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CARCASS AND MEAT QUALITY CHARACTERISTICS OF WILD BOAR CROSSBREDS

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Abstract: Due to the growing interest in the production and consumption of wild boar meat, the quality attributes of meat products should be well established. To characterize the quality of wild boar cross meat, two males and two females reared in the same environment were slaughtered at an average of one year of age, and meat samples were was collected and analyzed for different parameters such as for moisture, pH value, protein, fat, iron, phosphorous, calcium, water holding capacity through the measure of cooking loss. Data obtained for live body weight, carcass biochemical characteristics, and meat quality traits were submitted to one-way analysis of variance (ANOVA) using a general linear model (uni-variate) in Statistical Package for Social Sciences (SPSS) computer program and the level of significance was determined observing the probability value (p) obtained through ANOVA of respective traits. To study the association among nutritive values and body parts, Pearson's correlation coefficients were determined using in Statistical Package for Social Sciences (SPSS) computer program. The pH values were found to be in the range of 5.78 to 5.90. Moisture, total ash, fat, and protein contents were observed to be in the range of 71.38 to 73.57 %, 0.89 to 1.10 %, 4.34 to 5.54 %, and 16.73 to 18.84 % respectively. Iron, phosphorous, and calcium content were found to be in the range of 1.94 to 2.94 mg/100g, 20.17 to 37.57 mg/100g, and 170.68 to 190.88 mg/100g respectively whereas cooking loss was in the range of 31.59 to 26.88 %. Sensory evaluation of meat samples was examined by a group of panelists according to the hedonic rating test. The consumer preference was similar to both types of meat samples (male and female). The overall acceptance; however, were higher in female samples than in male samples due to boar taint evident during the cooking or eating of pork derived from non-castrated male pigs once they reach puberty. The comparison of wild crosses among available commercial pigs and indigenous pigs is warranted for further studies with an appropriate and defined production system to obtain lean meat as per the consumer preferences which could be extensively used in commercial pig production to provide high-quality pork.

Keywords: wild boar crossbreds; meat carcass; physiochemical analysis; sensory evaluation

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1. INTRODUCTION

Meat is an essential source edible constituent derived from animals that are consumed by humans as a source of food. It is one of the important sources of proteins, vitamins, minerals, etc. Increase in demand for quality meat products and awareness of consumers, food manufactures have been encouraged to produce homogenous and high-quality products (Anwer et al., 2013). So, the quality of the meat has become a great subject of concern in recent years. The chemical composition and sensory attributes of meat vary from animal to animal based on breed, sex, age, weight, environment, storage time, temperature, etc. (Venel et al., 2001).

Ethnic groups of Nepal such as Rai, Gurung, Magar, Tamang are predominantly involved in pig rearing in certain areas of the country. It has been practiced in the poor sanitary conditions by farmers of these ethnic groups and so, restrictions have been imposed by ethnicity and religious belief on farming of pig. Therefore, as compared to other livestock areas, very little attention has been received from policymakers on this sector (Gurung, 1990; Dhaubadel, 1992). However, improved breeds having economical and commercial importance have been maintained for breeding and fattening in some urban areas. As a result of which, pig rearing is gaining popularity in recent time around cities areas of the country. Interestingly, consumption of wild boar meat has cultural significance and people of Nepal consume wild boar meat at *Maghe Sankranti* festival. Presently, the government has lifted the ban partially (personal communication, Department of National Parks and Wildlife Conservation, 2016) and allowed to rear wild boars and cross with domesticated pigs only to the licensed farmers. This has triggered interest in the consumption of wild boar irrespective of caste and religion. The popularity of wild boar meat in differentiated consumers exhibits the demand for leaner meat as well as something different from indigenous pigs which once were taboo to many of the communities and religions. In Nepal, wild boars are considered as herbivores that consume 90-95% of plant-originated food, and the rest of the part is derived from animal-originated foods and lives in a cleaner environment unlike other domesticated or semi-domesticated populations of pigs (Genov, 1981; Pinna et al., 2007).

Recently, the regulation against rearing wild boar has been lifted partially, so the number of male wild boars used as a sire is very limited in the market. Furthermore, the mating problem in pure wild boar in captivity is one of the major problems complained by the farmers (Personal experience, Field visit, Kawasoti, Chitwan, 2019) whereas mating wild boar males with commercial and indigenous pigs is successful (Personal experience) at Swine and Avian Research Program, NARC, 2017). The present experiment thus was conceived to use wild boar as a sire and cross with Duroc which is a renowned lean meat breed. Duroc pigs also possess a significant amount of lean muscle and when they are slaughtered the carcasses yield a high amount of usable flesh. With the avail of wild boar and its crossbreds in the market, to attend to differentiated consumer demand, the quality attributes of this product should be well established.

