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COMPARISON OF QUALITY ATTRIBUTES OF BUFFALO MEAT CURRY AT DIFFERENT STORAGE TEMPERATURE

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Background. The product quality of curry is determined by the food animal source, raw materials and the method of processing. Moreover the scientific information on processing and quality of traditional buffalo meat curry from different groups of buffaloes is not available. This study was undertaken to develop processed curry from different buffalo groups and to compare its quality during storage at ambient and refrigeration temperature.
Material and methods. The meat samples were collected from the longissimus dorsi muscle of the carcasses from each group of buffaloes slaughtered according to the traditional halal method. Buffalo meat curry was prepared in a pressure cooker with the standardized formulation. This final product was subjected to evaluation of quality and shelf life.

Results. To evaluate the effect of different groups of meat samples on the quality of curry, product yield, pH, proximate composition, water activity (a_w), thiobarbituric acid reactive substances (TBARS), calorific value, sensory attributes and microbiological assay were determined The energy of meat curry from young buffaloes was significantly lower than the meat curry from spent animal groups. The overall acceptability of curry decreased significantly during 3 days ambient storage compared to refrigeration storage.

Conclusions. Scientific processing by adopting good manufacturing practices and suitable packaging helped greatly to improve the shelf life of the ambient temperature stored buffalo meat curry. Buffalo meat curry from young male group showed better product characteristics and overall acceptability scores than spent buffalo group.

Key words: buffalo meat, meat products, curry, technology, quality, shelf life

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INTRODUCTION

Traditional buffalo meat products are highly relished widely in all buffalo rearing countries of Asia, Africa, Australia, Europe and South America. Indian consumers prefer meat curry over any other processed meat products. Buffalo meat curry is one of the highly relished traditional meat products in India. Traditional buffalo meat curry in rural areas of India is formulated using high spices and condiments. This traditionally processed meat product is intended to serve hot. Due to great regional diversity, this product displays variations in processing method and sensory quality. Although increasing urbanization and change in lifestyle have changed in the past few years, the liking for traditional meat products still exists among people. Traditional Indian meat based foods require many preparatory steps and longer preparation time. In order to minimize such burden of processing in the kitchen and to cater for the needs of the increasing working population, the demand for ready-to-eat meat products is growing in Indian and overseas markets.

The product quality of curry is determined by the food animal source, raw materials and the method of processing. The packaging and storage condition does influence the shelf life of buffalo meat curry, too. According with Papadima and Bloukas [1999] storage conditions affected the microflora, pH, weight losses and water activity but had no effect on composition, colour and sensory attributes of traditionally processed Greek sausages. 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 Ansorena and Iciar Astiasaran [2004] proved that vacuum packaging of the dry fermented sausages was the best method to prevent formation of lipid oxidation volatile compounds. Some aspects of improving of food shelf life by the use of modern methods of packing are presented by Otles and Yalicin [2007] and Otles [2008 a, b]. As per Ruiz Capillas et al. [2007] 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.

Refrigerators are not commonly available in every household in developing countries. In addition, frequent interrupted power supply is a day to day problem in countries like India. Under these situations, people process the buffalo meat curry 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 buffalo meat curry without refrigerator storage. But the quality of curry stored at ambient temperature up to an acceptable storage period would definitely differ with the quality of curry stored at refrigerator for the same period. But there is no scientific evidence of this hypothesis. Moreover, the scientific information on processing and quality of traditional buffalo meat curry from different groups of buffaloes is not available. Considering the above points, a study was undertaken to develop processed curry from different buffalo groups and to compare its quality during storage at ambient (37 ±1°C) and refrigeration (4 ±1°C) temperature for a specific storage period.

