Carcass Characteristics And Physiological Status Of Nutrients Including Heavy Metal And Pesticide Residues In Selected Beef Wholesale Cuts Of Indian Zebu Cattle.

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ABSTRACT

A study was carried out to assess the carcass characteristics, proximate composition, fatty acid profile, essential macro and micro-elements as well as the levels of some heavy metals and pesticide residues in some wholesale cutup parts (round, loin, flank and chuck) of pasture-fed Indian zebu cattle after collecting samples from the Tangra slaughter house, Kolkata, India. The carcass characters, weight of the wholesale cuts and plucks were having agreement with the standard values. Significant ($P<0.05$) differences were observed in terms of moisture, crude protein, total lipid, energy, different fatty acids and cholesterol among the four different cut-up parts. The pH, Water Holding Capacity (WHC), fibre diameter and sarcomere length also varied significantly ($P<0.05$) among them. The concentration of Iron (Fe) and Sodium (Na) was highest in round, Calcium (Ca) was highest in flank whereas the Potassium (K), Magnesium (Mg), Zinc (Zn), Selenium (Se) and Phosphorus (P) was found to be highest in chuck. The differences were also significant ($P<0.05$). Regarding the heavy metals, i.e. Lead (Pb), Arsenic (As), Cadmium (Cd) and Cromium (Cr) and pesticide residues (DDT and Endosulfan), all the values was highest in loin part and almost lowest in round. The amount of Aldrin was found to be below the detectable limit in all the four cut-up parts.

Key words : *carcass characters, nutrients, heavy metals, pesticides in beef.*

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INTRODUCTION

The ethics and aesthetics of carnivory aside, meat is a high grade source of nutrients, a universally called food and an important source of high-value animal protein that contributes significant amount of bio-available iron and zinc as well as Vitamin A, E and the B-complex vitamins to the diet (Valsta et al. 2005). In the second half of 20th century, meat production increased roughly fivefold and meat consumption has soared in countries that are undergoing rapid industrialization. Apart from those who for ethnic, racial or religious reasons do not eat any meat (mostly in Asia), most of the worlds' population are meat consumers (Harrington, 1994). The annual meat production is projected to increase from 218 million tonnes in 1997-99 to 376 million tonnes by 2030 (FAOSTAT, 2008). A recent report by the Foreign Agricultural Service (FAS) of USDA states that for the second year in a row in 2013, India will be the worlds' largest beef exporter. The total global meat trade is projected at 27 million metric tonnes (MMT) up 2.4% from 2012 with beef at 9 MMT, 33.2% of total trade (Korves, 2012). Calorie-for-calorie, beef is one of the most naturally nutrient-rich foods. On average, a 3oz serving of lean beef is about 150 calories and also an excellent source of six nutrients, i.e. protein, zinc, vit. B12, vit. B6, niacin and selenium and also phosphorous, choline, iron and riboflavin (USDA, 2011). Apart from these glorious perspectives of meat, the 'darker' side depicts that tissue heavy metal concentrations in animals are closely related to heavy metal levels in feedstuffs, the dose of heavy metal and the duration of heavy metal load, other tissues that could be injured include liver, reproductive tract, the immune and nervous system and blood of human being (Maracek et al. 1998). These lead to a silent transformation of consumers from 'bulk-consumers' to 'selective-consumers' and they expect that the product they purchase are of high quality and positive to their health (Thulasi, 2006). They also believe to the concept of 'food today for medicines tomorrow'. These 'concerned consumers' prefer meat cuts with high lean meat yield (LMY%) to carcass with higher proportion of fat (Johnson et al. 2005). Keeping in view the above context, the study was prepared to judge the carcass characteristics and physiological status of various nutrients including the

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presence of some heavy metal and pesticide residues in some selected beef cut-up parts of Indian zebu cattle.