The pH of meat cells in the living animal which is 7.0-7.2 gradually falls after slaughter following the anaerobic postmortem glycolysis and attains ultimate pH of about 5.5 after 24-48 h (Immonen et al., 2000; Immonen & Puolanne, 2000; Alvarez et al., 2019). pH is a measure of meat quality; meats such as PSE (Pale, Soft, and Exudative) and DFD (Dark, Firm, and Dry) meats show undesired pH (Keenan, 2016; Adzitey and Nurul, 2011). Lower the pH of the muscle proteins, the lower their ability to bind water. Thus, pH has an influence on the water holding capacity of meat, which is an important property of fresh meat as it influences the final weight of the product and acceptance from consumers (den Hertog-Meischke et al., 1997).

The foremost characteristic of wild meat which widely attracts consumers is unique sensory attributes such as smell, taste, and texture (Soriano et al., 2006; Vergara et al., 2003; Szmańko et al., 2007). Also, wild boar meat has owned several beneficial nutritional and meat quality properties which could be able to create a stable platform for meat producers to attract consumers. One of the biggest challenges for the meat industry is to extract reliable information regarding meat quality with its production process ensuring the quality of meats for the consumers (Liu et al., 2003). It is, therefore, necessary to study and understand characteristics of meat quality traits as well as factors affecting those traits (Joo et al., 2013). Specifically in Nepal, pigs have taken a significant cultural priority in some ethnic communities yet negligible number of research has been done on carcass and meat quality of indigenous, exotic and crossbred pig. To the knowledge of the authors, the present study is the novel research aiming at improving the quality of exotic pig meat crossing with wild boar available in the country in order to target the taste preference of the local people. In this study, we have assessed the meat yield of different cuts, meat quality focusing on biochemical and sensory attributes of the wild boar crossbreds (wild boar X Duroc) and compared the results with published information.

2. METHODS

2.1. Preparation of samples

The examination was performed in four wild boar crosses (Wild Boar crossed with Duroc; two males and two females) which were reared in the same environment in the Swine and Avian Research Program under Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal. The male and female crossbred pigs were considered for the study to understand the significant gender-dependent variation/ sexual dimorphism among carcass, meat quality and vital organs as well as proximate composition of biochemical parameters. These animals, which were one year of age, were subjected to electric stunning before slaughtering them. Pre-slaughter mass, mass of warm and cold carcasses were measured with accuracy of 0.1 kg using digital balance. After evisceration, 0.5 kg muscle from various body parts (head, shoulder, front leg, mid-section, ham) were collected and weighed for sampling and transported to National Food Research Center, Khumaltar for storage and further analysis. Meat samples of these wild boar crosses were subjected to numerous analyses concerning their quality attributes and significant parameters.

2.2. Phenotypic Data

The live weight of all the sampled wild boar crosses and the weights of all the internal vital organs (heart, liver, lungs, kidney) were recorded. The analyzed phenotypic data are specified in Table 1.

2.3. Meat Quality Traits and Parameters

Meat quality traits such as pH, moisture, total ash, crude fat, crude protein, Iron, calcium, and phosphorus were determined from the longissimus muscle. Moisture and ash contents were determined according to the method described in Egan et al. (1981). Iron, phosphorous, and calcium contents were determined using UV-VIS spectrophotometer as described by Hornsey (2006), AOAC (1990), and Jamil and Rahim (2018) methods. Estimation of fat (by ether extraction method) and crude protein in the meat samples were determined by the micro-Kjeldahl method described in AOAC (1995). The pH of samples was measured by inserting a special spear tip electrode after making an incision of 2-3 cm deep in meat and recording pH after holding the pressed meat for 10 sec (Landvogt, 1991). The analyzed trait data are shown in Table 2.

For the estimation of cooking loss as a measure of water holding capacity, meat slices of thickness about 2.5 cm and weight of about 100 g were taken after noting their weight. Prepared samples were placed in a thin-walled plastic bag (heat-sealed under vacuum) and dipped in hot water maintained at 75ºC for 50 min as a method of cooking. Samples were cooled to room temperature; bags were removed and were dried using blotting paper before weighing their weight. Cooking loss was calculated as a percentage of original weight (Subba, 2001) (Table 3).

