Research Article

Impact of Breed, Age and Gender on Beef Quality Traits; A Comparison from Native to Crossbred Cattle

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Abstract | The diversity of native Pakistani cattle genetic resources is important as a human food source. With the increase in beef demand, the development of beef production is considered important by the state. Beef quality characteristics, i.e., marbling, flavor, juiciness and tenderness, are getting more consideration by consumers, thus the present study determined the impact of breed, age and gender on beef quality traits. A total of 180 cattle samples were taken equally from two local zebu cattle breeds (i.e., Dhanni and Dajal) and one crossbred (Holstein Friesian X Sahiwal). The findings reveal that cattle breeds and their age have significant (P <0.05) effects on marbling trait, showed a relatively higher (8.80%) marbling trait than crossbreds. The water holding capacity (WHC, 79.0 %) trait was found significantly (P <0.05) higher in crossbred cattle, followed by Dhanni and Dajal cattle. The age of the animals showed significant (P < 0.05) effect on the WHC of beef samples. The sarcomere length (SL) of muscle fiber fluctuated significantly across the breeds and ages groups. This study also revealed that cattle breed and age do have significant effect on the moisture content of beef. The present study revealed that no significant effect of age on muscle fiber diameter. This study not only augments breeds, gender and age role of Zebu cattle on beef quality traits but also suggest that Dhanni beef quality characteristics are found relatively better than Dajal and Crossbred cattle which might be considered as important for future policy maker for meat industry in Pakistan.

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Introduction

Beef from Zebu cattle is recognized as a significant food resource, with factors such as genetics, age, gender, management techniques, and diet influencing the nutritional content of Zebu beef (Gagaoua *et al.*, 2016; Barnes *et al.*, 2012; Xie *et al.*, 2012). Genetic diversity along with other factors play a key role

leads to variation in nutritional composition of meat. Technical approach is required for assessment of different factors such as breeds, gender and age to conclude the nutritional values of meat from different cross and pure Zebu breeds.

Meat quality traits i.e., the tenderness, marbling, juiciness, water-holding capacity are key factors influencing consumer satisfaction while selecting beef and or its products. In case of fulfillment of the consumer satisfaction different meat quality characters has different grades which in turn defines the quality of the meat (Hopkins *et al.*, 2014; Dransfield *et al.*, 2003).

The structure of the muscle and its physiology are important attributes in determining the quality of the meat, which is strongly influenced by the breed (Waritthitham *et al.*, 2010). Zebu cattle breeds have some advantages such as low maintenance requirements, harsh environment tolerance, disease resistant, while having some disadvantages such as their dressing percentage are low and daily weight gain is lower as compare to other crossbreds (Li *et al.*, 2009). Consumers pay special attribute to variation in the quality of beef products. If consumers are not satisfied from the product, it may result in refusal of the product (Bonny *et al.*, 2018) thus lead to the loss for the company and producers. Cattle breeds attaining early puberty will have higher intramuscular fat deposition as compare to late-maturing breeds (Irshad *et al.*, 2013). Age of animal at slaughtering is an important factor which determines the final quality of the meat produced (Clinquart *et al.*, 2022). Handling of the animal before slaughtering and succeeding pH changes of the muscles play a vital role in determining the final quality of meat. There are some factors that lead to unsatisfactory meat quality characteristics such as transport time, stress during transport and feed withdrawal (Warner *et al.*, 2010), which have a negative impact on meat quality. As a result, the final pH will be higher, resulting in unfavourable meat quality (Troy *et al.*, 2016; Troy and Kerry, 2010).

Important factors such as Growth rate, carcass yield, and feed efficiency are positively influenced in bulls (fertile adult bovine males) as compared to steers (castrated adult bovine males) (O'Riordan *et al.*, 2011). Marbling has prime importance in beef production system in term of it effect on Quality (Moran *et al.*, 2017). Gender has been an important trait which is associated with many aspects of meat quality parameters and has a significant effect on fat deposition and tenderness of the beef (Guerrero *et al.*, 2013).

