

**MEAT YIELD, QUALITY AND CARCASS CHARACTERISTICS OF
INDIGENOUS AND CROSSBRED CATTLE REARED UNDER IMPROVED
FEEDING SYSTEM**



**A Dissertation
Of
DOCTOR OF PHILOSOPHY
By
MD. ABU BAKKUR SIDDIQUE**

Registration No.: 0905093

Session: 2013

**Department of General Animal Science and Nutrition
Faculty of Veterinary and Animal Science
Hajee Mohammad Danesh Science and Technology University
Dinajpur-5200**

December, 2016

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DECLARATION

I declare that, except where otherwise stated, this dissertation is entirely my own work and has not been submitted in any form to any other university for any degree.

Date.....

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The Author

LIST OF ABBREVIATIONS AND SYMBOLS

ADF	=	Acid Detergent Fiber
ADG	=	Average Daily Gain
AI	=	Artificial Insemination
AOAC	=	Association of Official Analytical Chemist
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
BCS	=	Body Condition Score
BDT	=	Bangladeshi Taka
BER	=	Bangladesh Economic Review
BW	=	Body Weight
C	=	Celsius
CF	=	Crude Fiber
CFU	=	Colony Forming Unit
CGSB	=	Canadian General Standards Board
cm	=	Centimeter
Conc.	=	Concentrate
CP	=	Crude Protein
d	=	day
DLS	=	Directorate of Livestock Services
DM	=	Dry Matter
DMI	=	Dry Matter Intake
<i>E. coli</i>	=	<i>Escherichia coli</i>
e.g.	=	Example Gratis
Fig.	=	Figure
g	=	gram
gm	=	gram
GDP	=	Gross Domestic Product
GIT	=	Gastro-intestinal tract
HCW	=	Hot Carcass Weight
HF	=	Holstein Friesian
HQ	=	Hind quarter
IM	=	Intramuscular
ISO	=	International Organization for Standardization
Kg	=	Kilogram
Km	=	Kilometer
KPH	=	Kidney Pelvic Heart
L	=	Local
LMA	=	Longissimus Muscle Area
LW	=	Live Weight
LWG	=	Live Weight Gain

LIST OF ABBREVIATIONS AND SYMBOLS

ME	=	Metabolizable Energy
MJ	=	Mega joule
ml	=	Milliliter
NGO	=	Non Government Organization
NaCl	=	Sodium Chloride
OM	=	Organic Matter
P	=	Probability
PBS	=	Phosphate Buffer Saline
PCA	=	Plate Count Agar
PPM	=	Potassium Per Manganate
QG	=	Quality Grade
REA	=	Rib Eye Area
RCC	=	Red Chittagong Cattle
rpm	=	rotations per minute
SD	=	Standard Deviation
SEM	=	Standard Error of Means
Sig.	=	Significant
SPSS	=	Statistical Package for Social Science
Sq	=	Square
Tk	=	Taka
TVC	=	Total Viable Count
UMS	=	Urea Molasses Straw
USDA	=	United States Department of Agriculture
YG	=	Yield Grade
-	=	Negative
%	=	Percentage
*	=	Significant at 5% level of probability
**	=	Significant at 1% level of probability
µg	=	Microgram
µl	=	Microlitre
/	=	Per
+	=	Positive
<	=	Less than
>	=	Greater than
°C	=	Degree Celsius

MEAT YIELD, QUALITY AND CARCASS CHARACTERISTICS OF INDIGENOUS AND CROSSBRED CATTLE REARED UNDER IMPROVED FEEDING SYSTEM

ABSTRACT

Md. Abu Bakkur Siddque

A study was conducted to develop suitable and cost effective feeding system for improving performance and meat quality of indigenous and crossbred (HF × L) cattle of Bangladesh. After conducting a baseline survey on the existing feeding and management systems of indigenous and crossbred cattle, and the socio-economic conditions of the farmers, 40 farmers were selected for the fattening program from two villages (Kathalbaria and Char Faridpur) of Raiganj upazila of Sirajganj district. Twenty indigenous bulls (average body weight 208.08 ± 13.98 kg) and twenty crossbred (L × HF) bulls (average body weight 256.26 ± 26.85 kg) of 24 months of age were divided into four equal groups were fed on four diets (T_0 , T_1 , T_2 and T_3) up to 120 days, where T_0 referred to the conventional diet and T_1 , T_2 and T_3 referred as improved diets. Required DM for individual animal was supplied by roughage and concentrate sources of the ration in the ratio of 2:1. Local grass and paddy straw were supplied to group T_0 and T_1 , Napier grass and straw to group T_2 , and Napier grass, straw and Ipil ipil leaf to group T_3 as roughage; whereas concentrate was supplied as 1.5% of live weight. The results revealed that, total DM intake, FCR and ADG of experimental animals were affected ($p < 0.01$) by feed treatment, breed, and interaction of breed and feed treatment. Crossbred bulls of diet group T_3 showed the highest DM intake (11.07 kg/d) and ADG (1.17 kg), and the lowest FCR (9.48); while indigenous bulls of group T_0 showed the lowest DM intake (5.32 kg/d), ADG (0.27 kg) and the highest FCR (19.7). Breed type and feed treatment interaction had significant ($p < 0.01$) effect on pre-slaughter body measurements, carcass yield characteristics, and most of the parameters for yield of primal cuts and non-carcass components of the experimental animals. Feed treatments also affected ($p < 0.01$) different pre-slaughter body measurements, carcass yield characteristics, weights of most of the primal cuts as percent of chilled carcass weight of indigenous bulls, and most of the parameters for yield of non-carcass components. Different body measurements, carcass yield parameters and non-carcass components were significantly higher ($p < 0.01$) for crossbred bulls than the indigenous bulls, but yield of primal cuts did not affected ($p > 0.05$) by breed type. The highest retail cut percentage (54.59%, yield grade-1.00) was found for group T_3 of crossbred bulls and the lowest retail cut percentage (52.45%, yield grade-1.97) was found for group T_0 of native bulls. Among different physical properties of meat breed and feed treatment interaction significantly affected cooking loss ($p < 0.01$), marbling score ($p < 0.05$) and color score ($p < 0.01$); but did not affect ($p > 0.05$) meat pH and drip loss. Feed treatments had no significant effect on physical properties of meat of indigenous bulls, except effect ($p < 0.01$) on cooking loss and color score of meat of crossbred bulls. Cooking loss and marbling score of meat were significantly higher ($p < 0.01$ and $p < 0.05$) for crossbred bulls than the native bulls, while meat pH, drip loss and color score were not affected ($p > 0.05$) by breed type. Breed and feed treatment interaction had significant effect ($p < 0.01$) on proximate compositions of meat, but the proximate compositions did not vary significantly ($p > 0.05$) among different feed treatment groups. Moisture content was higher ($p < 0.01$) for meat of crossbred bulls, while protein, fat and ash content of meat was lower ($p < 0.01$) in crossbred bulls than the native bulls. The sensory properties of beef i.e. the tenderness, chewiness, fineness, beef flavor intensity and color of beef from indigenous bulls were higher than the crossbred bulls although not significant ($p > 0.05$); which caused higher ($p < 0.05$) overall acceptability of meat for indigenous bulls than the crossbred bulls. Total viable count (TVC) of beef ranged from $3.63 \log_{10}$ CFU/g to $4.90 \log_{10}$ CFU/g ($P < 0.01$) among different feed treatment groups of indigenous and crossbred bulls, but did not exceed the recommended safe limit of ICMSF (1986) for beef. Feed cost per day (BDT/d), feed cost per kg LW gain (BDT/kg LWG), total cost (BDT) and net return (BDT) were also affected ($p < 0.01$) by feed treatments, breed type and interaction of breed and feed treatment. Indigenous and crossbred bulls fed diet T_3 had comparatively higher daily feed cost (76.66 and 112.9 BDT/d, respectively), and lower feed costs per kg LW gain (BDT 156/kg LWG and BDT 96.78/kg LWG, respectively); while lower daily feed costs (45.99 and 59.26 BDT/d, respectively), and higher feed cost per kg LW gain (169.94 and 130.86 BDT/kg LWG, respectively) were found for diet T_0 . Both for indigenous and crossbred bulls, diet T_0 showed significantly ($p < 0.01$) lower total costs (33305.2 BDT and 47577 BDT, respectively) and net returns (622.8 BDT and 2324.8 BDT, respectively), while improved diet (T_3) showed significantly ($p < 0.01$) higher total costs (42569.8 BDT and 56563 BDT, respectively) and net returns (2951.6 and 6683 BDT, respectively) in this cattle fattening program. Crossbred bulls showed significantly higher ($p < 0.01$) total cost and net return than the indigenous bulls. So considering all the above findings, it may be concluded that fattening of indigenous bulls could be suitable for production of better quality beef meat with lower cooking loss, marbling, prime color, higher protein, fat, ash content and consumer acceptability. But, crossbred (HF × L) bulls treated with improved diet T_3 (rice straw + Napier grass + concentrate + Ipil ipil leaf) could be more effective and economically feasible for beef cattle production in Bangladesh.

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CHAPTER I

INTRODUCTION

Bangladesh is a developing country of only 147570 sq km area (BBS, 2004) with a large population of about 15 cores. The living standard of this country largely depends on agriculture as it is agrarian. Livestock being one of the four components of agriculture (crops, livestock, fisheries and forestry) plays a vital role in our national economy. According to the report of Bangladesh Economic Review (2014), 16.33% of agricultural GDP comes from the livestock and the livestock subsector which solely contributes of 1.78% to national GDP. Another report shows that the growing livestock sector in Bangladesh accounts for around 13 percent of the agricultural GDP (BBS, 2011). More than 10 million people directly depend on the livestock and fisheries sectors for their livelihood. A large proportion of these people are smallholders whose production of milk, meat, and eggs increased significantly between 2002 and 2008 primarily for improved breed, feed and fodder; available veterinary health services; and investments led by the private sector. Some technological interventions with improved breed, feed, housing, and management systems have greatly improved meat and egg production in Bangladesh (Karim *et al.*, 2010). The livestock resources of Bangladesh are mainly based on cattle, goat, sheep, buffalo and poultry. About 24.5 million cattle heads are distributed throughout the country ranking 12th in the world and 3rd in Asian countries (FAO, 2010). The growth of livestock production is the second highest among all other subsector of agriculture in Bangladesh (BER, 2012). But, the production and consumption of livestock products are still much lower compared to other countries.

Livestock rearing is an age-old occupation of the poor and has the potential of making a strong contribution to poverty reduction. Livestock could be the most valuable tool to help poor farmers by developing farming system that are scientifically, economically, environmentally and socially sustainable. Livestock production is an important element which may help narrow down the wide nutritional gap prevalent in this country through supplying meat, milk and eggs. The poverty reduction effects of livestock operate through a number of channels. The rearing of domestic animals is a major source of food, cash income and storage of savings; with small land requirements and potentially high returns, poor

farmers can diversify income sources, enhance incomes, create asset bases and meet emergencies.

Among meat consumption of 180 countries in the world, Bangladesh stands in 18th position which is about only 7.13 kg per capita per year (DLS, 2009) compared to the USA of 124 kg and the global average of 38 kg (Smith *et al.*, 2007). Another report of FAO shows that, the average per capita meat consumption is 42.1 kg/year in the world. Developed and developing countries consume 82.9 and 31.1 kg/year, respectively (FAO, 2009). Beef is considered as a high source of animal protein in Bangladesh. Due to the livestock population in Bangladesh, it is well above the average from many other countries of the world. Beef in Bangladesh, usually comes from the unproductive aged bullocks, cows and culled animals of the farm and partly from the imported cattle from the neighboring country, India. About 10-12% of total beef comes from growing animal during the Muslim religious festival, Eid-ul-Azha (Begum *et al.*, 2007). The annual meat production in Bangladesh is about 2.33 million tones where the beef contributes around 1.45 million tons (FAO, 2013). The projected production of meat is 2.87 million tons in 2015, but its total requirement would be 6.86 million tons. It indicates a huge gap exists between production and the total requirement. To satisfy the animal protein requirement, beef fattening can play an important role. It is also an emerging sector for employment and improving socio economic condition of rural masses by generating gainful employment and augmenting family income particularly small and marginal farmers in rural areas. The Directorate of Livestock Services (DLS) of the Government of Bangladesh has taken beef fattening as an action program to generate income for the rural poor farmer.

Indigenous cattle is an inseparable and integrated part of agricultural farming system in Bangladesh since it plays a crucial role in the livelihood system and well-being of the people of Bangladesh and thereby taking part significantly in meeting the Millennium Development Goal. Indigenous cattle are integral contributor of food, agricultural power, agrarian culture, heritage and biodiversity (FAO, 2007). Indigenous cattle has an astonishing feat of adaptability not only to the climatic condition but also to the traditional husbandry practices, subsistence on poor quality feeds and fodder, regular breeder and better resistance capabilities to withstand environmental stress and tropical diseases (Wahed, 1971), but the productivity of our indigenous cattle has been at jeopardy for long. Along

with the genetic potentiality, poor nutrition is also the most important factor for low production which is due to poor and inadequate supply of feed (Haq *et al.*, 1992; Islam and Ahmed, 1992; Rahman, 1989). A number of efforts have been made in the past to improve performance of indigenous cattle of Bangladesh which were mainly based on crossbreeding or upgrading of local animals with exotic dairy breeds. But no fruitful improvement has so far been achieved due to indiscriminate breeding policy. The crossbreds are not well adapted to the traditional production systems as indigenous cattle. They need higher amount of nutrients for their maintenance and production in addition to improved management and better health care. Although indigenous cattle of Bangladesh are low producer of milk and meat but they possess high resistance to parasitic infection and other diseases and are also capable to utilize poor quality fibrous feed resources efficiently.

Livestock in Bangladesh mainly lives on crop and cereal by-products inedible to human beings as well as roadside grasses, tree leaves and aquatic plants. Rice straw is the basal feed for ruminants with low nutritive value and low digestibility. Very little grains are available for feeding animals. This has resulted in shortage of quality diet as well as required nutrition for ruminants, causing stunted growth, reproduction problems, working inability, lower growth rates and reduced productivity. So, it is very important to establish an improved and economically feasible ration for our livestock.

Most of the beef cattle are fattened allegedly by unscrupulous cattle traders in Bangladesh. They use inorganic substances; growth promoting steroids and feed additives for beef cattle production. Farmers use different inorganic substances and pesticides for fodder production. As this harmful process to fatten cattle starts several months before Eid-ul-Azha, the animals are affected with serious diseases, which may cause serious health hazards for consumers.

But now, day by day consumers are becoming more aware of safety and quality of food products. Further, as purchasing power of common people is increasing persistently, they are interested to consume safer product without bothering to pay more. So, the production of safer beef products without any chemical and microbial residues is the order of the day. Consumption of beef depends on different factors like consumers' preference, nutritional value, appearance etc of different cuts of beef carcass. It is important to know which portion of the carcass is rich in protein or fat or calcium and phosphorus etc. There are considerable

differences between the preferences of individuals including preferences for different cuts of meat lean or fatty, muscle or organ meats, methods of cooking etc. The major aspects of meat quality mainly rely on flavor, juiciness, tenderness and color of meat cuts. Moreover, changes in the global market and the occurrence of foot and mouth disease, tuberculosis, brucellosis, anthrax and food poisoning outbreaks related to meat consumption have increased beef safety concerns. So, it is very important to determine the physical, chemical, sensory and microbial quality of different primal cuts of beef carcass.

The key constraints in beef fattening and meat production in Bangladesh are; lack of quality livestock breed, and artificial insemination, limited skill of farmers in beef fattening, limited skill of butchers, lack of organized marketing system of livestock and products, inadequate veterinary cares, medicine, treatment and extension services, poor quality of slaughter house, outdated meat and control act etc. So, government should take necessary steps to overcome the constraints in quality beef production.

Many research works have already been carried out on the quality of different cuts of beef carcass (Jennifer *et al.*, 2000; Savell *et al.*, 2007; Kerth *et al.*, 2015), preservation of beef in Bangladesh (Anam, 2003; Rahman, 2007; Modak *et al.*, 2009 and Rahman, 2013) and quality in relation to age (Islam, 2013 and Roy *et al.*, 2013). But still now no research work is available on overall effect of different feeding treatments, carcass & meat yield characteristics, physical, chemical, microbial and sensory qualities of meat of indigenous and crossbred cattle fattened under improved feeding system and cost benefit analyses in comparison with traditional beef fattening.

So, the present study was conducted to get information about the following objectives:

- To study the comparative feeding planes of nutrition, intake, growth and feed conversion efficiency of indigenous and crossbred bulls.
- To determine carcass and meat yield characteristics of indigenous and crossbred cattle reared under improved feeding system.
- To study meat quality and cost-benefit analyses of indigenous and crossbred cattle reared under improved feeding system.

