International Food Research Journal 24(1): 153-158 (February 2017)
Journal homepage: *http://www.ifrj.upm.edu.my*

Carcass and meat quality of triple cross (Ghungroo x Hampshire x Duroc) fattener pigs

*Thomas, R., Banik, S., Mohan, N. H. and Sarma, D. K.

ICAR-National Research Centre on Pig, Indian Council of Agricultural Research, Rani, Guwahati – 781 131, Assam, India

Article history

Received: 18 December 2015
Received in revised form: 19 March 2016
Accepted: 23 March 2016

Keywords

Ghungroo
Triple cross
Carcass composition
Indigenous pig
Back fat thickness
Cholesterol content

Abstract

A triple cross pig variety (Ghungroo x Hampshire x Duroc, $G_{25}H_{25}D_{50}$) was developed as a fattener pig. Pure parental lines of Hampshire and Duroc (male) and Ghungroo (female) pigs were used as exotic and indigenous germplasm, respectively. A total of 14 gilts and 20 barrows from triple cross pigs were slaughtered at the age of 10 months for evaluating the different parameters. Carcass traits indicated a meat: bone ratio of 2.95 and fat: lean ratio of 0.17 for this pig variety. The carcass length ranged from 61.5 cm – 93 cm, while that of the loin eye area varied from 1.30 in^2 – 5.50 in^2. Back fat thickness at three-quarters of the length of the transverse section of the exposed *M. longissimus thoracis et lumborum* between the 10th and 11th ribs was in the range of 0.7 cm – 2.25 cm. Moisture: protein ratio varied from 3.20 to 3.39 and no significant (P>0.05) difference was observed between gilts and barrows. The cholesterol content in *M. longissimus thoracis et lumborum* varied from 47.83 mg/100g – 71.19 mg/100g, with an average of 59.70 mg/ 100g.

© All Rights Reserved

Introduction

In order to address the gap between demand and supply of pork in the country, resulted mostly from the comparatively smaller body size and poor growth rate of indigenous pig breeds (Banik *et al.*, 2012), ICAR-National Research Centre on Pig has undertaken a massive crossbreeding programme to upgrade the indigenous pig germplasm available in India. Pure parental lines of Hampshire and Duroc (male) and Ghungroo (female) pigs, maintained through selective breeding at pig breeding farm of ICAR-National Research Centre on Pig were used as exotic and indigenous germplasm, respectively. Ghungroo, the first registered pig breed of India, is famous for superior reproductive performance, believed to have tolerance to disease challenges prevalent in tropical hot and humid agro-climatic condition and well adaptable (Barman *et al.*, 2015). Hampshire pig, on other hand, is known for its higher growth rate and better carcass traits and found to be widely accepted in Indian scenario (Naskar *et al.*, 2014).

The pedigreed parental line of Hampshire and Ghungroo pigs were mated to produce F1, followed by inter-se mating for five generations to stabilize the heterosis effect. A total of 11 and 17 number of sire and dam lines has been used for the breeding programme with a mating ratio of 1:2.5. Subsequently, selected population was crossed with Duroc males to develop a triple cross fattener pig variety (Ghungroo x Hampshire x Duroc, $G_{25}H_{25}D_{50}$). Duroc was used as terminal sire in this breeding programme due to its high potential of lean meat production with superior growth rate. As a fattener pig, the production and reproduction traits of the developed three breed cross were studied at ICAR-National Research Centre on Pig (Banik *et al.* 2012; Thomas *et al.*, 2014; Gokuldas *et al.*, 2015). Within this context, the objective of the present study was to investigate the detailed carcass and meat quality parameters of the triple cross pigs. The present paper reports the yields of carcass, by-products, primal and sub-primal cuts; meat quality parameters, proximate composition and cholesterol content in pork. The information is very much important for initiating a mass scale production of this variety for releasing to the farmers filed as a fattener pig.

