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Profiles of colour, minerals, amino acids and fatty acids of *musculus longissimus thoracis et lumborum* of Ghungroo pigs

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ABSTRACT

Carcass composition and meat quality were evaluated in Ghungroo, the first registered indigenous pig breed of India. Ghungroo pigs (16 gilts and 26 barrows) were slaughtered at the age of 10 months for evaluating the different parameters. Instrumental colour measurement indicated that the coordinates were in the following range: lightness (L*), 39.17 - 57.39; redness (a*, red ± green), 8.37 - 14.21; and yellowness (b*, yellow ± blue), 13.08 - 18.17. Haem iron content was significantly higher in barrows compared to gilts. The mineral contents in the *musculus (M.) longissimus thoracis et lumborum* were in the following range: potassium, 289 – 349 mg/100g; zinc, 0.58 – 0.91 mg/100g; copper, 0.13 – 0.17 mg/100g; manganese, 0.05 –0.06 mg/100g and magnesium, 4.72 –7.37 mg/100g. Significant differences were not observed in the concentration of any of the estimated amino acids between the sexes. Fatty acid profiling of *M. longissimus thoracis et lumborum* indicated that saturated and unsaturated fatty acids were in the range of 32.17 - 41.19% and 58.98 - 68.15%, respectively. Results further indicated a concentration of 0.88 – 1.73% omega-3 fatty acids; 19.95 - 27.23% omega-6 fatty acids and 14.52 - 23.47% essential fatty acids in the Ghungroo muscle tissues.

Key words: Fatty acid profile, Ghungroo, Indigenous pig, Meat quality, Mineral contents

Pig production in India is still in the nascent stages in terms of growth performance and meat production, despite having sizable number of indigenous pig population. As a part of study of improvement of indigenous pig population in India, the carcass and meat qualities of Ghungroo, the first registered pig breed of indigenous origin in India, were evaluated. The importance of conserving this indigenous germplasm is suggested also by the fact that, generally, the Ghungroo pig breed seems to be free from the halothane gene (Naskar *et al.* 2014). Also, due to the comparatively high age at slaughter, as a consequence of low growth rate, meat of indigenous pigs including Ghungroo pigs, are redder and less bright, and has lower cooking loss than the improved pigs (Thomas *et al.* 2014). The quantity and chemical properties of lipids in meat are regarded as important factors affecting carcass quality and it has been generally accepted that factors, such as breed and anatomical location, produce changes in the amount and composition of meat lipids (Lawrie 1998). The present paper reports the profiles of colour, minerals, amino acids and fatty acids in the meat of Ghungroo pigs.

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MATERIALS AND METHODS

The experiment was conducted with 42 Ghungroo pigs (16 gilts and 26 barrows) reared at the Research Farm of ICAR-National Research Centre on Pig. The pigs were taken for slaughter at their predetermined slaughter age of 10 months, as per the institute's slaughter policy for the indigenous breeds. Pigs were slaughtered in the R&D Pork Processing Plant of the institute (HACCP and ISO 9001:2008 certified, certificate number –1100263; Food Safety Standards Authority of India Licensed, license number - 10312001000151). Pigs were electrically stunned (head-only) by low voltage current, shackled on the left leg and exsanguinated in the vertical position on the over head rail. Thereafter, the pigs were scalded at 65°C, followed by hair removal on an automatic dehairing machine. Following slaughter, carcasses were scraped, washed, split, eviscerated and chilled according to standard commercial practices. A block of loin comprising between ribs 8 and 11 was taken from the left side of each carcass, samples were identified and frozen at –20 ± 1°C until analysis of other parameters. Before being measured, samples were thawed at room temperature overnight.

The color of the meat was measured at the 8th and 9th thoracic vertebra at 24 h post mortem using a software with a 30 mm aperture set for illumination D 65/10° standard observer angle, after exposing the surface to the air for 30

min at 4°C. The instrument was first standardized with black tile followed by white tile. The samples were placed over the viewing aperture and then covered with the lid. The following colour coordinates were determined: lightness (L*), redness (a*, red ± green) and yellowness (b*, yellow ± blue). In addition, hue angle, which describes the hue as well as the saturation index or chroma (C*), which describes the brightness or vividness of colour, were also measured. All the determinations were performed in triplicate. The concentration of heme iron was assayed from the total content of heme (Hornsey 1956). Non-heme iron content was determined as per Rhee and Ziprin (1987). All the determinations were performed in triplicate.