MATERIAL AND METHODS

Raw materials

The meat from young male (about 18 months old), aged/spent male (culled buffalo bullock) and spent female (culled buffalo female) buffaloes (> 10 years) were procured from meat market, Bareilly, Uttar Pradesh, India. The meat samples were collected from the longissimus dorsi muscle of the carcasses of almost similar conformation from each group of buffaloes slaughtered according to the traditional halal method. The meat was obtained within 6 hours of slaughter, packed in low density polyethylene (LDPE) bags and conditioned at 4 ±1°C in a refrigerator (Godrej Cold Gold, India) for about 24 hours. Later, the separable fat and connective tissue were removed. The meat was portioned, packed in LDPE bags and transferred to the freezer (Vest Frost, Denmark) maintained at –18 ±1°C until it was processed. The meat was thawed at 4 ±1°C for 12 hours before it was processed for meat curry.

Refined salt (Tata salt, Tata chemicals Ltd. Mumbai, India), refined mustard oil (Dhara, Dhara Vegetable Oil & Foods Co. Ltd., Anand, India), spice mix ingredients and vegetables were procured from local market. Spice ingredients, free from extraneous matter, were dried in a hot air oven at 50°C for 4 hrs. The ingredients were ground in a home mixer (Remi Equipments, India) and sieved through a fine mesh. The powders were mixed in suitable proportion to make a spice mix (*curry masala*) for buffalo meat curry (Table 1). Fresh curd prepared for domestic consumption was used to marinade the buffalo meat chunks in the preparation of curry.

Table 1. Composition of spice mix (*curry masala*) for buffalo meat curry

Sl. No.	Ingredient	Percent in the mix
1	2	3
1	coriander powder (*Dhania*)	25.0
2	cumin seeds (*Zeera*)	12.0
3	dried ginger (*Sont*)	10.0
4	aniseed (*Soanf*)	10.0
5	black pepper (*Kali mirch*)	10.0
6	capsicum (*Mirch powder*)	5.0
7	degi mirch	5.0
8	turmeric (*Haldi*)	5.0
9	caraway seed (*Ajowain*)	2.5
10	cardamon (*Bada elaichi*)	2.5
11	cinnamon (*Dal chini*)	2.5
12	cloves (*Laung*)	2.5
13	nutmeg (*Jaiphal*)	2.5
14	split bengal gram (*Channa dal*)	1.5

Table 1 – cont.

1	2	3
15	mace (*Javithri*)	1.0
16	curry leaf powder	1.0
17	bay leaf (*Tej patha*)	1.0
18	poppy seeds (*Kaskas*)	1.0
Total		100.0

Processing of buffalo meat curry

Buffalo meat curry (about 1500 g) was prepared in a pressure cooker (Cello, India) from different groups of buffaloes with the following standardized formulation (Table 2). The meat chunks (3-4 cm cubes) cut from three different groups of buffaloes were washed once with potable water. The chunks were mixed in a glass dish with curd, ginger paste, half of the salt and half of the spice mix. They were allowed to marinade for 45 minutes and 75 minutes for young male and spent male/spent female buffalo meat chunks respectively. Half of the oil was heated in a pressure cooker and the onion paste was fried to golden brown followed by the addition of garlic paste. Then the marinaded meat was added and allowed to cook in its own juice for 10 minutes. The remaining oil, salt and spice mix were added and mixed well. The required quantity of water was added, the lid was closed and pressure cooked on sim after the first whistle for 25 minutes and 30 minutes for meat curry from young male and spent male/spent female buffaloes respectively. After opening the lid, the meat curry was stirred well and taken out with sufficient thick gravy and cooled to the room temperature. Then the cooking yield of the finished product was determined. The experiment was repeated three times.

Table 2. Standardized formulation of buffalo meat curry

Sl. No.	Ingredient	Percent of meat	Part for 1500 g of meat
1	meat chunks, g		1 500
2	water, ml	50	750
3	onion paste, g	18	270
4	oil, ml	6	90
5	garlic paste, g	6	90
6	curd, g	5	75
7	curry powder, g	2	30
8	salt, g	2	30
9	ginger paste, g	1	15
10	degi mirch, g	0.2	3
Total			2 853

Reheating of packaged buffalo meat curry

The ready to eat buffalo meat curry was vacuum packaged in laminated pouches (Nylon/LDPE) using a Rochermatic packaging machine (Model VM19S, Osnabruck, Germany) and reheated by steam cooking without pressure in a water boiler (Snow King, India). The time of reheating was standardized in such a way to attain a desired internal temperature of 90°C in the finished product [Thomas et al. 2007]. The temperature was recorded with a digital probe thermometer (Model CT-809, Century Instruments (P) Ltd., Chandigarh, India). It took approximately 10 minutes to reach 90°C in the packaged cooked curry. The product was held at this temperature for about 10 minutes. This final product was cooled to room temperature and subjected to evaluation of quality and shelf life.