Materials and Methods

Animals, slaughter, dressing of the carcass, chilling regime and cutting scheme

The experiment was conducted with 34 numbers of Ghungroo x Hampshire x Duroc (G_{25}:H_{25}:D_{50}) triple cross pigs (14 females and 20 castrated males) reared at the Research Farm of ICAR-National Research Centre on Pig. The piglets were creep-fed on a 20% crude protein diet and 13.53 MJ/kg digestible energy; the diet for the weaners contained 18% crude protein,

*Corresponding author.
Email: *thomasrlpt@gmail.com*
Tel: +91-9435341531

13.33 MJ/kg digestible energy while the growing pigs were fed on a 16% crude protein diet and 13.53 MJ/kg digestible energy. 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. The afternoon prior to slaughter, different body measurements were taken at the farm. Upon arrival of the animals at the abattoir, their weight was determined and used as the live weight in the experimental analysis. Whilst in lairage, the animals were kept off feed for 14-16 h, but were given free access to water. Pigs were slaughtered in the R&D Pork Processing Plant of the institute (HACCP and ISO 9001:2008 certified, Food Safety Standards Authority of India Licensed, license number - 10312001000151), located at approximately 50 m from the Research Farm.

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. At slaughter, the blood was collected and weighed. Thereafter, the pigs were scalded at 65^{o}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. The dressed (head-on, distal ends of legs removed, leaf fat-on) hot carcass was washed and weighed. The gastrointestinal tract, kidneys, liver, heart, lungs, spleen and intestines were also weighed at slaughter. After chilling for 18 h at 2±1°C, the carcasses were again weighed to assess the chilled carcass weight. The left side of each carcass was ribbed between 10th and 11thrib positions prior to fabrication. Loin eye area and fat depth measurements (three-quarters of the length of the transverse section of the exposed *M. longissimus thoracis et lumborum*) were taken between the 10th and 11th ribs. Back fat thickness was measured with a ruler and the loin eye area (LEA) of *M. longissimus thoracis et lumborum* was measured using USDA approved measuring scale. The average back fat thickness at three points was calculated based on the corresponding back fat thickness at first thoracic, last thoracic and last lumbar vertebrae. Carcass length was measured from the anterior edge of the symphysis pubis to the vascular impression on the anterior edge of the first rib. Carcass measurements were taken by the same individual throughout the trial. The carcasses were fabricated into trimmed standard pork cuts viz. ham, loin, belly, spare ribs, picnic shoulder, butt and jowl. Yield of primal cuts were calculated by summing up the yields of ham, loin, boston butt and picnic shoulder. Each standard cut was further weighted and dissected into soft tissues (muscle, fat and trimmings) and inedible parts (skin and bone). 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^{o}C until analysis of other parameters. Before being measured, samples were thawed at room temperature overnight.

pH45 and pHu

At 45 min post-mortem, the pH value was measured in the *M. longissimus thoracis et lumborum* between 13th and 14th rib on the intact carcasses, using a portable digital pH metre (Oakton Instruments Model pH 100 Series, Nilis, IL) fitted with a Cole Parmer spear type electrode (Cole Palmer Instrument Company, Vernon Hills, IL). After chilling for 18 h, pH was assessed again before the carcasses were cut into primals. The ultimate pH (pHu) was measured using the same pH metre at 48 h post-mortem. All the determinations were performed in triplicate.

Visual colour, marbling, firmness and belly leanness

Chops from the lumbar region of the loin were used for assessment of the following traits: (a) visual lean colour score using a six point scale (1: pale pinkish grey and 6: dark purplish red), (b) marbling score using a ten point scale (1: devoid to practically devoid and 10: abundant), c) lean firmness score using a six point scale (1: very soft and 6: very firm) and finally, (d) belly leanness score on a seven point scale (1: only fat/no visible lean and 7: only lean) (National Pork Producers Council, 1991).

Proximate composition

The moisture, crude protein (N x 6.25), fat, ash and crude fibre contents were determined by the Association of Official Analytical Chemists' approved methods 925.10, 920.87, 920.85, 923.03 and 963.09, respectively (AOAC, 2005). All the determinations were performed in triplicate.