MATERIALS AND METHODS

Samples were collected from 20 slaughter cattle (4-5 years of age) slaughtered by Halal method at Tangra Slaughter House prior to 24 hours of fasting of animals. The body weight of the animals was recorded just before the slaughter. The hot carcass weight was measured 45 minutes after slaughter and defined as the carcass weight of the slaughtered animal's body after being skinned, bled and eviscerated and after removal of the genitalia, limbs at the carpus and tarsus, the head of the tail, the kidneys as well as the perirenal, omental and intestinal fat. Subcutaneous adipose tissues were dissected from the surface of the carcass and inside of the skin. The left side of the cold carcass (after being chilled at 6°C for 24 hours) was dissected in various cuts, i.e. hip, sirloin, loin, flank, rib, plate, chuck, brisket and shank from which samples in triplicate were collected for analysis and the mean values were taken. The moisture, protein, ether extract and ash content of meat samples were determined by the method described by AOAC (1995). The method of O'Fallon et al. (2007) was followed for the estimation of fatty acid. The method of Folch et al. (1957) was used to extract lipid from raw and cooked meat samples and total cholesterol in the lipid extracts was determined by adopting the Liberman-Burchard method as described by Sabir et al. (2003) with slight modifications. The pH of the finely minced meat sample was determined by the method of Trout et al. (1992). Water holding capacity of meat sample was estimated by following the method as described by Nakamura and Kotah (1985) and Dal Bosco et al. (2001). Fiber diameter was measured as per the method outlined by Jeremiah and Martin (1982). The sarcomere length was measured adapting the procedures of Warner et al. (1997). The total phosphorous was assayed using the AOAC (1984) spectrophotometric procedure and calcium, sodium, potassium, magnesium assays were measured by atomic absorption spectrophotometry (Perkin Elmer, 1982). Lead (Pb), Arsenic (As), Cadmium (Cd), Cromium (Cr), Zinc (Zn), Iron (Fe) and Selenium (Se) were measured following the method of Hall (1997). For detection of pesticide residues namely Aldrin, Endosulfan and DDT in meat cuts, the method of Darko and Acquaah (2007) was followed.

All the data which were obtained during the present investigation were analyzed statistically to draw valid conclusion in SPSS (Version 16.0) software. One way analysis of variance (ANOVA) technique was used to compare the means of varying parts. F-statistics were calculated to test the level of significance for each variable under study. Duncan's test (at 5% level of significance) was used to test the homogeneity of means of different parts.

RESULTS AND DISCUSSION

The carcass characteristics (Table 1), i.e. the slaughter weight (kg), hot carcass weight (kg), chilled carcass weight (kg), carcass length (cm) and Loin-eye area (cm2) showed the values of (Mean±SE): 227.43±1.62, 123.95±0.88, 121.68±0.87, 83.78±0.40 and 52.13±0.36 respectively. Jaturasitha et al. (2004) also recorded almost similar values in terms of percentage in the 3 year old Thai native Zebu cattle (Bos indicus). The weight of the wholesale cuts (i.e. chuck, Fore shank, Brisket, Rib, Plate, Flank, Short loin, Sirloin, and Round) depicted in Table 1 showed that the values (kg) were 31.65, 6.26, 7.02, 10, 10.56, 5.99, 8.48, 13.13 and 26.36 respectively where the chuck portion was having the highest value and the flank portion the least which were in agreement with the findings of Phaowphaisal and Wijitphan (2006) and Fadol and Babiker (2010). The values (kg) for heart, liver, lung and trachea, spleen, head, blood and skin depicted in Table 1 shows 0.76, 2.36, 2.45, 0.59, 6.99, 4.54 and 19.31 respectively which were also in agreement with the findings of Phaowphaisal and Wijitphan (2006) and Alemayehu et al. (2013).

