



The Quality Characteristics of Cold Cuts Processed from Beef and Buffalo Meat: A Comparative Study

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Abstract | The aim of the present study was to decide whether buffalo is appropriate for the production of various cold meat cuts and to compare the quality of these products to those formulated with beef. To achieve this goal, two cold meat cuts products (meatloaf and cooked roast meat) were processed from beef and buffalo meat using Good Manufacturing Practices and finally tested for sensory, chemical, and physicochemical quality attributes. The results showed that there were non-significant variations in sensory parameters between beef and buffalo products meanwhile the key distinctions were noted in color and tenderness, where beef products marginally outperforming those of buffalo. The chemical analysis showed that buffalo products had significantly lower moisture content and collagen solubility when compared to beef products. Moreover, buffalo cold cuts showed non-significant differences in pH and lightness (L^*) values, while an obvious increase in redness (a^*) and a decrease in yellowness (b^*) values in comparison to beef products.

Keywords | Buffalo, Beef, Cold cuts, Roast, Quality

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INTRODUCTION

The water buffaloes (*Bubalus bubalis*) have a total population of 204 million spreading worldwide in 129 countries. Around 198 million of them (97.0%) are reared in Asia, with India accounting for 54% of them, 3.50 million are in Africa, almost entirely in Egypt (3.4 million), 1.98 million in America, and 0.47 million in European countries. Moreover, the world production of buffalo meat is about 4.30 million tons of which 90% from Asia and 1% from African countries (FAO, 2021). Buffalo meat is rated healthier than beef due to its lower contents of fat and cholesterol (Kandeepan et al., 2009), in addition to its higher contents of protein (Naveena et al., 2004) and oleic fatty acid (Tamburrano et al., 2019), which considered one

of the most important fatty acid for the human body. Although buffalo meat is equivalent to beef in most of the physicochemical and organoleptic parameters (Anjaneyulu et al., 1990), it is rarely used primarily as table meat because most buffaloes are slaughtered when their useful working life has ended, resulting in poor meat quality characteristics (Naveena and Kiran, 2014), especially unacceptable toughness and darker color (Modi et al., 2004).

The reasonable domestic needs, the higher lean and lower fat as well as good binding properties (Kandeepan et al., 2009) make buffalo a potential source of good technological properties meat that has recently gained significance. Moreover, the rapid and continuous increase in the beef price, which is the basic raw material for manufacturing different meat products made many consumers unable to

purchase such products, especially in underdeveloped and developing countries, which prompted many meat processors to replace beef with the lower price buffalo meat. Buffalo meat is used to formulate sausages (Sachindra et al., 2005), meatloaves, dry-cured products (Anjaneyulu et al., 2007), and burgers patties (Suman and Sharma, 2003; Modi et al., 2004) with nearly the same organoleptic characteristics of beef but more acceptable color owing to the white color of the fat.

Because of changing consumer behavior, the Egyptian demand for processed meat products is rising. Therefore, understanding how the form of meat influences the manufacturing characteristics of the finished product is crucial for producing value-added items like meatloaf, and roasts. Although the majority of imported meat for processing comes from Indian buffalo, there were few studies on cold cuts processed from buffalo meat. Therefore, the current research was conducted to establish if the buffalo meat is suitable for the processing of cold cuts of quality comparable to those of beef.

MATERIAL AND METHODS

EXPERIMENTAL DESIGN

The strategy of the current study was to formulate corned meatloaf and cooked roast meat from both beef and buffalo meat. Three independent batches from both products were produced from buffalo meat to follow up their different quality attributes in comparison with those experimentally produced from beef. Immediately after processing, three samples from each product were withdrawn and subjected to sensory, chemical, and physicochemical analysis, where each test was performed three times for each sample.

MEAT AND ADDITIVES

Imported deep-frozen Brazillian (beef) and Indian (Buffalo) topsides and silversides were obtained from a local supplier in Cairo, Egypt within one month after its production. Moreover, sodium chloride, potato starch, and soy isolate were obtained from local distributors in Cairo, Egypt. Sodium nitrite, sodium tripolyphosphate, ascorbic acid, and spices oleoresins were provided from Loba Chemie (Mumbai, India).