2.4. Sensory Evaluation

The assessment of sensory meat quality was performed considering various parameters such as color, water binding, tenderness, and flavor. A hedonic rating test was performed by the group of panelists to conduct preference mapping studies to capture liking scores. A score of 7 or higher on a nine-point scale is generally indicative of a highly acceptable sensory attribute (Everitt, 2009). Color, flavor, taste, texture, and juiciness differences of meat were determined through a sensory test by 15 consumers solely to assess consumer preferences for the meat-based on a 9-points Hedonic rating scale (Table 4). Each panelist evaluated two cubes (2 cm^3 each) from each sample for all the mentioned parameters.

2.5. Statistical Analysis of Data

Data obtained for live body weight, carcass biochemical characteristics, and meat quality traits were submitted to one-way analysis of variance (ANOVA) using a general linear model (uni-variate) in Statistical Package for Social Sciences (SPSS) computer program and the level of significance was determined observing the probability value (p) obtained through ANOVA of respective traits. To study the association among nutritive values and body parts, Pearson's correlation coefficients were determined using in Statistical Package for Social Sciences (SPSS) computer program.

3. RESULTS AND DISCUSSION

3.1. Body Weight, Carcass Characteristics and Organs Weights

The results regarding mean values for the body weight, carcass characteristics, and vital organ weight are given in Table 1. The overall mean live body, head, shoulder/front leg, mid-

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section and leg/ham weight were 137.0, 10.6, 41.4, 39.0 and 32.8 kg respectively. Similarly, overall mean weight for internal vital organs such as heart, liver, lungs, kidney and spleen were 0.44, 2.19, 1.65, 0.56 and 0.38 kg respectively. Based on the procession of the data of these traits, it can be claimed that there is no significant difference ($p>0.05$) between males and females when raised for meat purposes.

Table 1 Weight traits of external and internal organs with phenotypic means and standard deviation

Weight Traits (kg)	Overall Mean	Male(n=2)	Female(n=2)	Level of significance
External organs				
Live wt.	137.0±7.79	138.5±15.5	135.5±1.50	NS
Head wt.	10.65±0.61	12.29±1.02	12.29±0.67	NS
Shoulder and front leg wt.	41.37±3.06	45.94±5.90	36.78±1.64	NS
Mid-section wt.	39.01±1.87	38.495±3.17	39.52±1.96	NS
Leg /ham wt.	32.77±1.30	33.94±2.16	31.6±1.44	NS
Internal organs				
Heart wt.	0.44±0.04	0.49±0.03	0.39±0.08	NS
Liver wt.	2.19±0.36	2.37±0.24	2.00±0.68	NS
Lungs wt.	1.65±0.12	1.93±0.09	1.37±0.23	NS
Kidney wt.	0.56±0.04	0.69±0.01	0.44±0.07	NS
Spleen wt.	0.38±0.08	0.40±0.10	0.36±0.13	NS

Note: NS denotes non-significant, n: number of obervations, kg: kilograms, wt.: weight

3.2. Proximate Analysis of Meat Components

Parameters such as pH, moisture, total ash, crude fat, crude protein, Iron, calcium, phosphorus were observed (Table 2). The results on the mean values for these chemical compositions are not significantly varied except for crude protein and crude fat. The females had about 19% higher crude fat than males whereas males had 10.5% higher crude protein than female pigs as presented in Table 2.

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Table 2 Proximate composition of biochemical parameters with means and standard deviation

Traits	Overall mean	Male (n=2)	Female (n=2)	Level of significance
Dry matter %	27.47±0.72	27.42±0.94	27.53±1.10	NS
Total Ash %	0.99±0.03	1.06±0.04	0.92±0.03	NS
Crude fat %	4.94±0.05	4.42±0.07	5.47±0.07	p<0.01
Crude Protein %	17.78±0.05	18.77±0.07	16.80±0.06	p<0.01
Iron mg/100g	2.56±0.22	2.78±0.16	2.35±0.41	NS
Calcium mg/100g	31.17±3.69	27.15±6.98	35.18±2.39	NS
Phosphorous mg/100g	177.36±4.73	181.72±9.16	173.00±2.32	NS
pH Value	5.83±0.03	5.85±0.05	5.82±0.03	NS
Temperature ^{o}C	18.34±0.27	18.37±0.53	18.30±0.10	NS
Moisture %	72.53±0.72	72.58±0.94	72.48±1.09	NS

Note: NS denotes not significant; p<0.01: significant at 1 % significance level; n: number of observations