Comparison of quality of buffalo meat curry

The buffalo meat curry processed as per the standardized formulation was stored at ambient temperature (37 ±1°C) in a incubator (Bharat Instruments & Chemicals, New Delhi, India) and refrigerator (Godrej Cold Gold, India). To evaluate the effect of different groups of meat samples on the quality of curry, product yield, pH, proximate composition, water activity (a_w), thiobarbituric acid reactive substances (TBARS), calorific value, sensory attributes and microbiological assay were determined on the day of processing.

Buffalo meat curry for both ambient and refrigeration storage was processed in the same batch, having same quality characteristics on day one in each group. In the preliminary trials, the sensory panel indicated that the sensory attributes of ambient temperature stored buffalo meat curry was acceptable upto day 3. Therefore, the comparison of quality changes in buffalo meat curry stored at ambient (37 ±1°C) and refrigeration (4 ±1°C) temperature was evaluated on the alternate day i.e. day 3. The product was compared for its various physicochemical, microbiological and sensory quality attributes.

Analytical procedures

Physicochemical properties. pH of the homogenate prepared from buffalo meat curry was recorded by immersing combined glass electrode of digital pH meter (Model CP 901, Century Instruments Ltd., Chandigarh, India). The moisture content was determined by oven drying, protein by Kjeldahl nitrogen estimation and fat by Soxhlet extraction with petroleum ether [AOAC 2002]. Cooking yield was calculated as the percentage of weight of meat product before and after cooking. Gross energy of buffalo meat products was determined by Gallenkamp Ballistic Bomb Calorimeter [Haque and Murari Lal 1999]. The samples were ignited and burnt in excess oxygen in the bomb to 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 was 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 used to develop a pink colour in the distillate of buffalo meat curry. 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 [Koniecko 1979]. Water activity of meat products were measured by a Pawkit water activity meter (Decagon Devices, Pullman, Washington, USA).

Microbiological quality. All the microbiological parameters of buffalo meat curry were determined as per the methods described by APHA [2001]. Ready made media from Hi-Media Laboratories (P) Ltd., Mumbai, India were used for the enumeration of different microbes. Preparation of samples and serial dilution of buffalo meat curry were done near the flame in a horizontal laminar flow unit (Model YSI-188, Yarco Sales (P) Ltd., New Delhi, India) which was pre-sterilized by ultraviolet radiation, observing all possible aseptic precautions. Sterile peptone water (0.1%) was used as diluent for making serial dilutions. The number of colonies were multiplied with reciprocal of the dilution and expressed as $\log_{10}$ cfu/g.

Plate count agar (M091) was used to enumerate total plate count. The plates were incubated at 37 ±1°C for 48 hrs and plates showing 30-300 colonies were counted. Violet Red Bile Agar (VRBA, M049A) was used as the media for coliform count. The plates were incubated at 37 ±1°C for 48 hrs. The number of red purple/pink colony was counted. Anaerobic agar (M 228) media was used to enumerate the anaerobes present in the vacuum packaged sample. The plates were incubated at 37 ±1°C for 48 hrs and the colonies with white colour were counted. About 20 ml of MRS agar (M 6411), melted and maintained at 44-46°C (added with 1ml glycerol/100 ml media) was poured gently to prepare plates for the enumeration of *Lactobacilli*. The plates were incubated at 37 ±1°C for 48 hrs and the colonies with white colour were counted. Baired Parker agar with sulpha (M 1140) cooled to 50°C and aseptically mixed with 50 ml concentrated egg yolk emulsion and 3 ml sterile 3.5% potassium tellurite solution (or 5 ml of ready made egg yolk tellurite emulsion per 100 ml of media) was used to prepare plates for *Staphylococcus* count. The plates were incubated at 37 ±1°C for 48 hrs. The number of intensely dark black, shiny, regular shaped colonies surrounded by clear halos was counted. The sterile cooled Potato Dextrose agar (M 096) medium acidified with 10% sterilized tartaric acid solution (1 ml/100 ml of media) was used for yeast and mold count. The plates were incubated at 25°C for 7 days. Black, white, yellow, red or greenish black coloured colonies appeared on the plates were counted.