PRODUCTION OF CORNED MEATLOAF

For the production of corned beef meatloaf, the frozen Brazillian topsides were completely thawed at 10°C and trimmed to remove its fat and connective tissue cover, and chopped to obtain 25 mm chunks. One-quarter of meat chunks were chopped in the bowl cutter with common salt, polyphosphates, nitrite, ascorbic acid, water, ice, and spices oleoresins for short time. After that, the rest of the meat chunks was added, mixed with soy isolate, potato starch to

not more than zero°C to form the meat batter. The prepared batter was tumbled for 6 hours, then filled in vacuum bag casing, pressed in rectangular former to form its shape, and cooked using a humid cooking program at 95°C room temperature to 73°C core temperature followed by dry cooking for 3 min. The product was then cooled, hanged in nets, dried at 60°C for 30 minutes, smoked for 15 minutes at 65°C. After smoking, the product was cooled and kept at 4°C. Another batch was formulated following the same procedures except that using frozen Indian topsides for the production of corned buffalo meatloaf.

PRODUCTION OF COOKED ROAST MEAT

The cooked roast beef was prepared by injection of thawed Brazilian silverside meat blocks with about 20% of its weight with the previously prepared brine (cold water, 1.5% common salt, 0.05% injectable polyphosphates, 1% injectable soy isolate, 150 ppm sodium nitrite, 5000 ppm ascorbic acid, quantum sufficient of spice oleoresins) following the Good Manufacturing Practices Guidelines using a multi-needle brine injector machine. Each meat block was injected four times with the brine solution. Injected meat blocks were tumbled for 8 hours and finally cooked. The cooking program started with dry cooking for 45 minutes at 65°C, smoking for 15 minutes at 65°C, dry cooking for 3 minutes at 70°C, steam cooking till 73°C core temperature, and finally dry cooking for 15 minutes at 80°C. After that. The cooked roast meat was cooled and stored at 4°C. At the same time of this experiment, Indian silverside meat blocks were used and prepared following the same procedures for the production of Cooked roast buffalo meat.

INVESTIGATIONS

Sensory evaluation: Shortly before the sensory analysis, 15 staff members of the Department of the Food Hygiene in the Cairo University received several training sessions to be familiar with the investigated sensory parameters specified for each product. All samples were randomly coded and the panelists scored each sample using an 8-point hedonic scale (AMSA, 2015).

CHEMICAL ANALYSIS

Proximate chemical analysis: Each Sample (about 3 kg) was minced using a 5 mm mincing plate, mixed thoroughly, and finally rendered into a uniform mass. The moisture percentage was determined by hot air drying of the sample at 100°C to obtain a constant weight. A 6.25 constant factor and the nitrogen content determined by the micro-Kjeldahl method were used to obtain the total protein content. The fat was extracted using an ether/petroleum ether mixture and the Soxhlet method. A 5 grams sample was ignited at 500°C for 5 hours to determine the ash percent (AOAC, 2005).

Measurement of collagen content and solubility: Two g from each replicate were dissolved completely in 40 ml of 6 N HCL at 105°C for 18 hours. After homogenization, the sample was filtered and adjusted to 50 ml with distilled water. The pH of the filtrate was adjusted to 7.0. One ml of the filtrate was mixed with 0.001 M copper sulfate, 2.5 N NaOH, and 6% H₂SO₄ (1 ml each), then incubated for 5 minutes at room temperature, then water bath heated at 80°C for 5 minutes. After cooling in an ice bath, 4 ml of 3N H₂SO₄ and 5% 4-Dimethylaminobenzaldehyde in n-propanol (2%) were mixed and heated in a water bath for 16 minutes at 70°C. The absorbance of the sample was measured at 540 nm (Mahendrakar et al., 1988). The total collagen (g%) was calculated using the hydroxyproline standard curve (Woessner, 1961).

