspension was recorded using digital pH meter (Systronics Model 335).

Extract Release Volume (ERV): Extract Release Volume was determined as per the procedure outlined by Pearson, 1968. An extraction reagent was prepared by mixing 50 mL of 0.2-M Potassium Dihydrogen Orthophosphate with 3.72 mL of 0.2 M NaOH and then diluted with distilled water to 200 mL . The pH of the reagent was corrected to 5.8. Fifteen gram of meat sample was blended with 60 mL of extraction reagent for 2 min. The homogenate was passed immediately through a filter paper and the filtrate was collected in a measuring cylinder. The volume of the filtrate (in mL) collected within first 15 min after pouring the homogenate into the funnel was recorded as the extract release volume.

Water Holding Capacity (WHC): The method used for determining the WHC was a modification of the high speed centrifugation method (Harris and Shorthose, 1988).In this method, 2 g meat samples were accurately weighed and then centrifuged at 6000 rev min^{-1} for 10 min using a centrifuge machine (REMI model). No water was added to the samples and, after centrifuging, the juice expressed was decanted off or used for other purposes, if required. The meat samples were removed from the tubes with forceps, carefully dried with tissue paper and then reweighed, to determine liquid loss. The water content of the muscles when raw and after centrifuging was determined by oven drying (105°C for 24 h).

Thio Barbituric Acid (TBA) number: Thiobarbituric acid number of meat samples was determined as per Strange *et al*., (1977) with slight modifications. 20 g of minced meat were blended with 50 mL of precooled 20% TCA (Trichloro Acetic Acid) solution for 2 min. The blended contents were transferred to a beaker by rinsing with 5 mL of cold distilled water and mixed together. The mixture was filtered through Whatman filter paper No.42. The filtrate was named as TCA extract. Five mL of freshly prepared 0.01 M 2- TBA solution (stored not more than 10 days at 4°C in amber glass bottle) were mixed with 5 mL of TCA extract in clean oven dried test tubes in boiling waterbath for 30 min. The absorbance (A) at 532 nm was reported as TBA number.

Tyrosine value: The procedure of (Strange *et al*., 1977) was followed with slight modification. 2.5 mL of TCA extract was diluted with equal amount of distilled water. 10 mL of 0.5 N freshly prepared Sodium Hydroxide and 3 mL of diluted Folin and Ciacalteu's reagent (1:2 with distilled water) were added. After 30 min Optical Density (OD) was measured at 730 nm in a Spectrophotometer. Tyrosine value was calculated by referring to the standard curve prepared as per the procedure of Pearson, 1968 and expressed as mg of tyrosine per 100 g of meat.

Chilling (drip) loss: Weight of the meat packaged before keeping in chiller storage and after experimental period were noted and their difference in weights were expressed in percentage (%).

Drip loss was estimated by measuring the exuded meat juices after thawing and expressed as percentage (%) of the initial weight.

Proximate composition: The moisture, protein, ether extract and ash contents of buffalo meat were determined by the methods of (AOAC, 1995).

Statistical analysis: In the present investigation the data obtained from the experiment were statistically analyzed and interpreted for different types of estimation following the methodology as outlined by Snedecor and Cochran (1994).

RESULTS

Physicochemical parameters pH: The pH of chilled and frozen buffalo meat after post slaughter showed an increasing trend with increase in storage period (Table1). On 4th day, the pH of chiller (4 ± 1°C) stored buffalo meat is equal to the freezer (-10 ± 1°C) stored meat (Table1). On 14^{th} day of freezer storage the pH increased significantly ($p<0.05$) from the value on 4th and 7th. With progress in frozen storage, a significant ($p<0.05$) difference in pH was observed between 30th, 60^{th} and 75th days.

Water Holding Capacity (WHC): The Water Holding Capacity (WHC) of chilled and frozen buffalo meat after post slaughter showed a decreasing trend with increase in storage period (Table 1). On 4 day storage, the WHC of chilled (4±1°C) buffalo meat was higher than the frozen (-10±1 °C) buffalo meat. The WHC of 7 day chilled meat differed significantly ($p<0.05$) with the value of freezer stored meat on the same day. The results showed a significant reduction in WHC on 7th and 14th days of freezer storage respectively. Subsequent storage of 30^{th}, 60th and 75th days in freezer showed a quite significant decline in WHC.