In Table 2, the moisture content (%) was found to be 73.13±0.01, 68.51±0.06, 72.12±0.01 and 73.08±0.01 in round, loin, flank and chuck respectively in raw beef cuts and the values differed significantly ($P<0.05$) which were in agreement with the findings of Seggern and Calkins (2005) and Gabeyehu et al. (2013). The crude protein content (%) in the four studied raw wholesale cuts i.e. round, loin, flank in beef shows that the round had the highest crude protein content (21.72 ± 0.03) followed by flank (21.61 ± 0.01), chuck (21.47 ± 0.01) and loin (21.34 ± 0.01) which were in agreement with the findings of Adeniyi et al. (2011) and Gebeyehu et al. (2013). The loin (11.20±0.01) was having the highest total lipid value compared to chuck (6.56±0.01), flank (6.35±0.01) and round (4.58±0.02) which were in agreement with the findings of U.S.D.A (1966) and the differences were significant ($P<0.05$). The significant differences among the various cuts also justified the statement of Lawrie (1998). The energy content (kcal) among the four different raw wholesale beef cuts depicted 129.5±0.03 for round, 189.28±0.02 for loin, 145.33±0.02 for flank and 142.73±0.02 for chuck. The highest value in loin might be attributed to the fact that it contained higher percentage of fat than other three cut-up parts. The values were in agreement with the finding of U.S.D.A (1966) and Patten et al. (2008). The total ash (%) in raw wholesale cuts of beef revealed that the values were almost similar in loin and round (1.08±0.00 and 1.07±0.01) and in between flank and chuck (0.89±0.09 and 0.89±0.01). Significant ($P<0.05$) differences were observed between the loin and round to that of chuck and flank in terms of ash content.

Table 3 in the present study indicated that the amount of Myristic acid (C14:0) varied significantly ($P<0.05$) among the four analyzed beef cuts and Loin and Flank had the highest value followed by round and chuck. The concentration of Palmitic Acid (C16:0) also varied significantly ($P<0.05$) with the highest value in Loin (27.06±0.01) followed by chuck (26.44±0.01), round (25.94±0.01) and flank (25.81±0.01). The concentration of Stearic acid (C18:0) varied significantly with the highest value in flank (16.32±0.01) followed by Loin (12.74 ±0.01), round (10.92±0.01) and chuck (10.83±0.01). The Myristoleic acid (C14:1n-5) was found to be highest in chuck (1.56 ± 0.01) followed by round (1.47 ± 0.01), loin (1.56 ± 0.01) and flank (1.06 ± 0.01). The Palmitoleic acid (C16:1n-7) content was found significantly higher in chuck than the round, loin and flank. The Oleic acid (C18:1n-9) content was found to be highest in round and lowest in flank. The Cis-vaccenic acid (C18:1c11) differed significantly among the four raw beef cuts in terms of quantity and the sequence of mean values were chuck (1.55)> round (1.38)> loin (1.23) flank (1.08). The Trans-vaccenic acid (C18:1t11) also differed significantly among the four cuts in terms of quantity and the sequence of mean values were loin (3.55)> flank (3.45)> chuck (3.09)> round (2.94). The linoleic acid (C18:2n-6) content was highest in loin (1.97) and lowest in flank (1.75). The 18:2cis-9,trans-11 fatty acid values among the four raw wholesale beef cuts showed that the highest mean was in round (0.64) and the lowest mean was in flank (0.55). The 18:2 trans-10,cis-12 fatty acid values among the four raw wholesale beef cuts differed significantly and was highest in chuck (0.16) and flank (0.16) and lowest in round (0.08). The results depicted in Table 2 clearly depicted that in beef, the saturated fatty acid (SFA) proportion was higher than that of Polyunsaturated fatty acid (PUFA) and Monounsaturated fatty acids (MUFA) and that was in agreement with the findings of Almeida et al. (2006). As the beef fattens, the concentration of saturated fatty acids and monounsaturated fatty acids increase at a greater rate than that of PUFA (DeSmet et al. 2004) which supported the present study. Significant variations were also observed among the four raw beef cuts which supported the findings of Zajac et al. (2007). The difference in fatty acid content of different cuts of beef might be influenced by a wide variety of factors including animal breed, external and internal fat levels, climate, breeding, feeding and rearing conditions (Bragagnolo, 1997).