For the determination of collagen solubility, 5g from each replicate were boiled for 30 min. The sample was macerated with 50 ml distilled water for 2 min, centrifuged (1500 rpm/ 30 min.), and hydrolyzed in 40 ml of 6 N HCL at 105°C for 18 hours. After that, the same procedures used for the measurement of total collagen content were performed for the determination of soluble collagen content (g%). Collagen solubility percentage was expressed as the percent of collagen solubility to collagen content (Naewbanij et al., 1983).

PHYSICOCHEMICAL ANALYSIS

pH value: The pH was assayed by Lovibond Senso Direct digital pH-meter equipped with Senso Direct (Type 330) probe-type electrode calibrated every two samples using 7.0 and 4.0. buffers. Five g sample from each replicate was mixed with 20 ml distilled water at the low speed for 1 min, and 3 reading were obtained and the mean pH-value estimated.

Shear force measurement: Nine portions of 2×2×2 cm from each replicate were cored (0.5 inches) parallel with the sliced surface, hooked to an Instron model 2519-105 (USA) to evaluate the shear force. The crosshead speed of the shear device was calibrated at 200 mm/minutes.

Color evaluation: Before instrumental color evaluation, A Konica Minolta Chromameter (CR 410, Japan) was calibrated for light source index set using a white plate and light trap. The average score for each sample was recorded in Hunter value (lightness, redness, yellowness).

STATISTICAL ANALYSIS

Each analysis was run in three replicates, and collected data were statistically analyzed by T-test procedures using SPSS 23.0 for windows. Results were recorded as mean ± SE, and the least significant (LSD) at P< 0.05 was performed to compare the differences between the mean val-

ues of cold cuts processed by beef and buffalo meat.

RESULTS AND DISCUSSION

The color scores for both buffalo loaf and roast were lower than beef products. Moreover, buffalo loaf had lower tenderness and overall acceptability scores than beef products. The other sensory panel scores indicated that processing of corned meatloaf and cooked roast by buffalo meat resulted in non-significant (P>0.05) differences in most of the examined sensory parameters when compared with beef (Table 1 and 2). The lower color scores of buffalo products may be related to the physiological dark color of buffalo meat, which may be originated from its higher myoglobin content (Kandeepan et al., 2013). The lower-fat (Kandeepan et al., 2009) and higher connective tissue (Naveena et al., 2004) contents of buffalo meat are considered the main causes of lower tenderness scores of buffalo products. In general, most buffaloes in different countries were slaughtered at an advanced age (8-10 years) when their working life ended (Naveena and Kiran, 2014), which leads to tough meat due to the inactivation of μ -calpain (Morgan et al., 1993) and dark color due to increase in myoglobin concentration in old animal (Modi et al., 2004).

The proximate chemical composition showed that cold cuts processed from buffalo meat had significantly lower moisture content, with non-significant changes in protein, fat, and ash contents as compared with beef (Table 3), indicating the close similarity of both types of meat. Anjaneyulu et al. (2007) reported that chemical, physical, nutritional and organoleptic properties of buffalo meat were comparable with beef, particularly when slaughtered at the same age. Proximate chemical analyses were fixed with the sensory examination (Table 1 and 2), where the cold cuts processed from both beef and buffalo showed nearly identical sensory panel scores with lower tenderness in buffalo cold cuts, which may be resulted from the lower moisture and fat contents of buffalo meat. Moisture and fat results were in harmony with those reported by Alkhanky (2015) who found that the moisture content was significantly lower, while fat content non-significantly differed in buffalo meat than those of beef. Moreover, Spanghero et al. (2004) reported non-significantly differences in ash content in both beef and buffalo meat. On the contrary, the protein data of this study were in disagreement with Aziz et al. (2012) and Kandeepan et al. (2013) who established that buffalo meat contained higher protein content than beef. Moreover, the lower protein content of buffalo meat was reported by Alkhanky (2015).