Extract Release Volume (ERV): In the present study, the Extract Release Volume (ERV) in buffalo meat after post slaughter decreased quite significantly ($p<0.05$) with

Table 1: Effect of low temperature preseravation on mean ph, erv and whc of buffalo meat over different days of storage period Whc of buffalo meat over different days of storage period

	Temperature treatment			
	Chiller(4±1oC)	Freezer(–10±1oC)	SED	Significanc
pH				
Day 0	5.6[d]	5.6[d]	0.03	NS
Day 4	5.7[d]	5.7[d]	0.04	NS
Day 7	6.2[a]	5.7[d]	0.03	p<0.05
Day 14		5.8[cd]	0.12	p<0.05
Day 30		5.9[c]	0.02	p<0.05
Day 60		6.0[b]	0.03	p<0.05
Day 75		6.1[ab]	0.01	p<0.05
ERV (mL)				
Day 0	24.0[a]	24.0[a]	1.07	NS
Day 4	19.3[bc]	22.1[ab]	0.76	p<0.05
Day 7	14.5[d]	21.7[b]	1.09	p<0.05
Day 14		19.8[bc]	0.23	p<0.05
Day 30		18.8[c]	1.19	p<0.05
Day 60		17.5[cd]	0.87	p<0.05
Day 75		15.5[d]	0.03	p<0.05
WHC (%)				
Day 0	76.0[a]	76.0[a]	0.57	NS
Day 4	71.8[ab]	73.7[ab]	0.6	7NS
Day 7	67.7[c]	71.9[b]	1.10	p<0.05
Day 14		67.9[c]	1.10	p<0.05
Day 30		63.0[d]	1.52	p<0.05
Day 60		57.8[e]	1.08	p<0.05
Day 75		53.9[f]	0.07	p<0.05

[a-f] Treatment means are different (p<0.05) if they have no common superscript letter

Table 2: Effect of low temperature preseravation on mean tba no., tyrosine value, chilling loss and drip loss of buffalo meat over different days of storage period

	Temperature treatment			
	Chiller (4±1oC)	Freezer (–10±1oC)	SED	Significance
TBA No.				
Day 0	0.1[d]	0.1[d]	0.01	NS
Day 4	0.2[c]	0.2[c]	0.01	NS
Day 7	0.3[a]	0.2[c]	0.01	p<0.05
Day 14		0.2[c]	0.01	p<0.05
Day 30		0.3[b]	0.01	p<0.05
Day 60		0.3[b]	0.01	p<0.05
Day 75		0.3[b]	0.01	p<0.05
Tyrosine value(mg%)				
Day 0	24.9[e]	24.9[e]	0.89	NS
Day 4	29.6[c]	27.2[d]	0.69	p<0.05
Day 73	5.6[a]	29.1[c]	0.64	p<0.05
Day 14		30.1[c]	0.64	p<0.05
Day 30		32.2[b]	0.67	p<0.05
Day 60		34.2[a]	0.73	p<0.05
Day 75		34.9[a]	0.01	p<0.05
Chilling loss and drip loss(%)				
Day 0	0	0		
Day 4	0.2[fh]	3.2[g]	0.23	p<0.05
Day 7	0.7[f]	5.0[e]	0.41	p<0.05
Day 14		10.9[d]	0.29	p<0.05
Day 30		12.1[c]	0.54	p<0.05
Day 60		15.0[b]	0.60	p<0.05
Day 75		17.1[a]	0.06	p<0.05

[a-fh] Treatment means are different (p<0.05) if they have no common superscript letter

increase in storage period in the chiller and freezer (Table 2). On 4 day storage, the results showed a higher ERV in freezer than in chiller stored meat. 7 day chilled meat resulted in lower ERV. This differed significantly (p<0.05) with the value of freezer stored meat on the same day. The results showed a quite significant (p<0.05) reduction in ERV on 7th, 14 th and 30th days of freezer storage.

