

COMPARING THE PHYSICO-CHEMICAL CHARACTERISTICS AND SENSORY ATTRIBUTES OF IMPORTED BRAZILIAN BEEF MEAT AND IMPORTED INDIAN BUFFALO MEAT

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doi: 10.15414/jmbfs.2018.8.1.672-677

ARTICLE INFO

Received 23. 4. 2018
Revised 17. 6. 2018
Accepted 18. 6. 2018
Published 1. 8. 2018

Regular article



ABSTRACT

The main objective of the current study was to compare the physico-chemical characteristics and sensory attributes of imported Brazilian beef meat and imported Indian buffalo meat. Chuck samples were collected and examined for proximate chemical composition, soluble proteins, pH, TVB-N, TBA, color, shear force, fatty acid profile and sensory attributes. The results revealed higher total protein, fat, total soluble protein and lower collagen solubility of imported frozen Indian buffalo meat chuck samples. However, there is non-significant difference in pH, TVB-N, TBA, fatty acid profile. Sensory attributes indicated significantly higher appearance, tenderness and juiciness scores for imported Brazilian beef meat. Moreover, the significant decreasing shear force, a^* and significant increasing L^* values were observed in imported frozen Brazilian meat chuck samples. These attributes can make Indian buffalo meat a good choice for meat processing after Brazilian beef meat. Moreover, these results will help meat processors to find an alternative source for raw meat materials for production of high quality meat products.

Keywords: Imported Brazilian meat, Imported Indian meat, technological properties, sensory

INTRODUCTION

Native breeds of cattle represent the main source of high quality meat for Egyptians due to their considerable contents of proteins, essential amino acids, vitamins and iron. However, the continuous increasing of the prices of these meat in recent years in Egypt, due to slow growth in domestic meat production, resulted in rapid increase in the demand for meat to satisfy the daily need of consumers. It has been reported that the demand of people for red meat was doubly increased as result of the crises of avian influenza which widely spread all over the world (Badawi, 2008).

Currently, Egypt is facing a great problem of how to provide adequate supplies of meat and how to overcome increasing the prices of local meat. With current low meat production, meat importation is the main option to bridge the gap between the consumption and domestic supply. Imported frozen meat is considered a great source of meat which have become accepted and consumed all over the Arabic World. Egypt is considered one of the main countries which depend mainly on importation of frozen meat (Abdelaziz *et al.*, 2017).

Egypt imports great amounts of frozen meat every year from different countries not only to reflect their consumer's local needs but also importation of meat was formed as a main part of the process of greater harmonization of trade in our market (Al-Sabagh *et al.*, 2016). Moreover, the meat processing industries require consistent supplies of high quality meat as basic ingredients and this demand cannot be met locally and they are totally reliant on imported meat. The amount of imported frozen beef in Egypt reaches about 138670 tons and buffalo meat is 88322 tons (GOVS, 2017).

The key suppliers of frozen meat in 2015 were Brazil, India, Sudan, United States and Australia. Brazil is the dominant supplier of the frozen beef while India is the sole supplier of frozen buffalo meat. It is estimated that 80% of the Brazilian herd consists of Zebu (*Bos indicus*) breeds (ABIEC, 2014; USDA, 2014; Aroeira *et al.* 2016). India is the largest buffalo meat producer (1.48 million MT) and exporter (0.343 million tons) in the world (FAO, 2004). In 2016, the frozen meat imports have totaled 301,244 MT (million ton), of which 101,044 MT or 33 percent are frozen buffalo meat from India, while 196,934 MT are frozen bovine meat mainly from Brazil.

In the recent years, there has been a tendency for consuming meat products among the Egyptian consumers due to continuous changes in the life style. Moreover, with the high cost of meat and the demand of a growing population, the technological developments in meat processing has given consumers a much greater choice over the food they can buy (Vernam and Sutherland, 1995).

Meat processing in Egypt depends mainly on the imported frozen meat to save local meat as a table meat. Therefore, it is important to choose the most suitable meat of high quality to enable meat industry to produce high quality meat products. To the best of our knowledge, the study of technological, nutritional and sensory characteristics of frozen meat obtained from different sources still limited. Therefore, the objective of the current research was to study the technological properties, nutritional quality and sensory characteristics of imported beef and buffalo. This study may help meat processors in different countries to choose the best meat to be imported and used as a raw material for processing of different meat products.