CHAPTER II

REVIEW OF LITERATURE

The review of literature is performed with a view to obtain information relating to the present research work undertaken. The contributions made by numerous research workers are compiled and the publications are listed in the bibliography. In our country, very few research works have been done so far on the differences of meat yield, beef quality and carcass characteristics of indigenous and crossbred cattle reared under improved feeding system along with the cost benefit analysis. However, a lot of works have been carried out on beef quality and other meat in many parts of the world. In view to focus an easy overview of literature is presented into several sections as follows:

2.1 Status of cattle fattening in Bangladesh

Sarma *et al.* (2014) studied the profitability of beef cattle fattening in the northern char area of Bangladesh. A total of 150 cattle fatteners were randomly selected from two districts representing the highest concentration of fatteners in the char area. Socioeconomic data as well as data on beef fattening were collected from the people selected at Pabna and Sirajgonj district. Descriptive statistics was used to analysis the socio-economic characteristics of beef producers, the profit function was used to determine the profitability of beef market and regression analysis was used to determine the factor affecting profitability of beef cattle. In spite of beef cattle production was profitable agribusiness most of the farmers adopt traditional beef fattening system for beef fattening target the cattle marketing during the Muslim festival “Eid-ul-Azha”. Profitability margin equals BDT 13,350.84 per cattle. The benefit cost ratio of the entire enterprise was 0.52 that means cattle fattening enterprise is profitable and feasible business enterprise. The major problems facing the farmers include high cost of feeds, inadequate credit facilities, disease attack, illegal use of human drugs for cattle fattening, price fluctuation and inadequate extension services.

Hossain (2013) conducted a study to find out the present status of organic beef cattle production in Sirajgonj district of Bangladesh. The data was collected through an interview schedule involving 30 respondents of three unions under Shahjadpur upazila who were involved in beef cattle production. The age of respondents ranged from 29 to 65 years. About 76% respondents used own capital for beef cattle production, 17% took bank loan

and 7% from other sources such as NGO loan and lending for beef cattle production. About 7% respondents had experience of short time training for beef cattle production and rest 93% had no experience of training on beef cattle production. About 80% farmers use crossbred cattle (mainly Holstein, Sindhi, Sahiwal and Jersey breed) and 20% use indigenous breed for fattening. About 63% farmers not purchase, they used own source cattle for beef cattle production, whereas, 37% farmers purchased cattle occasionally usually 3-6 months before Eid-ul-Azha. About 53% farmers fattened cattle for 3 months and 37% farmer practices for 6 months and rest 10 % for more than 6 months. About 83% farmers used cultivated fodder and only 17% farmers used cultivated fodder and roadside grass. About 73% farmers used Artificial insemination technique whereas, 13% farmers used natural breeding and 14% farmers uses both techniques for livestock breeding. About 87% farmers vaccinated their beef cattle regularly and 37% farmers used vitamin mineral supplement in feed. Most of the farmers (80%) practiced de-worming of their beef cattle. About 63% farmers reported anywhere and everywhere use of growth promoter, 57% reported high cost of vitamin mineral supplementation, 43% reported unavailable organic fertilizer, 23% reported lack of indigenous breed, 30% reported lack of pasture land, 17% reported lack of technical knowledge about organic beef cattle production and 10% reported lack of training facilities were the major problems in organic beef cattle production.

Rahman (2012) stated that, an experiment was conducted to investigate the cattle fattening programs of rural farmers at three Upazila (Birganj, Kaharul, and Khansama) in Dinajpur district of Bangladesh through field survey. Data were collected from randomly selected 75 farmers who involved in small scale cattle fattening through personal interview schedule during the period from 15th January to 15th February, 2012. The selected characteristics were socio economic condition of the farmer (age, level of education, household size, family income from cattle fattening, farm size)factors associated with cattle fattening, daily routine activities, feeding and marketing system of fattening cattle, problems of cattle fattening and cost benefit analysis. Pearson's Product Moment Correlation Co-efficient (r) was computed to describe the relationships between the concerned variables. Out of the 75 respondents 54.7% were involved in agriculture, 26.7% in business, 13.3% in service and 5.3% in beef fattening. With a mean of 1.69 and standard deviation is 0.9. The total respondents were classified into four categories. The major category 41 of the respondents belongs to farmer categories which has also own land and 20 businessman, 10 service holder and 4 are directly

related to cattle fattening. Most of the farmers (54%) who are directly related to Agriculture are more involved in fattening than those who are related to business (26.7%) or service sector (13.3%) respectively. Correlation analyses indicated that six characteristics of the farmers, namely level of education, family income from on farm and off farm activities, income from livestock and poultry, training experience, extension media contact, cattle price and knowledge on adopting cattle fattening program had significant positive relationships with this program. Household size, farm size, farming experience and social mobility had no relationship with this program. On the other hand, age had significant negative relationship with cattle fattening program. The main problem in adopting cattle fattening was lack of money & knowledge.

Begum *et al.* (2007) investigated the cattle fattening programs of rural farmers in Panchagarh district of Bangladesh through field survey. In this study 40% farmers had primary level of education and 20% had no education. About 56.7% farmers used cattle of 2-3 years of age and 36.7% farmers used cattle of 1-2 years age. About 70% farmers used bulls and 70% farmers had an average of 1-4 cattle for fattening. Fattening period of 3-6 months and 7-12 months were reported by 60% and 30% farmers, respectively. Separate houses for cattle were provided by 86.7% of the farmers. About 63.4% farmers washed their cattle in ponds and rivers regularly. About 76.7% farmers had taken short training on livestock rearing from Rangpur, Dinajpur Rural Service (RDRS) and Panchagarh Youth Training Centre and 80% farmers de-wormed their cattle before starting the fattening program. About 96.6% of farmers reported shortages of animal feed and 86.6% reported lack of credit as the major problems of cattle fattening. Average buying and selling prices and net profit were Taka/cattle 7528, 9542 and 2055, respectively. Small scale cattle fattening programs could be recommended as an income generating activity for the rural farmers of Bangladesh.

Baset *et al.* (2003) stated that, a large number of farmers involved in bull fattening just before 3-4 months of Eid-Ul-Azha (Muslim festival), when they sell the animals with profitable prices. Cattle fattening for beef production have become an important business of the small farmers in Bangladesh. In few areas of Bangladesh a small scale commercial beef fattening program has already been started. Straw is the important crop residue; contribute the, major portion of the fibrous part of the diet of the beef cattle. Rice straw is the basal feed

for ruminants with low nutritive value and low digestibility. Farmers use rice straw of traditional varieties, green grass, sugarcane tops, wheat and rice bran, molasses, pulse bran and locally available resources such as pumpkin, carrot, banana, vegetable by products, rice gruel, boiled rice bran, oil cakes etc for beef fattening. The chemical treatment of straw is the most effective and economic method to improving the quality. Straw is mainly treated with urea and molasses and in some cases chemical treatment also done by the farmers. Urea molasses straw treatment in beef cattle resulted higher body weight, dressing percentage and also in better carcass quality than untreated straw. The acute shortage of feeds and fodder has long been identified as a serious constraint to optimum livestock production in Bangladesh. The nutritional factor is considered a major constraint to livestock productivity. Traditional grazing field is scarce except in some pockets in Pabna and Sylhet districts. Farmers used three years old cattle fattening period is 4.5 months in rural areas of Bangladesh.

Hashem *et al.* (1999) investigated the cattle fattening programs of rural farmers in different districts of Bangladesh through field survey. In that study 51.2% farmers had primary level of education and 28% had no education at all. About 60.4% farmers used cattle of 2-3 years of age and 32.2% farmers used cattle of 1-2 years age. About 70.4% farmers used bulls and only 5.2% used females. About 71.20% farmers had an average of 2 cattle for fattening and 28.80% farmers had an average of 3 cattle. Fattening periods of 3-6 months and 7-12 months were reported by 42% and 30% farmers respectively. About 86.40% farmers financed their cattle fattening business by themselves. Separate houses for cattle were provided by 86% of the farmers. All the farmers washed and groomed their cattle in ponds and rivers. About 92% of the farmers did not have any training on cattle fattening, where as only 8% farmers had taken training on livestock rearing from the local Youth Training Centers. About 61.2% farmers de-wormed their cattle before starting the fattening programs. About 72.8% farmers did not vaccinate against infectious diseases for their cattle. For treatment of cattle only 24% of farmers had taken help from a Veterinary Surgeon. About 46.4% of farmers bought their cattle at 2-4 thousand taka per cattle. Average buying and selling prices and net profits (Taka/cattle) were taka 5043, 8360 and 3648, respectively. About 96.8% of farmers reported shortages of animal feed and 84% reported lack of credit as the major problems for cattle fattening.

Hossain *et al.* (1996) conducted a study upon nine selected women of Dhalla village under Singair thana of Manikganj district to evaluate the beef fattening as an income generating source being practiced by the vulnerable group of women. The fattening programme was financed by the local Grameen Bank, Dhalla branch. It was found that each woman borrowed average loan money amounting to Tk 7,333.00 @ 20% interest per annum from the Grameen Bank. The study revealed that the average net income of each women was Tk. 7745.00/season (5.77 months) having 1.78 animals on an average. Individual record showed that two, out of these nine women earned an average net income of Tk. 650.00 where as the other four women had an average income of Tk. 4800.00/season. On the other hand, the remaining three women earned a net income of Tk. 11,700.00, 16,500.00 and 21,000.00/season, respectively. The reasons behind these increased amounts of income by these three particular women were that their investment per animal was higher and the overall management of the fattening program was very good.

2.2 Breed selection for cattle fattening

CAN/CGSB (2006) listed the principles of organic livestock production standard and stated that the producers should: a) select breeds and types of livestock that are suitable for site-specific conditions within the local environment and production system and that are resistant to prevalent diseases and parasites; b) use natural methods of reproduction; however, artificial insemination is permitted; c) not use embryo transfer techniques using genetic engineering or related technology; d) not use reproductive hormones to trigger and synchronize estrus.

Chander *et al.* (2006) stated that the breed should be chosen which are adaptable to local conditions. Breeding goals should not be in opposition to animal natural behavior and should be directed towards good health. The use of genetically engineered species or breeds is not allowed. Reproduction technique should be natural. Artificial insemination is allowed only upon veterinary necessity. Hormonal treatment for more meat production should be prohibited. Disease prevention in organic beef production is preferably based on the principle that appropriate breeds or strains of animals should be selected.

Sagsoz *et al.* (2005) conducted an experiment to compare growth characteristics of Holstein [Holstein-Friesian] (n=12), Brown Swiss (n=10) and Holstein x Brown Swiss crossbred (n=6)

spring-born calves supplement with grain during the wintering period. No breed effect on body weight, feed intake, average daily gain and feed conversion ratio was observed. However, bull calves gained more body weight and consumed less amount of feed per kg body weight gained than heifer calves. Moreover, no breed by sex interaction effect on growth performance variables was observed. Lack of breed differences could be attributed to grain supplementation.

Ender *et al.* (2001) carried out an experiment to analyze if the type and/or breed have any effect on the dynamics of beef production during growth which corresponds to slaughter age. Bull calves of selected breeds (n=113) were fattened and slaughtered after birth and at 6, 12, 18 and 24 months of age, respectively. In all carcass value parameters clear age differences were registered with breed $\times$ age interactions. Findings revealed that in comparison with Holstein-Friesian, the Red Spotted young bulls can be fattened up to relatively high final weights with improved dressing percentage due to their increased growth capacity.

Magnusson (2001) reviewed a number of breeding strategies for improved disease resistance in organic beef cattle production. These include: a) the recording of disease incidence in the progeny with the lowest incidence, b) the use of breeds possessing certain major histocompatibility complex antigens known to be associated with resistance to certain infections, and c) the identification of a set or combination of immune parameters with high heritability in breeding programs.

Pabion *et al.* (2000) stated that, the study was conducted to estimate genetic parameters for the weights of different wholesale cuts, using an experimental and a commercial data set. The experimental and commercial data sets included 413 and 635 crossbred Belgian Blue, Charolais, Limousin, Angus, Holstein and Simmental cattle, respectively. Univariate analysis using a mixed linear animal model with relationships were undertaken to estimate the heritability of cold carcass weight. Carcass conformation and fat and the cut weight, whereas a series of bivariate analyses was used to estimate the phenotypic and genetic correlations between carcass weight, carcass conformation, carcass fat and major primal cuts. Heritability estimates for cold carcass weight in both data sets were moderate (>0.48), whereas heritability estimates for carcass conformation and fat grading were greater in the commercial data set (>0.63) than in the experimental study (>0.33). Across both data sets,

heritability estimates for wholesale cut weight in the forequarter varied from 0.03 to 0.79, whereas heritability estimates of carcass cut weight in the hindquarter varied from 0.14 to 0.86. Heritability estimates for cut weights expressed as a proportion of the entire carcass weight varied from 0.01 to 0.91. Genetic correlations were strong among the different carcass weights within the experimental and the commercial studies. Genetic correlations between the weights of selected carcass cuts and carcass weight were moderate to high (minimum 0.45; maximum 0.88) in both data sets. Positive genetic correlations were observed in the commercial data sets between the different wholesale cut weights and carcass conformation, whereas these were positive and negative in the experimental data sets. However, the genetic correlations were less than unity, suggesting a benefit of more direct selection on high value cuts.

Nogalski and Kijak (1998) compared fattening performance from 181 to 540 days of age of 27 Polish Black and White and 20 Limousin × Polish Black and White heifers and bulls. Crossbred bulls and heifers were heavier at 540 days of age and had greater daily gains than the respective pure breeds ($p < 0.01$). Feed conversion efficiency was also greater for crossbreds than purebreds ($p < 0.05$). Crossbreds had a lower percentage of internal fat in the carcass and a greater *longissimus dorsi* muscle area than purebreds ($p < 0.01$). The purebreds had a lower dressing percentage than the crossbreds ($p < 0.01$).

Ozbeyaz et al. (1997) reported that ten Brangus × Jersey (F_1) and 28 Limousin × Jersey (F_1) crossbreds were studied at a state farm in Turkey. For the 3 crossbred types respectively, overall daily weight gain during the 510-day fattening period averaged 0.64, 0.59 and 0.54 kg for males and 0.53, 0.54 and 0.54 kg for females. For both sexes there were no significant differences between breed types in respect of daily weight gain. Brangus crossbred males had gained about 39.6 kg more live weight than Limousin crossbreds at the end of the fattening period, but the difference was not significant. Brangus crossbred males were 64 kg and Limousin crossbreds were 24.4 kg heavier than Simmental crossbreds; these differences were significant. For groups of 4 Brangus × Jersey, Simmental × Jersey and Limousin × Jersey bulls slaughtered at 457.5, 436.8 and 450.7 kg respectively.

2.3 Housing

Chander *et al.* (2011) stated that the main objective of organic housing and management standards is to provide an opportunity for animal to exhibit all its normal behavior patterns. This will be helpful to minimize the stress to the animal. Stress free animals are likely to have a positive effect upon both the health and production capacity.

CAN/CGSB (2006) stated that the producer of organic beef cattle should establish and maintain animal living conditions that accommodate the health and natural behavior of all animals, including: a) access to the outdoors, shade, shelter, rotational pasture, exercise areas, fresh air and natural daylight suitable to the species, its stage of production, the climate and environment; b) access to fresh water and high-quality feed in accordance with the needs of the animal; c) sufficient space and freedom to lie down in full lateral recumbency, stand up, stretch their limbs and turn freely, and express normal patterns of behavior.; d) livestock housing should have non-slip floors. The floor should not be entirely of slatted or grid construction. Building should have areas for bedding and resting that are sufficiently large, solidly build, comfortable, clean and dry. They should be covered with a thick layer of dry bedding that can absorb excrement; e) the management of barns and the grazing management of pasture should be designed to avoid soil degradation, long term damage to vegetation or water contamination; f) cattle should be allowed a period of exercise each day, when possible, and at least twice a week and g) housing, pens, equipment and utensils should be properly cleaned and disinfected to prevent cross infection and build-up of disease carrying organisms.

Khansari *et al.* (1990) stated that the housing conditions and the access to straw bedding used in organic animal farming might lead to the conclusion that the animals would be less stressed than conventionally kept animals. Stress affects the immune response of humans and animals, but to date the effect of potentially lower stress conditions in organic animal farming on the immune response of the animals has not yet been dissected.

2.4 Feeding of fattening cattle

Asimwe *et al.* (2015) conducted a study on 50 steers (183 ± 4 kg initial body weight, 3 years of age) to assess effects of days in feedlot on performance, carcass characteristics and meat quality of Tanzania shorthorn zebu (TSZ) cattle with the aim of determining appropriate

finishing period. Periods were 0 day (P0), 25 days (P25), 50 days (P50), 75 days (P75) and 100 days (P100) with 10 animals per period. Steers were housed in individual pens, fed with a concentrate diet and hay on an *ad libitum* basis except the P0 group which was slaughtered at the beginning of trial. Long stay in feedlot, P100, increased concentrate dry matter intake by 2 kg DM/day over short stay, P25. Final weight and total gain increased ($p < 0.05$) from P25 (22.6 kg) to P100 steers (95.4 kg). Periods had no influence ($p > 0.05$) on an average daily gain (ADG) and feed conversion ratio (FCR) but affected carcass characteristics. Empty body weight (EBW) and hot carcass weight (HCW) increased by 61 and 65 %, respectively, from no feedlot, P0 to P100. Dressing percentage was high ($p < 0.05$) for P100 steers. Carcass measurements, internal fat, fat thickness and carcass total fat were the highest ($p < 0.05$) on P100 steers and the lowest on P0 steers. Rate of pH decline increased with days in feedlot, while cooking loss and shear force values decreased in advanced ageing time. Feedlot periods of 75 and 100 days resulted into high intake, carcass measurements and tenderness, but 100 days further increased carcass fatness and fat thickness levels, thus, with this particular feeding system and animal's condition, 75 days is the recommended period to finish TSZ cattle in feedlots.