The crude protein was ranged from 16.80±0.06 to 18.77±0.07%. The crude protein content was significantly higher in the flesh of male boars in comparison to female bores. Similarly, the content of crude fat was higher in the flesh of female boars. Wild boar crosses had higher crude fat than Duroc and wild boar. Fat percentage is affected by the production management system. If animals are reared in an intensive management system, the crude fat content is higher (Bhattarai et al., 2020). Likewise, moisture content was in the range of 71.38 to 73.57%. Meat contains about 75% moisture, of which about 95% lies in free form (free moisture) and the remainder about 5% lies as the water of hydration bound to hydrophilic groups of the protein (Offer and Knight, 1988b; del Puerto et al., 2016). A part of this moisture can be released from meat by applying pressure and other physical forces (Warner, 2017). Total Ash content was found to be in the range of 0.89 to 1.10%. The pH of meat samples in the current studies was ranged from 5.78 to 5.90 when measured at 18.4 and 18.9 ^{0}C respectively. Meat products show variation in pH; cooked sausage has a pH value between 5.9 and 6.2, and that of dry sausage lies between 4.8 and 5.5 (Landvogt, 1991).

The meat of wild boar is found to contain more protein and less fat than the meat of a domestic pig. The result on a crude protein of the wild boar crosses in the current study was found lower compared to its parents, 22.79±0.78 in Duroc (Choi et al., 2014) and 21.81 to 22.92 in wild boar (Kumar, 2018). The crude fat in the flesh of male and female boars was 4.42±0.07% and 5.47±0.07% respectively. Past studies showed that the crude fat content is higher in crossbreeds

than in Duroc and wild boar (Choi et al., 2014; Kumar, 2018). The results of dry matter, total ash, iron, calcium, and phosphorous contents in the current study were 27.47±0.72%, 0.99±0.03%, 2.56±0.22 31.17±3.69 177.36±4.73 respectively (Table 2) which were comparable to the findings as reported by various researchers (Anwer et al., 2013; Choi et al., 2014; Kumar, 2018).
There is a close connection between the pH of the flesh and its water-holding properties including drip loss and cooking loss. Water released from meat and meat products can be described as drip, purge, or cooking loss, and they are inversely related to water holding capacity (Warner, 2014).

The cooking loss of the meat flesh was in the range of 26.88 to 31.59% with no significant difference among males and female pigs (Table 3). Cooking loss is considered as one of the measures of water holding capacity of meat. Cooking losses are due to the denaturation of proteins, which results in structural changes that cause fluid to be expelled (Offer and Knight, 1988a). When boiling, filamentary entities such as myofilaments and collagen undergo shrinking and destroys the cell membrane. Intra and extracellular water is therefore released when meat is heated (Tornberg, 2004). Meat having good water holding capacity has less cooking loss and vice versa (Aaslyng et al., 2003). But the extent of cooking loss depends on pH, geometry, and surface area of the meat, and heat treatment conditions such as temperature, speed of heating, time, etc (Utama et al., 2018; Goñi and Salvadori, 2010; Purslow et al., 2016). Therefore, experimental conditions must be comparable for comparing this parameter.

Table 3 Thawing loss and cooking loss with means and standard deviation

Traits	Overall mean	Male (n=2)	Female (n=2)	Level of significance
Cooking loss %	29.12±0.83	26.88±1.18	31.59±1.29	NS
Thawing loss %	6.54±0.53	5.55±0.99	7.53±0.29	NS

Note: NS denotes not significant.

3.3. Sensory Evaluation

In judging the cooked meat flesh, the overall acceptance was higher in the flesh of male boars compared to female boars. Panelists noticed boar taint, typical rancid flavor present in cooked flesh of male boar, however, they did not care for that in overall preference. This might be the cause of the cultural preference of male animals for meat purposes.
Results of sensory attributes (color, flavor, taste, texture, juiciness) shown in Table 4 indicate the likeness of the meat in the group of panelists based on the hedonic rating scale (1-9). The color of fresh meat is determined largely by the concentration of the chromo-protein myoglobin and some extent by the concentration of hemoglobin. The chemical state of myoglobin has a major impact on the perception of color. Thus, consumers prefer fresh meat. (Suman and Joseph, 2013). The water-soluble constituents are responsible for the particular meaty flavor. The species differences in flavor are attributed to a difference in the flavor of the lipid fraction of meat (Walker and Hudson, 2014). As yet, sensory evaluation appears to be the only reliable method for assessing meat flavor.