The cholesterol content (mg/100gm), pH, WHC (%), fibre diameter (μm) and sarcomere length (μm) depicted in Table 4 showed that the cholesterol content of the four raw wholesale beef cuts differed significantly ($P<0.05$) where the round had the highest value (61.15) followed by chuck (58.55), loin (41.31) and flank (30.28) which were in agreement with Almeida et al. (2006) and Van Heerden (2007). The pH values of the raw wholesale beef cuts also varied significantly ($P<0.05$) with the following sequence of mean values: chuck (5.84)> flank (5.78)> round (5.77)> loin (5.74). Galli et al. (2008) reported that the mean pH in cull cows and early weaned cattle was 5.51 to 5.56. Though the present study depicted slight higher values and that might be due to the effect of breed, genotype, managemental or age factors. However, Delgado et al. (2005) showed that the mean values of beef longissimus dorsi muscles varied from 5.71 to 5.73 which were in contrast with the present findings. The WHC (%) of all the four raw wholesale beef cuts showed significant ($P<0.05$) difference and chuck had the highest value (12.04) and round had the lowest (11.82) and the values were in agreement with the findings of Stanicic et al. (2012). The muscle fiber diameter (μm) also differed significantly among the raw wholesale beef cuts and the round had the highest value (55.65) followed by chuck (52.62), flank (49.56) and loin (48.93). The sarcomere length (μm) among the four raw wholesale beef cuts showed that the highest value was in round (1.97) followed by chuck (1.66), loin (1.48) and flank (1.46). McKeith et al. (1985) showed that the mean value of sarcomere length in Longissimus muscle of beef varied from 1.54 to 1.72 which was in agreement with present study.

The concentration of various macro and micro minerals in four different raw wholesale beef cuts depicted in Table 5 showed that there was a wide variation in mean content of Calcium in loin (23.63) and flank (23.73) to that of round (5.34) and chuck (5.04) and the difference was significant ($P<0.05$). The Iron (Fe) content in four raw wholesale beef cuts showed that the highest concentration was in round (2.93) followed by chuck (2.44), loin (1.55) and flank (1.54) and they differed significantly ($P<0.05$). The Sodium (Na) content was highest in round (62.17) and lowest in loin (53.82). The Potassium (K) content in raw beef cuts showed a significant difference where chuck had the highest mean value (366.39) followed by round (360.38), flank (326.45) and loin (321.39). The Magnesium (Mg) content among the four raw beef cuts differed significantly where the chuck had the highest value (25.38) and the lowest in loin (21.43). The content of Zn, Se and P showed an interesting and almost similar trend among the four wholesale beef cuts where in all cases of raw samples, chuck showed the highest values (4.42, 32.47 and 219.52) followed by round (4.35, 30.58 and 217.23), flank (3.64, 25.62 and 197.55) and loin (3.54, 24.57 and 194.52). The values of the different minerals depicted in Table 4 were almost in agreement with the findings of Huerta-Leidenz et al. (2003), Huerta-Montauti et al. (2007), Maria et al. (2008) and Serap et al. (2010)., though there was slight difference in values in some cases and that might be attributed to the difference in feeding regime, age, gender, region and other managemental factors (Doyle, 1980). The present study also justified the statement of Doornebal and Murray (1981) and Maatescu et al. (2012) who found that mineral content in beef varied due to muscle effect.

The results in Table 6 showed that the concentration (μg/kg) of Lead (Pb) among the four raw wholesale beef cuts differed significantly where the loin had the highest mean (7.75) followed by flank (5.88), chuck (4.97) and round (4.18) which were in agreement with the findings of Alonso et al. (2000) and Abou Doina (2008), however, the difference might be due to variation in the amount of exposure of the animals to the element. The highest concentrations of As, Cd and Cr were recorded in loin (5.04, 1.41 and 10.89) and the lowest in round (2.16, 0.41 and 5.16) which supported the findings of Humphreys (1990), Alonso et al. (2000), Licata et al. (2004) and Khalafalla et al. (2011).