Sensory evaluation. Standard sensory evaluation method using 8-point descriptive scale was followed, where: 8 – excellent, 1 – extremely poor. A seven member experienced sensory panel consisted of scientists and post graduate students of Division of Livestock Products Technology, IVRI, Izatnagar, India, judged the samples. The panelists were trained and well acquainted with different sensory attributes during their post graduate/doctoral programme. They were briefly explained about the nature of the experiment without disclosing the identity of samples. The final product of ready to eat buffalo meat curry held at ambient (37 ±1°C) and refrigeration (4 ±1°C) temperature was evaluated on day 3. The stored samples were warmed (40-45°C) using microwave oven (LG electronics India (P) Ltd., Mumbai) for 1 min and served to the panelists. The panelists evaluated the samples for appearance, flavour, juiciness, tenderness, connective tissue residue and overall acceptability using scores ranging 1 to 8.

Statistical analysis. The data generated by repeating the experiments for different quality characteristics were compiled and analysed using SPSS (version 10.0 for Windows; SPSS, Chicago, III., U.S.A.) with randomized block design. The data were subjected to analysis of variance, least significant difference, paired t-test [Snedecor and

Cochran 1995] and Duncan's multiple range test [Steel and Torrie 1981] for comparing the means to find the difference between groups and storage period. The smallest difference ($D_{5\%}$) for two means to be significantly different ($P < 0.05$) was reported.

RESULTS AND DISCUSSION

Quality evaluation of buffalo meat curry

Physicochemical characteristics. The pH of the meat from young buffaloes was significantly ($P < 0.05$) higher than the spent female buffalo meat but not with male buffalo meat (Table 3). A significantly ($P < 0.05$) lower pH was observed in spent female buffalo meat compared to other two groups. The pH of spent male and female buffalo meat did not differ significantly. The lower and higher ultimate pH values might be attributed to the degree of stress exposed in each group of animals [Gregory 1998]. The pH of the curry prepared from different groups did not vary significantly. The ingredients in the formulation might have neutralized the differences in meat pH in the final product.

Table 3. Physicochemical characteristics of meat curry prepared from different groups of buffaloes

Parameter	Young male	Spent male	Spent female
Meat pH	5.61 ±0.12^{a}	5.51 ±0.06^{ab}	5.36 ±0.02^{b}
Curry pH	5.87 ±0.02	5.84 ±0.01	5.84 ±0.03
Yield, %*	52.18 ±0.96	54.29 ±0.44	53.33 ±0.86
Moisture, %	58.73 ±1.40	59.26 ±1.02	59.57 ±2.16
Protein, %	22.07 ±0.80^{b}	23.75 ±0.32^{ab}	24.90 ±0.43^{a}
Fat, %	6.77 ±0.80	7.14 ±0.91	6.82 ±0.61
Energy, kcal per 100 g DM	510.05 ±10.87^{c}	519.56 ±2.37^{b}	526.98 ±20.29^{a}
Water activity	0.91 ±0.01^{b}	0.92 ±0.01^{ab}	0.93 ±0.01^{a}

n = 6, *n = 3. Means with different superscripts in the same row indicate significant difference ($P < 0.05$).

The product yield did not differ significantly among buffalo meat groups. Curry prepared from young male buffalo meat had markedly lower product yield. Where as, a higher product yield was noticed in spent male buffalo meat curry. Cooking loss decreased with increase in age of the buffalo carcass [Robertson et al. 1986].