WHC, drip loss, emulsifying capacity, sarcomere length, muscle fibre diameter and cholesterol content

Water holding capacity (WHC) was determined at 24 h post mortem by the filter paper method (scoring and weighing; Kauffman *et al*., 1986). Drip loss of samples, taken approximately 30 h post mortem was measured according to the bag-method (Honikel, 1998). Emulsifying capacity was determined at 24 h post mortem as per the method described by Swift *et al.* (1961) with minor modifications and expressed as the amount of oil (ml) emulsified by one gram of protein. Sarcomere length and muscle fibre diameter were determined on fresh

Table 1. Yield of carcass components and by-products from triple cross (G_{25} x H_{25} x D_{50}) fattener pigs

Parameter	Gilts (n_1) Mean ±SEM	Barrows (n_2) Mean ±SEM	t-value	Combined (n_3) Mean ±SEM	Min.	Max.
Live weight (kg)	87.50±1.20	98.30±1.73	51.56**	93.00 ±1.33	78.50	116.00
Hot carcass weight (kg)	62.75±0.87	73.10±0.83	32.72**	67.30±0.27	55.50	83.00
Dressing percentage (%)	72.08±1.28	72.79±1.02	4.57	72.37±1.10	71.15	74.49
Head (kg)	4.95±0.37	5.28±0.44	3.90	5.20±0.41	4.60	5.60
Heart (kg)	0.23±0.16	0.25±0.15	1.10	0.25±0.15	0.20	0.35
Liver (kg)	1.13±0.47	1.24±0.38	4.72	1.20±0.40	0.95	1.55
Kidney (kg)	0.22±0.12	0.22±0.15	0.86	0.22±0.14	0.19	0.28
Spleen (kg)	0.11±0.12	0.11±0.16	0.94	0.11±0.14	0.10	0.15
Lungs (kg)	0.62±0.20	0.67±0.27	1.59	0.65±0.25	0.55	0.90
Removable blood (kg)	3.45±0.81	3.80±0.76	8.69	3.60±0.79	3.00	4.50
Stomach-with contents (kg)	3.71±0.49	4.08±0.67	8.94	3.80±0.56	3.15	4.90
Length of small intestine (m)	18.88±1.14	19.35±1.06	6.81	19.10±1.08	17.10	20.50
Length of large intestine (m)	4.72±0.85	4.97±0.77	6.47	4.80±0.81	4.30	5.60

**$P<0.01$, n_1=14; n_2=20; n_3=34

M. longissimus thoracis et lumborum at 45 min post mortem as per the methods described by Cross *et al.* (2012) and Jermiah and Martin (1977), respectively with minor modifications. Cholesterol was extracted using the method of Maraschiello *et al.* (1996) and then quantified by HPLC. A Shimadzu LC-6A high-performance liquid chromatograph (HPLC) equipped with a C18 reverse-phase column (250 x 4.6 mm x 5 µm) was used. The mobile phase was acetonitrile/2-propanol (55:45 v/v) at a flow rate of 1.2 ml/min. The detection wavelength was 210 nm and retention time was 13.89 min. All the determinations were performed in duplicate.

WB shear force

Five cm long cylindrical pieces (1 x1 cm^2 cross section) were cut parallel to the direction of the muscle fibres 24 h post mortem, and subsequently sheared perpendicular to the muscle fibre direction with a 3 mm thick Warner-Bratzler shear blade attached to a TA-XT2 Texture Analyser (Stable Micro Systems, Godalming, UK) equipped with a 500 Kg load cell and a crosshead speed of 2 mm/s. The Texture Expert software (version 1.20; Stable Micro Systems) was used for data collection and WB shear force values were recorded as the maximum peak force of shearing (expressed in N). All the determinations were performed in duplicate.

Statistical analysis

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

The details of yield of carcass and by-products from 10 month old Ghungroo x Hampshire x Duroc triple cross pigs are depicted in Table 1. The live weight of the triple cross pigs ranged from 78.5 kg-116 kg, with an average of 93 kg. Hot carcass weight ranged from 55.5 kg – 83 kg with an average of 67.3 kg, while the chilled carcass weight ranged from 54.3 kg – 81.2 kg. Similarly, the dressing percentage varied from 71.15 % - 74.49 % with an average of 72.37 %. Yield of removable blood at the time of sticking ranged from 3 kg – 4.5 kg. The yield of leaf fat was in the range of 1.1 kg – 2.75 kg. The length of small and large intestines were in the range of 17.1 m – 20.5 m and 4.3 m – 5.6 m, respectively. Also, no significant ($P>0.05$) difference was found for any of the observed parameters among gilts and barrows, except for hot and chilled carcass weights (Table 1).