MATERIAL AND METHODS

Preparation of meat samples

Samples of imported frozen chucks of Brazilian beef and Indian buffalo within the first third of their shelf life were obtained from different meat stores in Cairo, Egypt. Each sample (*Longissimus dorsi*) was represented by 3 blocks (2 kg each). The samples were transferred immediately in cooling ice box to the laboratory of Food Hygiene Department, Faculty of Veterinary Medicine, Cairo University. In the laboratory the external fat and connective tissue of each block were dissected and each block was prepared for estimation of proximate chemical composition, soluble proteins, pH, TVB-N, TBA, color, shear force, fatty acid profile and sensory attributes. The values of these parameters represent the mean of 3 independent replicates.

Investigations

Proximate analysis

Moisture, protein, fat and ash contents were determined according to the method of AOAC (2000). For determination of moisture contents (g/100g), 3 g of sample were dried at 100 °C until constant weight was obtained. Protein content (g/100g) was determined according to the Kjeldahl method of analysis. For conversion of nitrogen into crude protein, a factor 6.25 was used. Fat (g/100g) was determined by 6-cycle extraction with petroleum ether in a Soxhlet apparatus and calculating the weight loss. Ash was determined by ignition at 500 °C for 5 h (g/100g).

Measurement of soluble proteins

Collagen solubility

Collagen solubility was calculated according to the method described by **Naewbanij et al. (1983)** by heating 5 g from these samples to boiling temperature and holding them for 30 min. The cooked meat was then cut into small pieces and homogenized with 50 ml distilled water at 4 ± 1 °C in a blender for 2 min. The extract was then centrifuged (MLW T5, GRD) at 4500 rpm for 30 min. Aliquots of cooked out juice and centrifugate were hydrolyzed for 18 h. and soluble hydroxyproline was calculated.

Sarcoplasmic proteins, total and myofibrillar proteins solubility

Sarcoplasmic protein solubility was determined according to the method described by (**Joo et al., 1999**) through homogenizing one gram from each imported frozen Brazilian beef and Indian buffalo meat chuck samples in 10ml of ice-cold 25 mmol/l potassium phosphate buffer (pH 7.2) using a stomacher (Lab blender 400) at the lowest setting. Homogenate was left to stand in a shaking water bath (GFL-1083, Germany) at 4 ± 1 °C overnight. The mixture was then centrifuged at 4500 rpm for 20 minutes and the protein concentration of the supernatant was determined using Kjeldahl method (**Tyszkiewicz and Klossowska, 1997**).

Total soluble proteins were determined by homogenizing one gram from each chuck meat samples in 20 ml ice-cold 1.1 mol/l potassium iodide in a 100 mol/L phosphate buffer (pH 7.2). The procedures for homogenization, shaking, centrifugation, and protein determination were the same as described for sarcoplasmic protein. Myofibrillar proteins were obtained by calculating the difference between total and sarcoplasmic protein.

pH, total volatile base nitrogen (TVB-N) and thiobarbituric acid (TBA) values

For measurement of pH value, five grams of each chuck meat sample was homogenized with 20 ml distilled water for 10–15 s (**Kandeepan, et al., 2009**). The pH was measured using a pH meter (Lovibond Senso Direct) with a probe type electrode (Senso Direct Type 330) which was calibrated every two samples using two buffers 7.0 and 4.0. The Total Volatile Base Nitrogen (TVB-N, mg/100g sample) was measured according to the method of **Keasley et al. (1983)** using a macro-Kjeldahl distillation method. Moreover, the thiobarbituric acid (TBA) value was measured by the method outlined by **Du and Ahn (2002)** and expressed as milligrams of malondialdehyde per kilogram of sample.

Color evaluation and measurement of shear force

Croma meter (Konica Minolta, model CR 410, Japan) has been used to measure the color of the examined chuck meat samples. The apparatus was calibrated using a white plate and light trap supplied by the manufacturer. The L* (lightness), a* (redness), and b* (yellowness) values were obtained using CIE standard illuminant D₆₅ light source. From each sample surface, three measurements were taken at each time. The average score of triplicate experiments was recorded, and expressed as CIE lightness (L*), redness (a*), and yellowness (b*) (**Shin et al., 2008**).

From each cooked meat block, four samples (1x 1x1 cm) were cut parallel to the longitudinal orientation of muscle fibers, and the shear force was estimated by Instron Universal Testing Machine (Model 2519-105, USA). The shear force machine was adjusted at crosshead speed of 200 mm/min. An average shear force value was calculated and recorded for each sample (**Shackelford et al., 2004**).