The moisture content of buffalo meat curry did not differ significantly among groups. Markedly higher moisture content was observed in spent male and female buffalo meat curry in comparison to the curry prepared from young male buffalo meat. The moisture content was related to the degree of cooking loss in the final product.

The protein content of curry prepared from young male buffalo meat was significantly ($P < 0.01$) lower than that of the spent female buffalo meat curry. Where as,

the protein content of spent male buffalo meat curry did not differ significantly either with young male or spent female buffalo meat curry. The difference in protein content of meat curry was due to their difference in protein content of the meat. The higher level of protein in the final product was contributed by the added ingredients in the meat curry and also due to moisture loss during cooking.

The fat content of buffalo meat curry did not differ significantly among the groups. The markedly higher fat content of the spent male and female buffalo meat curry was contributed by their fat level of the meat. Older buffaloes had a slightly higher fat compared to young buffaloes [Uriyapongson et al. 1996]. The oil used in the processing of buffalo meat curry contributed to the higher fat level of the final product.

The energy of meat curry from young buffaloes was significantly ($P < 0.05$) lower than the meat curry from spent animal groups. The lower energy level of young male buffalo meat curry was related to its lower protein and fat content of the meat. The energy level of the meat increased with age and fat content of the animal [Charles 1982, Mohan et al. 1987]. Meat curry from spent female buffaloes had significantly ($P < 0.05$) higher energy level than that of meat curry from spent male buffalo meat due to its higher protein and fat content. Meat from females had higher total calorie content than castrates and intact males [Johnson et al. 1995].

The water activity (a_w) of meat curry from young male and spent male buffaloes did not differ significantly. Likewise, there was no significant difference in water activity of spent male and female buffalo meat curry. But a_w of young male buffalo meat curry was significantly ($P < 0.05$) lower than a_w of spent female buffalo meat curry. As observed in the present study, the products in the vicinity of 0.92 a_w were preferred by the sensory panel [Leistner et al. 1981].

Quality comparison of buffalo meat curry stored at ambient (37 ±1°C) and refrigerated (4 ±1°C) storage

Physicochemical characteristics. Physicochemical characteristics of buffalo meat curry stored at ambient and refrigeration temperatures on day 3 are shown in Table 4. Storage of products at ambient temperature increased their pH than refrigeration temperature. The significantly ($P < 0.05$) higher pH observed in sample from spent females stored at 37 ±1°C could be attributed to the higher microbial load, especially TPC. It was well documented that increase in spoilage organisms could result in higher protein degradation and thereby production of amines from meat proteins, which in turn increase their pH [Frazier and Westhoff 1989, Lawrie 1998]. Similarly, a markedly higher pH was reported for ready-to-eat mutton curry stored at 27°C compared to those stored at 3°C [Himanish Das and Radhakrishna 2001]. TBARS values increased significantly ($P < 0.05$) in spent buffalo meat curry stored at ambient temperature compared to their refrigerated counterparts during 3 days storage. This could be attributed to the increased rate of lipid oxidation at higher storage temperature [Pearson and Gillet 1997], which was accelerated by the increased moisture loss from the products at higher storage temperature [Labuza et al. 1972]. It was also due to the higher microbial proliferation occurred in the samples stored at ambient temperature. A positive correlation between microbial load and TBARS values was reported in ground buffalo meat [Sahoo and Anjaneyulu 1997]. A similar observation was also reported in ready to eat mutton curry stored at 27°C and 3°C [Himanish Das and Radhakrishna 2001].