To evaluate the mineral composition, meat samples from *M. longissimus thoracis et lumborum* were trimmed of visible adipose and connective tissue, chopped and dried in oven at 105°C to obtain a constant weight. After that, the samples were ashed in a covered crucible at 550°C in a furnace for 16 h to obtain a white residual ash. The ashes were subjected to an acid digestion process in an Erlen-flask, covered with a micro glass-ball to avoid projections, with 1 M hydrochloric acid and 1 M nitric acid solution heated on a hot plate (AOAC 2005). Determination of Cu, Zn, Mg, K and Mn were performed by flame atomic absorption spectrophotometer as per AOAC (2005). All the determinations were performed in duplicate.

M. longissimus thoracis et lumborum samples were minced using 3 mm hole plate of a meat mincer and the amino acid composition was measured as per Suzuki *et al.* (1991). For assessing the amino acid composition, 10 g of minced meat was suspended in 2.5 volumes (v/w) of deionized water by homogenizing for 60 sec. This suspension was centrifuged at 15,000 × g for 15 min, and the supernatant was collected through 2 layers of gauze. The soluble protein in the supernatant was sedimented by adding the same volume (v/v) of 3% sodium sulphosalicylate. Precipitated protein was removed through filter paper no. 5. The filtrate clarified through the membrane filter (pore size 0.45 pm) was subjected to amino acid analysis on a high-performance liquid chromatograph (HPLC) with a system for amino acid analysis composed of a column (25cm × 4.6mm) and a RF-535 OPA detector. All the determinations were performed in duplicate.

M. longissimus thoracis et lumborum samples were homogenized and 1 g of the sample was extracted with chloroform methanol 2:1 (v/v) according to Salvatori *et al.* (2008). Fatty acid methyl esters (FAMEs) were prepared by esterification using methanol in the presence of sulphuric acid (5% of sulphuric acid in methanol). FAMEs were analysed in a gas chromatograph, equipped with a flame ionization detector (FID). They were separated on a semi capillary column (TPA fused-silica column, 30 m length, 0.53 mm id, and 1.0 mm film thickness). The injector and detector temperatures were held at 230°C and the oven temperature, at 220°C. The carrier gas was nitrogen at a flow rate of 1.8 ml/min. Identification of FAMEs was based on retention times of reference compounds. Fatty acid composition was expressed as a percentage of the major FAMEs. To assess the nutritional implications, the SFA/unsaturated fatty acids (UFA) and the PUFA/SFA ratios were calculated. All the determinations were performed in duplicate.

The data collected for different carcass and meat quality parameters were subjected to statistical analysis using SPSS, version 14.0. Mean, standard error of mean (SEM), t-values, minimum (Min) and maximum (Max) values are reported.

RESULTS AND DISCUSSION

Instrumental colour values and mineral composition of *M. longissimus thoracis et lumborum* of Ghungroo pigs are mentioned in Table 1. Instrumental colour measurement indicated that the coordinates were in the following range: lightness (L*), 39.17–57.39; redness (a*, red ± green), 8.37–14.21; and yellowness (b*, yellow ± blue), 13.08–18.17.

Table 1. Instrumental colour values and mineral composition of *M. longissimus thoracis et lumborum* of Ghungroo pigs

Parameter	Gilts (n_1) mean ±SEM	Barrows (n_2) mean ±SEM	t-value	Combined (n_3) mean ±SEM	Min.	Max.
Instrumental colour values						
L*	46.58±0.42	44.69±0.53	142.75**	45.88±0.48	39.17	57.39
a*	10.08±0.19	11.65±0.33	72.61**	10.58±0.29	8.37	14.21
b*	15.80±0.25	15.93±0.28	3.50	15.82±0.26	13.08	18.17
Chroma	18.95±0.14	19.86±0.19	272.00**	19.01±0.16	16.73	21.41
Hue	56.17±0.21	56.98±0.27	1.46	56.32±0.23	52.83	58.37
Mineral composition						
Total iron (mg/100g)	2.18±0.23	2.52±0.20	45.50**	2.43±0.20	1.79	3.07
Haem iron (mg/100g)	1.24±0.17	1.61±0.23	112.00**	1.57±0.22	1.13	2.11
Non-haem iron (mg/100g)	0.80±0.12	0.89±0.13	5.75	0.86±0.13	0.39	1.37
Potassium (mg/100g)	318±0.21	327±0.28	2.59	322±0.26	289	349
Zinc (mg/100g)	0.77±0.20	0.79±0.26	1.55	0.79±0.24	0.58	0.91
Copper (mg/100g)	0.15±0.21	0.14±0.26	2.00	0.15±0.23	0.13	0.17
Manganese (mg/100g)	0.05±0.07	0.04±0.06	4.00	0.05±0.07	0.05	0.06
Magnesium (mg/100g)	6.31±0.17	6.37±0.15	3.57	6.33±0.17	4.72	7.37