Fatty acid profile

The total lipids from each of the examined chuck meat samples were extracted (in duplicate) with hexane at 1:50 (wt/vol) ratio in each extraction operation (**Romero et al., 1998**). The fatty acids content of each sample were extracted according to **Folch et al. (1957)**. Lipid extracts of each sample were saponified for 30 min. at 60°C with 40 ml/g 0.5 N NaOH in methanol and then methylated with boron trifluoride-methanol complex to achieve complete conversion to methyl esters (**IUPAC, 1987**). The resultant fatty acid methyl esters were separated and analyzed by means of an automated gas liquid chromatograph equipped with a 1.8 m×3.2mm stainless steel column packed in GP 10% sp 2330 on 100/200 Chromosorb WAW. The samples were chromatographed in a temperature gradient of 110- 210°C. The flow rate of the carrier gas (nitrogen) was 22 ml/min. To each sample, a known amount of an internal standard (methyl laurate) was added. A standard of known composition was analyzed to verify the identity of the fatty acids in the samples. Fatty acid peaks determined by gas chromatography were then used to calculate amounts of fatty acids (g/100g FAME) according to calculations described by **Slover and Lanza (1979)**.

Sensory evaluation and cooking loss

Meat chunks samples were wrapped with aluminum foil and cooked using hot air oven (Heraeus, D-63450 Hanau, Germany) at 180°C. After chunks were exited in the cooking device, a needle thermocouple probe was inserted into the geometric center of the chunks and post-cooking temperature rise was monitored with previously calibrated hand-held thermometer (Hanna HI 985091-1, USA), to achieve a final core temperature of 70 °C. Cooking loss percentage for each samples were calculated from the difference of weight before and after cooking. Prior to analysis, panelists from Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University were trained in the definition and intensities of different sensory attributes of imported frozen Brazilian beef and Indian buffalo meat. Cooked samples were coded with random numbers and evaluated by 5 well trained panelists. The panelists were asked to score each sample for appearance, flavor, tenderness, juiciness and overall acceptability using 8-points numerical scores with 8- being highly desirable and 1 being highly undesirable (**AMSA, 1995**).

Statistical analysis

Statistical analysis for data was carried out using SPSS statistics 17.0 for windows. Data of proximate chemical composition, sensory evaluation, deterioration criteria, soluble proteins, shear force and colour values (L*, a* and b*) of imported frozen Brazilian beef and imported frozen Indian buffalo were analyzed using Paired-samples T test to compare results between the two different types of meat. Significances were determined using least square difference test (LSD) procedure. Differences were considered significant at the $P < 0.05$ level.

RESULTS AND DISCUSSION

Proximate chemical analysis

The results of proximate chemical composition revealed significantly ($P < 0.05$) higher moisture contents and significantly ($P < 0.05$) lower protein and fat contents in imported frozen Brazilian beef chuck meat when compared with the frozen Indian buffalo chuck meat samples. However, the ash content of imported frozen Brazilian meat chuck samples were not significantly ($P > 0.05$) different from that of imported frozen Indian meat chuck samples (Table 1). The results of moisture contents was not in agreement with **Lapitan et al. (2008)** and **Aziz et al. (2012)** who reported non-significant difference of moisture content between cattle and buffalo meat. Lower moisture contents for Indian frozen buffalo meat was observed by **Brackebusche et al. (1991)** and **Alkhanky (2015)**. The obtained data for protein contents were in good agreement with **Lapitan et al. (2008)**, **Aziz et al. (2012)** and **Kandeepan et al. (2013)** who reported higher protein contents of buffalo meat in comparison with beef meat. However, lower protein contents for imported buffalo meat was recorded by **Brackebusche et al. (1991)** and **Alkhanky (2015)**. The data of fat contents were not in agreement with **Aziz et al. (2012)** who reported lower fat contents for buffalo meat in comparison with beef meat and **Brackebusche et al. (1991)** and **Alkhanky (2015)** who observed non-significant change in fat contents between buffalo and beef meat. Moreover, the data for ash contents were in agreement with **Spanghero et al. (2004)** who observed non-significant difference in ash contents between buffalo and beef. However, lower ash contents in buffalo meat was observed by **Aziz et al. (2012)**.