Thio Barbituric Acid (TBA) value: The buffalo meat showed an increasing Thiobarbituric Acid (TBA) value with increase in storage period (Table 2). On 4th day of storage, the TBA value is equal in chiller (4±1°C) to in freezer (-10±1°C). The TBA values increased significantly (p<0.05) on prolonged days of freezer storage.

Tyrosine value: In the present study, the tyrosine value of buffalo meat increased significantly (p<0.05) with increase in storage period (Table 2). 4 day chilled buffalo meat showed a significantly (p<0.05) higher tyrosine value than the frozen meat. Tyrosine value increased quite significantly (p<0.05) on 7 th, 14th, 30th, 60th and 75th days of frozen storage.

Chilling (Drip) loss: On the 4th day in the present study, the observations showed a significant chilling loss in the stored buffalo meat (Table2). On the same day, the frozen (-10 ± 1°C) buffalo meat showed a significant drip loss.

Proximate composition moisture: The moisture content of buffalo meat decreased quite significantly (p<0.05) with prolonged storage period in chiller and freezer (Table 3). 4 day stored buffalo meat in chiller (4±1°C) showed higher moisture content than the freezer (-10±1°C). The values decreased gradually with increase in freezer storage. The moisture content of 30 th and 60th days of frozen meat showed a significant p<0.05 variation.

Protein: The present study showed a decrease in protein content of buffalo meat with increase in storage period (Table 3). 4 day freezer stored buffalo meat showed a higher protein content than the chilled meat. The results showed a gradual decrease in protein content in 7,14,30,60 and 75 days of frozen buffalo meat. The results showed a significant (p<0.05) decline in protein content at 30 and 60 days of storage. As the storage period in the freezer increased, the amount of protein got decreased

Ether extract: The fat content of buffalo meat decreased with increase in storage period (Table 3). 4 days of chiller stored meat showed a lesser fat content than the freezer stored meat. It was evident that though chilling and freezing decreased the fat content, chilling bettered freezing in the effort. The scores declined significantly (p<0.05) with increase in freezer storage.

Table 3: Effect of low temperature preseravation on mean moisture, protein, ether ectract and ash contents of buffalo meat over different days of storage period

	Temperature treatment			
	Chiller (4±1oC)	Freezer (–10±1oC)	SED	Significance
Moisture(%)				
Day 0	76.9a	76.9a	0.01	NS
Day 4	76.3a	76.2a	0.09	NS
Day 7	72.9d	75.7ab	0.03	p<0.05
Day 14		74.2c	0.04	p<0.05
Day 30		70.7e	0.03	p<0.05
Day 60		68.3f	0.04	p<0.05
Day 75		65.2g	0.03	p<0.05
Protein(%)				
Day 0	20.3a	20.3a	0.06	NS
Day 4	19.0b	19.8ab	0.06	p<0.05
Day 7	15.7d	19.7ab	0.09	p<0.05
Day 14		19.2ab	0.09	p<0.05
Day 30		18.1cb	0.06	p<0.05
Day 60		16.6de	0.07	p<0.05
Day 75		16.2d	0.01	p<0.05
Ether extract(%)				
Day 0	1.7a	1.7a	0.07	NS
Day 4	1.6ab	1.6ab	0.03	NS
Day 7	1.4c	1.6ab	0.03	p<0.05
Day 14		1.5ab	0.07	p<0.05
Day 30		1.5ab	0.06	p<0.05
Day 60		1.5ab	0.001	p<0.05
Day 75		1.4c	0.002	p<0.05
Ash(%)				
Day 0	1.2	1.2	0.08	NS
Day 4	1.2	1.1	0.01	NS
Day 7	1.1	1.1	0.05	NS
Day 14		1.1	0.01	NS
Day 30		1.0	0.01	NS
Day 60		1.0	0.05	NS
Day 75		1.0	0.01	NS

[a-de] Treatment means are different (p<0.05) if they have no common superscript letter.[a-f] Treatment means are different (p<0.05) if they have no common superscript letter

Ash: The ash content of buffalo meat decreased non significantly (p<0.05) with increase in storage period (Table 3). The results showed a higher value for 4 days of chilled meat than the frozen meat. 75th day chilled meat showed the lowest overall acceptance score. This differed significantly (p<0.05) with the score of frozen meat on the same day. A gradual decline in score was recorded on prolonged days of freezer storage.