**P<0.01; *P<0.05; n_1, 16; n_2, 26; n_3, 42.

Similarly, hue angle, which describes the hue as well as the saturation index and chroma (C*), which describes the brightness or vividness of colour, were in the range of 52.83 – 58.37 and 16.73 – 21.41, respectively. Among the sexes, gilts had significantly (P<0.01) higher lightness values, while barrows had significantly (P<0.01) higher a* and chroma values. The differences in redness in the *M. longissimus thoracis et lumborum* show that barrows had a higher concentration of haem pigments. Further investigations on pH, water holding capacity and colour are needed to better understand the interactions between them in Ghungroo pigs.

The average iron content in the muscle was 2.43 mg/100g, of which the contribution of haem and non-haem iron was 1.57 mg/100g and 0.86 mg/100g, respectively. It was also found that iron content was significantly (P<0.01) higher in barrows compared to gilts, and this difference was observed only for haem iron, while non-haem iron content was identical for both gilts and barrows (Table 1). However, Cross *et al.* (2012), who analyzed iron content in different muscles of pork, showed that neither non-haem iron content nor total haem pigment concentration in muscle tissue was significantly affected by sex. Breed and sex differences between the early maturing Ghungroo pigs used in this study and the Large White castrated male pigs used by those workers could have accounted for the difference in the iron content. Estimated mineral contents in the *M. longissimus thoracis et lumborum* were in the following range: potassium, 289 – 349 mg/100g; zinc, 0.58 –0.91 mg/100g; copper, 0.13 – 0.17 mg/100g; manganese, 0.05 –0.06 mg/100g and magnesium, 4.72 –7.37 mg/100g (Table 1). Also, no significant (P>0.05) difference was found for these minerals among gilts and barrows.

The details of amino acid composition in *M. longissimus dorsi* of Ghungroo pigs are mentioned in Table 2. The estimated average values for different amino acids were in the following descending order: glutamic acid, 1.92 g/100g; arginine, 1.64 g/100g; histidine, 1.31 g/100g; aspartic acid, 1.11 g/100g; lysine, 1.02 g/100g; proline, 0.88 g/100g; leucine, 0.87 g/100g; threonine, 0.64 g/100g; serine, 0.52 g/100g; valine, 0.49 g/100g; phenylalanine, 0.45 g/100g; tyrosine, 0.44 g/100g; isoleucine, 0.41 g/100g; alanine, 0.39 g/100g; methionine, 0.23 g/100g; tryptophan, 0.19 g/100g; cystine, 0.17 g/100g; and glysine, 0.02 g/100g. However, significant (P>0.05) differences were not observed in the concentration of any of the estimated amino acids between the sexes, and the present findings were in accordance with the data given by Suzuki *et al.* (1991). Also, as it is the first study of this kind in Ghungroo pig, detailed studies involving muscles other than *M. longissimus thoracis et lumborum* need to be carried out for further validation of the current findings.

Estimation of fatty acid profiles of *M. longissimus thoracis et lumborum* indicated that saturated fatty acids (SFA) and unsaturated fatty acids (UFA) were in the range of 32.17 - 41.19% and 58.98 - 68.15%, respectively, while the UFA:SFA ratio varied from 1.62 to 1.91 (Table 3). Palmitic acid (range, 18.39 - 26.54%) and stearic acid (range, 7.16 - 14.35%) constituted the major part of saturated fatty acids. Similarly in unsaturated fatty acids, mono-unsaturated fatty acids (MUFA) constituted about 39.46% (range, 33.84 - 44.64%) while poly-unsaturated fatty acids (PUFA) accounted for 24.82% (range, 21.39 - 29.08%). Among MUFA, oleic acid alone contributed for 32.97% (range, 25.36 - 39.72%), while the major contributors in PUFA were linoleic acid (19.02%) and arachidonic acid (3.98%). The quantity and chemical properties of lipids in meat are regarded as important factors

Table 2. Amino acid composition (g/100g) of *M. longissimus thoracis et lumborum* of Ghungroo pigs