Soluble proteins

The collagen solubility of imported frozen Brazilian beef meat chuck samples were significantly ($P < 0.05$) higher than that of Indian buffalo meat chuck samples (Table 2). These results were in good agreement with **Naveena et al. (2004)** and **Moon (2006)**. Lower collagen solubility values of beef were recorded by **Koohmarae et al. (1991)** and **Sullivan and Calkins (2010)**. However, higher collagen solubility for Indian male buffalo was observed by **Kandeepan et al. (2009)**. The total soluble proteins, sarcoplasmic soluble proteins and myofibrillar soluble proteins of Indian buffalo meat chuck samples revealed non-significant ($P > 0.05$) higher when compared with those of imported frozen Brazilian beef meat chuck samples (Table 2). **Naveena et al. (2004)** reported that the total soluble protein, sarcoplasmic soluble protein and myofibrillar soluble protein of Indian buffalo meat were 8.12, 1.91 and 6.21 g/100g, respectively which, were higher than the values obtained in this study. The soluble fraction of collagen present in meat is responsible for the extent of tenderness of the product and meat with higher salt soluble protein can retain more water to improve the cohesiveness and binding strength of the product during processing (**Swan and Boles, 2006**). Therefore, it can be expected that meat products processed from imported frozen Brazilian beef meat chuck will be tenderer and the meat products

processed from imported frozen Indian buffalo meat will show improved cohesiveness and binding strength of processed products.

Deterioration criteria

The obtained data of deterioration criteria showed non-significant ($P > 0.05$) difference in pH, TVB-N and TBA values of imported frozen Brazilian beef and Indian buffalo meat chuck samples (Table 3). A significantly ($P < 0.05$) higher pH values for imported frozen Brazilian beef were reported by **Mohamed (2017)** when compared with Indian buffalo meat samples and the author attributed these results to many inherent and exogenous factors including genetics, age, sex, diet, pre/post-slaughter handling and microbiota (**Mach et al., 2008**). A non-significant ($P > 0.05$) differences in TVB-N values of imported frozen Brazilian beef and Indian buffalo meat samples were recorded by **Ebrahim et al. (2011)** and **Mohamed (2017)**. A non-significant ($P > 0.05$) differences in TBARS values of imported frozen Brazilian beef and Indian buffalo meat samples were observed by **Mohamed (2017)** and **Ghazalah (2013)**. However, higher TBA values for buffalo meat in comparison with beef were obtained by **Ficco et al. (2010)**.

Color and shear force values

Imported frozen Brazilian beef meat chuck samples revealed significantly ($P < 0.05$) higher L^* values, significantly ($P < 0.05$) lower a^* values and non-significantly ($P > 0.05$) different b^* values when compared with imported frozen Indian buffalo meat chuck samples (Table 4). These observations were not in agreement with **Ficco et al. (2010)** who recorded higher L^* values, lower a^* values and lower b^* values for buffalo meat when compared with those of beef meat. The higher a^* values for imported frozen Indian buffalo meat samples may be attributed to its higher sarcoplasmic soluble protein contents which, contribute to the colour of meat.

Imported frozen Brazilian beef meat chuck samples revealed significantly ($P < 0.05$) lower shear force values in comparison with those of imported frozen Indian buffalo meat chuck samples (Table 4). These results were in agreement with **Moon (2006)** and **Failla et al. (2007)** who recorded non-significant difference in shear values of beef and buffalo *Longissimus thoracis*. However, they were not in agreement with those of **Neath et al. (2007)** who observed significantly lower shear force values for buffalo meat when compared with beef. A shear force value of 4 Kgf for Indian buffalo meat was recorded by **Naveena et al. (2004)** which, was lower than that obtained in this study. The higher shear force values for Indian buffalo meat may be explained by the lower collagen solubility. It has been also stated that the connective tissue in the buffalo meat had a higher contribution to toughness of that meat (**Robertson et al., 1986**).

Fatty acid profile

The results of Fatty acid profile revealed non-significant ($P > 0.05$) differences between imported frozen Brazilian beef and Indian buffalo meat chuck samples for all fatty acids except C14:0 which was significantly ($P < 0.05$) higher in imported frozen Brazilian beef chuck samples. Moreover, there were no significant ($P > 0.05$) difference in total saturated, total unsaturated and trans