DISCUSSION

When compared with the zero day a gradual increase in pH was observed in chiller and freezer stored meat. The results revealed that pH values increased with increasing storage period, which was also observed by Jayesh and Venkataramanujam, 2000. The autolysis and increase in microbial load raised the pH in 4 day chiller (4±1°C) stored meat. On the same day, pH in freezer (-10± 1 °C) storage was comparatively low. 7 day freezer stored buffalo meat showed a pH much lower than 7 day chiller stored meat. (Kondaiah *et al*., 1986) observed a pH of 5.62± 0.14 on the same day. There was no significant rise in pH on 14th and 30th day of freezer storage. 60th and 75th days of freezer storage resulted in significantly higher pH. This significant increase in pH with prolonged freezer storage may be attributed to the fact that meat undergoes autolysis resulting in decrease in ERV and WHC with increase in pH (Strange *et al*., 1977). But a final pH between 6.0 and 6.5 needs further investigation (Pearson, 1968).

Prolonged storage of buffalo meat showed a significantly lower WHC than its fresh state. Freezing produces some changes in the tissue, which reduces the WHC after thawing (Sanguinetti *et al*., 1985). Chilling resulted in poor WHC than freezing (Kondaiah *et al*., 1986). WHC in the 4th day freezer stored meat was higher than the 4th day chiller stored meat. A high level of WHC in freezer was due to better water retention of meat caused by an immobilization of tissue water within the myofibrillar system (Hamm, 1975). In 7 day chilled meat the WHC was observed to be lower than on 7th and 14th days of freezer stored meat. The loss of WHC observed was partly due to increased denaturation of protein and partly due to enhanced movement of water into extracellular spaces. The values decreased much lower on 30th, 60th and 75th days of freezer storage. The loss of WHC in prolonged storage of meats may be due to the rate in post mortem pH falls, ice crystal formation, high ionic strength, protein denaturation, drip loss and above all, the bulk of meat stored and the capacity of the refrigeration facility (Lawrie, 1998).

The ERV of freshly slaughtered buffalo meat was significantly higher than the stored meat. The observations of ERV on the 4th day showed much lesser quantity in chiller (4±1°C) than in freezer (-10±1°C) stored meat. The significantly (P< 0.05) lower value in chiller may be due to a comparatively higher pH, total plate count (Strange *et al*., 1977) and increased thiobarbituric acid value (Sushil Kumar *et al*., 2000). In 7 day chilled meat the ERV was observed to be much lower than values of 7th, 14th, 30th 60th and 75th days of frozen buffalo meat. A study by Jayesh and Venkataramanujam (2000) showed ERV values of 21.08 mL and 20.75 mL on 30th and 60th days of frozen stored mutton respectively. In the present study, a significant (p<0.05) decrease in ERV agreed with the fact that at the time of spoilage there was a decrease in ERV and an increase in pH and TBA values. (Pearson, 1968) reported that meat could be considered acceptable provided that the ERV is atleast 17 mL.

The TBA value of fresh buffalo meat was significantly lower than the chiller and freezer stored meat. Das *et al.* (1988) observed the TBA value of fresh buffalo meat as 0.07±0.07. This increase in TBA value was mainly attributed to the oxygen permeability of the packaged meat (Sen, 1996) leading to lipid oxidation (Strange *et al.*, 1977). A significantly ($p<0.05$) high TBA values were observed in buffalo meat stored for 4 days in chiller (4±1°C) and freezer (-10±1°C) than the fresh state. A gradual and significant ($p<0.05$) rise in TBA no. was observed on 7th and 14th days of freezer storage. (Anand *et al.*, 1999) noticed a consistent rise in TBA with lipid peroxidation. As the preservation reached 30th, 60th and 75th days, the observations showed highly significant ($p<0.05$) values on the respective days.(Strange *et al.*, 1977) observed that the changes observed in TBA numbers were not specifically due to bacterial action.