Parameter	Gilts (n_1) mean ±SEM	Barrows (n_2) mean ±SEM	t-value	Combined (n_3) mean ±SEM	Min.	Max.
Aspartic acid	1.14±0.08	1.09±0.06	4.16	1.11±0.08	0.77	1.53
Serine	0.51±0.03	0.54±0.02	0.87	0.52±0.02	0.29	0.86
Glutamic acid	1.97±0.14	1.90±0.18	2.05	1.92±0.17	1.38	2.43
Glysine	0.02±0.01	0.02±0.01	1.00	0.02±0.01	0.02	0.04
Histidine	1.30±0.04	1.33±0.05	0.77	1.31±0.05	0.96	1.83
Arginine	1.60±0.07	1.67±0.08	1.00	1.64±0.08	1.28	1.96
Threonine	0.65±0.05	0.68±0.06	3.29	0.64±0.05	0.27	.093
Alanine	0.37±0.03	0.41±0.03	1.94	0.39±0.03	0.17	0.88
Proline	0.91±0.06	0.87±0.05	6.10	0.88±0.06	0.35	1.27
Cystine	0.17±0.01	0.17±0.01	0.66	0.17±0.01	0.07	0.31
Tyrosine	0.41±0.02	0.46±0.02	8.66	0.44±0.02	0.25	0.74
Valine	0.52±0.03	0.47±0.04	8.66	0.49±0.03	0.28	0.79
Methionine	0.20±0.02	0.24±0.02	3.46	0.23±0.02	0.09	0.56
Lysine	1.00±0.03	1.03±0.04	1.65	1.02±0.04	0.89	1.27
Isoleucine	0.38±0.05	0.42±0.03	3.93	0.41±0.03	0.19	0.74
Leucine	0.89±0.05	0.83±0.08	7.39	0.87±0.05	0.37	0.14
Phenylalanine	0.42±0.02	0.47±0.04	4.18	0.45±0.02	0.19	0.92
Tryptophan	0.19±0.01	0.18±0.01	1.96	0.19±0.01	0.06	0.28

n_1, 16; n_2, 26; n_3, 42.

affecting carcass quality and it is generally accepted that factors such sex and anatomical location, produce changes in the amount and composition of meat lipids. The intramuscular fat has some effect on the organoleptic qualities of meat (Maw *et al.* 2003). Knowledge of the fat content in carcass musculature and its composition is important, both for a better understanding of the growth processes and for the nutritional value of meat and its associated quality. The fatty acid profile of the polar lipids was found to be more polyunsaturated in gilts compared to barrows. Even though we did not develop evidence to explain these results, it is reasonable to speculate that the level of intramuscular fat depot could account for the majority of the variations in the percentage of different fatty acid components among the sexes examined in this study. Numerous authors (Fortin *et al.* 2005, Wood *et al.* 2008) have stated that sex may play an important role in meat fatty acid profiles.

The percentage of C 18:1, C 18:2, C 18:3 and C 20:4 were significantly (P<0.05) higher in gilts, while barrows had significantly (P<0.05) higher percentage of C 14:0 and C 18:0 (Table 3). Gilts had significantly (P<0.01) higher unsaturated fatty acids including essential fatty acids, while barrows had significantly (P<0.05) higher saturated fatty acid contents. The changes in the fatty acid composition of intramuscular lipids are related to the relative changes in concentration among the lipid classes and this is an important factor in the alterations in specific fatty acid concentrations. The higher concentrations of C 18:2 and lower concentrations of C 18:0 in gilts were expected, as reported earlier (Fortin *et al.* 2005, Wood *et al.* 2008). Other studies also reported that the level of C18:2 was higher in the meat from female pigs (Leskanich 1999). We must also consider that the amounts of 18:2 accumulated in the animal tissues depend on the diet because its synthesis in the mammalian body is not possible and, for this reason, the accumulation of 18:2 in the muscle might be related to the amount of dietary linoleic acid (Wood *et al.* 2008). In conclusion, sex influenced fatty acid composition of *M. longissimus thoracis et lumborum* in this study. However, more research is needed to establish whether this difference exists among the other muscles in Ghungroo pigs. The MUFA:SFA ratio was in the range of 0.97 –1.3, while PUFA:SFA ratio varied from 0.61 – 0.74. Results further indicated that the concentration of omega-3 (n-3) fatty acids in the *M. longissimus thoracis et lumborum* of Ghungroo pig was in the range of 0.88 – 1.73% (average, 1.33%), while the omega-6 (n-6) fatty acids were accountable for about 23.16% (range, 19.95 - 27.23%). *M. longissimus thoracis et lumborum* of Ghungroo pig contained 19.46% (range, 14.52 - 23.47%) essential fatty acids (EFA).