Aviles *et al.* (2015) stated that, a total of 100 young bulls were allotted a 2×2 factorial arrangement of treatments to determine the effect of the feeding system (concentrate and wheat straw: T; total mixed ration comprised of the same concentrate, maize silage and wheat straw: TMR) and breed (Limousine: LI; Retinta: RE) on growth performance, carcass characteristics and meat quality. The diets were administrated *ad libitum* for 193 days. The average daily weight gain was similar ($p > 0.05$) for both diets, while the LI bulls grew significantly ($p < 0.05$) more than RE. T bulls showed higher L^* , a^* and rib bone percentage. TMR bulls showed higher carcass yield, conformation and fatness, and greater changes in ultrasound measurements. Instrumental meat quality, except shear force at 1 and 21 days of ageing, was not affected ($p > 0.05$) by the diets. Breed significantly affected most of the analyzed characteristics.

Moya *et al.* (2015) reported that, one hundred sixty crossbred steers (538 ± 36 kg BW) were used in an 84-d experiment with a randomized block design to study the effects of wheat or barley grain processed to 2 different indices on growth performance, feeding behavior, carcass characteristics, stress, and temperament of finishing beef cattle. Treatments were a

wheat-based diet (88.4% of diet DM; WH) and a barley-based diet (89% of diet DM; BA), processed to an index of either 75% (HI) or 85% (LO) of their original volume weight. Cattle were allocated to 16 feedlot pens (10 animals per pen, 4 pens per treatment), 8 of which were equipped with the Grow Safe system for monitoring feeding behavior. Flight speed, hair, and saliva samples were collected on d 1, 28, 56, and 84 to determine temperament, acute, and chronic stress. All steers were slaughtered at the end of the experiment, and carcass quality was evaluated. Cattle fed WH had a lower ($p<0.05$) meal length and frequency of visits per meal and tended ($p=0.10$) to have a lower DMI, meal size, and feeding time than those fed BA. The LO processing index increased ($p=0.05$) DMI and reduced ($p<0.05$) the G : F and the percentage of saleable meat of the carcass compared to HI.

Rashid *et al.* (2015a) evaluated the growth performance and cost per gain of Brahman $\times$ Local crossbred bull calves receiving three diets with varying concentrate to roughage ratio (C : R) of 75 : 25, 65 : 35 and 55 : 45 on dry matter (DM) basis. Twelve bull calves (aging 11.5 ± 1.2 months and 170.8 ± 13 kg live weight) divided into three equal groups were fed on three diets. The C : R ratio did not affect ($p>0.05$) the intake of feed and nutrients, feed efficiency (7.04, 6.94 and 6.76) and average daily gain (981, 958 and 976 g). Animals fed diet with C : R – 55 : 45 had the lowest feed cost (136.8 BDT/kg LW gain), which was increased (147.5 and 153.8 BDT) non-significantly ($p>0.05$) with the increasing level of concentrate. The diet consisting of 55% concentrate mixture showed similar result with the diet consisting of 75%concentrate mixture, but was comparatively economic. It was concluded that the diet consisting of 55 : 45 C : R may be used for economic beef production.

Rashid *et al.* (2015b) reported that, twelve local $\times$ Brahman (L $\times$ B) bulls of average 20 ± 1.5 months of age and 343 ± 20 kg live weight divided into three equal groups were fed a mixed concentrate diet (CON); 1:1 CON and UMS (Urea and Molasses impregnated straw at a ratio of 3:15:82 on dry matter basis; and the UMS diet alone. The average daily DM intake of CON group was 7.56 kg/head; feeding UMS with concentrate at 1:1 ratio increased daily DM intake to 10.2 kg. The DM intake was reduced when UMS was fed alone. The average daily live weight gain was 954 and 873 g for CON and CON: UMS and was reduced to 205g/head on UMS alone. Feed conversion rate was 34.7 on UMS, much poorer than that of CON and CON : UMS. The feed cost of producing one kg live weight was calculated to be

2.26, 2.04 and 2.60 US\$, respectively for the three diets. Considering feed conversion rate and cost per kg gain, a mixed diet of concentrate and UMS (1:1) is the most appropriate for F₁ Local × Brahman crossbred bulls.

Dung *et al.* (2013) carried out a study to investigate feeding system for fattening cattle at smallholder in Central Vietnam including: farming resources, feed resources, feed intake, diet structure and average daily gain (ADG) of cattle. A total of 40 households were randomly selected to collect data by recording daily from beginning to end of fattening cattle process. Results showed that 100% of households used at least two kind of concentrate and more than 65% of households used elephant grass or native grass for cattle. Dry matter (DM) intake ranged from 5.54 to 5.89 kg/day. Concentrate and crude protein (CP) proportion in diet was from 24.0 to 37.0% and 8.37 to 9.82%, respectively. The ADG of cattle was from 0.43 to 0.69 kg/day. In conclusion, feed resources for fattening cattle at smallholder were variety, of which included concentrate and roughage feed, however, concentrate and CP proportion in diet was low.

Roy *et al.* (2013) investigated the effects of age and breed on growth, feed intake, carcass characteristics and meat quality attributes of longissimus muscle in Pabna cattle (n=12), Red Chittagong cattle (n=15) and Brahman crossbred bulls (n=15) reared on a single plane of nutrition for 125 days. The age groups of bulls were 18 months, 24 months and 30 months. Three bulls from each age group of three genotypes except, Brahman crossbred where 7 bulls under 24 months age group were randomly selected for slaughtering. Brahman crossbred bulls consumed the highest total dry matter daily (6.91 kg/d), followed by Pabna (5.33 kg/d) and RCC (4.46 kg/d) bulls and the breed differences were significant (p<0.01). As the age in different breeds increase dry matter intakes increased linearly (p<0.01). The breed × age interaction was significant for dry matter intake (p<0.01).

Bures and Barton (2012) investigated the effects of sex and slaughter age on growth, feed intake, carcass composition and meat quality attributes of *musculus longissimus lumborum* in Charolais × Simmental bulls (n=12) and heifers (n=12) reared and finished under identical management conditions. The animals entered the experiment at similar age (251 days) and were slaughtered at 14 or 18 months of age. Bulls gained more rapidly (p<0.001), consumed more dry matter daily (p<0.05), and had a higher killing-out proportion (p<0.05). The sex ×

slaughter age interaction was significant ($p < 0.01$) for feed conversion ratio, which deteriorated markedly more in heifers than in bulls as slaughter age increased.

Leo *et al.* (2012) evaluated the differences in growth performance and carcass characteristics of Bali cattle subjected to oil palm integration and two different feedlot finishing systems (basal vs. high energy). Eighteen, 24-30 months old male Bali cattle were involved in this study. The animals were randomly allotted into 3 feeding groups: Integration (INT), (n=6 animals), Feedlot A (FA) with basal energy (n=6 animals) and Feedlot B (FB) with high energy (n=6 animals). The animals assigned to the integration system were allowed to graze on the native forages and legumes available under the oil palm plantation. The basal energy diet consisted of 5 kg Palm Kernel Cake (PKC) pellets + *ad libitum* corn stover and the high energy diet which consisted of 5 kg Palm Kernel Cake (PKC) pellets + *ad libitum* corn stover + 400 g calcium soap of palm oil fatty acids (Megalac®, Volac International Limited, UK) were fed to the animals in FA and FB, respectively. The feeding trial was conducted for 120 consecutive days excluding 3 weeks of adaptation period. The data suggested that some of the growth parameters and carcass traits in Bali cattle can be enhanced through the feedlot finishing system.

Anderson *et al.* (2003) stated that large amounts of roughage were important to avoid metabolic and feeding related disorders, which could be a major problem in conventional grain fed beef production of bulls and calves, although calves were fed large amount of roughage, e.g. while grazing, periodic feeding with large quantities of cereals could still result in feeding related disorders.

Nielsen (2003) reported a farm study in Denmark, including six organic farms with steer production showing that roughage accounted for 64-84% of total dry matter (DM) consumption per year. Pastures account for 22-56% and cereals/concentrates for 16-37% of the total dry matter consumption per year. These results confirmed that organic steer production was based on high amounts of roughage and only small amounts of cereals/concentrates compared to conventional production of bulls and calves.

Field *et al.* (2002) stated that almost all nutrients in the diet played a crucial role in maintaining an optimal immune response such that deficient and excessive intakes could have negative consequences for the immune status and the susceptibility to a variety of

pathogens. Several selected nutrients such as glutamine, arginine, fatty acids, vitamin E and C, zinc and selenium had also been shown to affect the immune response.

Tareque (2001) reported that, out of the total dry matter available in Bangladesh, 69% constitutes dry roughage, 87% of which was rice straw. The contribution of green roughage to the total available dry matter was 27% which consists of sweet potato leaves, natural grasses (road sides, embankments, fallow lands, cultivable wastes, homesteads, etc.), weeds available from cultivable areas, water hyacinth, cultivated fodder, and sugarcane tops supplying 496 tons of crude protein and 52,546 million MJ metabolizable energy. Concentrates consisted of rice polish, wheat bran, oilcakes, pulse bran, molasses, cotton seed cake, fish meal, broken rice which contribute 5% of the total dry matter and 243 thousand tons of crude protein and 18,244 million MJ metabolizable energy.

Jorge *et al.* (1998) found from 36 months of age, 36 Gir, Guzera, Tabapua and Nelore bulls, with an initial body weight of 357.6, 362.0, 369.6 and 376.4 kg respectively, were finished in a feedlot on a diet containing 50% concentrates. Bulls were slaughtered at a body weight of 405, 450 or 500 kg. There were no significant differences among the bulls with the 3 slaughter weights in daily gain or carcass daily gain, but bulls slaughtered at 500 kg had a significantly longer period in the feedlot and a lower efficiency of gain than bulls slaughtered at a lower weight.

2.5 Health care

Chander *et al.* (2011) stated that the main objective to organic housing and management standards was to provide an opportunity for animal to exhibit all its normal behavior patterns. This would be helpful to minimize the stress to the animal. Stress free animals were likely to have a positive effect upon both the health and production capacity.

CAN/CGSB (2006) stated that the producer should establish and maintain preventive livestock health care practices, including: a) provision of a feed ration sufficient to meet nutritional requirements, including vitamins, minerals, protein, fatty acids, energy sources and fiber (ruminants), in accordance with this standard; b) establishment of appropriate housing, pasture conditions, space allowance and sanitation practices, to minimize crowding and the occurrence and spread of disease and parasites; c) provision of conditions that allow for exercise, freedom of movement, and a reduction in stress appropriate to the

species; d) provision of prompt treatment for animals with detectable disease, lesions, lameness, injury and other physical ailments. It is also stated that, the producer of organic beef cattle should not administer: a) veterinary drugs, other than vaccines, in the absence of illness, with the exception of anesthetics and analgesics used in permitted physical alterations; b) synthetic compounds to stimulate or retard growth or production, including hormones for growth promotion; c) synthetic parasiticides to meat animals; d) chemical allopathic veterinary drugs (e.g. pharmaceuticals, antibiotics, hormones and steroids) for preventive treatments.

IFOAM (2000) stated that where preventive practices and vaccines were inadequate to prevent sickness or injury and where disease and health problems require treatment, the use of biological, cultural, and physical treatments and practices were permitted, in accordance with organic production system. Medical treatment for sick or injured animals should not be withheld to preserve their organic status. All appropriate medications should be used to restore animals to health when methods acceptable to organic production fail. Shipping of diseased animals to slaughter for human consumption was prohibited. Sick and medicated animals should be quarantined from healthy animals. Hormonal treatment should only be used for therapeutic reasons and under veterinary supervision. The meat from animals so treated should not be organic meat unless the treatment is permitted by Organic Production System.

2.6 Record keeping

Chander *et al.* (2011) stated that, the organic beef production needs to maintain records for a number of reasons. Certainly, records are important for the financial management of any organic beef production enterprise. However, records are also important to verify the organic status of the animals and the production, harvesting and handling practices associated with them and their products. Organic production generally requires more record keeping than conventional production, it can seem onerous to producers in developing count.

2.7 Live weight change

Malole *et al.* (2014) examined the costs and benefits of indigenous beef cattle fattening schemes in Shinyanga Urban and Kishapu Districts in Tanzania. Specifically, in this study

the net profit (NP) for fatteners between beef cattle fattening schemes had been determined. The schemes were divided into two main categories, scheme 1 in which the animals were fed on cottonseed hulls (CSHL) based diets and scheme 2 on cottonseed cake (CSC) based diets. The average daily gains (ADG) of 1.5, 1.3 and 1.0 for Tanzania Short Horn Zebu (TSHZ) males, steers and females were higher than the 1.2, 1.0 and 0.9 for TSHZ males, steers and females in scheme 1, respectively. Additionally, the feed conversion ratios (FCRs) of about 5.0, 5.5, 6.3 for TSHZ males, steers and females in scheme 2 were lower than 7.2, 8.6, 8.6 for TSHZ males, steers and females in scheme 1.

Nogalski *et al.* (2014) stated that, carcass quality was determined by the animal's age and body weight (BW) at the end of the fattening period. The aim of this study was to determine the optimum finishing weight of young crossbred 'Polish Holstein Friesian' (PHF) × 'Limousin' (LIM) steers and bulls, based on their slaughter value. The experimental materials comprised 60 animals, including 30 bulls and 30 steers, fed farm-made feeds. At 2 or 3 wk of age, one half of calves were castrated. Bloodless castration was carried out using a rubber elastrator. Calves were reared under a conventional system, and were fattened semi-intensively. Daily gains ranged from 800 to 950 g. Calves were fattened to 450, 500, 550, or 600 kg BW. According to the researchers steers should be fattened to slaughter weight of 500-550 kg BW to prevent excessive fat deposition.

Mailey (2013) said that, the younger the cattle, the more efficient the animal is at converting feed into kilograms of live weight. Bulls are the most efficient converters and should be pushed for slaughter, if they are within 200kg of their slaughter weight, over a 150day intensive feeding period.

Roy *et al.* (2013) investigated the effects of age and breed on growth, feed intake, carcass characteristics and meat quality attributes of longissimus muscle in Pabna cattle (n=12), Red Chittagong cattle (n=15) and Brahman crossbred bulls (n=15) reared on a single plane of nutrition for 125 days. The age groups of bulls were 18 months, 24 months and 30 months. Three bulls from each age group of three genotypes except, Brahman crossbred where 7 bulls under 24 months age group were randomly selected for slaughtering. Brahman crossbred and Pabna bulls showed similar growth performances ($p<0.01$) while the RCC bulls had significantly ($p<0.01$) lower daily growth rate. Nevertheless, both the native breeds were more efficient ($p<0.01$) in converting feed to gain than the Brahman crossbreds.

Bulls under 30 months age group of both native and Brahman crossbred had significantly ($p<0.01$) lower FCR than that of bulls under 18 months and 24 months age groups. The breed $\times$ age interaction was daily live weight gain ($p<0.05$) and feed conversion ratio ($p<0.01$).

Keane (2010) stated that, cattle finishing strategies might involve feeding a high energy diet throughout or following a period of moderate growth. The objective of this study was to compare Holstein Friesian (HF) and Belgian Blue $\times$ Holstein Friesian (BB) steers (24 per breed type, initial live weight 434 and 431 kg for HF and BB, respectively) finished to 560 kg or 620 kg target slaughter weight, on either a concentrate diet *ad libitum* from the start of the finishing period (C), or on a concentrate diet *ad libitum* following an 84-day period on grass silage (SC). Mean daily live-weight gain was higher for C than SC ($p<0.001$) and for slaughter at 560 kg than at 620 kg ($p<0.05$). When slaughtered at 620 kg live weight there was no difference between the feeding treatments in net energy required per unit carcass-weight gain. While both breed types had similar live-weight gain BB had 9% greater ($p<0.01$) carcass-weight gain and were 14% more efficient ($p<0.01$) in converting feed energy to carcass weight.

Vaz et al. (2011) revealed that early weaning didn't alter the weight and finishing of steers carcasses. Carcass quantitative characteristics of 68 Braford steers of two weaning ages: 91 days, early weaning (EW); 160 days, conventional weaning (CW), classified at slaughter in three live weight groups: light (≤ 350 kg), medium (351 a 370 kg) and heavy (≥ 371 kg), were evaluated. Steers were finished on summer pasture (*Pennisetum americanum*) and slaughtered at 16 months of age. No significant differences were observed between weaning ages for final weight.