In the present study, the tyrosine value of buffalo meat increased from its zero day value. The increase in tyrosine value may be attributed mainly to intrinsic (autolysis) changes in meat and partly to bacterial action (Agnihotri 1988; Dainty *et al.*, 1975; Strange *et al.*, 1977). 4th day chiller (4±1°C) stored buffalo meat showed a significantly ($p<0.05$) higher tyrosine value higher than the freezer (-10±1°C) stored meat. (Dainty *et al.*, 1975) attributed the increased concentration of tyrosine to the proteolytic enzymes produced at the late logarithmic phase of the bacterial growth. This supports the observations of chilled meat. Subsequently the tyrosine value increased respectively on 7th , 14th, 30th, 60th and 75th days of freezer storage. (Ziauddin *et al.*, 1993) concluded that the spoiled buffalo meat had a tyrosine value of 63-79 mg%.

On the 4th day in the present study, the observations showed a significant chilling loss in the stored buffalo meat. On the same day, the frozen (-10±1°C) buffalo meat showed a significant drip loss.(Van der wal *et al.*, 1995) observed a drip loss in buffalo longissimus lumborum as 3.9% in conventional chilling when meat was nearer to the ultimate pH. As the storage period in the freezer increased, the amount of drip got increased (Ambrosiades *et al.*, 1994; Steven *et al.*, 1998; Strange, 1987; Ziauddin *et al.*, 1993), as recorded in the present study. This marked increase in drip on later days of storage were due to shortening of the sarcomere (Honikel *et al.*, 1968), increased enzyme activity (Strange1987), the degree of fibre distribution and translocation of water (Ramsbottom and Koonz, 1939). (Curie and Wolfe, 1983) showed that the amount of juice squeezed from beef muscles increased from 1-30% as the extracellular space increased with storage time.

The moisture content of the freshly slaughtered buffalo meat was higher than the chiller and freezer stored meat. A slight difference in moisture content was observed between the 4th day chiller and freezer stored meat. This loss in moisture was due to evaporation of moisture from meat in chiller (Arief *et al.*, 1989). Whereas, it was due to sublimation of surface water of the meat to colder surfaces in the vicinity of the freezer (Taylor *et al.*, 1990). Gradually the moisture content of the meat decreased on 7th and 14th days of freezer storage. (Kondaiah *et al.*, 1986) studied the moisture content of frozen buffalo meat at –10°C for 7 days as 76.4%. Subsequently, on 30th, 60th and 75th days of freezer storage a significant ($p<0.05$) decrease in moisture content was recorded. The marked moisture losses encountered in later storage periods may be accounted for the myofibrillar distortion undergone by the meat in the freezer that led to the poor water retention ability of the meat.

The protein content of fresh buffalo meat decreased significantly as the storage period increased. In fact, Krishnan and(Sharma, 1991) reported buffalo skeletal meat containing 20.32% total protein. The main reason behind decline in protein on prolonged storage was due to protein denaturation exhibited in drip loss and proteolysis induced by enzymatic activities of psychrotrophic microbial growth (Peterson and Gunderson1960). Buffalo meat stored for 4 days in chiller (4± 1°C) showed a significantly lower protein content than the freezer (-10±1°C) stored meat. The lower protein content of chilled meat might be due to increased microbial growth resulted from higher water activity (a_w) and enzymatic autolysis (Rao *et al.*, 1998) In 7 day chilled meat the protein content was observed to be lower than 7th and 14th days of freezer stored meat. In fact, on 30th, 60th and 75th days of frozen storage the meat has lost a significant ($p<0.05$) amount of protein. This significant loss in later days of freezer storage might be a result of ice formation raising the solute concentration in the tissue.

In the present study the total lipid content of the buffalo meat decreased with the increase in storage period. (Joksimovic, 1971) stated a fat content of 1.08% in buffalo bulls. The fat content of 4th day chiller stored meat was markedly lower than the freezer stored buffalo meat. A marked difference in chiller might be attributed to the exposure of strong light, as in display cabinets, which accelerated oxidation of fats causing discolouration (Lea, 1938). The fat content of the 7th day chilled meat differed significantly ($p<0.05$) with the value of frozen stored meat on the same day. There was a gradual decrease in fat content on 7th and 14th day stored buffalo meat. Subsequently 30th, 60th and 75th day freezer stored

buffalo meat showed a decreased fat content. This lipid oxidation occurred during freezer storage of meat was mainly due to losses in triglyceride fraction. Agnihotri (1988) reported deterioration in meat lipids took place due to intermediary activities of endogenous meat enzymes leading to hydrolysis of fat.