Table 4. Comparison of physicochemical and microbiological characteristics of buffalo meat curry at refrigerated (4 ±1°C) and ambient (37 ±1°C) storage on day 3

Parameters Groups	Storage period, days		
	4 ±1°C	37 ±1°C	t-value
pH			
young male	5.90 ±0.02	5.90 ±0.03	0.102
spent male	5.86 ±0.01	5.91 ±0.02	1.818
spent female	5.86 ±0.04	5.93 ±0.02	3.427*
TBARS value, mg of malonaldehyde per 1 kg			
young male	0.33 ±0.01	0.40 ±0.04	2.259
spent male	0.27 ±0.01	0.37 ±0.04	3.172*
spent female	0.28 ±0.01	0.43 ±0.07	2.563*
Total plate count, log cfu/g			
young male	1.23 ±0.08	2.93 ±0.23	9.037**
spent male	1.36 ±0.09	3.52 ±0.03	30.183**
spent female	1.68 ±0.17	3.10 ±0.12	8.133**
Staphylococcus aureus count, log cfu/g			
young male	1.28 ±0.06	2.26 ±0.40	2.399
spent male	1.00 ±0.01	3.44 ±0.15	16.743**
spent female	1.20 ±0.06	2.42 ±0.23	4.445**
Total anaerobic count, log cfu/g			
young male	ND	ND	
spent male	ND	ND	
spent female	ND	1.37 ±0.23	5.839**
Lactobacillus count, log cfu/g			
young male	ND	2.57 ±0.19	13.699**
spent male	ND	1.20 ±0.13	9.460**
spent female	ND	2.09 ±0.12	17.062**
Yeast and mold count, log cfu/g			
young male	1.26 ±0.16	1.00 ±0.01	1.581
spent male	1.00 ±0.01	ND	
spent female	1.00 ±0.01	1.00 ±0.01	

n = 6, *P < 0.05, **P < 0.01, ND – not detected.

Microbiological characteristics. Storage of buffalo meat curry at ambient storage for 3 days significantly ($P < 0.01$) increased the total plate count which was due to the multiplication of microbes [Lawrie 1998]. Similarly, a 5 log cfu/g increase in TPC, during 8 hours storage at 30°C was observed in minced sheep meat [Narasimha Rao and Ramesh 1988]. Coliforms were not noticed in any of the samples both at ambient and refrigerated storage. *Staphylococcus aureus* count of spent buffalo meat curry increased significantly ($P < 0.01$) during 3 days ambient storage compared to their refrigerated counterparts. Microbial spoilage of meat at higher temperatures was mainly due to the growth of mesophilic organisms such as *Staphylococcus aureus* and *E. coli* [Narasimha Rao and Ramesh 1988]. Total anaerobes and *Lactobacillus* count were not found in any of the 3 days refrigerated samples. Refrigeration storage for 3 days inhibited the growth of total anaerobes and *lactobacillus* count in buffalo meat curry. Anaerobes were found only in spent female buffalo meat curry at 3 days ambient storage. Whereas, the ambient stored buffalo meat curry had a significantly ($P < 0.01$) higher *lactobacillus* count. A significant increase in *lactobacillus* count was reported in cooked pork sausages at 10°C compared to 4°C [Pexara et al. 2002].

Sensory attributes. The appearance of spent female buffalo meat curry declined significantly ($P < 0.05$) during 3 days ambient storage compared to refrigerated storage (Table 5). It could be attributed partly to the concentration of meat pigments due

Table 5. Comparison of sensory attributes of buffalo meat curry at refrigerated (4 ±1°C) and ambient (37 ±1°C) storage on day 3

Parameters Groups	Storage period, days		
	4 ±1°C	37 ±1°C	t-value
1	2	3	4
Appearance			
young male	7.07 ±0.04	6.93 ±0.10	1.474
spent male	7.10 ±0.04	6.90 ±0.10	1.896
spent female	7.10 ±0.04	6.86 ±0.09	2.682*
Flavour			
young male	6.98 ±0.11	6.37 ±0.19	2.479*
spent male	6.88 ±0.06	6.33 ±0.15	3.18**
spent female	7.04 ±0.06	6.55 ±0.15	3.444**
Juiciness			
young male	7.05 ±0.06	6.56 ±0.16	2.851**
spent male	6.81 ±0.05	6.43 ±0.11	2.961**
spent female	6.88 ±0.03	6.67 ±0.10	2.045*
Tenderness			
young male	7.02 ±0.04	6.93 ±0.11	0.801
spent male	6.95 ±0.08	6.81 ±0.09	1.099
spent female	6.81 ±0.05	6.80 ±0.09	0.103

Table 5 – cont.