Ozluturk et al. (2008) reported that, seventeen Eastern Anatolian Red (EAR) bulls at 20 months of age were divided into 2 treatment groups and fed for either 168 days (S) or 210 days (L). Initial and final weights were not significantly different. While bulls in the L group had the highest total weight gain (149.0 vs. 177.2 kg), feed efficiency ratio was superior for the cattle fed for 168 days.

Mynek and Gulinski (2007) conducted an experiment on 55 young purebred Black and White (BW) bulls and 73 bulls being commercial crossbreds of BW with beef cattle. Daily

live weight gain from 990 to 927g was found related to a higher dressing percentage, ranging from 58.3% in crossbreds to 55.9% in pure BW bulls.

Kirkland *et al.* (2007) observed that, the NOR bulls have higher food efficiency and produce more highly conformed carcasses than HF bulls, but HF bulls produce more tender meat. The beef production potential of Norwegian Red (NOR) compared with 'modern' Holstein-Friesian (HF) cattle. The study used a total of 64 bulls in a 2 × 2 factorial design encompassing two breeds (HF and NOR) and two slaughter ages (485; E, and 610; L, days). The mean initial age and live weight of the HF bulls were 179 (s.d. 47.1) days and 203 (s.d. 64.0) kg, while the corresponding data for NOR bulls were 176 (s.d. 39.7) days and 185 (s.d. 63.6) kg, respectively.

Barton *et al.* (2006) compared breed effects on live weight gain, slaughter characteristics and carcass composition in Aberdeen Angus, Charolais, Hereford and Simmental bulls. The experiment extended over 2 years and involved totally 96 animals. The target slaughter live weights were determined 550 kg for earlier maturing breeds Aberdeen Angus and Hereford and 630 kg for later maturing breeds Charolais and Simmental. Charolais and Simmental gained more rapidly ($p < 0.05$) than Aberdeen Angus while Hereford were intermediate. Hereford had lower ($p < 0.05$) dressing percentage than the other breeds. Percentages of grade I meat were significantly higher ($p < 0.05$) in Charolais and Simmental. The highest percentage of separable fat was recorded in Hereford ($p < 0.05$). Charolais and Simmental had lower ($p < 0.05$) thickness of subcutaneous fat over MLLT than Aberdeen Angus and Hereford. The later maturing bulls generally tended to achieve higher live weight gains during the experiment, produced less fat and had higher percentage of meat from high priced joints in comparison with earlier maturing animals.

Rahman (2001) conducted an experiment for 150 days to find out the effect of UMS feeding on feed intake, nutrient digestibility, growth, feeding behavior and carcass characteristics of indigenous growing bulls. Six bulls of two year of age were randomly selected for two treatment groups having 3 replications in each. Control and treated groups received rice straw + green grass and UMS + green grass, respectively. Concentrate supplement (Rice polish + wheat bran + mustard oil cake) was given at the rate of 1.35 kg per day per bull for treatment groups. Live weight at finishing was 150.17 ± 9.78 and 169 ± 3.06 kg for the bulls of control and treated group respectively and differs significantly ($p < 0.05$). Average daily

body weight gain was 365.33 ± 42.85 and 492.67 ± 29.09 gram the bulls of control and treated group respectively.

Chowdhury and Huque (1998) in a 60-day study, assigned 12 native growing bulls, 35 months old, 273 kg live weight for treatments consisting of chopped rice straw *ad libitum* supplemented with 3% urea (US) + 15% cane molasses (UMS) or 3% urea + 30% rice gruel (UGS) and observed daily live weight changes during the experimental period were 292,125 and 19 g, respectively for UMS, UGS and US.

Lozand et al. (1987) carried out an experiment for 70 days with Hereford $\times$ Aberdeen, Angus $\times$ Zebu steers weighing initially about 274 kg in a 2×2 randomized block factorial experiment. Taking 3 replications each of two steers were given diet of molasses and urea with sunflower meal or cotton seed meal. Average daily gains were 1.015, 0.980, 0.0884 and 1.060 kg with the four treatments respectively.

Daniel et al. (1986) carried out an experiment with crossbred calves fed on urea molasses liquid diet, six Holstein Friesian $\times$ Hariana calves; 8-12 months of age were given a conventional ration (CR). A similar group was given to appetite for 150 days urea 2.5, molasses 9.2, minerals 3 and water 2.5% then CR to day 306 and final 1.5 times CR to day 336. The control group was given 2kg green sorghum and wheat straw to appetite where as the second group got straw 0.8 kg/kg live weight. The animals were weighed initially and at 150, 306 and 336 days. Daily weight gains for the three periods were 458, 651 and 608, 102, 679 and 983 g in control and second group respectively. It was concluded that younger calves fed on urea molasses had a much lower growth rate than older ones.

Su et al. (1984) observed body weight change with beef cattle using molasses and urea. A total of 30 Charolais $\times$ Chienese Yellow cattle of 17-19 months old were fed in 5 groups on a low energy, low protein diet without or with urea 0.06 and molasses 0.5, 1.0, 1.5 or 2.0 kg/head/day. The result showed that average total body weight gain was 32.3, 36.0, 37.2 and 37.5 kg. The 4th group which gains 39 kg ate 1.96 kg concentrates daily, 1.5 kg molasses and 120 g urea. Compared with the 1st group, the 3rd took 0.35 kg less concentrate for each kg gained. It was suggested that a daily allowance of molasses and urea at 1.06-1.45 and 0.1-0.2% of body weight respectively was suitable.

Haque *et al.* (1984) in an experiment used three groups of local Bangladeshi male calves 4 in each group and were given diets based on rice straw untreated or treated with ammonia generated from urea or from urine. Daily supplement of rice bran (400 g), oil cake (200 g) and fresh road side grass (1kg) were given during 105 days. Body weight gains from straw treated with ammonia using either urea or urine as a source, 162 and 171 g/d were significantly higher than the gain untreated straw, 95g/d.

2.8 Pre-slaughter body measurement

Taiwo *et al.* (2010) examined the effects of breed, age, sex and body condition scores on linear body measurements on White Fulani (Bunaji), Rahaji and Sokoto Gudai was significantly ($p<0.05$) superior to Rahaji and White Fulani in height at withers (HAW), heart girth (HG) and depth of at rear flank region (DARF). Body measurements increased with age. Maximum increase was between 1-3 years. Sex of animals significantly ($p<0.05$) affected most body measurements, bulls being superior to cows in height at hips (HAH), width at hips (WAH) and DARF which are good measures of tissue development. Also body condition scores (BCS) significantly ($p<0.05$) affected all body measurements. Distributions of animals in the three conditions (fat, medium and lean) were 21, 51.2 and 27.5% respectively. Animals with medium BCS showed consistent relationship with body measurements. Within breed, BCS were strongly ($p<0.01$) related to body measurements to make linear measures a possible good indices and reliable indicator of BCS which can be used to assess beef cattle under field conditions.

Alberti *et al.* (2008) reported that, a total of 436 young bulls from fifteen Western European breeds, including beef, dairy and local types from five countries, were studied to assess variability in live weight, live weight gain, body measurements and carcass traits. Animals were lodged indoors, and fed a diet based on concentrate and straw offered *ad libitum* from 9 months of age to slaughter at 15 months of age. The weight, body length, height at withers and pelvis width, of the animals were recorded at 9, 12 and 15 months of age. After slaughter, 15 carcass variables were recorded, including carcass weight, EU classification scores, morphological measurements and dissection data. Data were analyzed by GLM, regression and principal component analysis procedures. Significant differences were found between breeds for all variables studied, however, the body size measurements and the

carcass traits were more useful to discriminate among cattle breeds, than either live weight or daily gain.

Bene *et al.* (2007) took body measurements of 110 beef cows of 9 breeds (Hungarian Simmental, Hereford, Aberdeen Angus, Red Angus, Lincoln Red, Shaver, Charolais, Limousin and Blonde d'Aquitaine) in December 2004. The absolute, relative measurements and measurement indices moreover correlations between age, live weight and measurements were evaluated and compared for the mentioned breeds. Animals in study were born between 1989 and 2002, kept on the same condition on peat-bog soil pasture at Keszthely. Significant differences ($p < 0.05$) were found among breeds in most of the body measurements. Blonde d' Aquitaine was the heaviest in live weight (638 kg), highest as for the height at withers (142.5 cm), height at rump (146.6 cm) and length of the body (151.5 cm). Limousin had longest measurements as for the length of the rump (47.4 cm) and width of the rump (58.3 cm). Shaver had the longest width between shoulders (52.9 cm) and width of the head (25.1 cm) while Lincoln Red the longest length of the head (52.8 cm). The correlations between live weight and measurements were medium or strong positive ($r = 0.40 - 0.83$), between age and measurements slight positive ($r = 0.01 - 0.46$), among the different measurements medium or strong positive ($r = 0.22 - 0.81$).

2.9 Carcass Yield Characteristics

2.9.1 Dressing percentage

Khalafalla *et al.* (2011) reported that, eighty fattened Sudan Baggara bulls were used to examine the variations on slaughtering performance and carcass measurements due to slaughter weight variation. The work also aimed at studying the use of carcass measurements to predict carcass weight. Animals were divided into four groups of 20 animals each (200-250, 251- 300, 301-350 and 351-400 kg body weight groups). After slaughtering, dressing and evisceration, carcass and all organs were individually weighed. The carcass was also weighed after chilling at 4°C for 24 hours. Hot and chilled dressing percentages as well as the carcass measurements increased with the increase of slaughter weight.

Zahradkova *et al.* (2010) determined the effects of breed and a diet containing linseed on the growth and carcass composition characteristics of heifers. A total of 48 Limousin (LI)

and Charolais (CH) heifers with an average weight of 270 kg were assigned to two diets containing either extruded linseed (LIN) or no supplemental oilseed (CON). The target slaughter weight was set at 500 kg. The diet had no effect on any of the observed production traits. The CH heifers had higher live weight gains ($p < 0.001$) and a lower feed conversion ratio ($p < 0.001$). The LI heifers had a higher dressing percentage ($p < 0.001$), higher meat to bone ratio ($p < 0.001$), greater *m. longissimus lumborum et thoracis* area ($p < 0.05$), and produced more internal and carcass fat ($p < 0.05$).

Barton *et al.* (2006) compared breed effects on live weight gain, slaughter characteristics and carcass composition in Aberdeen Angus, Charolais, Hereford and Simmental bulls. The experiment extended over 2 years and involved totally 96 animals. The target slaughter live weights were determined 550 kg for earlier maturing breeds Aberdeen Angus and Hereford and 630 kg for later maturing breeds Charolais and Simmental. Charolais and Simmental gained more rapidly ($p < 0.05$) than Aberdeen Angus while Hereford were intermediate. Hereford had lower ($p < 0.05$) dressing percentage than the other breeds. Percentages of grade I meat were significantly higher ($p < 0.05$) in Charolais and Simmental.

Ozbeyaz *et al.* (1997) reported that ten Brangus × Jersey (F_1) and 28 Limousin × Jersey (F_1) crossbreds were studied at a state farm in Turkey. For the 3 crossbred types respectively, overall daily weight gain during the 510-day fattening period averaged 0.64, 0.59 and 0.54 kg for males and 0.53, 0.54 and 0.54 kg for females. For both sexes there were no significant differences between breed types in respect of daily weight gain. Brangus crossbred males had gained about 39.6 kg more live weight than Limousin crossbreds at the end of the fattening period, but the difference was not significant. Brangus crossbred males were 64 kg and Limousin crossbreds were 24.4 kg heavier than Simmental crossbreds; these differences were significant. For groups of 4 Brangus × Jersey, Simmental × Jersey and Limousin × Jersey bulls slaughtered at 457.5, 436.8 and 450.7 kg respectively. Dressing percentage averaged 58.0, 56.1 and 58.2, skin weight 36.5, 37.8 and 39.3 kg, bone percentage 16.0, 16.2 and 15.9 and rib-eye-area 86.3, 96.4 and 95.6 cm².

Colpan *et al.* (1995) reported that male Limousin × Jersey beef cattle, from 12 to 18 months old in 2 groups of 6 each were fed on a diet containing 80% concentrates and 20% roughages consisting of 85% sugar beet pulp and 15% wheat straw or that diet supplement with 1.5% zeolite. Average live weight at the end of feeding was 333.25 and 354.80 kg, respectively and

average daily gain 1132 and 1246 gm. The cattle took 7.860 and 7.418 kg DM/kg gain. At slaughter, average cold carcasses were 188.60 and 148.23 and 204.20 and 161.00 kg respectively. The average hot and cold dressing percentage was 56.71 and 55.54 and 56.54 and 55.39.

2.9.2 Meat to bone ratio

Bures and Barton (2012) investigated the effects of sex and slaughter age on growth, feed intake, carcass composition and meat quality attributes of *musculus longissimus lumborum* in Charolais × Simmental bulls (n = 12) and heifers (n = 12) reared and finished under identical management conditions. The animals entered the experiment at similar age (251 days) and were slaughtered at 14 or 18 months of age. Bulls gained more rapidly ($p < 0.001$), consumed more dry matter daily ($p < 0.05$), and had a higher killing-out proportion ($p < 0.05$). The sex × slaughter age interaction was significant ($p < 0.01$) for feed conversion ratio, which deteriorated markedly more in heifers than in bulls as slaughter age increased. Bulls produced leaner carcasses with a higher proportion of total meat ($p < 0.001$). While bulls contributed to high-priced meat by a higher proportion of meat from the shoulder ($p < 0.01$), heifers had higher proportions of meat from the rump and loin ($p < 0.05$). Older animals were generally fatter and their carcasses contained lower proportions of high priced meat ($p < 0.01$) and bones ($p < 0.05$).

Zahradkova et al. (2010) determined the effects of breed and a diet containing linseed on the growth and carcass composition characteristics of heifers. A total of 48 Limousin (LI) and Charolais (CH) heifers with an average weight of 270 kg were assigned to two diets containing either extruded linseed (LIN) or no supplemental oilseed (CON). The target slaughter weight was set at 500 kg. The diet had no effect on any of the observed production traits. The CH heifers had higher live weight gains ($p < 0.001$) and a lower feed conversion ratio ($p < 0.001$). The LI heifers had a higher dressing percentage ($p < 0.001$), higher meat to bone ratio ($p < 0.001$), greater m. *longissimus lumborum et thoracis* area ($p < 0.05$), and produced more internal and carcass fat ($p < 0.05$). It was concluded that purebred LI heifers grew less rapidly and less efficiently but produced heavier carcasses with a more favorable meat to bone ratio compared to purebred CH heifers.

Orrellana *et al.* (2009) characterized and compared the carcass characteristics, cholesterol concentration, fatty acid composition of intramuscular fat and subcutaneous fat, and meat quality of Criollo Argentino and Braford steers reared in an extensive system, without supplementation, and slaughtered at approximately 400 kg live weight. The Braford steers had greater ($p < 0.05$) carcass weight, yield, conformation score, marbling, fat thickness and fatness score than Criollo Argentino steers. The tissue composition of the 10th rib was: 68.1% vs. 63.6% muscle, 23.9% vs. 20.4% bone and 8.2% vs. 16.3% fat for the Criollo Argentino and Braford breeds, respectively.

Afolayan *et al.* (2002) reported that, the animals were boned out after slaughter and comprised 182 steers from the Southern Crossbreeding Program (progeny from Hereford cows crossed with seven sire breeds: Angus, Belgian Blue, Hereford, Jersey, Limousin, South Devon and Wagyu) and 59 steers from the Davies Gene Mapping Project (pure Limousin, pure Jersey and Limousin $\times$ Jersey). Stepwise regression was used to indicate the relative importance of variables in each model designed to estimate the percentage of meat, bone and fat from the carcass weight. The meat, bone and fat yields correspond to 70, 19 and 11% of the carcass on weight basis. The prediction equations developed accounted for 93, 87, 74 and 65% of the variation in carcass, meat, bone and fat weight respectively without breed in the model.

Dolezal *et al.* (1982) reported that, thirty-eight steers and thirty heifers (14 to 17 months of age, from F (1) Hereford $\times$ Brahman cows bred to Angus or Hereford bulls), were either forage-fed for 123 days on millet-Bermuda grass pasture or grain-fed for 90 days on a high-concentrate diet and were then commercially slaughtered. Warm carcass weights ranged from 167.8 kg to 324.3 kg. At 24 h post mortem, Texas Agricultural Experiment Station personnel (1) assigned scores or took measurements on each carcass for all factors used in yield grading and quality grading, (2) measured the length of hind leg (HL) and carcass length (CL) and (3) assigned a score for carcass muscling (MS) and, as appropriate, made an adjusted longissimus muscle area (ALA) evaluation. The 9th-10th-11th rib section from one side of each carcass was physically separated into longissimus muscle, fat, 'other soft tissue' and bone and ether extract determinations of the longissimus muscle and 'other soft tissue' components were made and used to adjust the yields of each of these components to a fat-free basis. Muscle to bone ratios ranged from 2.38 to 4.37. With age and carcass weight held

constant, diet, breed and sex explained only 35.8% of the variation in muscle to bone ratio. The best simple correlation with muscle to bone ratio was ALA/CL ($r = 0.59$). Other measures significantly correlated with muscle to bone ratio included ALA ($r = 0.55$), MS ($r = 0.50$) and carcass weight ($r = 0.49$). Multiple regression analyses identified a three-variable subset comprised of ALA, carcass weight and CL which was related ($p < 0.01$) to muscle to bone ratio ($R^2 = 0.41$). Data suggest that muscle to bone ratios differ widely among beef carcasses of similar genetic-management history and that there is carcass measures useful for predicting muscle to bone ratio.