Our results helps to understand the profiles of colour,

Table 3. Fatty acid profile (% of total fatty acids) of *M. longissimus thoracis et lumborum* of Ghungroo pigs

Parameter	Gilts (n_1) mean ±SEM	Barrows (n_2) mean ±SEM	t-value	Combined (n_3) mean ±SEM	Min.	Max.
Myristic acid, C 14:0	1.17±0.06	1.32±0.03	17.71*	1.21±0.05	0.79	1.63
Palmitic acid, C 16:0	22.17±0.21	22.46±0.34	3.67	22.29±0.29	18.39	26.54
Palmitoleic acid, C 16:1	2.79±0.05	2.68±0.07	7.77	2.75±0.07	1.83	3.57
Heptadecanoic acid, C17:0	0.20±0.01	0.20±0.01	0.48	0.20±0.01	0.15	0.29
Stearic acid, C 18:0	12.01±0.36	12.86±0.24	12.31*	12.28±0.28	7.16	14.35
Oleic acid, C 18:1	34.83±0.67	31.22±0.52	138.00**	32.97±0.59	25.36	39.72
trans Vaccenic acid, C 18:1, t11	3.83±0.24	3.71±0.29	5.01	3.74±0.28	2.79	4.18
Linoleic acid, C 18:2	19.27±0.49	18.82±0.42	12.44*	19.02±0.47	11.06	24.75
Alpha-linolenic acid, C 18:3	0.51±0.01	0.41±0.01	12.00*	0.44±0.01	0.29	0.63
Gamma-linolenic acid, C 18:3	0.19±0.01	0.14±0.01	1.73	0.16±0.01	0.09	0.33
Arachidic acid, C 20:0	0.31±0.03	0.39±0.02	2.95	0.33±0.03	0.15	0.74
Arachidonic acid, C 20:4	4.08±0.20	3.86±0.28	12.70*	3.98±0.26	1.94	5.70
Eicosa pentanoic acid, C 20:5	0.69±0.04	0.56±0.05	3.75	0.61±0.05	0.11	1.20
Behenic acid, C 22:0	0.24±0.02	0.36±0.03	6.25	0.29±0.02	0.08	0.61
Docosa pentanoic acid, C 22:5	0.38±0.03	0.30±0.05	3.67	0.33±0.03	0.06	0.59
Docosa hexanoic acid, C 22:6	0.33±0.02	0.25±0.05	3.36	0.28±0.04	0.08	0.81
Saturated fatty acids, SFA (%)	35.11±0.29	37.69±0.38	18.24*	36.60±0.32	32.17	41.19
Unsaturated fatty acids, UFA (%)	66.07±0.57	63.38±0.48	38.84**	64.28±0.53	58.98	68.15
UFA/SFA	1.83±0.04	1.74±0.03	7.20	1.76±0.04	1.62	1.91
Mono-unsaturated fatty acids, MUFA (%)	41.54±0.41	38.76±0.48	18.80*	39.46±0.47	33.84	44.64
Poly-unsaturated fatty acids, PUFA (%)	25.37±0.29	24.11±0.22	7.57	24.82±0.27	21.39	29.08
MUFA/SFA	1.13±0.02	1.04±0.02	15.50*	1.08±0.02	0.97	1.30
PUFA/SFA	0.71±0.02	0.64±0.03	4.57	0.68±0.03	0.61	0.74
PUFA n-6	23.85±0.49	23.01±0.42	128.00**	23.16±0.45	19.95	27.23
PUFA n-3	1.39±0.07	1.28±0.05	8.70	1.33±0.07	0.88	1.73
PUFA n-6/ n-3	15.83±0.14	15.37±0.21	9.44	15.41±0.19	13.19	18.78
Essential fatty acids, EFA (%)	19.62±0.38	18.93±0.29	29.86**	19.46±0.32	14.52	23.47

**P<0.01; *P<0.05; n_1, 16; n_2, 26; n_3, 42.

minerals, amino acids and fatty acids with respect to gilts and barrows among Ghungroo pigs. The extent of differences in some of the observed parameters among the sexes in Ghungroo pigs and its implications for physical characteristics and carcass composition merits further investigation. In conclusion, the present study indicated that the Ghungroo pig has the potential for quality pork production and is suitable for pork production breeding programmes in India aimed at obtaining good quality pork. Further studies are in progress at the institute to evaluate the sensory properties of processed pork products produced from meat of Ghungroo pigs.

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