The results of the chemical analysis also showed non-significant differences in both collagen content and solubility among beef and buffalo loaves (Table 3). Moreover, the

Table 1: Sensory analysis of beef and buffalo corned meatloaf

| | Beef | Buffalo |
|-----------------------|------------------------|------------------------|
| Color | 6.00±0.30 ^a | 5.17±0.58 ^b |
| Flavor | 6.00±0.03 ^a | 6.00±0.58 ^a |
| Juiciness | 5.67±0.05 ^a | 5.33±0.58 ^a |
| Tenderness | 6.67±0.30 ^a | 5.33±0.67 ^b |
| Binding | 6.00±0.58 ^a | 6.00±0.06 ^a |
| Overall Acceptability | 6.07±0.15 ^a | 5.57±0.43 ^b |

^{a-b}: Means with different letters for each product are significantly different at p-value ≤ 0.05.

Table 2: Sensory analysis of beef and buffalo cooked roast

| | Beef | Buffalo |
|-----------------------|------------------------|------------------------|
| Cured color | 6.33±0.33 ^a | 5.67±0.33 ^b |
| Color uniformity | 6.67±0.33 ^a | 6.33±0.33 ^a |
| Flavor | 7.00±0.10 ^a | 6.67±0.33 ^a |
| Juiciness | 7.00±0.20 ^a | 6.33±0.33 ^a |
| Tenderness | 7.00±0.22 ^a | 7.00±0.33 ^a |
| Overall Acceptability | 6.80±0.12 ^a | 6.40±0.12 ^a |

^{a-b}: Means with different letters for each product are significantly different at p-value ≤ 0.05.

Table 3: Proximate chemical and physicochemical parameters of beef and buffalo cold cuts

| | Corned meatloaf | | Cooked roast | |
|-----------------------|-------------------------|--------------------------|-------------------------|-------------------------|
| | Beef | Buffalo | Beef | Buffalo |
| Moisture% | 70.70±0.06 ^a | 69.61±0.69 ^b | 72.56±1.70 ^a | 71.81±1.41 ^b |
| Protein% | 16.22±0.08 ^a | 16.72±0.28 ^a | 18.75±0.58 ^a | 16.98±0.56 ^a |
| Fat% | 5.45±0.10 ^a | 5.26±0.78 ^a | 3.88±1.38 ^a | 3.30±1.38 ^a |
| Ash% | 3.18±0.04 ^a | 3.16±0.20 ^a | 3.70±0.04 ^a | 3.66±0.17 ^a |
| Collagen content% | 0.55±0.33 ^a | 0.76±0.07 ^a | 2.06±0.02 ^a | 2.17±0.06 ^a |
| Collagen solubility | 0.46±0.28 ^a | 0.29±0.09 ^a | 1.52±0.01 ^a | 0.06±0.03 ^b |
| Collagen solubility % | 83.64±6.80 ^a | 38.16±12.83 ^b | 73.79±0.18 ^b | 2.76±1.25 ^a |
| pH | 6.57±0.03 ^a | 6.62±0.01 ^a | 6.20±0.01 ^a | 6.40±0.01 ^b |
| Shear force | 6.25±0.000 ^a | 7.25±0.375 ^b | 7.07±0.061 ^a | 9.29±0.01 ^b |
| Lightness L* | 42.90±0.01 ^a | 43.08±0.35 ^a | 45.36±4.84 ^a | 46.38±1.73 ^a |
| Redness a* | 20.77±0.02 ^a | 23.64±1.05 ^b | 15.02±0.15 ^a | 16.30±0.07 ^b |
| Yellowness b* | 11.77±0.01 ^a | 10.91±0.081 ^b | 16.21±2.09 ^a | 15.63±2.72 ^a |

^{a-b}: Means with different letters for each product are significantly different at p-value ≤ 0.05.

cooked roast processed with buffalo meat showed non-significant elevation in the collagen content with significant reduction in collagen solubility compared to beef. The data also showed that the collagen solubility % was significantly lower in buffalo cold cuts than beef products. Collagen is a predominant connective tissue protein responsible for meat toughness (Swan et al., 1995), while soluble collagen is responsible for the tenderness of meat and meat products (Kandeepan et al., 2013). These facts act as other causes for increasing the toughness by using buffalo meat in the formulation of meat products. Comparable data were recorded by Robertson et al. (1986), Naveena et al. (2004), and Moon (2006), however; Kandeepan et al. (2009) re-

corded higher collagen solubility in buffalo meat.