The yield of standard pork cuts and their dissection details are mentioned in Table 2 and Table 3. Yield of different cuts viz. ham, loin, spare ribs, bacon, shoulder, butt and jowl were in the range of 16.1 kg – 22.85 kg; 16.25 kg – 22.3 kg; 4.75 kg – 7.9 kg; 2.7 kg – 6.1 kg; 6.15 kg – 9.3 kg; 5.8 kg – 9 kg and 0.8 kg – 1.65 kg, respectively. Four primal cuts (ham, loin, shoulder and butt) together accounted for 82.29% of the total carcass weight, where ham alone contributed for 29.19%. Among the sexes, yield of ham, butt and four primal cuts together were significantly ($P<0.05$) higher in barrows compared to gilts, which contradicts with previous research (Lebret *et al*., 2001). However, Ellis *et al.* (1996) found that carcass yield was greater in gilts than in barrows. The discrepancies observed among the authors could be related to differences in the method used for trimming at the slaughterhouse. Complete dissection of the carcass, on an average

Table 2. Yield of standard pork cuts from triple cross (G_{25} x H_{25} x D_{50}) fattener pigs and their dissection details

Parameter	Gilts (n_1) Mean ±SEM	Barrows (n_2) Mean ±SEM	t-value	Combined (n_3) Mean ±SEM	Min.	Max.
Ham (kg)	17.20±0.28	21.15±0.31	16.19*	19.30±0.30	16.10	22.85
Loin (kg)	17.98±0.11	20.85±0.14	6.07	19.20±0.12	16.25	22.30
Spare ribs (kg)	6.09±0.05	6.38±0.06	3.22	6.30±0.06	4.75	7.90
Bacon (kg)	4.18±0.05	3.94±0.05	8.25	4.00±0.05	2.70	6.10
Picnic Shoulder (kg)	7.79±0.06	8.84±0.10	5.19	8.10±0.08	6.15	9.30
Boston Butt (kg)	7.26±0.14	8.47±0.18	9.28	7.80±0.16	5.80	9.00
Jowl (kg)	1.35±0.03	1.44±0.03	0.89	1.40±0.03	0.80	1.65
Percentage of ham in the carcass (%)	26.74±0.13	29.87±0.08	17.25*	29.19±0.10	27.40	31.10
Percent of 4 primal cuts to carcass wt (%)	82.08±0.55	82.97±0.89	7.18	82.29±0.74	78.60	84.10

*$P<0.05$; $n_1=14$; $n_2=20$; $n_3=34$

Table 3. Deboning details of entire carcass from triple cross (G_{25} x H_{25} x D_{50}) fattener pigs and their dissection details

Parameter	Gilts (n_1) Mean ±SEM	Barrows (n_2) Mean ±SEM	t-value	Combined (n_3) Mean ±SEM	Min.	Max.
Lean meat (kg)	33.49±0.48	37.82±0.33	32.51**	35.08±0.37	26.10	39.50
Separable fat (kg)	5.82±0.19	6.85±0.11	18.37*	6.07±0.14	3.85	9.30
Bone (kg)	10.83±0.10	12.76±0.13	23.00*	11.91±0.11	8.40	15.50
Skin (kg)	10.21±0.15	11.06±0.18	8.41	10.48±0.16	6.90	13.80
Trimmings and fascia (kg)	2.18±0.11	2.37±0.14	6.10	2.30±0.13	1.60	3.15
Meat: Bone ratio	2.92±0.01	2.97±0.01	2.87	2.95±0.01	2.76	3.08
Fat : Lean ratio	0.15±0.08	0.18±0.06	4.22	0.17±0.06	0.14	0.21

**$P<0.01$, *$P<0.05$; $n_1=14$; $n_2=20$; $n_3=34$

yielded 35.08 kg lean meat, 6.07 kg separable fat, 11.91 kg bone, 10.48 kg skin and 2.3 kg trimmings and facia, while the yield of lean meat and separable fat were significantly (P<0.01) higher in barrows in comparison to gilts. The meat: bone ratio was in the range of 2.76 to 3.08, while fat: lean ratio varied from 0.14 to 0.21 and no significant (P>0.05) difference was observed for these parameters among the gilts and barrows.