fatty acids between imported frozen Brazilian beef and Indian buffalo meat chuck samples (Table 5). Previously, **Mendoza et al. (2015)** recorded significant ($P < 0.05$) higher values for C17:0, C18:0, C20:0, C22:0, C24:0, C17:1 trans, C18:1 trans (elaidic), C20:1 cis, C20:2 cis ω 6, C20:3 cis ω 6, C20:4 ω 6 and C20:5 cis ω 3 in Buffalo's intramuscular lipids of longissimus thoracis muscle when compared with those of Brahman beef. However, Brahman revealed significant ($P < 0.05$) higher values for C14:0, C15:0, C16:1 trans, C20:3 cis ω 3 and C22:4 ω 6. It has been reported that the main saturated fatty acids present in beef intramuscular fat are palmitic (C16:0) and stearic acid (C18:0) (**Frank et al., 2016; Hwang and Joo, 2017**). Moreover, beef intramuscular fat showed a higher overall concentration of mono unsaturated fatty acids, especially oleic acid (C18:1 n-9) as well as polyunsaturated fatty acids (**Joo et al., 2017**). Meanwhile, Palmitic, stearic, oleic and linoleic acids were the most predominant fatty acids in the phospholipids of buffalo meat (**Kesava and Kowale, 1991**).

Sensory evaluation

The appearance, tenderness and juiciness scores of imported frozen Brazilian beef were significantly ($P < 0.05$) higher than those of Indian buffalo meat. However, the flavor and overall acceptability scores of imported frozen Brazilian beef were not significantly ($P > 0.05$) higher than those of imported frozen Indian buffalo meat chuck samples (Table 6). It has been reported by **Ghazalah (2013)** that the odour and texture scores of imported frozen Brazilian and Indian meat were not significantly ($P > 0.05$) different. Meanwhile, **Saleh et al. (2016)** observed that the tenderness scores of Brazilian beef meat were significantly ($P < 0.05$) higher than those of Indian buffalo meat. **Spanghero et al. (2004)** reported that the overall acceptability of raw buffalo and bovine meat were not significantly different, however, tenderness of beef was perceived to be significantly better than buffalo.

The lower scores for appearance in imported buffalo meat may be attributed to the darker color of this meat. This was in agreement with **Kandeepan et al. (2013)** who observed that the major features of buffalo meat were its dark red colour, good marbling, low connective tissue and the desirable texture. The darker color which has been observed in imported frozen Indian buffalo chuck meat may be attributed to the higher soluble sarcoplasmic protein content in this meat. The lower scores for tenderness and juiciness of buffalo meat may be attributed to the significantly ($P > 0.05$) higher cooking loss percentage when it was compared with that of Brazilian beef meat (Table 6). This was in good agreement with **Uriyapongson (2007)** who observed that meat from buffalo was more tougher and less juicy than beef.

Table 1 Proximate chemical composition of Brazilian and Indian chuck meat samples

Proximate chemical composition	Moisture (g/100g)	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)
Brazilian beef meat	70.54 ^a ± 0.35	22.04 ^a ± 0.38	5.85 ^a ± 0.12	1.45 ^a ± 0.08
Indian buffalo meat	66.46 ^b ± 0.34	24.39 ^b ± 0.34	7.33 ^b ± 0.24	1.61 ^a ± 0.09

^{a-b} Means with different superscripts within the same column are significantly ($P < 0.05$) different.
 * Values represent the mean of 3 independent replicates ± SE

Table 2 Soluble proteins of Brazilian and Indian chuck meat samples

Soluble proteins	Collagen solubility (g/100g)	Total soluble protein (g/100g)	Sarcoplasmic soluble protein (g/100g)	Myofibrillar soluble protein (g/100g)
Brazilian beef meat	0.07 ^a ± 0.01	7.34 ^a ± 0.41	4.57 ^a ± 0.26	2.77 ^a ± 0.25
Indian buffalo meat	0.04 ^b ± 0.00	7.75 ^a ± 0.33	4.61 ^a ± 0.26	3.15 ^a ± 0.36

^{a-b} Means with different superscripts within the same column are significantly ($P < 0.05$) different.
 * Values represent the mean of 3 independent replicates ± SE

Table 3 Deterioration criteria of Brazilian and Indian chuck meat samples

Deterioration criteria	pH	TVB-N (mg/100g)	TBA (mg/kg)
Brazilian beef meat	5.88 ^a ±0.07	9.54 ^a ±0.55	0.43 ^a ±0.06
Indian buffalo meat	5.87 ^a ±0.07	9.55 ^a ±0.44	0.47 ^a ±0.07

^{a-b} Means with different superscripts within the same column are significantly ($P < 0.05$) different.
 * Values represent the mean of 3 independent replicates ± SE