2.9.3 Yield grade

2.9.3.1 Fat cover

Bonin *et al.* (2014) investigated the influence of Nellore bulls on carcass and meat quality traits. They used 475 young uncastrated males, the progeny of 54 bulls, to evaluate characteristics of the following carcass traits: hot carcass weight, rib-eye-area, and fat thickness. They also evaluated the following beef quality traits: marbling, color, drip loss, cooking loss, and shear force at 0, 7, and 14 days of aging. Bulls had a significant influence ($p \leq 0.05$) on rib-eye area, fat thickness, marbling and drip loss at 14 days of aging and color at all aging periods. Based on these results, the use of bulls with high breeding values for these traits can provide important advances in carcass traits and meat quality in breeding programs of Nellore cattle that are raised in tropical conditions.

Arboitte *et al.* (2012) evaluated carcass characteristics of small and medium-frame Aberdeen Angus young steers, finished in feedlot and slaughtered with similar subcutaneous fat thickness. The average age and live weight at the start of feedlot were respectively 298 days and 202 kg. The steers were confined during 158 days, and slaughtered with average subcutaneous fat thickness of 6.4 mm. The feed consisted of sorghum silage and concentrate at 60:40 ratio of dry matter during the first 63 days and 50:50 afterward. The frame was calculated by formula $F = -11.548 + (0.4878 \times h) - (0.0289 \times ID) + (0.0000146 \times ID^2) + (0.0000759 \times ID \times h)$, where h is the height and ID the age, in days. Steers with medium frame showed superiority in important marketing aspects such as warm carcass ($p < 0.0001$) and cold carcass ($p < 0.0001$) weights. Muscularity measurements such as *longissimus dorsi* area in relation to cold carcass ($p = 0.0477$) and empty body ($p = 0.0419$)

weights were lower for medium-frame steers. Carcass conformation, *longissimus dorsi* area and cushion thickness were similar in both frame.

Luchiari et al. (2005) observed that hanging beef carcasses in different configurations in the cooler affect some carcass muscle tenderness. Carcasses were chilled for 48 hours, when samples from the *Longissimus dorsi* (LD) at the 12th rib and the *Biceps femories* (BF) at the P8 site were removed, kept under refrigeration (0-2 degrees C) for five days. Fat thickness measured at the 12th rib was lower ($p<0.05$) for HQ (3.8 mm) than FQ (4.3 mm). Total cooking losses were not different between HQ (19.7%) and FQ (18.9%). Hanging beef carcass by the forequarter caused an improvement in tenderness of the LD without any detrimental effect on the BF (cap of rump).

Minick et al. (2000) reported that, ultrasound carcass data from yearling Angus bulls were analyzed to determine trends in rib-eye-area. Bulls with a heavier scan weight had larger rib-eyes. Also, bulls with an increased amount of 12-13th rib fat had larger rib-eyes. The most efficient bulls with the largest rib-eyes had the greatest amount of external rib fat.

May et al. (1992) selected commercial slaughter steers (n=329) and heifers (n=335) to vary in slaughter frame size and muscle thickness score, as well as carcass adjusted 12th-rib fat thickness. Within the same phenotypic group, percentage of trimmable fat increased by 2.32% as 12th -rib fat thickness increased by 0.75 cm. Holding frame size, sex class, and fat thickness constant, there was a higher percentage yield of chuck roll, rib eye roll, and strip loin for carcasses from thick-muscled cattle than for those from average- and thin-muscled cattle.

2.9.3.2 KPH%

Rashid et al. (2015c) stated that, twelve Brahman crossbred growing bulls, divided into three groups, were fed three diets; 100% concentrate diet (A), a 1:1 mixed diet on dry matter of Urea-Molasses-Straw (UMS) and concentrate diet (B) and sole UMS diet (C), respectively, to evaluate the effects of concentrate level on slaughterhouse by-products, carcass characteristics and meat traits. The animals were fed for a period of 90 days and three animals from each group were slaughtered at the end of the trial. Among carcass traits, hot dressing percentage, kidney-pelvic-heart fat, abdominal fat and back fat thickness increased

linearly ($p < 0.01$) with the increased level of concentrate in diets, while longissimus muscle area did not vary among diet groups.

Crews *et al.* (2008) estimated the genetic parameters required for genetic evaluation of retail product percentage (RPP) in Simmental cattle. Carcass weight (HCW), subcutaneous fat thickness (FAT), longissimus muscle area (REA) and kidney, pelvic, and heart fat (KPH) records were available to compute RPP on steers ($n = 5171$) and heifers ($n = 1400$) from the American Simmental Association database; animals were sired by 561 Simmental bulls and out of 5886 crossbred dams. Genetic parameters were estimated using residual maximal likelihood and a four trait animal model for the components of RPP including fixed harvest contemporary group effects, random animal genetic effects, and a linear covariate for age at harvest. Heritability estimates were 0.51 ± 0.05 , 0.36 ± 0.05 , 0.46 ± 0.05 , and 0.18 ± 0.05 for HCW, FAT, REA and KPH respectively. Non-zero genetic correlations were estimated between HCW and REA ($r_g = 0.51 \pm 0.06$) and between REA and FAT ($r_g = -0.43 \pm 0.08$), but other genetic correlation estimates among the component traits were low. As a linear function of its components, heritability and genetic correlations involving RPP were estimated using index methods. The heritability estimate for RPP was 0.41, and genetic correlations were -0.17 , -0.83 , 0.67 , and 0.01 with HCW, FAT, REA and KPH respectively. Therefore, RPP was strongly associated with muscle and fat deposition, but essentially independent of carcass weight and internal body cavity fat. Genetic evaluation of RPP would be straightforward using multiple trait index methods and genetic regression, although the inclusion of KPH would be of marginal value.

Ozluturk *et al.* (2008) reported that, seventeen Eastern Anatolian Red (EAR) bulls at 20 months of age were divided into 2 treatment groups and fed for either 168 days (S) or 210 days (L). Initial and final weights were not significantly different. While bulls in the L group had the highest total weight gain (149.0 vs. 177.2 kg), feed efficiency ratio was superior for the cattle fed for 168 days. Carcass weight, spleen and front + hind feet weights as a percentage of slaughter weight, weight of kidney fat, percentage of kidney, pelvic, and heart fat, and yield grade all increased ($p < 0.05$) with feeding time.

Camfield *et al.* (1999) developed carcasses of 342 steers of known genetic backgrounds from four fundamentally different growth types either on pasture or feedlot regimens to study differences in carcass traits. Growth types were large framed-late maturing (LL),

intermediate framed-intermediate maturing (II), intermediate framed-early maturing (IE), and small framed-early maturing (SE). Differences in carcass traits reflected genetic differences among growth types. The LL steers had heavier BW, HCW, and CCW and larger LMA ($p < 0.05$) than steers of other growth types, regardless of development regimen. Among pasture-developed steer carcasses, IE and SE steers had higher ($p < 0.05$) MARB and QG than either LL or II steers. Carcasses of large framed-late maturing steers had the lowest ($p < 0.05$) MARB and QG of the growth types. Carcasses of the II, IE, and SE steers had a higher ($p < 0.05$) numerical value for YG than carcasses of the LL steers. Among the carcasses of the feedlot-developed steers, IE and SE steers had the highest ($p < 0.05$) MARB and QG. Carcasses from the IE and SE steers were fatter ($p < 0.05$) than those from LL or II steers. Carcasses of the LL steers had the lowest percentage of KPH of growth types developed in the feedlot. No difference was observed in KPH for carcasses of II, IE, and SE steers. The LL steer carcasses had the lowest numerical value for YG of all growth types.

Marshall (1994) evaluated the effects of dam breed-type (Simmental $\times$ Hereford, Angus $\times$ Hereford, and Tarentaise $\times$ Hereford) and mating system (rotational versus rota-terminal) on carcass characteristics. Means for dam breed-type and mating system were adjusted in separate analyses to one of three slaughter endpoints: 437-day slaughter age, 734-lb carcass weight, or 0.49 inches of carcass fat thickness. Calves from Simmental $\times$ Hereford dams had heavier carcasses compared to the other two dam breed- types when adjusted to a constant slaughter age or fat thickness. Calves from Angus $\times$ Hereford dams tended to have more external fat, smaller rib eye area, and more marbling than calves from the other two dam types on an age-constant and carcass weight-constant basis. Breed did not have significant effect ($p > 0.05$) effect on KPH fat percentage. Terminal-sired (Charolais) calves had less external fat and larger rib eye area than rotational calves at a constant age or carcass weight. The dam breed-type $\times$ mating system interaction generally did not approach significance.

Nour *et al.* (1983) reported that, the effects of live weight on carcass weight and on carcass characteristics were quantified using 145 large and small cattle represented by Holstein and small-framed Angus steers. Cattle were fed to one of five final weights ranging from 363 to 544 kg for Angus and from 454 to 612 kg for Holstein. Angus carcasses had greater fat thickness and higher estimated percentage kidney, pelvic and heart fat (KPHF) except at heavier weights where percentage KPHF was greater for Holstein carcasses. Fat thickness

increased 0.005 cm/kg faster ($p<0.005$) and percentage KPHF increased 0.005 percentage units/kg slower ($p<0.025$) for Angus carcasses.

2.9.3.3 Rib-eye-area (REA)

Dashdorj *et al.* (2012) evaluated carcass characteristics and meat quality traits as a function of endpoint months of slaughter age (26 vs 32 mon) and chiller ageing (1 vs 10 d) for *m. longissimus* of 26 Hanwoo steers fed with commercial diets including whole crop barley silage. Totally twenty six Hanwoo steers for 6 mon of age that were fed until 26 mon of age constituted the short term-fed group and fed until 32 mon of age constituted long-term fed group. Carcasses were chilled for 24 h and were graded. Strip loin samples were divided into two age groups (1 d and 10 d). Long-term feeding increased carcass weight, rib-eye-area, yield grade, marbling score, firmness and quality grade of the meat.

Stickel (2012) reported that, crossbred yearling steers ($n=144$ initial BW 367 ± 18.46 kg) were randomly allotted by BW to a randomized complete block design with a 2×3 factorial treatment arrangement to 1) assess the impact of supplementing dried distiller grain with soluble (DDGS) while grazing late season forage for 90 d and 2) the impact of a short feeding period on animal performance, carcass characteristics and meat quality traits. Treatments consisted of DDGS supplementation during grazing (0 or 1% of BW as DDGS; DM basis) and finishing days on feed (DOF; 75, 100, 125). During grazing supplemented cattle had greater ($p<0.01$) ADG than un-supplemented cattle but un-supplemented cattle had greater ADG than supplemented cattle during the finishing period. There were no differences between grazing treatments for DMI ($p=0.91$) during the finishing period. Supplemented cattle had decreased ($p=0.02$) G: F during the finishing period compared to un-supplemented cattle. Supplemented cattle had heavier ($p<0.01$) HCW and larger ($p=0.02$) LM area than un-supplemented cattle. Increasing DOF linearly increased ($p\leq 0.03$) HCW, 12th rib fat thickness, LM area and USDA marbling score. No differences were observed for USDA yield grade.

Steiner *et al.* (2003) determined the accuracy and repeatability of beef carcass longissimus muscle area (LMA) measurements obtained by three different methods. Longissimus muscle area for beef carcass sides ($n=100$) randomly selected in a commercial packing plant was determined – (1) independently by three USDA grading supervisor "experts" using the

grid method to obtain triplicate measurements of the same longissimus muscle (LM); 2) by three different Colorado State University personnel tracing the LMA on acetate paper and subsequently measuring the area via a polar planimeter three different times (total of $3 \times 3 = 9$ observations/LM); and 3) by use of two identical video image analysis (VIA) instruments making triplicate measurements for each LM using three different procedures. Video image analysis Procedure 1 required that LMA be measured by placing the camera head unit over the LM and collecting three sequential images without moving the camera head unit while carcasses were in a stationary position; Procedure 2 required measurement of LMA by placing the camera head unit over the LM and collecting three images, but removing and repositioning the camera head unit between collection of each image while carcasses were in a stationary position; and Procedure 3 required that LMA be measured by placing the camera head unit over the LM and obtaining an image while carcasses were in continuous motion (chain speed of 360 carcasses/ h) during three different circulations past the grading stand. Overall, VIA-derived LMA measurements were highly accurate for all three procedures compared with expert-gridded ($R^2 = 0.92, 0.90,$ and 0.84 for Procedures 1, 2, and 3, respectively) and acetate/planimeter-traced ($R^2 = 0.94, 0.93,$ and 0.86 for Procedures 1, 2, and 3, respectively) LMA measurements. Instrument LMA repeatability also was comparable to expert-gridded and acetate/planimeter-traced LMA repeatability, as the means of the absolute differences between individual measurements and the average of those same measurements per LM were 1.29, 1.35, 0.52, 0.84, and 1.87 cm² for expert-gridded, acetate/planimeter-traced, and VIA Procedures 1, 2, and 3, respectively. Therefore, VIA instrumentation can be used to assess beef carcass LMA in both a stationary and operational scenario with high levels of accuracy and repeatability.

Minick *et al.* (2000) reported that, ultrasound carcass data from yearling Angus bulls were analyzed to determine trends in rib-eye-area. Bulls with a heavier scan weight had larger rib-eyes. Also, bulls with an increased amount of 12-13th rib fat had larger rib-eyes. The most efficient bulls with the largest rib-eyes had the greatest amount of external rib fat.

Sullivan and Miller (1997) stated that, a genetic evaluation model was developed for rib-eye-area of yearling beef bulls. The model was designed to rank bulls genetically at a fixed age, resulting in genetic evaluations that could be easily combined with evaluations for other traits of economic importance. Relative individual body weights and breed were

important factors influencing the age adjustment factors for the model. Breed effects on the age adjustment factors could only be estimated for the major breeds, but the relative weight effects apply to bulls of all breeds. The age adjustment factors have been implemented in genetic evaluation programs to calculate within and across breed EPD for rib eye area of centrally evaluated beef bulls in Ontario.

2.9.3.4 Hot carcass weight

Islam (2013) conducted an experiment to establish relationship between age and beef quality of indigenous cattle. Three different ages of indigenous beef cattle which are of <1.6, 1.6-2 and 2-3 years, with three replication of each as were taken for this study. Hot carcass weight values at different ages were statistically significant ($p < 0.05$). The highest hot carcass weight was 126.77 kg observed in 2-3 years cattle. The lowest value was 72.45 kg found in <1.6 years cattle. But the value of hot carcass weight of 1.6-2 years indigenous cattle was 72.45 kg which were identical to the <1.6 years cattle.

Khalafalla *et al.* (2011) reported that, eighty fattened Sudan Baggara bulls were used to examine the variations on slaughtering performance and carcass measurements due to slaughter weight variation. The work also aimed at studying the use of carcass measurements to predict carcass weight. Animals were divided into four groups of 20 animals each (200 - 250, 251 - 300, 301 - 350 and 351 - 400 kg body weight groups). After slaughtering, dressing and evisceration, carcass and all organs were individually weighed. The carcass was also weighed after chilling at 4° C for 24 hours. Measurements of carcass length, leg length, leg circumference, chest circumference, barrel circumference were taken on the cold carcass. One way analysis of variance was used to examine the effect of slaughter weight on the obtained data. Regressions of cold carcass weight on its measurements were also calculated. Hot and chilled dressing percentages as well as the carcass measurements increased with the increase of slaughter weight. The opposite trend was observed for gut fill, total, internal and external non carcass components percentages. Leg circumference correlation with carcass weight had the highest coefficient. The study concluded that the Western Sudan Baggara bulls were promising beef animals. The optimum finishing weight range of this type of cattle was 301 - 350 kg. The leg circumference measurement can be used satisfactorily for prediction of carcass weight using the following equation: $y = 4.62x - 273$.

Vaz et al., (2011) revealed that early weaning doesn't alter the weight and finishing of steers carcasses. Carcass quantitative characteristics of 68 Braford steers of two weaning ages: 91 days, early weaning (EW); 160 days, conventional weaning (CW), classified at slaughter in three live weight groups: light (≤ 350 kg), medium (351 and 370 kg) and heavy (≥ 371 kg), were evaluated. Steers were finished on summer pasture (*Pennisetum americanum*) and slaughtered at 16 months of age. No significant differences were observed between weaning ages for hot carcass weight (EW=193.0 kg; CW=193.2 kg) and cold carcass weight (EW=188.6 kg; CW=188.5 kg).