Among the tested pesticide residues in the present study (Table 5), the amount of Aldrin in different beef cuts was found to be below the detectable limit (BDL). The concentration (μg/kg) of Dichlorodiphenyltrichloroethane (DDT) among the four raw wholesale beef cuts clearly showed its highest concentration in loin (53.76) followed by chuck (29.90), flank (28.99) and round (20.96). In case of Endosulfan, the loin again showed the highest mean value (1.83) followed by flank (0.86), chuck (0.72) and round (0.17) in raw beef cuts. The present study supported the findings of Vijayan et al. (2006), Sengupta et al. (2009) and Noha et al. (2010).

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Table : 1. Carcass characteristics of Indian Zebu cattle (Min, Max, Mean and S.E).

Carcass Characteristics	Minimum	Maximum	Mean	Std.Error
Slaughter weight (kg)	218.40	236.50	227.43	1.62
hot carcass wt(kg)	119.03	128.89	123.95	0.88
Chilled carcas wt (kg)	116.84	126.53	121.68	0.87
Carcass length (cm)	82.20	86.20	83.78	0.40
Loin eye area (cm^2)	51.00	54.00	52.13	0.36
Chuck (kg)	31.65	34.28	32.96	0.24
Fore shank(kg)	6.26	6.78	6.52	0.05
Brisket(kg)	7.02	7.60	7.31	0.05
Rib(kg)	10.00	10.83	10.42	0.07
Plate(kg)	10.56	11.44	11.00	0.08
Flank(kg)	5.99	6.49	6.24	0.04
Short loin(kg)	8.48	9.19	8.83	0.06
Sirloin(kg)	13.13	14.22	13.68	0.10
Round(kg)	26.36	28.54	27.45	0.20
Heart(kg)	0.76	0.83	0.80	0.01
liver(kg)	2.36	2.55	2.46	0.02
Lungh &trachea (kg)	2.45	2.65	2.55	0.02
Spleen(kg)	0.59	0.64	0.61	0.00
Head (kg)	6.99	7.57	7.28	0.05
Blood (kg)	4.54	4.92	4.73	0.03
Skin(kg)	19.31	20.91	20.10	0.14

n= 24 for each tissue of each species for each metal
a,b,c Means bearing different superscripts in a row differed significantly (P<0.05)
A, B Means bearing different superscripts in a column within a parameter differed significantly (P>0.05)

Table: 2. Proximate composition of some wholesale raw beef cuts with Duncan's test results at 5% level of significance.

Meat type	Wholesale cut		Moisture (%)	Crude protein (%)	Total lipid (%)	Energy (kcal)	Total ash (gm)
Raw	Round	Mean	73.13a	21.72a	4.58d	129.50d	1.07a
		SE	0.01	0.03	0.02	0.03	0.01
	Loin	Mean	68.51c	21.34d	11.20a	189.28a	1.08a
		SE	0.06	0.01	0.01	0.02	0.00
	Flank	Mean	72.12b	21.61b	6.35c	145.33b	0.89b
		SE	0.01	0.01	0.01	0.02	0.09
	Chuck	Mean	73.08a	21.47c	6.56b	142.73c	0.89b
		SE	0.01	0.01	0.01	0.02	0.01

• Means with different superscripts in a column differ significantly (P<0.05).

Table: 3. Fatty acid composition of Raw meat from different wholesale cuts of Beef carcass with Duncan's Test results at 5% level of significance.