The different carcass traits of Ghungroo x Hampshire x Duroc triple cross pigs are depicted in Table 4. At 10 months of age, the carcass length ranged from 61.5 cm – 93 cm, while that of the loin eye area varied from 1.3 in^2 – 5.5 in^2. Back fat thickness at three-quarters of the length of the transverse section of the exposed *M. longissimus thoracis et lumborum* between the 10th and 11th ribs was in the range of 0.7 cm – 2.25 cm, while the average back fat thickness calculated based on the corresponding back fat thickness at first thoracic, last thoracic and last lumbar vertebrae was in the range of 0.9 cm – 2.1 cm. As expected, barrows had slightly fatter carcasses than gilts which agree with Cisneros *et al.* (1996). Carcass length was significantly (P<0.05) higher in barrows while the carcass muscling score was significantly (P<0.05) higher in gilts. In India, loin eye area and back fat thickness are historically been important in commercial pig classification, but the carcass length and conformation has had little weighting. However, attention to carcass conformation is becoming more widespread in recent times, as its effects on meat yield and the shape of retail cuts are being recognized (Banik *et al.*, 2012). Barrows had slightly more intramuscular fat (marbling) than gilts, which is in line with the higher carcass fat content observed for castrates, and agrees with Leach *et al.* (1996).

pH45 and pHu were in the range of 6.43 – 6.74 and 5.54 – 5.77, respectively (Table 4). Sex did not influence the pH of the meat as reported by Cisneros *et al.* (1996) and Leach *et al.* (1996). Water holding capacity varied from 68.5% to 83.1%, while the drip loss was in the range of 1.42% to 2.65%. However, differences in water holding capacity between sexes were not observed. Emulsifying capacity, expressed as the amount of oil (ml) emulsified by one gram of protein, was in the range of 101 – 132.5 with an average of 109.5. WB shear force and the work of shear, determined 24 h post mortem, were in the range of 53.38 N – 76.13 N and 218.5 Ns – 312.9 Ns, respectively. Gender did not affect Warner-Bratzler shear force, values which confirm previous observations by Hamilton *et al.* (2000). Among the

Table 4. Selected carcass and meat quality parameters of triple cross (G_{25} x H_{25} x D_{50}) fattener pigs

Parameter	Gilts (n_1) Mean ±SEM	Barrows (n_2) Mean ±SEM	t-value	Combined (n_3) Mean ±SEM	Min.	Max.
Carcass length (cm)	71.49±1.27	77.11±1.38	22.91*	75.19±1.32	61.5	93.0
Loin eye area (in^2)	3.88±0.14	4.37±0.19	9.17	4.10±0.16	1.30	5.50
Back fat thickness at 10th rib (cm)	1.43±0.16	1.54±0.27	2.19	1.50±0.21	0.70	2.25
Marbling (1-10 scale)	1.95±0.12	2.17±0.12	8.58	2.10±0.12	1.00	3.00
pH_{45}	6.60±0.01	6.57±0.01	3.17	6.58±0.01	6.43	6.74
pHu	5.77±0.01	5.72±0.01	4.39	5.74±0.01	5.54	5.77
Drip loss (%)	2.03±0.02	1.89±0.04	7.23	1.93±0.03	1.42	2.65
Water holding capacity (%)	74.92±0.22	73.86±0.18	6.72	74.47±0.19	68.50	83.1
Emulsifying capacity (ml of oil/g of protein)	103.30±2.17	115.86±1.85	17.16*	109.5±1.95	101.0	132.5
Sarcomere length (μ)	2.13±0.02	2.17±0.03	0.62	2.16±0.02	2.00	3.00
Muscle fibre diameter (μ)	10.35±0.13	11.08±0.16	9.13	10.65±0.15	9.00	13.00
WB shear force (N)	62.65±1.17	60.91±1.28	6.88	61.39±1.21	53.38	76.13
Work of shear (Ns)	238.94±3.42	274.71±3.76	108.37**	251.3±3.51	218.5	312.9