Table 4 Color and shear force values of Brazilian and Indian chuck meat samples

	Color			Shear force (Kgf)
	L*	a*	b*	
Brazilian beef meat	40.08 ^a ± 0.36	20.23 ^a ± 0.37	11.19 ^a ± 0.41	3.80 ^a ± 0.43
Indian buffalo meat	37.09 ^b ± 0.84	22.05 ^b ± 1.24	10.66 ^a ± 0.54	5.13 ^b ± 0.54

^{a-b} Means with different superscripts within the same column are significantly ($P < 0.05$) different.
 * Values represent the mean of 3 independent replicates ± SE

Table 5 Fatty acid profile (g/100g FAME) of Brazilian and Indian meat chucks samples

	Brazilian beef meat	Indian buffalo meat
<i>C12:0</i>	0.03 ^a ±0.00	0.02 ^a ±0.00
<i>C13:0</i>	0.09 ^a ±0.00	0.09 ^a ±0.00
<i>C14:0</i>	2.95 ^a ±0.11	1.64 ^b ±0.09
<i>C14:1</i>	0.31 ^a ±0.03	0.33 ^a ±0.13
<i>C15:0</i>	0.79 ^a ±0.02	0.59 ^a ±0.32
<i>C15:1</i>	0.31 ^a ±0.15	0.27 ^a ±0.19
<i>C16:0</i>	23.39 ^a ±0.43	22.20 ^a ±0.91
<i>C16:1</i>	1.56 ^a ±0.08	1.84 ^a ±0.23
<i>C17:0</i>	2.04 ^a ±0.05	1.71 ^a ±0.76
<i>C17:1</i>	0.64 ^a ±0.02	0.96 ^a ±0.09
<i>C18:0</i>	26.25 ^a ±1.26	24.23 ^a ±1.06
<i>C18:1</i>	33.41 ^a ±1.07	34.76 ^a ±1.60
<i>C18:2t</i>	0.46 ^a ±0.23	0.34 ^a ±0.22
<i>C18:2</i>	2.33 ^a ±0.08	3.32 ^a ±0.99
<i>C18:3</i>	1.05 ^a ±0.02	0.94 ^a ±0.29
<i>C18:4</i>	0.17 ^a ±0.17	0.00 ^a ±0.00
<i>C20:0</i>	0.25 ^a ±0.04	1.02 ^a ±0.66
<i>C20:1</i>	0.20 ^a ±0.04	0.36 ^a ±0.06
<i>C22:0</i>	0.09 ^a ±0.00	0.18 ^a ±0.06
<i>C24:0</i>	0.04 ^a ±0.00	0.00 ^a ±0.00
<i>Unknown</i>	3.61 ^a ±0.15	3.16 ^a ±0.98
<i>Total saturated</i>	55.92 ^a ±1.91	51.68 ^a ±3.86
<i>Monounsaturated</i>	36.43 ^a ±1.39	38.52 ^a ±2.30
<i>Polyunsaturated</i>	4.01 ^a ±0.50	4.60 ^a ±1.50
<i>Total unsaturated</i>	40.44 ^a ±1.89	43.12 ^a ±3.80
<i>Trans fatty acids</i>	0.46 ^a ±0.23	0.34 ^a ±0.22

^{a-b} Means with different superscripts within the same row significantly ($P < 0.05$) different.
 * Values represent the mean of 3 independent replicates ± SE.

Table 6 Sensory quality and cooking loss percentage of cooked Brazilian and Indian chuck meat samples

	Appearance	Flavor	Tenderness	Juiciness	Overall acceptability	Cooking loss %
Brazilian beef meat	6.50 ^a ±0.16	5.94 ^a ±0.33	5.61 ^a ±0.42	5.50 ^a ±0.21	5.50 ^a ± 0.41	42.28 ^a ±0.06
Indian buffalo meat	5.77 ^b ±0.16	5.51 ^a ±0.34	4.00 ^b ±0.38	4.61 ^b ±0.15	4.96 ^a ±0.45	59.76 ^b ±0.08

^{a-b} Means with different superscripts within the same column are Significantly ($P < 0.05$) different.
 * Values represent the mean of 3 independent replicates ± SE

CONCLUSION

It could be concluded from the current study that Indian buffalo meat has higher protein and fat contents with lower moisture contents when compared with Brazilian beef meat. Moreover, the fatty acid composition of Indian buffalo fat was not significantly different than that of Brazilian beef. These attributes can make Indian buffalo meat a good choice for meat processing after Brazilian beef meat. These results will help meat processors to find an alternative source for raw meat materials for production of high quality meat products.

Acknowledgments: This study was financially supported from Faculty of Veterinary Medicine, Cairo University, Cairo, Egypt.

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