The ash content of the fresh buffalo meat was higher than the chiller and freezer stored meat. (Borone *et al*., 1982) reported higher ash content (1.3%) for buffalo meat than in cattle (1.1%). Infact, a non-significant decrease in ash percentage was reported by (Ziauddin *et al*., 1994) which coincided with this study.

In summary, the results distinctly revealed a significant ($p<0.05$) variation in physicochemical parameters at different storage periods of chiller and freezer. It was evident that at a given instant freezer maintained the meat better than chiller with respect to physicochemical parameters. The values of ERV and WHC decreased with increasing storage period. Where as pH, TBA no, tyrosine value, chilling and drip loss exhibited an increasing trend. The proximate analysis indicated a highly significant ($p<0.05$) variation against different storage periods. From the observations, it was clear that the proximate composition decreased with increasing storage periods. Even at this point, in a given moment, freezer maintained the quality better than the chiller storage. In fact, fat and ash content did not show any significant variation.

CONCLUSION

Although 60 days of frozen meat increased some of the sensory parameters, owing to the fact that meat is praised for its richness in protein, domestic frozen meat would be best if consumed before 30 days of storage. The loss of protein as drip with increased frozen storage was mainly attributed to the large extracellular ice crystal formation in the muscle fibres. Taking into account of all the above considerations, it may be concluded that a storage period upto 4 days in chiller ($4 \pm 1°C$) and 30 days in freezer ($-10 \pm 1°C$) would satisfactorily maintain the buffalo meat quality.

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REFERENCES

Agnihotri, M.K., 1988. A comparative study on shelf life and microbial spoilage of refrigerated buffalo meat. Ph.D., thesis submitted to IVRI, Izatnagar.

Ambrosiadis, I., N. Theodorakakos, S. Georgekis and S. Lekkas, 1994. Effect of thawing methods on quality of frozen meat and drip loss. Fleischwirt. pp: 320-325.

Anand, S.k., N.K. Pandey and S.S. Verma, 1999. Effect of sodium hypophosphite decontamination and modified atmosphere packaging on microbial profile of chicken carcasses under refrigerated Storage. Indian J. Poultry. Sci., pp: 280-284.

Aoac, 1995. Official methods of analysis. 16th Ed. Association of official analytical chemists, washington dc.

Apeda, 2003. Export of agro and processed food products including meat and meat products. Agricultural and processed food products export development authority. Ministry of commerce, government of india.

Arief, M.A., K.P. Reddy and V.R. Reddy, 1989. Influence of packaging (wrapping) materials and storage periods on certain chemical and organoleptic characteristics of broiler cut up parts. Kerala J. Vet. Sci., pp: 107-114.

Borone, C.M.A., S. Gigli and F. Grasso, 1982. Comparative study of meat quality in cattle and buffaloes. 9. Chemical composition at 36 weeks of age. Produzione-animale, pp: 63-71.

Curie, R.W. and F.H Wolfe, 1983. Meat Sci., pp: 8-147.

Dainty, R.H., B.G. Shaw and T.A. Roberts, 1975. Food microbiology: Advances and prospects. (T.A. Roberts and F.A. Skinner, Eds.). society for applied bacteriology. Symposium series No.11. Academic press, London, pp: 151.

Das, C., C.V. Govindarajan, M.P. Arumugam, and P. Kuttinarayan, 1988. Effect of certain packaging materials on physical and physico chemical qualities of buffalo meat. Kerala J. Vet. Sci., pp: 89-96.

Effect of thawing rate on the exudate production of frozen beef. J. Food Sci., pp: 697-700.

F.A.O., 2004. The state of food and agriculture. Food and agriculture organisation, rome.

Gillespie, E. L., 1960. Methods of analysis. The science of meat and meat products. W.H. Freeman and company, London, pp: 234.

Hamm, R., 1975. Water holding capacity. Meat (d. J. A. Cole and r. A. Lawrie, Eds.). butterworths, London, pp: 321.