The goal of this study was to look at the effects of breed, age and gender on meat quality in locally slaughtered cattle, and the key breed selection in order to support beef industry development in Pakistan.

Materials and Methods

Experimental animal and samples collection

A total of 180 beef cattle comprising of Dajal, Dhanni and crossbred (Holstein Friesian X Sahiwal) cattle were selected for beef quality study. A total of 60 beef samples were collected per each breed. The experimental animals were divided in to the following three age groups as following (Group1 consist of 08-18 months age young stock, Group2, age ranged from 18.1 to 48 months, and Group 3 covered the age of above 49 months cattle) as highlighted in Figure 1. Before slaughtering, all the live cattle were assigned groups based on their breed, age and sex and tried to keep the similar body score conditions cattle for present study (Knock and Carroll, 2019), the age of cattle were properly recorded using dentition.

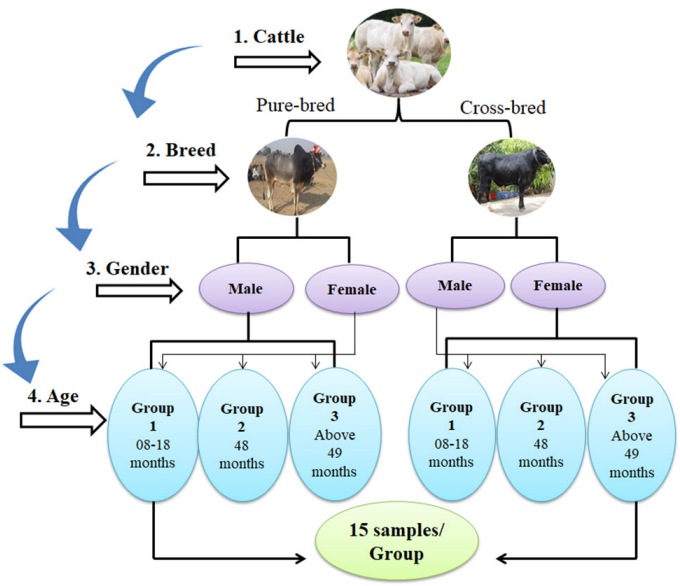

Figure 1: *Technical route of study and that exploited for measuring the research objectives.*

Measurement of muscle fiber diameter and sarcomere length

A beef sample of weight 5.0 g was dissected from the cross sectional surface of the longissimus dorsi

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muscle. Each sample was homogenized in a blender separately, containing 15 ml of 0.25 M sucrose solution and 15.0 ml of 1.0 M EDTA (ethylenedinitrilo tetra acetic acid) for 15 seconds interpreted with a 5 second interval to produce homogenized slurry. One drop of homogenized slurry was picked up and placed on a glass slide. The slide was covered with a cover slip and was examined under the microscope using a calibrated micrometer (Jeremiah and Martin, 1985). The similar procedure was adopted for measurement of sarcomere length. The sarcomere length of the sample was measured using a micrometer, which was fitted in the microscope. Length of 20 myofibrils was noted randomly, and its average was expressed in micrometer.

Moisture analysis of beef samples

The oven was pre-heated and all the petri dishes were dried by heating for one minute. Empty petri dishes were weighed. The minced beef sample of weighed 10.0g was uniformly spread in the petri dishes with the help of a spoon and placed in an oven at 65°Cfor a period of 24 to 48 hours for complete drying of beef samples. After complete drying in the oven the samples were kept in desiccators for some time to make it cool. The weights of petri dishes along with dried samples were determined and noted.

Marbling

According to USDA marbling is divided into nine classes. Each sample taken from Longissimus dorsi muscle were examined and graded for marbling according to USDA standard. The following scores were used on account of presence of fat droplets or molecules in the intra myofibril bundles; 0. Devoid 1. Partial devoid 2. Traces 3. Small 4. Slight 5. Modest 6. Moderate 7. Slight Abundant, 8. Moderate Abundant and 9. Abundant (USDA, 1997). United States standards for grades of carcass beef. Agriculture Marketing Service, USDA, Washington, DC. USA).