**P<0.01, *P<0.05; n_1=14; n_2=20; n_3=34

Table 5. Proximate composition and cholesterol contents of *M. longissimus thoracis et lumborum* of triple cross (G_{25} x H_{25} x D_{50}) fattener pigs

Parameter	Gilts (n_1) Mean ±SEM	Barrows (n_2) Mean ±SEM	t-value	Combined (n_3) Mean ±SEM	Min.	Max.
Moisture (%)	73.19±0.15	72.07±0.19	16.52*	72.78±0.16	69.15	75.87
Dry matter (%)	26.98±0.11	27.48±0.16	3.88	27.22±0.14	24.13	30.85
Crude protein (%)	21.48±0.13	22.08±0.17	9.17	21.85±0.14	19.15	22.68
Crude fat (%)	3.17±0.16	3.53±0.21	16.82*	3.40±0.19	1.94	4.62
Crude fibre (%)	1.06±0.17	1.12±0.22	0.95	1.10±0.19	0.70	1.30
Total ash (%)	0.86±0.08	0.93±0.07	1.51	0.90±0.07	0.72	0.97
Moisture : Protein ratio	3.33±0.09	3.30±0.06	1.38	3.31±0.07	3.20	3.39
Cholesterol (mg/100g)	58.15±0.88	61.08±0.62	23.87**	59.70±0.71	47.83	71.19

**P<0.01, *P<0.05; n_1=14; n_2=20; n_3=34

sexes, meat from the gilts had significantly (P<0.01) higher emulsifying capacity and work of shear compared to barrows.

Proximate composition and cholesterol content in *M. longissimus thoracis et lumborum* of triple cross pigs are mentioned in Table 5. Different proximate principles were in the following range: moisture, 69.15% - 75.87%; crude protein, 19.15% -22.68%; crude fat, 1.94% - 4.62%; crude fibre, 0.7% - 1.3% and total ash, 0.72% - 0.97%. Among the sexes, meat from the gilts had significantly (P<0.05) higher moisture content, while that from the barrows had significantly (P<0.05) higher fat content. The trend of higher rate of fat deposition in the muscles of castrated male pigs was consistent with the reports of other workers. Huff-Lonergan *et al.* (2002) found higher intramuscular fat in hogs than boars at 91 kg body weight, while Essien (1988) reported significantly higher per cent fat in the muscles of barrows over those of gilts. Cholesterol content in the muscle was in the range of 47.83 -71.19 mg/100g, with an average of 59.7 mg/ 100g. Moisture: protein ratio varied from 3.2 to 3.39 with an average of 3.31 and no significant (P>0.05) difference was observed between gilts and barrows.

Conclusions

In the present study, the carcass traits of triple cross (Ghungroo x Hampshire x Duroc, $G_{25}H_{25}D_{50}$) pig variety were evaluated. Results of this study help to understand the details of carcass components and quality attributes of meat from this breed among gilts and barrows. Such knowledge helps to under-build genetic choices for breeding purposes or in genetic selection.

Acknowledgements

The research work mentioned in this article was carried out under the project on ‘Assessing the carcass and meat quality of indigenous pig breeds of India’. The authors wish to thank Indian Council of Agricultural Research for the financial assistance to undertake this project. The authors also acknowledge the financial assistance received from Department of Biotechnology, Government of India under grant No.BCIL-NER-BPMC-2012-1421.

References

AOAC. 2005. Official methods of analysis. 18th edn. AOAC Int., Arlington, VA.

Banik, S., Naskar, S., Pankaj, P. K., Sahoo, N. R., Tamuli, M. K. and Das. A. 2012. Effect of different body measurements on body weight in Ghungroo pigs. Indian Journal of Animal Sciences 82: 1094–1097.