1	2	3	4
Connective tissue residue			
young male	7.07 ±0.04	7.07 ±0.04	0.00
spent male	6.93 ±0.06	6.79 ±0.09	1.606
spent female	6.81 ±0.05	6.68 ±0.12	0.896
Overall acceptability			
young male	6.98 ±0.08	6.44 ±0.20	2.401*
spent male	6.80 ±0.07	6.36 ±0.13	3.054**
spent female	6.89 ±0.10	6.64 ±0.15	1.369

n = 6, *P < 0.05, **P < 0.01.
*Based on 8 point descriptive scale.

to increased moisture loss and non-enzymatic browning resulted from the interaction between lipid oxidation products and amino acids at higher temperature [Che Man et al. 1995]. The flavour scores decreased significantly in all groups of ambient stored buffalo meat curry. The increased rate of lipid oxidation during ambient storage was attributed to a significant reduction in flavour scores. Flavour changes were higher in case of room temperature stored mutton curry compared to refrigerated product [Himanish Das and Radhakrishna 2001]. The juiciness scores decreased significantly in ambient stored buffalo meat curry compared to refrigeration storage. The decrease in moisture content of the curry during ambient storage resulted in lower juiciness scores. Tenderness and connective tissue residue scores did not differ significantly between ambient and refrigeration storage. The overall acceptability of curry prepared from young and spent male buffalo meat decreased significantly during 3 days ambient storage compared to refrigeration storage.

CONCLUSIONS

Scientific processing by adopting good manufacturing practices and suitable packaging helped greatly to improve the shelf life of the ambient temperature stored buffalo meat curry. Buffalo meat curry from young male group showed better product characteristics and overall acceptability scores than spent buffalo group. Ambient stored buffalo meat curry resulted in significant deterioration of quality parameters compared to the refrigeration storage.

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PORÓWNANIE JAKOŚCI WYROBÓW TYPU CURRY OTRZYMANYCH Z MIĘSA BAWOLEGO PRZECHOWYWANEGO W RÓŻNYCH TEMPERATURACH

Wstęp. Jakość wyrobów mięsnych typu curry zależy zarówno od jakości surowca mięsnego, jak i sposobu ich wyrobu. Nie istnieją wiarygodne informacje na temat wpływu rodzaju mięsa bawolego na jakość curry wyprodukowanego według metod tradycyjnych. Celem pracy było zbadanie tego wpływu i określenie trwałości analizowanych wyrobów.
Materiał i metody. Do produkcji curry używano mięsa uzyskanego z mięśnia *longissimus dorsi* pobranego z tusz bawołów zarówno młodych, jak i starszych (poprodukcyjnych), ubitych zgodnie z tradycyjną metodą halal. Curry wyprodukowano z wykorzystaniem standardowych receptur oraz poddano ocenie jakości i trwałości.
Wyniki. W celu oceny wpływu rodzaju mięsa i warunków przechowywania wyrobu badano: wydajność poprodukcyjną, wartość pH, skład podstawowy, aktywność wodną, wartość TBARS, wartości kaloryczne, jakość sensoryczną oraz czystość mikrobiologiczną. Wartość energetyczna wyrobów z mięs sztuk młodych była istotnie niższa niż ze sztuk starszych. Jakość konsumencka wyrobu przechowywanego przez trzy dni w temperaturze pokojowej była znacznie gorsza od prób przechowywanych w warunkach chłodniczych.
Wnioski. Zastosowanie nowoczesnych metod produkcji i pakowania w istotny sposób może poprawić trwałość curry otrzymywanego z mięsa bawolego. Produkt uzyskany z mięsa ze sztuk młodych charakteryzował się znacznie lepszą jakością niż otrzymany ze sztuk starszych.

Słowa kluczowe: mięso bawole, wyroby mięsne, curry, gulasz, technologia, jakość, trwałość

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