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Table 4 Sensory attributes of meat samples based on hedonic rating scale

Sample	Color	Flavor	Taste	Texture	Juiciness	Overall acceptance (mean)
Male A	7	8	8	8	7	8
Male B	7	8	8	8	8	8
Female A	7	8	8	7	7	7
Female B	7	8	8	7	7	7

Hedonic Rating Scale

Like extremely	9	Like slightly	6	Dislike moderately	3
Like very much	8	Neither like nor dislike	5	Dislike very much	2
Like moderately	7	Dislike slightly	4	Dislike extremely	1

3.4. Correlation Among The Nutritive Values of Wild Boar Meat

Findings revealed that there was both negative and positive association among the nutritional parameters of wild boar meat i.e. dry matter (DM), total ash (TA), crude protein (CP), iron (Fe), calcium (Ca), and phosphorous (K). The correlation coefficients (r) among these parameters varied from -0.99 to 0.86 (Table 5). Accordingly, there was a significantly high negative association between crude protein (CP) and crude fiber (CF) of wild boar crosses. This finding has proven that the higher the protein, the lesser the fat. Similarly, negative correlation coefficients were observed for DM with TA and Ca; TA with CF and Ca; CF with Fe and K, CP with K; and Ca with K. On the other hand, there was a positive association of DM with CF (weak), CP (weak), Fe (high), and K (high). Similarly, TA had strongly high to weakly positively correlated with Ca, and Fe and K, respectively. A similar trend was also observed between CF and Ca, CP and Fe, Cp and K, and Fe and K as presented in Table 5.

Table 5 Relationship among the nutritive values of wild boar meat computed with proximate analysis.

Traits	TA	CF	CP	Fe	Ca	K
DM	-0.49	0.06	0.02	0.75	-0.26	0.66
TA		-0.87	0.86	0.18	-0.34	0.14
CF			-0.99*	-0.52	0.70	-0.60
CP				0.61	-0.64	0.60
Fe					-0.38	0.72
Ca						-0.89

Note: dry matter (DM), total ash (TA), crude fiber (CF), crude protein (CP), iron (Fe), calcium (Ca) and phosphorous (K); *. Correlation is significant at the 0.05 level (2-tailed).

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3.5. Correlation among the carcass traits of wild boar

Results indicated that almost all the carcass traits including live weight (LWT), head weight (HDW), shoulder with foreshank weight (SFW), the middle part of carcass weight (MSW), ham weight (HMW), heart weight (HRW), liver weight (LVW), lungs weight (LNW), and kidney weight (KDW) of wild boar were positively correlated except the correlation between LWT and LVW of slaughtered animals (Table 6). A significantly high positive association was observed between HDW and SFW (r= 0.95), HRW and LNW (r= 0.96), and LNW and KDW (r= 0.96) whereas, a weak to high positive correlation was observed for other cases.

Table 6 Relationship among the body parts of wild boar meat computed with proximate analysis.

Traits	HDW	SFW	MSW	HMW	HRW	LVW	LNW	KDW
LWT	0.53	0.77	0.85	0.81	0.43	-0.18	0.34	0.11
HDW		**0.95***	0.29	0.87	0.88	0.41	0.95	0.89
SFW			0.51	0.94	0.80	0.20	0.83	0.71
MSW				0.73	0.45	0.13	0.25	-0.02
HMW					0.87	0.38	0.82	0.64
HRW						0.75	**0.96***	0.87
LVW							0.67	0.67
LNW								**0.96***

Note: live weight (LWT), head weight (HDW), shoulder and front-leg weight (SFW), mid-section weight (MSW), ham weight (HMW), heart weight (HRW), liver weight (LVW), lungs weight (LNW), and kidney weight (KDW); *. Correlation is significant at the 0.05 level (2-tailed).

4. CONCLUSION

In the current scenario of Nepal, there are very limited data and research publications for wild boar and pigs with special emphasis on carcass traits. The present study is the preliminary research conducted with the limited number of samples of Wild boar and Duroc crosses. Crossbreds exhibited similar quality of meat except higher crude fat and lower crude protein in comparison to their parents: Duroc and Wild boar. Sensory evaluation of meat samples has proven the acceptance of taste of meat as per the preference of consumers. The comparison of wild crosses among available commercial pigs and indigenous pigs is warranted for further studies with an appropriate and defined production system to obtain lean meat as per the consumer preferences which could be extensively used in commercial pig production to provide high-quality pork.

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