Water holding capacity

Meat samples (5.0g) was taken and minced for 5 minutes and when properly minced, sample was taken and placed in the center of two filter papers. A polythene sheet was wrapped around the filter papers and placed on a flat rigid surface. A weight of 2.80 kg was placed on the wrapped filter papers and applied for 5 minutes. Then the meat sample was weighedand difference noted (Whiting and Jenkins 1981).

Statistical analysis

The data obtained from the trial was put in Microsoft excel sheet and run for summery statistics. Data was exported to Genstat software for statistical analysis was used. A 3×3×2 factorial design was used where cattle breed were three and three age groups of animals for further analysis, as the breeds and age groups have three levels (post weaned young stock, young adults and mature) and for sex study animals were divided into two levels male and female. Correlation of the various quality parameters were analyzed through Pearson correlation coefficient methods. The means were also compared through LSD. The significance level was α (Greek symbol for Alpha) at 0.05 for the present study analysis.

Results and Discussion

Marbling

Breed, age groups and sex effects on marbling trait of beef samples were presented in the Table 1. Results showed that Zebu cattle breeds and their age groups have significant ($P < 0.05$) influence on the marbling traits. Marbling score of Dhanni cattle breeds in all age groups were found higher than crossbred and Dajal cattle. The highest (6.80) marbling score for Dhannibeef samples followed by the Friesian and Sahiwal crossbreds (6.20). With increase in age of the animals, the marbling score also increased. Thus, highest marbling score was shown in mature cattle samples (age group 3), followed by group 2. However, gender of the animals has no significant effect on beef marbling characteristic.

Water holding capacity

Water holding capacity (WHC) of three cattle groups and three age groups were presented in the Table 1. The WHC ranges from 58.80 to 91.11% with an average of 77.20%. This result shows that there is direct relation between age of animals and its beef WHC, and also significant ($P < 0.05$) mean were observed for this association. WHC is also significantly influenced by breed ($P < 0.05$) in the beef samples. Highest 79.03% WHC was found in crossbred beef samples, followed by Dhanni cattle 78.31% while lowest value obtained for Dajal breed Table 1. Within a breed and age group the sex of animal did not show significant effect on WHC.

Effect of breed and age on beef moisture content

Moisture content of beef samples were highlighted

in Table 1. Moisture content ranges between 64.0 to 81.0% with a mean value of 74.0%. The obtained results further revealed that advancement in age of animals has significantly (P < 0.05) inversely proportional to the moisture content in beef. The juvenile group of animals showed more moisture content (78%) than younger animals (75%) and followed by mature animals. Gender of animals showed significant (P < 0.05) effect on moisture content of beef samples. It is obvious from the data that the beef samples of male animals have higher moisture content as compare to beef samples from female animals. Average, female animals have (1.5%) lesser moisture content than male animals. There was no significant effect of breed on moisture content of the analyzed samples.

Muscle fiber diameter

The discoveries regarding muscle fiber diameter (MFD) in different cattle breeds were shown in the Table 1. Different age groups were significantly (P <0.001) effect at the MFD traits of beef. As animals, age is advanced; the muscle fiber diameter significantly increases and the mean values of different age groups are presented in Table 1. The average mean of MFD for the youngest group is (49.60µm) followed by group two (65.47µm) while highest (75.97µm) was observed for group three animals. The effect of gender on MFD was non-significant, where values of MFD in males are (63.40µm) and for female (63.96µm).

Sarcomere length

The effect of breed, age group of cattle and sex on the sarcomere length of muscle fiber are presented in the Table 1. Findings revealed that sarcomere Length (SC) of beef samples were significantly (P < 0.001) different among the present study zebu cattle breeds. The average values for SC were highest for Dhanni breed (1.99µm) followed by Dajal (1.96 µm) and the smallest length was noted for crossbred cattle (1.84 µm). The available findings further exposed the significant difference (P < 0.001), and inverse relationship between age of the animals and SL. Group 1 animals have highest average length (2.42 µm) followed by group 2 (2.10 µm) and group 3 (1.28 µm). These results also illustrated that sex has no significant (P > 0.05) effect on SL in beef samples of different breeds.