Arnett (2010) stated that because of being slower growing, Jersey cattle required additional time on feed to achieve acceptable market weights and yield acceptable hot carcass weights. The objective of this study was to evaluate the effects of forage level (12 vs. 24% Sudan grass: alfalfa hay, DM-basis) in steam-flaked, corn-based finishing diets on carcass characteristics, palatability, and retail color stability of Jersey beef. Seventy-nine Jersey steers were blocked by weight and randomly assigned one of the following treatments for a 385-d trial period: Jersey low-12% (JL; n = 38) or Jersey high-24% (JH; n = 39) forage, DM-basis. Steers fed the low forage diet had greater ($p < 0.05$) back fat and tended to have greater dressing percent compared to steers fed the high forage diet. Live weight, HCW, LMA, and USDA Yield Grade were not affected ($p > 0.05$) by forage level. Steers fed the low forage diet on average tended to bring a 6% greater value (\$ 63.73 more per head) compared to steers fed the high forage diet.

Alves et al. (2007) observed on effects of dam age, gender, season at the slaughter moment and the municipality from which the animal were determined in the carcass weight. Variance analysis and differences amongst groups were analyzed using SPSS version 19. Carcass weight was 102.60 ± 17.86 kg for slaughter age of 7.79 ± 1.26 months. Dams between two and three years old produced calves with lower carcass weight (99.08 ± 14.74 kg) when compared to older mothers (102.59 ± 17.65 kg). Animals slaughtered in spring (105.63 ± 17.18 kg) and winter (104.38 ± 18.36 kg) had heavier carcasses compared to those slaughtered in Summer (100.39 ± 18.07 kg) and Autumn (99.11 ± 16.95 kg). The municipality where animals came from influenced the carcass weight: animals slaughtered in Montalegre (105.20 ± 19.04 kg), Boticas (105.02 ± 18.58 kg) and Cabeceiras de Basto (107.41 ± 18.67 kg)

are the ones who have higher weight and the animals from Vila Verde (95.63 ± 14.75 kg) have the lower carcass weight.

Plessis and Hoffman (2007) observed in sweet veld areas, steers from small to medium framed breeds could be raised successfully and slaughtered at 30 months of age without supplementation of natural pastures. Slaughtering steers at younger ages might require supplementary feeding or feedlot finishing. An experiment on Simmental (SX), Bonsmara (BX) and Nguni (NG) crossbreeds were raised on natural sweet veld pastures and slaughtered at 18 or 30 months of age. Slaughter occurred at the end of the wet summer season. Carcass traits were significantly influenced by the breed and slaughter age.

Wheeler et al. (1996) compared carcass and *longissimus thoracis* palatability traits from 888 steers obtained from mating Hereford and Angus cows to Hereford or Angus (HA), Charolais (Ch), Gelbvieh (Gb), Pinzgauer (Pz), Shorthorn (Sh), Galloway (Gw), Longhorn (Lh), Nellore (Ne), Piedmontese (Pm), and Salers (Sa) sires. Data were adjusted to constant age (426 d), carcass weight (324 kg), fat thickness (1.2 cm) and fat trim percentage (23%). At a constant age of 426 d, carcasses from Ch steers were heaviest ($p < 0.05$) and Gw and Lh carcasses were lightest ($p < 0.05$). Adjusted fat thickness was greatest ($p < 0.05$) on carcasses from HA and least ($p < 0.05$) on carcasses from Ch, Gb, Lh, and Pm steers. USDA numerical yield grades were lowest ($p < 0.05$) for carcasses from Pm and highest ($p < 0.05$) for carcasses from HA, Ne, and Sh steers.

2.10 Yield of primal cut

Goonewardene et al. (2012) carried out an experiment on the carcass, primal cuts (brisket, loin and short loin, chuck, flank, plate, rib, round and shank) and fat depots in three Beef Booster® composites ($n = 176$) from 274-456 days at slaughter, and determine harvest times at which M is maximized and F is optimized. Composites were from lines M1, M2, M3, M4 and TX. The SM type contained M3 and other small breeds; AH contained M1 and M2 which had either Angus (A) or Hereford (H), and GLC contained both M4 made up of either Gelbveith (G) or Limousin (L) and TX made up of Charolais (C). Tissue weights and proportions were analyzed by covariance within slaughter time (274, 347, 372, 399, 427 and 456 d, respectively) with composite type (SM, AH and GLC) as fixed, year (1 & 2) as random and age within slaughter time as a covariate. In the carcass and primal cuts, the weights of

M, weight and percent F increased while the percent M decreased with slaughter age. SM had less M ($p<0.05$) than AH and GLC in the carcass and primal cuts with the exception of the loin, plate and rib at 399 day, and the shank and rib at 427 day. The proportion of F in the carcass was similar ($p<0.05$) for SM and AH at 372, 399 and 427 day. The M:F ratio decreased with age and the decrease was more pronounced in SM and AH than GLC. The round had the least amount and proportion of F in all primal cuts differed ($p<0.05$) between composites especially beyond 399° C. The SM and AH can be harvested 60 and 30 days earlier respectively, so as to increase % M and decrease % F.

Dana *et al.* (1999) carried out an experiment on the relationship of beef primal cut composition to overall carcass composition. The beef chuck primal is the animal's shoulder and accounts for approximately 26 percent of the carcass weight. This section contains a portion of the backbone, five rib bones and portions of the blades and arm bones. The brisket is well suited for moist-heat methods of cooking, such as simmering or braising. The rib primal accounts for approximately 10 percent of the carcass weight and are best known for yielding prime rib roast, also called rib roast. The rib eye muscle (the center muscle) provides structural support, rather than mobility, and is therefore quite tender. It also contains large amounts of marbling compared to the rest of the carcass and produces rich, full flavored roasts and steaks. Although roasting the rib-eye muscle on the rib bones produces a moister roast, the bones can be removed to produce a boneless rib-eye roast. Rib meat may also be ground. The short loin is the front portion of the beef loin, located just behind the rib. It accounts for approximately 8 percent of the carcass weight and yields many of the most tender and expensive cuts of beef. The short loin also provides a great example of the give and take inherent in cut selection. The sirloin, located between the short loin and the round, accounts for approximately 9 percent of the carcass weight and contains part of the backbone as well as part of the hipbone. The round is very large, accounting for approximately 27 percent of the carcass weight. Meat from the round- the hind leg of the animal- is flavorful and lean. Steaks from the round can be marinated and grilled or braised (like Swiss steak). Round roast should be cooked with moist heat. Round steak is cut on average $\frac{3}{4}$ inch thick. Other cuts from this primal include minute steak (a round steak cut into smaller portions and tenderized) that can be used for chicken-fried steak; dried beef, usually thin-sliced and fully cured; and hind shank, a very flavorful cut that makes excellent

soup stock. In the round, one cannot get full cut round steaks and top, eye, and bottom round steaks. They are from the same muscles.

Jones *et al.* (1990) selected beef carcasses (129 steers and 80 heifers) differing in weight, muscling, fatness and marbling score to represent the full spectrum of USDA yield grades; one side was fabricated into boneless primal cuts. Heifers tended to have a higher predicted percentage of seam fat than did steers across all YG. Primals from USDA choice carcasses had approximately 1 percentage point more predicted seam fat than did USDA select primals at the same YG and sex-class. The YG 2.5 heifers had similar proportions of predicted seam fat from primals as YG 3.5 steers, but YG 3.5 heifers tended to have more seam fat than YG 4.5 steers. The same trend was noted between YG 4.5 heifers and YG 5.5 steers, indicating a sex-related deposition of seam fat in fed cattle.

Nour *et al.* (1983) fed diets of either 10% or 93% corn silage to small-frame Angus or large-frame Holstein steers. Serial harvest of steers occurred at 363-544 kg for Angus and 454-635 kg for Holstein steers. Carcass primal cuts were obtained and trimmed to 1 cm of subcutaneous fat thickness. Weight of trimmed primal cuts at a given shrunk live weight was not affected by diet for Angus steers. However, Holstein steers fed the low-silage diet yielded 6.73 kg more of trimmed primal cuts than high-silage Holstein steers when compared at a constant shrunk live weight. The trimmed primal cut yield of low-silage Holstein steers was better than either Angus-diet combination, while the yield for the high-silage Holstein steers was less than for either Angus-diet combination.

Johnson and Charles (1981) carried out an experiment on Eleven Angus, 12 Friesian and 12 Hereford steers were used to investigate the degree of accuracy and usefulness of primal cut tissues in predicting side composition. The criteria used for evaluating the cuts were: (a) standard error of estimate of the equation, (b) homogeneity of 'b' values among breeds, (c) appreciable bone content in cut to allow the prediction of side bone, and (d) the absence of major difficulties in the replication and dissection of cuts. Simple and multiple regression analyses showed that the most accurate predictors of carcass composition, in descending order, with standard errors of estimate of muscle, fat and bone percentages respectively, were hindquarter plus rib cut (0.84%, 0.88%, 0.48%); rib cut (1.13%, 1.26%, 0.59%); loin (1.24%, 1.21%, 0.72%). The most useful of four easily obtained carcass variables in improving the prediction accuracy of carcass components from multiple regression proved

to be primal cut weight and fat thickness at the 12th rib, particularly the former. Both significantly reduced the standard errors of estimate of muscle, fat or bone in equations based on loin, rib cut and loin plus rib cut, but not in equations based on hindquarter plus rib cut and hindquarter.

2.11 Yield of non-carcass component

Sestari *et al.* (2012) conducted a study to evaluate carcass characteristics, non-carcass components and meat quality of Nellore cattle in feedlot and fed with different corn hybrids (flint, semi-flint and semi-dent) in the diet. Twenty-seven animals averaging 350 ± 24 kg of body weight and 24 months of age were used. The animals were distributed in a completely randomized design with three treatments (T), where, T1 – diet with flint corn (TDFC), T2 – diet with semi-flint corn (TDSFC) and T3 – diet with semi-dent corn (TDSDC), with 9 replicates per treatment. The animals were fed *ad libitum* twice daily (at 8:00 am and 4:00 pm) with iso-caloric and iso-nitrogenous diet, with 30% of sugar cane bagasse and 70% concentrate (88% maize, 8% soybean meal, 3% mineral and vitamin supplement and 1% urea) for 95 days (14 days of adaptation and 3 experimental periods of 27 days each). The animals were weighed at the beginning of the experiment and after each period of 27 days, always in a fasting period of 16 hours. At the end of the experiment, the animals were slaughtered in a commercial slaughter house, measuring non-carcass components (weight of blood, feet, hide, head, tail, organs, fat removed for cleaning), gastrointestinal tract (pharynx, esophagus, stomach and intestines) and carcass characteristics (hot carcass, cold carcass yield, carcass length, leg length, thigh thickness, perimeter of leg, arm length, arm thickness, arm perimeter, front weight, rear weight and conformation). There was no significant difference ($p>0.05$) between treatments for the evaluated parameters for carcass characteristics and non-carcass components.

Khalafala *et al.* (2011) reported that, eighty fattened Sudan Baggara bulls were used to examine the variations on slaughtering performance and carcass measurements due to slaughter weight variation. The work also aimed at studying the use of carcass measurements to predict carcass weight. Animals were divided into four groups of 20 animals each (200 - 250, 251 - 300, 301 - 350 and 351 - 400 kg body weight groups). After slaughtering, dressing and evisceration, carcass and all organs were individually weighed. The carcass was also weighed after chilling at 4° C for 24 hours. Hot and chilled dressing

percentages as well as the carcass measurements increased with the increase of slaughter weight. The opposite trend was observed for gut fill, total, internal and external non carcass components percentages.

2.12 Physical properties of meat

2.12.1 Color

Alamin *et al.* (2015) stated that, the study aimed to evaluate the quality attributes of fresh camel meat and beef. The result showed that hunter lightness (L) values were highly significant ($p < 0.001$) between the types of meat. Beef recorded higher values of lightness compared to camel meat as (35.40 and 29.56) respectively. Redness (a) values was significantly ($p < 0.01$) different between the types of meat studied, hence beef recorded the higher values than that in camel meat as (19.60 and 16.45) respectively. The yellowness (b) values were significantly ($p < 0.001$) different between treatments, However, beef recorded the higher values than in camel meat as (7.78 and 5.10) respectively. In general, camel meat appeared brighter red than beef.

Suman *et al.* (2014) stated that, surface color and its stability are critical traits governing the marketability of fresh beef when sold, whereas internal cooked color is utilized as an indicator for doneness at the point of consumption. A multitude of exogenous and endogenous factors interact with the redox biochemistry of myoglobin in post-mortem skeletal muscles. The scientific principles of these biomolecular interactions are applied by the meat industry as interventions for pre-harvest (i.e. diet, animal management) and post-harvest (i.e. packaging, aging, antioxidants) strategies to improve color stability in fresh and cooked beef. This research suggested that the effects of several of these strategies are specific to type of animal, feeding regimen, packaging system, and muscle source.

Arnett (2010) evaluated the effects of forage level (12 vs. 24% Sudan grass: alfalfa hay, DM-basis) in steam-flaked, corn-based finishing diets on carcass characteristics, palatability, and retail color stability of Jersey beef. Seventy-nine Jersey steers were blocked by weight and randomly assigned one of the following treatments for a 385-d trial period: Jersey low-12% (JL; $n = 38$) or Jersey high-24% (JH; $n = 39$) forage, DM-basis. Forty-eight hours postmortem (PM), strip loins were removed, vacuum-packaged, and aged at 3° C for 18 d PM. Following the aging period, steaks from the longissimus muscle were sliced, vacuum-packaged, and

frozen (-20° C) until analyzed. Objective color (L*, a*, b*) measurements decreased ($p < 0.05$) over time of display across treatments. There were no differences among treatments for L*; however, overall during retail display JH had greater ($p < 0.05$) a* and b* values than JL. Subjective color scores increased over time of display and were not affected by forage level.

Dunne *et al.* (2004) stated that, the purposes of this study were (i) to objectively measure the color of carcass fat and muscle of heifers that had been previously selected, subjectively, for the Italian market and (ii) to define instrumental color values which would describe the required fat color for that market. On one day during each of 5 months the 'b' (yellowness) value of carcass fat was measured at two positions (proximal pelvic limb area and the area between 9th rib and 4th lumbar vertebra) and the 'L' (lightness) and 'a' (redness) values of two muscles (*M. longissimus dorsi* (LD) and *M. rhomboideus thoracis* (RT)) were measured using a Minolta chromameter. Measurement date had a significant effect ($p < 0.05$) on 'b' values of fat at both positions, with carcasses displaying the most yellow fat on 13 June ($p < 0.05$). The LD was palest and most red on 11 April ($p < 0.05$) and the RT tended to be palest on 13 June but most red ($p < 0.05$) on 11 April. The 'L' value differed between muscles on 11 April ($p < 0.01$) and 19 December ($p < 0.05$) and the 'a' value differed between muscles on all dates except 13 June. The majority of carcasses on each date fell between muscles 'L' values of 31 and 35, regardless of muscle, and between muscle 'a' values of 18 and 22. It was concluded that application of a "cut-off" value to muscle color would be futile but as 81% of accepted carcasses had fat 'b' values below 14.2, regardless of position, that this could be used as a threshold of acceptable yellowness.

Yang *et al.* (2002) stated that, the effects of pasture-feeding alone and with vitamin E supplementation were evaluated and compared the findings with those obtained for grain-fed cattle (predominantly sorghum) with and without supplementation. Within each nutritional background, vitamin E supplementation did not alter meat color or color stability of fresh or 47-day aged muscle during 7-day aerobic storage. However, both control and supplemented grain-fed product had better meat color (more redness) compared with meat from grass-fed cattle. These differences in redness between pasture- and grain-fed fresh beef were not apparent after ageing.

Wulf and Wise (1999) conducted an study to determine the effects of measurement conditions on L^* , a^* , and b^* values, to determine the relationships among USDA quality grading factors, muscle pH, electrical impedance, and colorimeter readings, and to develop a classification system that could be used to sort beef carcasses with respect to muscle color. Data were collected over 2 days from 145 beef carcasses in a commercial packing plant. The exposed longissimus muscle at the 12th/13th rib was used for all muscle pH, electrical impedance, and colorimeter measurements. A Minolta Chroma Meter CR-310 was used to obtain L^* , a^* , and b^* readings. Bloom time, from 0 to 93 min, had a greater effect on a^* and b^* readings than on L^* readings. The L^* values stabilized after approximately 30 min bloom time, and a^* and b^* values stabilized after 78 min bloom time, but relative differences among carcasses in L^* , a^* , and b^* values did not change after 3 to 12 min bloom time. Days postmortem, cut surface (anterior versus posterior), and within-muscle location (medial vs. lateral) did not affect L^* , a^* , and b^* readings ($p>0.05$). Blotting the surface moisture from the longissimus muscle resulted in lower a^* readings ($p<0.05$), but did not affect L^* and b^* readings ($p>0.05$). The L^* , a^* , and b^* values were correlated with lean maturity scores (-0.67, -0.30, and -0.40, respectively), dark cutter discount (-0.60, -0.76, and -0.73, respectively), muscle pH (-0.57, -0.79, and -0.78, respectively), and electrical impedance (-0.27, -0.21, and -0.25, respectively). Two muscle color classification systems, nine classes each, are proposed, one system based on L^* and one system based on b^* . The main advantage of the L^* categorization system over the b^* system was that the L^* value was less sensitive to bloom time, and the main advantage of the b^* categorization system over the L^* system is that the b^* system was slightly more precise at segregating carcasses based upon corresponding differences in muscle pH.