Barman, K., Das, A., Thomas, R. and Banik, S. 2015. Effect of replacement of maize with water hyacinth foliage on nutrient utilization in crossbred (Hampshire × Ghungroo) grower pigs. Indian Journal of Animal Sciences 85: 435–436.

Cisneros, F., Ellis, M., McKeith, F. K., McCaw, J. and Fernando, R. L. 1996. Influence of slaughter weight on carcass characteristics, commercial cutting and meat quality of barrows and gilts from two genotypes. Journal of Animal Science 74: 925–933.

Cross, A. J., Harnly, J. M., Ferrucci, L. M., Risch, A., Mayne, S. T. and Sinha, R. 2012. Developing a heme iron database for meats according to meat type, cooking method and doneness level. Food and Nutrition Sciences 3: 905-913.

Ellis, M., Webb, A. J., Avery, P. J. and Brown, I. 1996. The influence of terminal sire genotype, sex, slaughter weight, feeding regime and slaughter-house on growth performance and carcass and meat quality in pigs and on the organoleptic properties of fresh pork. Animal Science 62: 521–530.

Essien, A. I. 1988. Chemical fat composition of muscles of the indigenous Nigerian pigs as influenced by age and sex. Meat Science 22: 131-142.

Gokuldas, P. P., Tamuli, M. K., Mohan, N. H., Barman, K. and Sahoo, N. R. 2015. A comparative analysis of reproductive performance of pig breeds under intensive management systems in sub-tropical climate. Indian Journal of Animal Sciences 85: 1042–1045.

Hamilton, D. N., Ellis, M., Miller, K. D., Mckeith, F. K. and Parret, D. F. 2000. The effect of the halothane and rendement napole genes on carcass and meat quality characteristics of pigs. Journal of Animal Science 78: 2862–2867.

Honikel, K. O. (1998). Reference methods for the assessment of physical characteristics of meat. Meat Science 49: 447–457.

Huff-Lonergan, E., Bass, T. J., Malek, M., Prusa, K. and Rothschild, M. F. 2002. Correlations among selected pork quality traits. Journal of Animal Science 80: 617–627.

Jermiah, L. E. and Martin, A. H. 1977. The influence of sex within breed of sires groups upon histological properties of bovine longissmus dorsi muscle during post-mortem aging. Canadian Journal of Animal Science 57: 7-14.

Kauffman, R. G., Eikelenboom. G., Van der Wal, P. G., Merkus, G. and Zaar, M. 1986. The use of filter paper to estimate drip loss of porcine musculature. Meat Science 18: 191-200.

Leach, L. M., Ellis, M., Sutton, D. S., McKeith, F. K. and Wilson, E. R. 1996. The growth performance, carcass characteristics, and meat quality of Halothane carrier and negative pigs. Journal of Animal Science 74: 934–943.

Lebret, B., Juin, H., Noblet, J. and Bonneau, M. 2001. The effects of two methods of increasing age at slaughter weight on carcass and muscle traits and meat sensory quality in pigs. Animal Science 72: 87–94.

Maraschiello, C., Diaz, I. and Garcia Regueiro, J. A. 1996. Determination of cholesterol in fat and muscle of pig by HPLC and capillary gas chromatography with solvent venting injection. Journal High Resolution Chromatography 19: 165–168.

Naskar, S., Mandal, G. P., Borah, S., Vashi, Y., Thomas, R. and Dhara, S. K. 2014. Evaluation of fatty acid profile in subcutaneous adipose tissue of indigenous and crossbred pigs. Indian Journal of Animal Sciences 84: 88–90.

National Pork Producers Council. 1991. Procedures to evaluate market hogs. 3rd edn. National Pork Producers Council, Des Moines, IA.

Swift, C. E., Lockett, C. and Fryer, A. J. 1961. Comminuted meat emulsions. The capacity of meat for emulsifying fat. Food Technology 15: 468-473.

Thomas, R., Jebin, N., Barman, K. and Das, A. 2014. Quality and shelf life evaluation of pork nuggets incorporated with fermented bamboo shoot *(Bambusa polymorpha)* mince. Meat Science 96: 1210–1218.