Meat type	WHOLESALE CUT		C14:0	C16:0	C18:0	C14:1n-5	C16:1N-7	C18:1 n-9	C18:1c11	C18:1t11	C18:2n-6	C18:2 c9t11	C18:2t10c12h
Raw	Round	Mean	3.50b	25.94c	10.92a	1.47b	5.16b	41.04a	1.38b	2.94d	1.75d	0.64a	0.08c
		SE	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00
	Loin	Mean	3.69a	27.06a	12.74b	1.36c	4.45c	38.45c	1.23c	3.55a	1.97a	0.55b	0.11b
		SE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
	Flank	Mean	3.69a	25.81d	16.32a	1.06d	3.16d	36.84d	1.08d	3.45b	1.94b	0.56b	0.16a
		SE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
	Chuck	Mean	3.43c	26.44b	10.83d	1.56a	5.55a	40.24b	1.55a	3.09c	1.87c	0.62a	0.16a
		SE	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00

• Means with different superscripts in a column differ significantly ($P<0.05$).

Table: 4. Cholesterol content and some physico-chemical properties of raw meat from different wholesale cuts of Beef carcass with Duncan's Test results at 5% level of significance.

Meat type	WHOLESALE CUT Type		Cholesterol (mg/100 gm)	pH	WHC (%)	Fibre Diameter (μm)	Sarcomere Length (μm)
Raw	Round	Mean	61.15a	5.77c	11.82d	55.65a	1.97a
		SE	0.01	0.01	0.01	0.01	0.00
	Loin	Mean	41.31c	5.74d	11.88c	48.93d	1.48c
		SE	0.03	0.00	0.01	0.01	0.01
	Flank	Mean	30.28d	5.78b	11.96b	49.56c	1.46c
		SE	0.03	0.00	0.01	0.01	0.01
	Chuck	Mean	58.55b	5.84a	12.04a	52.62b	1.66b
		SE	0.04	0.00	0.01	0.01	0.01

• Means with different superscripts in a column differ significantly ($P<0.05$).

Table: 5. Mineral content (mg/100gm) of Raw meat from different wholesale cuts of Beef carcass with Duncan's Test results at 5% level of significance.

Meat type	Wholesale cut type		Ca	Fe	Na	K	Mg	Zn	Se	P
Raw	Round	Mean	5.34b	2.93a	62.17a	360.38b	24.34b	4.35b	30.58b	217.23b
		SE	0.01	0.01	0.02	0.04	0.04	0.01	0.08	0.05
	Loin	Mean	23.63a	1.55c	53.82d	321.39d	21.43d	3.54d	24.57d	194.52d
		SE	0.01	0.01	0.01	0.08	0.05	0.01	0.04	0.05
	Flank	Mean	23.73a	1.54c	54.55c	326.45c	22.38c	3.64c	25.62c	197.55c
		SE	0.16	0.01	0.01	0.07	0.05	0.01	0.07	0.07
	Chuck	Mean	5.04c	2.44b	60.15b	366.39a	25.38a	4.42a	32.47a	219.52a
		SE	0.01	0.01	0.01	0.07	0.06	0.01	0.05	0.06

• Means with different superscripts in a column differ significantly ($P<0.05$).

Table: 6. Heavy metal and pesticide content (μg/kg) of Raw meat from different wholesale cuts of Beef carcass with Duncan's Test results at 5% level of significance.

Meat type	Wholesale cut type		Pb	As	Cd	Cr	DDT	Endosulfan	Aldrin
Raw	Round	Mean	4.18d	2.16c	0.41d	5.16d	20.96c	0.17d	BDL
		SE	0.02	0.14	0.06	0.08	0.73	0.02	
	Loin	Mean	7.75a	5.04a	1.41a	10.89a	53.76a	1.83a	BDL
		SE	0.19	0.08	0.02	0.13	1.62	0.04	
	Flank	Mean	5.88b	3.16b	0.77b	9.11b	28.99b	0.86b	BDL
		SE	0.14	0.04	0.02	0.07	0.65	0.03	
	Chuck	Mean	4.97c	2.08c	0.65c	7.30c	29.90b	0.72c	BDL
		SE	0.08	0.02	0.02	0.08	1.37	0.04	

• Means with different superscripts in a column differ significantly ($P<0.05$).