Murray (1989) stated that, the color of the *longissimus dorsi* (LD) muscles from 7695 beef carcasses were evaluated following carcass grading at a commercial abattoir in the Central Alberta Region. Darker-than-normal beef was found in 3.7% of steer and heifer carcasses. However, the incidence of true dark-cutting beef (i.e. dark in color and with a pH greater than 6.0) was estimated to be only 0.5%. The length of time between stunning and the measurement of color had a major impact on color. The incidence of dark-colored h post stunning, h than at 23–26 beef was three times higher at 15–18 apparently because of incomplete development of muscle color at the earlier times. Carcass fat cover, weight and conformation affected muscle color, with smaller and leaner carcasses yielding higher

frequency of dark-colored beef. Other factors influenced muscle color, including: (1) gender, (2) nutritional regime, (3) transit distance, (4) lairage time at the abattoir and (5) weather conditions. All of these could be explained by their effect on the time of color measurement or on carcass size and fatness.

2.12.2 pH

Sestari *et al.* (2012) conducted a study to evaluate carcass characteristics, non-carcass components and meat quality of Nellore cattle in feedlot and fed with different corn hybrids (flint, semi-flint and semi-dent) in the diet. Twenty-seven animals averaging 350 ± 24 kg of body weight and 24 months of age were used. The animals were distributed in a completely randomized design with three treatments (T), where, T1 – diet with flint corn (TDFC), T2 – diet with semi-flint corn (TDSFC) and T3 – diet with semi-dent corn (TDSDC), with 9 replicates per treatment. The animals were fed *ad libitum* twice daily (at 8:00 am and 4:00 pm) with isocaloric and isonitrogenous diet, with 30% of sugar cane bagasse and 70% concentrate (88% maize, 8% soybean meal, 3% mineral and vitamin supplement and 1% urea) for 95 days (14 days of adaptation and 3 experimental periods of 27 days each). For the parameters of meat quality, there was significant difference ($p < 0.05$) between treatments only in pH after 24 hours of slaughter. It was concluded that the use of different corn hybrids in the concentrated diet in feedlot cattle does not influence the carcass characteristics, non-carcass components and meat quality.

Marti *et al.* (2007) reported that, the castration and slaughter age could affect performance and meat quality independently from each other with the exception of subcutaneous, intermuscular and intramuscular fat percentages. 124 Holstein calves followed a 3×3 factorial design arrangement of treatments: castration age (intact bulls (INT), animals castrated at 8 month of age (CAS8) and animals castrated at 3 month of age (CAS3)); and animals slaughtered serially at different ages (10, 12 and 14 month of age). Muscle pH was measured in LM. They found castration improved meat pH.

Andrade *et al.* (2010) observed from 22 Nellore bovines and 22 Red Norte males at 24 months of age were collected at 24 hours post mortem, kept at 2° C and analyzed on days 1, 7, 14 and 21. They found values of final pH were similar among samples of Nellore and Red Norte animals.

Plessis and Hoffman (2007) observed in sweet veld areas, steers from small to medium framed breeds could be raised successfully and slaughtered at 30 months of age without supplementation of natural pastures. Slaughtering steers at younger ages might require supplementary feeding or feedlot finishing. An experiment on Simmental (SX), Bonsmara (BX) and Nguni (NG) crossbreds were raised on natural sweet veld pastures and slaughtered at 18 or 30 months of age. Slaughter occurred at the end of the wet summer season. The pH after 24 hours from slaughter of the longissimus muscle was 5.51 and 5.67 at 18 and 30 months of age, respectively.

Ke (2006) stated that, the pH of beef muscle affected water-holding capacity (WHC) and tenderness. When the pH was brought to 4.0 and below by immersion in citric acid or lactic acid or brought to ~7.0 after base immersion, WHC and tenderness of beef muscle increased. When the pH was brought back to the isoelectric point of the major myofibrillar proteins after either acid or alkaline treatment (e.g. from ~3.7 or 7.0 to ~5.5), most of the weight gained from prior acidic or basic treatment was lost. The Warner-Bratzler shear force values (WBSF) returned at least to the level of the WBSF of the controls after the readjustment of pH to 5.5. This reversibility strongly suggested that tenderization was not caused primarily by proteolysis. It was proposed that myofibrillar structures could swell and disrupt at acid/neutral pH due to electrostatic repulsion. When the pH was brought back near the isoelectric point, the myofibrillar structure might collapse and/or aggregate. Less water could be held with the aggregated proteins than in the initial myofibrillar structure of raw beef. Lactic acid and citric acid produced essentially the same shear force if WBSF values after marination were compared at a similar pH value. CaCl_2 showed a synergistic effect and negative effect, respectively, on the tenderization induced by citric acid and lactic acid. The solubility of beef myofibrillar proteins increased steeply from pH 4.27 to 4.03, where a significant decrease in WBSF was often observed. The solubility of beef muscle protein was below 20% between pH 6.9 and 7.6. The relation of protein solubilization to tenderization observed at acid pH was not seen in the tenderization induced by base treatment.

Renecker *et al.* (2005) reported that, twenty four reindeer (*Rangifer tarandus*) carcasses from male and female animals that ranged in age from calves to adults were purchased from Bering Sea Reindeer Products (BSRP), Nunivak Island, Alaska, USA. Pre-slaughter and

abattoir procedures were observed and evaluated. Carcasses were split in half, weighed and broke into wholesale primal cuts of chuck, rib loin and hindquarter. Each primal cut was weighed, boxed and frozen. Each half carcass of primal cuts was later dissected into lean tissue, bone and the three compartments of fat: subcutaneous, intramuscular and peritoneal. A portion of the loin was collected from each animal in order to obtain data on pH and shear force. Due to management and environmental effects, pH values were high and the meat was dark in color.

Page *et al.* (2001) conducted a study to define a beef carcass population in terms of muscle color, ultimate pH, and electrical impedance; to determine the relationships among color, pH, and impedance and with other carcasses characteristics; and to determine the effect of packing plant, breed type, and sex class on these variables. One thousand beef carcasses were selected at three packing plants to match the breed type, sex class, marbling score, dark-cutting discount, overall maturity, carcass weight, and yield grade distributions reported for the U.S. beef carcass population by the 1995 National Beef Quality Audit. Data collected on these carcasses included USDA quality and yield grade data and measurements of muscle color (L^* , a^* , b^*), muscle pH, and electrical impedance of the longissimus muscle. About one-half (53.1%) of the carcasses fell within a muscle pH range of 5.40 to 5.49, and 81.3% of the carcasses fell within a longissimus muscle pH range of 5.40 to 5.59. A longissimus muscle pH of 5.87 was the approximate cut-off between normal and dark-cutting carcasses. Color measurements (L^* , a^* , b^*) were correlated ($p < 0.05$) with lean maturity score (-0.58, -0.31, and -0.43, respectively) and with muscle pH (-0.40, -0.58, and -0.56, respectively). In addition, fat thickness was correlated with muscle pH and color ($p < 0.05$). There was a threshold at approximately 0.76 cm fat thickness, below which carcasses had higher muscle pH values and lower colorimeter readings. Steer carcasses ($L^* = 39.62$, $a^* = 25.20$, and $b^* = 11.03$) had slightly higher colorimeter readings ($p < 0.05$) than heifer carcasses ($L^* = 39.20$, $a^* = 24.78$, and $b^* = 10.80$) even though muscle pH was not different between steer and heifer carcasses. Dairy-type carcasses (pH = 5.59, $L^* = 37.56$, $a^* = 23.40$, and $b^* = 9.68$) had higher muscle pH values and lower colorimeter readings than either native-type (pH = 5.50, $L^* = 39.55$, $a^* = 25.13$, and $b^* = 11.00$) or Brahman-type (pH = 5.46, $L^* = 39.75$, $a^* = 25.17$, and $b^* = 11.05$) carcasses ($p < 0.05$).

Mcneil *et al.* (1991) stated that, the influence of chilling on the tenderness of meat was restricted to the effect of cold-shortening-induced toughness. After slaughter, the glycogen in the muscles broke down to form lactic acid in a process known as “glycolysis”. The muscles became acidic and the pH fell. In healthy, rested animals the glycogen broke down over a period of 48 hours, and the pH fell from 7.3 to about 5.4-5.6. When the glycogen was exhausted the muscle was in “rigor”. If muscle was cooled rapidly to below 10° C before it had set in rigor, “cold-shortening” toughness would occur due to muscle contraction. This underlines the benefit of electrical stimulation (ES) which uses up the glycogen so that the onset of rigor is accelerated and faster chilling can be carried out without causing cold-shortening.

Carse and Locker (1974) reported that, the surface pH values of lamb and beef carcasses stored at 5° C have been measured over a 5-day period. In both types of animal, muscle surfaces were at or near their minimum pH at 3 days, when the overall mean was pH 6.4. In the subsequent 2 days some sites showed no change in pH, while at others a small drop or a rise occurred. Rises in pH tended to be more common and greater on the beef. In lamb, intact muscle surfaces varied only from pH 6.3 to 6.6 at 3 days, while beef muscles varied widely, from pH 5.8 to 7.1. Muscle surfaces cut during dressing fell much more rapidly in pH, particularly in beef. Fatty sites fell from near pH 8.0 to near pH 7.0. The pH of beef surfaces chilled to -3° C fell more rapidly to lower final values than those at 5° C. At 5° C there was little multiplication of bacteria on fat surfaces, whereas on muscle they grew moderately, irrespective of pH.

2.12.3 Cooking loss

Alamin *et al.* (2015) conducted this study to evaluate the cooking loss of fresh and processed camel, beef and goat meat. The result showed that the cooking loss was with high significant different ($p < 0.01$) among the three types of meat. Cooking loss of fresh camel meat was the highest, followed by goat meat and beef as 36.3 of 34.15 & 31.75% respectively. The result showed that cooking loss was with high significant different ($p < 0.01$) among the three types of sausage. Camel sausage cooking loss was higher (24.12%) compared to beef and goat sausages as 21.45 and 22.0% respectively. The results showed that types of meat used for sausages making were not significantly different ($p > 0.05$) among the three types of sausages for cooking loss. The type of fillers used for sausages making affected significantly

($p < 0.01$) the cooking loss percent, sweet potato filler showed high percent of cooking loss compared to bread crumbs filler. Using sweet potato filler reduced the size of sausage fingers and diminished the weight.

Leygonie *et al.* (2012) observed loss of moisture due to cooking has been reported not to differ between fresh and frozen meat samples, as well as for samples frozen and thawed at different rates. This is believed to be due to the region in the muscle tissue from which cooking loss water originates. During cooking, the melting of the fat and the denaturation of the proteins reportedly causes the release of chemically bound water.

LinQiang *et al.* (2011) demonstrated that the excellent nutritional values of beef from cattle of different ages concordant with their chemical properties; on the other hand, their commercial value correlates more closely with their physical and sensory characteristics. They conducted an experiment on cattle of different ages were used to investigate the effect of age on beef quality. They found the value of cooking loss markedly decreased ($p < 0.05$).

Schonfeldt and Strydom (2011) reported that the cuts cooked according to a dry heat cooking method were reported juicier (both initial and sustained) than those cooked by moist heat methods. They investigated the juiciness and flavor characteristics of 15 aged primal beef cuts of electrically stimulated carcasses, from three different age groups, were assessed ($n=61$). Cooking losses were determined and proximate analyses (moisture, fat, nitrogen and ash) were performed. Initial impression of juiciness decreased with increased age of the animal and cooking losses increased nonlinearly with age, irrespective of the muscle.

Andrade *et al.* (2010) observed from 22 Nellore bovines and 22 Red Norte males 24 months of age were collected at 24 hours post mortem, kept at 2 °C and analyzed on days 1, 7, 14 and 21. They found values of cooking loss were similar among samples of Nellore and Red Norte animals.

WonMo *et al.* (2009) showed that the beef juiciness was reduced with the advancing shipping time of steers. They conducted this study and examined the influence of forage source (grass hay and rice straw) and shipping time (24, 26, 28 and 30 months) on feed conversion ratio, growth performance and carcass characteristics of Hanwoo steers. Sixty four Hanwoo steers at 6 months age were fed either grass hay ($n=32$) or rice straw ($n=32$) for

24, 26, 28 and 30 months of age. Steers fed on mixed grass hay gained significantly higher body weight at 24, 26, 28 and 30 months compared with those fed on rice straw. Shear force, cooking loss and water holding capacity of beef were reduced with advancing age of steers ($p < 0.05$).

Jama et al. (2008) investigated the effects of breed and ageing on beef cooking loss components. Correlations among the beef cooking loss components were also determined. *Longissimus thoracis et lumborum* (LTL) muscle steaks from Nguni, Bonsmara and Angus steers were prepared by an electric oven-broiling method using direct radiant heat at 260° C. They were placed in an oven pan on a rack to allow meat juices to drain during cooking and placed in the pre-heated oven 90 mm below the heat source. Raw and cooked weights were recorded. Percentage cooking loss, thawing loss, drip loss and evaporation loss were determined. Beef cooking loss components were affected ($p < 0.05$) by ageing with meat aged for two days having higher ($p < 0.05$) losses than meat aged for 21 days. Cooking loss components were not ($p > 0.05$) affected by breed. There were no ($p > 0.05$) significant correlations among the cooking loss components.

Brown et al. (2007) stated that, steers ($n=335$) of known genetic background from four fundamentally different growth types were subjected to two production systems to study differences in cooking loss (CL), tenderness and chemical composition. Growth types were animals with genetic potential for large mature weight-late maturing (LL), intermediate mature weight-early maturing (IE), and small mature weight-early maturing (SE). Each year, in a nine-year study, calves of each growth type were weaned and five steers of each growth type were developed on pasture or feedlot and harvested at approximately 20 and 14 months of age, respectively. Data collected were CL and Warner-Bratzler shear force (WBS) for the *Longissimus dorsi* (LM), *Psoas major* (PS) and *Quadriceps femories* (QF) muscles. The beef growth type $\times$ production system interaction was significant for CL and WBS of the LM and ash in the lean trim of the forequarter. Growth types of LL and IL had greater ($p < 0.05$) mean percentage CL in the PS and QF muscles than did IE and SE steers.

Locker and Daines (2006) stated that, techniques developed earlier to measure cooking loss in beef *sternomandibularis* and *rectus abdominis* muscles under defined conditions, have here been extended to other factors affecting cooking loss. Cold shortening of the muscle has no effect. Searing of the ends before cooking caused a slight increase in loss. In samples cooked

for varying times at 80 °C, cooking loss rises gradually up to 2 h, while cooking shortening and shear force reach a maximum much more quickly. Color changes are described in meat cooked for various times, then cut and exposed to air. Slow cooking gives higher cooking losses than fast, but a lower shear force. Histological studies have shown that in frozen sections maintained in aqueous media the annular shrinkage space is small and does not vary significantly between cooking treatments. The dehydration involved in paraffin sections exaggerates the shrinkage, although these sections show best the fused and apparently intact sarcolemmas. The electron microscope, however, reveals that there are many punctures in the membranes.

Scheeder *et al.* (2001) studied the effect of fatty acid composition on the properties of patties standardized to contain 15% fat. Patties were made of beef from 36 Brown Swiss bulls fed on six different diets with five of them containing additional fats to achieve a high variability in body lipid composition. When the feed contained full fat oilseeds (rapeseed, sunflower seed, linseed), the proportions of some nutritionally favorable fatty acids were increased in the patties. Patties made from the meat of bulls fed linseed and coconut oil could be distinguished in a sensory triangle test from most other groups. Cooking loss and instrumental texture properties showed no relation to fatty acid composition of patties.

2.12.4 Drip loss

Wyrwisz *et al.* (2012) analyzed the correlation between basic meat composition (water, protein, fat, and connective tissue contents), pH value, and physical parameters (texture and color, drip loss) of selected beef muscles. Five different muscles (LTH, SEM, SET, PSM, TRI) from 20 carcasses were examined. Measurements of the basic meat composition were conducted using a near infrared spectrometry method, color parameters in L*a*b system, and texture parameters. Drip loss correlated strongly negatively with the pH value. Depending on the muscle type, the correlation ranged $-0.601 \leq r \leq -0.282$, whereas drip loss correlated moderately positively with connective tissue content. The most significant positive correlation ($r \approx 0.67$) between hardness, tenderness, and fat content was noted in the SEM.

Plessis and Hoffman (2007) observed in sweet veld areas, steer from small to medium framed breeds could be raised successfully and slaughtered at 30 months of age without supplementation of natural pastures. Slaughtering steers at younger ages might require supplementary feeding or feedlot finishing. They conducted an experiment on Simmental (SX), Bonsmara (BX) and Nguni (NG) crossbreds were raised on natural sweet veld pastures and slaughtered at 18 or 30 months of age. Slaughter occurred at the end of the wet summer season. They found the values of drip losses were similar for the breeds and slaughter age groups.