Harris, P.V. and W.R. Shorthose, 1988. Water holding capacity measurements. In: developments in meat science-4. (R. Lawrie, Ed.). Elsevier Applied Science, New York, pp: 255.

Honikel, K.O., C.J. Kim, and R. Hamm, 1968. Sarcomere shortening of pre rigor muscles and its influence on drip loss. Meat Sci., pp: 267-282.

Jayesh, V. and V. Venkataramanujam, 2000. Effect of chilling and freezing on physico chemical quality of mutton. Indian Vet. J. pp: 743-745.

Joksimovic, J., 1971. Factors influencing buffalo meat colour. Zobornik radova poljoprivrednog-fakulteta. Univerzitet- u-Beogradu., pp: 12-537.

Kondaiah, N., A.S.R. Anjaneyulu, V. Kesava RAO and N. sharma, 1986. Effect of different handling conditions on quality of minced buffalo meat. Indian J. Anim. Sci., pp: 677-679.

Krishnan, K.R. and N. Sharma, 1991. Studies on the quality characteristics of buffalo skeletal, offal meats and their combinations. J. Food. Sci. Tech., pp: 304-307.

Lawrie, R.A., 1998. Meat science, pergamon press, newyork.

Lea, C.H., 1938. Spec. Rept. Fd. Invest. Bd., london. No.46. Cited by R.A. Lawrie, 1998.

Pearson, D., 1968. Application of chemical methods for assessment of beef quality. I. General considerations, sampling and determination of basic components. J. Sci. Food Agric., pp: 364-369.

Peterson, A.C. and M.G. Gunderson, 1960. Some characteristics of proteolytic enzymes from pseudomonas fluorescens. Applied Micro., pp: 98-103.

Ramsbottom, J.M. and G.H. Koonz, 1939. Food res., Cited by R.A. Lawrie, pp: 4-425.

Rao, D.N., K.K.S. Nair and P.Z. Sakhare, 1998. Meat microbiology and spoilage in tropical countries. Microbiology of meat and poultry. (A. Davies and R. Board, Eds.). Blackie academic and professional, London.

Sanguinetti, S.G., M. C. Anonand and A. Calvelo, 1985.

Sen, A.R., 1996. Quality changes in buffalo meat during storage in dry ice pack. Ph. D., thesis submitted to Ivri, Izatnagar.

Snedecor, G.W. and W.G. Cochran, 1994. Stastical methods. (8th Edn). Oxford and ibh publishing co, Calcutta

Steven, R., Payne., J. Cedric, Durham., M., Sheryl, Scot., E. Carrick and Devin, 1998. The effects of non-vacuum Strange, E.D., 1987. Quantitation and characterization of drip from frozen thawed and refrigerated pork liver. J. Food Sci., pp: 910-915.

Strange, E.D., R. C. Benedict, J.L. Smith and C.E. Swift, 1977. Evaluation of rapid tests for monitoring alterations in meat quality during storage. J. Food. Prot., pp: 843-847.

Sushil kumar, B.D. Sharma, P.K. Nanda, and S. Kumar, 2000. Application of hurdle technology for extending the shelf life of chicken meat. Indian J.Poultry Sci., pp: 286-290.

Taylor, A.A. ,N.F. Down, and B.G. Shaw, 1990. A comparison of modified atmosphere and vacuum skin packing for the storage of red meats. Int. J. Food sci. Tech., pp: 98-109.

Van Der Wal, P.G., B. Engel, G. Van Beek and C.H. Veerkamp, 1995. Chilling pig carcasses: Effects on temperature, weight loss and ultimate meat quality. Meat Sci., pp: 193-202.

Ziauddin, S. K., D.N. Rao, B.S. Ramesh, and B.L. AmL a, 1993. Physico-chemical characteristics of buffalo meat stored at elevated temp, Cheiron. pp: 11-18.

Ziauddin, S.K., 2003. Biochemical changes in muscle tissue- conversion of muscle to meat. Veterinarian, pp: 10-12.

Ziauddin, S.K., D.N. Rao, B.S. Ramesh and B.L AmL a, 1994. Effect of freezing, thawing and frozen storage on microbial profiles of buffalo meat. J. Food sci. Tech., pp: 465-467.