Data of pH measurement revealed that buffalo cooked roast had a significantly higher mean pH value than beef product, however, non-significant differences were reported among beef and buffalo corned loaves (Table 3). Variations in pH values of both products may be due to the difference in pH values between beef and buffalo meat used in their formulations. It has been reported that the pH of buffalo meat declined slower than that of beef after 40 min postmortem, where pH values of buffalo meat and beef were 6.70 and 6.40, respectively. Moreover, beef reached to ultimate pH of 5.8 after 24 hours, while buffalo

meat reached the same pH value after 48 hours postmortem (Neath et al., 2007). This finding may be related to the physiological feature of buffalo meat, where buffalo meat is usually covered with a thick fat layer, which keeps the temperature of meat high for a long time after slaughtering resulting in slower pH decline (Koochmaria et al., 1988).

Formulation of meatloaf and cooked roast by buffalo meat resulted in a significant increase in the mean shear force values in comparison with beef (Table 3). Higher shear values of buffalo cold cuts may be due to their higher collagen content and lower collagen solubility percentage was presented in Table 3. Moreover, the higher myofibrillar protein content (Aberle et al., 2001), thicker muscle diameter, and shorter sarcomere length (Nuraini et al., 2014) of buffalo meat than beef are potent reasons for increasing the shear force and decreasing the tenderness values of buffalo products. Similar results were obtained by Moon (2006) and Failla et al. (2007), however; high shear values were reported in beef (Neath et al., 2007).

Instrumental color evaluation of cold cuts clarified the presence of non-significant variations in lightness (L^*) values of cold cuts processed by both beef and buffalo meat, moreover; the yellowness (b^*) value was non-significantly lower in buffalo roast than in beef (Table 3). The buffalo loaf showed a significant lower yellowness (b^*) value than the beef loaf. Also, the redness (a^*) values were significantly higher in both products prepared from buffalo meat. Differences in color parameters of beef and buffalo cold cuts may be due to the variation in muscle fiber diameter, pH value, total pigment, and myoglobin contents among two meat species (Robertson et al., 1983; Kandeepan et al., 2013). Previous data reported that the thin muscle fibers reflected less light than the thick fibers (Robertson et al., 1983) so; the lightness (L^*) values of buffalo products were slightly higher than those of beef products. Moreover, the slightly higher pH value and the greater myoglobin content of buffalo meat rendered the buffalo products darker than beef products, where there was a positive correlation between these parameters and redness (a^*) of meat (Ilavarasan et al., 2016). Although, the previous studies reported higher yellowness (b^*) value for buffalo meat than that of beef due to its higher concentrations of polyunsaturated fatty acids and iron (Zicarelli et al., 2005) as well as the presence of compounds of net negative charges at certain particular situations in the amino acids of buffalo myoglobin (19 in helix A and 117 in helix G) that differ than beef (Dosi et al., 2006), lower yellowness (b^*) values of buffalo cold cuts were reported in this study. Lower yellowness (b^*) values of buffalo cold cuts may be explained by the higher amount of oleic acid of buffalo meat, which has antimicrobial and antioxidant properties

CONCLUSION

From the obtained results it could be concluded that buffalo cold cuts were similar to beef in almost all of their sensory, chemical, physicochemical, and technological properties, however; the higher collagen content, darker color, and toughness of buffalo cold cuts were the main problems noted in this study. Therefore, we recommended using buffalo meat in the processing of cold cuts to obtain the health benefits of this meat but the addition of aging agents and color modifiers during the processing of these products is necessary to be investigated for the production of high-quality products with good consumer acceptance.

AUTHOR'S CONTRIBUTION

All authors contributed equally in creating the article.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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