Table 1: *Breed, cattle age and sex effects on mean marbling score, percent water holding capacity, muscle fiber diameter, percent moisture content and sarcomere length of selected cattle in Peshawar, Pakistan.*

Breed	Age group 1		Age group 2		Age group 3		P-value
	Female	Male	Female	Male	Female	Male	
Marbling score							
Crossbred	3.80±0.31	3.20±0.09	4.60±0.13	4.60±0.14	6.20±0.31	5.60±0.13	P_1<0.01
Dajal	2.40±0.80	2.40±0.81	4.60±0.36	4.40±0.13	5.60±0.13	4.80±0.76	P_2<0.01
Dhanni	4.00±0.22	4.00±0.45	6.60±0.35	6.60±0.22	6.80±0.54	5.80±0.31	P_3= NS
Water holding capacity							
Crossbred	71.47±2.0	68.55±2.85	79.46±6.24	80.40±5.36	86.79±1.3	87.55±5.2	P_1<0.01
Dajal	62.37±6.72	62.93±10.09	77.15±3.32	76.91±1.50	84.04±3.76	82.12±2.07	P_2<0.01
Dhanni	70.10±3.8	69.23±2.92	81.40±3.03	80.27±1.0	85.56±4.3	83.31±1.0	P_3 = NS
Muscle fiber diameter							
Crossbred	55.40±4.6	48.80±5.9	63.00±4.4	67.40±4.1	76.80±6.5	78.40±9.4	P_1 = NS
Dajal	46.80±7.9	49.0±15.4	66.00±16.9	66.60±0.5	76.40±3.9	72.40±9.9	P_2<0.01
Dhanni	47.80±17.9	49.80±12.8	65.60±0.80	64.20±18.6	77.80±4.5	74.00±4.9	P_3 = NS
Moisture content							
Crossbred	76.8±0.7	78.39±0.44	75.20±0.34	74.70±0.35	69.74±1.25	70.67±2.8	P_1 = NS
Dajal	78.1±0.9	78.99±1.34	75.18±1.82	75.46±0.23	69.02±0.13	71.46±0.9	P2<0.01
Dhanni	78.9±1.1	78.54±1.98	73.97±1.09	75.11±0.99	68.08±3.40	70.02±1.9	P_3<0.01
Sarcomere length							
Crossbred	2.42±0.01	2.32±0.08	1.93±0.04	1.81±0.02	1.31±0.07	1.25±0.03	P_1<0.01
Dajal	2.44±0.01	2.43±0.01	2.07±0.07	2.33±0.01	1.20±0.01	1.32±0.03	P_2<0.01
Dhanni	2.45±0.01	2.43±0.03	2.24±0.01	2.20±0.06	1.24±0.04	1.37±0.03	P_3=NS

P_1 represent for breed, P_2 for age of the animals, P_3 value represent for gender, Non-significant (NS).

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The current study found that breed and age had a significant (P >0.001) effect on beef marbling characteristic. Similarly, various other studies also demonstrated the association between marbling score with breed and age of cattle (Vieira *et al*., 2007; Brooks *et al*., 2000). Another scientist Lim *et al*. (2013) had also observed that marbling is key trait in Beef quality. He also observed that breed has a vital effect on beef marbling score. The marbling score varies amongst cattle breeds, and this fact has been validated Kim and Lee (2003). Certain cattle breed attain puberty at early age, so young mature animal of that breed will show more marbling score than those animal who needs longer age to attain puberty. As the muscular growth rate is higher in younger animals as compare to older mature cattle; this is due to lower marbling score occur in the muscles. The very similar results are found in current study also and shown in the (Table 1). Cattle breed and age-related changes in beef marbling were studied and concluded a significant difference in the intramuscular fat content among different breeds. The marbling scores of beef increased significantly with progressing growth in the investigated breeds (Albrecht *et al*., 2006).

Water holding capacity, the ability of muscle to retain moisture, has a major impact on the juiciness of meat. The water holding capacity of meat is an important factor affecting the economic value of meat, as it influences drip losses during transport, storage, thawing and cooking (Lawrie *et al*., 1998). The results of the present study showed that cattle breed and age have a significant effect on the WHC characteristic of beef, which is consistent with the findings of Revilla *et al*., 2006; who investigated the effect of different breeds on WHC and concluded the obvious effect (Revilla *et al*., 2006). Author data analysis showed that WHC was not significantly affected (P > 0.05) by sex of the cattle. This dissimilarity might be due to species differences between the two similar natures of studies e.g., (cattle breeds were used in present study while in case of Nuraini *et al*. (2013) buffalo was used as experimental animal. Cheng and Sun (2008) were of the opinion that WHC is an important meat quality trait which is exaggerated by genetic makeup of the animals. Different breeds of cattle have different genetic patterns, as a result of these differences in beef samples from different breeds showed variation WHC. The same study is parallel with the present findings.

The surface area of muscle fiber and SL differ and it depends upon age of animals and the type of muscle (Ahnström *et al*., 2012). Thus, these findings supported present results that age of the animals effect the SL of muscles. The breed had a significant effect in respect of sarcomere length which can be observed by the differences in SL of the investigated breeds. These differences are actually caused by the shortening of sarcomeres during cold storage.

Moisture in beef is slightly more related to the age of the animal. The present results show that the moisture concentration in beef is significantly inversely related to the age of the animals. As the % fat content of beef increases with animal age (age progression), and leads to the decrease in moisture content due to access accumulation of triglyceride content in adipose tissue (Stika *et al*., 2007), Park *et al*. (2002) and Savell *et al*. (1987) concluded that fat content is inversely proportion to moisture in the bovine carcass. Another study demonstrated that as cattle grow older, the moisture content of meat decreases; hence meat quality drops (Lawrie, 1998). In a study of cattle of different age groups, it was found that the older group had higher protein content, muscle fibre diameter and density.

It is clearly obvious that there is a close and interdependent relationship between muscle size, its number, and fiber type (Ryu *et al*., 2004). Some other studies explained that prime consideration to the fact that beef quality traits have positive relationship with muscle fiber characteristics (Ozawa *et al*., 2000). Gender influence on MFD was investigated, and it was revealed that animal gender had no effect on fiber composition or diameter (Vestergaard *et al*., 2000). Based on his findings he revealed that as age of the animal increases its beef water content markedly decreases. The subject study findings are parallel with Jeremiah and Gibson (2003) who claimed that no differences were found among the breeds.

Conclusions and Recommendations

This study highlights the significant influence of breed, age and sex on meat quality traits in native and crossbred cattle. Dhanni cattle had higher marbling scores compared to Dajal and crossbred cattle, although crossbred cattle had the highest water retention. Age had a significant effect on water retention and sarcomere length, but not on muscle

fibre diameter. These results suggest that Dhanni cattle should be given higher priority in future breeding and beef production strategies to meet the growing consumer demand for premium beef in Pakistan. These findings will be of great value to policy makers and stakeholders in the improvement of beef production and quality standards.

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Novelty Statement

This research work provides insight into how beef quality traits are influenced by breed and gender and age of animals.

Author's Contribution

Abdur Rahman and Zahid Ullah: Performing the field and laboratory testing activities, and writing up the manuscript.
Ibrar Muhammad Khan and Siraj Uddin: Helped in data collection.
Muhammad Yasir Khan and Ikram Ullah: Assisted in data analysis and diagnostic laboratory testing.

Data availability
The datasets generated during the current study are available in the current draft.

Ethical approval
The experimental animals were kept under conducive environment and every possible effort were made to minimized stress upon the animals following ethical guidelines of Animal ethical committee, Department of Livestock Management, Breeding and Genetics, The University of Agriculture, Peshawar, Pakistan

Data availability
The datasets generated during the current study areavailable from the corresponding author on reasonable request.

Declaration of generative AI and AI-assisted technologies in the writing process
No Generative AI and AI-assisted technologies wer used in the writing process.

Conflict of interest
The authors have declared no conflict of interest.

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