Bhattacharya and Hanna (1989) packaged quarter-pound, ground beef patties in polyethylene bags. Packaged samples were stored at -12 , -23 and -34°C for 20 weeks. At 4 week intervals, samples were thawed and their drip loss, cooking loss and objective color were measured. The rate of change of these quality attributes, as a function of storage time, indicated that they were first order processes. The rate constants were affected by package type and fat content. The effect of storage temperature on rate constants was slight.

Anon and Calvelo (1980) stated that, one of the quality parameters of frozen meat is the amount of exudate which arises during thawing. The amount of drip obtained by centrifugation under standard conditions, and the protein composition of the exudate, has been correlated for different thermal histories. The results obtained show that the amount of exudate varies in relation to the time that the sample needs to pass from -1°C to -7°C (characteristic freezing time).

2.12.5 Marbling

Blomander (2015) stated that, marbling in beef meat might improve carcass characteristics such as tenderness and palatability. Because of this, it is of interest to find out how marbling is affected when different feeding strategies are applied. In this review the effects of feeds rich in fat, rumen protected feeds, distiller grains, finishing on pasture, restriction of vitamin A and on marbling was discussed. The effects of the feeding strategies on fatty acid composition were also considered. Most of the strategies had mixed results. All of the studies on vitamin A restriction had positive effect on marbling. Different breeds have different ability for marbling and the genetic material used in various studies probably affected the outcome. More research is required to make it possible to determine which

feeding strategy that suites which breed. More research is also required to find the right balance between intramuscular and intermuscular fat to increase slaughter yield.

Roy *et al.* (2013) investigated the effects of age and breed on growth, feed intake, carcass characteristics and meat quality attributes of longissimus muscle in Pabna cattle (n=12), Red Chittagong cattle (n=15) and Brahman crossbred bulls (n=15) reared on a single plane of nutrition for 125 days. The age groups of bulls were 18 months, 24 months and 30 months. Three bulls from each age group of 3 genotypes except, Brahman crossbred where 7 bulls under 24 months age group were randomly selected for slaughtering. This study revealed age of animals significantly influenced marbling score ($p<0.05$) and color of beef meat ($p<0.05$). As the age of animals increased marbling score and color of meat increased linearly ($p<0.05$), values higher at 30 months of age, indicating meat with more intramuscular fat along with a darker and more red color. However, no difference was observed ($p>0.05$) in color or marbling of the longissimus muscle of animals from the 3 genetic groups. Although, the differences were non-significant, but color of meat from native (Pabna and RCC) beef had relatively darker than that of Brahman crossbred beef, and RCC bulls had the lowest marbling score (2.78) than Pabna (3.56) and Brahman crossbred (3.56) beef. In general, breed effects had little influence on coloration and marbling of beef.

Tschida (2013) reported that, twenty purebred Jersey steers were used to evaluate lifetime growth and carcass development while finished on different caloric-density diets. Daily rations were distributed by pen during the growing phase and individually during the finishing phase. Finishing diets were formulated for either 70% concentrate (F70) or 85% concentrate (F85) to determine the influence of caloric density on body composition. Although all steers reached choice grade, F85 steers tended ($p<0.10$) to have greater marbling over F70 steers (640 versus 590, respectively). The result showed that Jersey steers had the ability to produce highly marbled carcasses with potential health benefits and acceptable meat attributes; however, the carcass quality must be valued against low growth efficiency.

Savell *et al.* (2007) observed that beef quality encompasses many different sensory properties, but is primarily defined by tenderness, juiciness and flavor. Marbling and maturity are the two primary factors involved in grading beef carcasses. Consumer acceptance of beef is dependent on quality graze, geographic location of the consumer, retail

cut selected, cooking style used, and other parameters. Much effort has been and will continue to be dedicated to improving quality in the beef industry in the future.

Ritchie (2005) stated that marbling as a moderately to highly heritable trait (about 0.40) which means that significant progress can be made by selecting for it within a breed. Most breeds provided Expected Progeny Differences (EPDs) for marbling in their genetic evaluation programs. By selecting sires having marbling EPDs that are well above breed average, a reasonable increase in a herd's marbling potential can be made in a couple of generations of selection. British breeds have a greater ability to marble than Continental and Brahman-influenced breeds. Among British breeds, Angus, Red Angus, and Shorthorn have a greater propensity to marble than most other breeds that originated in the British Isles. The only breed excelling these breeds in marbling is the Japanese Wagyu, which fits a limited but important niche market in the U.S. The scientific literature indicated that in general there are no major antagonisms between marbling and growth traits. In fact, some studies have shown a positive correlation between marbling and growth. On the carcass side, increased marbling tends to be correlated with increased subcutaneous (external) fat and a higher numeric yield grade, which would be considered an antagonism. On the other hand, it also suggests that marbling may be related to "easier-keeping" cows which would be especially advantageous in those environments where feed resources are limited.

Wheeler et al. (1996) compared carcass and *longissimus thoracis* palatability traits from 888 steers obtained from mating Hereford and Angus cows to Hereford or Angus (HA), Charolais (Ch), Gelbvieh (Gb), Pinzgauer (Pz), Shorthorn (Sh), Galloway (Gw), Longhorn (Lh), Nellore (Ne), Piedmontese (Pm), and Salers (Sa) sires. Data were adjusted to constant age (426 d), carcass weight (324 kg), fat thickness (1.2 cm), fat trim percentage (23%), and marbling end points. Marbling scores were highest ($p < 0.05$) for carcasses from HA, Pz, and Sh and lowest ($p < 0.05$) for carcasses from Ch, Ne, and Pm steers.

2.13 Proximate composition of meat

Dzhulamanov et al. (2015) analyzed the chemical composition of average meat samples and *M. longissimus dorsi*. In this study of qualitative structure of slaughter products the general regularity was revealed- increase of dry matter and fat contents and decrease in moisture with age. The process of fat deposition in the pulp of carcasses of compact body type

genotypes was more intensive. That led to maximum size (38.04%) of dry matter contents. Intensive accumulation of adipose tissue in compact body conformation group of bull calves had already begun with one year old age and 15 month age the protein and fat ratio reached 1:0.65. At the age of 21 months tall animals were the best protein and fat ratio: they had ratio 1:0.83 instead 1:1.28 and 1:0.99 at compact and the medium contemporaries. Compact bull calves had the highest of a forage's protein and energy expenses into own body nutrients, the smallest had tall contemporaries.

Jahan *et al.* (2015) conducted an experiment to assess whether elapsed time between slaughter and preservation and storage conditions influence the chemical and microbial changes of locally marketed beef. Meat samples were collected from local markets and divided into two groups, morning and evening beef. Morning beef was collected immediately after slaughtering from healthy cattle while evening one was collected 8 h after slaughtering. The samples were kept either in refrigerator (4° C) or freezer (-20° C). Refrigerated samples were stored for 7 days and analyzed on day 1st, 3rd and 7th while frozen samples were stored for 90 days and analyzed on day 3rd, 45th and 90th. Results showed that there was a significant difference in chemical and microbial parameters between morning and evening beef ($p < 0.01$ to 0.05). With respect to the advances of storage time, the dry matter, crude protein, ether extract and ash contents were increased in beef sample ($p < 0.01$), indicating the moisture loss from meat time elapsed after slaughtering.

Dzomba *et al.* (2014) assessed the quality, shelf-life and sensory properties of beef meat treated with *Cleome gynandra* and *Vigna unguiculata* extracts. Protein, fat content, ash (minerals), and pH were analyzed to determine the quality of the meat. Protein content was assayed using the Kjeldahl method while fat content was determined using ether-extraction on a Soxhlet apparatus. Ash analysis on defatted samples were performed by subjecting them to a temperature of 600° C in a muffle furnace for two hours and weight of the ash was used to estimate the mineral content. Shelf life analysis was measured using peroxide value and UV absorbance test. Fat composition ranged from 10.76 to 10.78% while pH values ranged from 5.8 to 6.0. There were no significant differences between the values, $p = 0.05$ showing that the treatment did not change meat pH and fat content. The additives maintained protein and mineral content of the meat samples. Protein content ranged from 49.47 to 52.01% while total mineral content ranged from 7.01 to 8.33%.

Omojola *et al.* (2014) reported that, a completely randomized design was employed to study the effect of three meat types of beef, chevon and pork on quality attributes of Danbunama (DB- a shredded meat product that is light, easy to pack and nutrient retaining and is traditionally produced from beef). Proximate composition of the raw meats and their respective DB was determined using standard procedures. Raw meat protein ranged from 21.2 to 22.9% while the moisture content varied from 64.14 to 71.98%. The product yields were 70.1, 74.1 and 68.9% for Beef Danbunama (BDB), Chevon Danbunama (CDB) and Pork Danbunama (PDB) respectively. Chevon Danbunama has the highest protein (46.73%) followed by PDB (41.78%) while BDB has the least value (39.75%).

Eke *et al.* (2013) evaluated the bioavailability of the Beef Based Dambu-Nama (BBDN) were evaluated by the analysis of the amino acids, minerals, vitamins and proximate composition using four processing treatments. Samples of Beef Based Dambu-nama (BBDN) were processed using (4) separate treatments and analyzed for their sensory and chemical characteristics. The chemical properties evaluated includes; chemical, amino-acid composition and the mineral contents. The treatments were 425 (cooked for 90 min and not fried), 509 (cooked for 60 min and fried for 10 min) and 511 (cooked for 60 min and not fried). Result of the proximate composition showed that the crude protein was high (37.14-45.86%), low fat content (11.2-17.84%) and high ash content (4.87-5.18%), which indicated that BBDN (beef based Dambu-nama) have a high nutrient content. Similarly, the low moisture content (5.10-7.00%) guarantees longer shelf life because of the low water activity which inhibits microbial growth. The amino acid composition also showed that BBDN have excellent values for both essential and non-essential amino acid which are important components for healing and protein synthesis processes.

Roy *et al.* (2013) studied the growth and meat quality of native and Brahman crossbred bulls at different ages. The study revealed that, the moisture in meat was not influenced ($p>0.05$) by different age and genetic group. Though, breed difference was not significant but Brahman meat had marginally higher ($p>0.05$) moisture content than meat in native animals. The variation of age was significantly ($p<0.01$) affected on protein content in meat, and in generally, it increased significantly with advancement of age in all three genetic groups. Though breed types had no effects on protein content in meat but Pabna meat exhibited relatively higher protein content (20.03 g/100 g) than RCC (19.98 g/100 g) and

Brahman crossbred beef (19.81 g/100 g). Fat (intra-muscular fat) contents in meat varied significantly ($p < 0.01$) due to the variations of both age and genetic groups. Older animals had significantly ($p < 0.01$) higher intra-muscular fat content than younger animals. Irrespective of breed types, RCC beef meat showed significantly ($p < 0.01$) lower IM fat (1.90 g/100 g) than other two genetic groups, and Pabna beef meat had the highest levels of IM fat (4.65 g/100 g) followed by Brahman crossbred beef meat (3.04 g/100 g). In general, the ash contents in meat increased significantly ($p < 0.01$) with advancement of age. Breed types did not influence on ash contents in meat. No differences were detected between breed $\times$ age interactions for the aforesaid physical and chemical properties of the experimental bulls.

Klumchanuan and Sruamsiri (2012) conducted an experiment to study the effect of sex and slaughter age on carcass composition of Thai swamp buffalo using 2×3 factorial arrangement in Completely Randomized Design, factor 1 = sex (male and female), factor 2 = age 3 (<3 years, 4-5 years, and >5 years). There were six treatment combinations each with 10 replications. The results showed that the meat from female buffalo had higher moisture percentage, fat percentage and collagen content than those from male buffalo ($p < 0.05$).*

Adeniyi *et al.* (2011) investigated the proximate composition, market prices and production cost per unit kilogram of four common meat types in the south-western area of Nigeria. The meat types were beef, broiler, African catfish and Tilapia and the parameters were crude protein (%), ether extract (%), ash (%), crude fiber (%) and nitrogen-free extract (%) and average market prices of the meat types. One hundred grams of each of the meat sample were obtained from freshly slaughtered cow, broiler chicken and fishes. Each sample was subdivided into four replicates which were later subjected to proximate analyses in a completely randomized design (CRD) while current market prices of each of the meat samples were investigated. Beef had the highest crude protein and fat content, while broiler meat and African catfish had higher mineral content than others. However, none of the samples had crude fiber.

LinQiang *et al.* (2011) demonstrated that the excellent nutritional values of beef from cattle of different ages concordant with their chemical properties; on the other hand, their commercial value correlates more closely with their physical and sensory characteristics. They conducted an experiment on cattle of different ages were used to investigate the effect

of age on beef quality. No significant differences were found in the contents of intramuscular fat, ash, amino acids (AA) and mineral elements.

Smith *et al.* (2011) evaluated the influence of various degrees of doneness on proximate composition and energy content of beef. Ten steaks were obtained from each of five USDA Prime, five USDA Choice, and five USDA Select strip loins and assigned to one of five degree of doneness treatments (two sets of treatments per strip loin): raw, medium rare (63 °C), medium (71 °C), well done (77 °C), and very well done (82 °C). After cooking, steaks were dissected into separable tissue components consisting of lean, fat, and refuse. Lean tissue was used to obtain proximate analyses of protein, moisture, fat, and ash. Degree of doneness did influence ($P < 0.05$) the nutrient composition of beef steaks. As the degree of doneness increased, percent fat and protein increased, while percent moisture decreased. Cooking steaks to a higher degree of doneness resulted in a higher caloric value when reported per 100 g basis.

Andrade *et al.* (2010) observed from 22 Nellore bovines and 22 Red Norte males at 24 months of age were collected at 24 hours post mortem, kept at 2 degrees C and analyzed on days 1, 7, 14 and 21. The animals were finished in confinement (112 days) with corn silage (50%) and concentrate (50%) *ad libitum*. Values of final pH, cooking loss, moisture, protein, fat and ash were similar among samples of Nellore and Red Norte animals.

Ito *et al.* (2010) carried out a study to evaluate carcass characteristics, chemical and fatty acid composition of the longissimus muscle of 78 Puruna bulls (39 bulls/treatment) slaughtered at 18 or 24 months old. The experimental design was completely randomized. The bulls were distributed into two systems: (1) Finished in feedlot 13 to 18 months old (T18), or (2) Finished in feedlot from 21 to 24 months old (T24). They found the content of moisture (73.27%), ash (1.05%), crude protein percentages (22.56%) and total cholesterol content (36.47 mg/100 g of muscle) were similar ($p < 0.05$) between both slaughter ages.

HyeongCheol *et al.* (2010) carried out an experiment to investigate the growth performance and meat quality improvement according to castration, optimal feeding management and ruminally protected amino acid-enriched fatty acid (RPAAFA) for the unselected Hanwoo bulls in the performance test. Bulls were castrated at approximately 14 months of age. Sixteen Hanwoo steers, 15 months of age and weighing 412.9 ± 24.9 kg, were

distributed into 2 groups. Steers were fed a basal diet supplemented with RPAAFA at 0 gm (control) or 100 gm (treatment), respectively for 12 months. Steers were slaughtered at 27 months of age. The content of moisture, fat, protein and ash in longissimus muscles were similar between control and treatment.

Sargentini et al. (2010) conducted an experiment on fourteen Maremmana young bulls fed on pastures supplemented with mixed hay and concentrates, according to an organic method, were slaughtered at 18 and 24 months of age to evaluate in vita and post-mortem performances. At slaughter, carcass yield was determined and carcass evaluation according to EU rules was made. Physico-chemical characteristics of *Longissimus thoracis* (LT) and *Caput longum triceps brachii* (TB) muscles were determined. TB muscle showed lower protein content and higher shear force, moisture, total lipids and ash than LT.

Schonfeldt and Strydom (2010) were investigated the physical composition and nutrient content of different age group carcasses and cuts of South African beef from equal fat classes. Carcasses from three different age groups and various fatness levels within each were obtained on the commercial market. The physical composition of the carcass and cuts had the greatest effect on the difference between age groups, with meat and bone increasing with an increase in age. Protein increased (including eleven of the amino acids measured) and moisture content decreased with age in the cooked cuts. When physical composition was excluded, lysine and iron were higher and linolenic acid lower in older compared to younger animals, thus meat from older animals which is mostly consumed by people with serve iron-deficiency anaemia in the rural parts of South Africa, is adequate to meet this need. Lysine as one of the nine essential amino acids for adults was higher in the C-age meat, contrary to belief that it is of inferior quality and can be recommended as part of a balanced diet. Palmitic acid (16:0) increased with age while Linoleic acid (18:2) decreased with age. Significant differences in fat content (subcutaneous and proximate), meat, moisture, various fatty acids (palmitic, stearic and oleic acids) and calcium were found between the different cuts.

Ivanor et al. (2008) carried out an experiment to evaluate the carcass characteristics, chemical composition and fatty acid profile of the Longissimus muscle (LM) of three cattle genetic groups (Purunã, PUR, 11; 1/2 Purunã vs. 1/2 British, PUB, 6 and 1/2 Charolais vs. 1/2 Caracu, CHC, 10) finished in pasture systems. The field work took place at the Lapa

Research Farm of the Agronomic Institute of Paraná, in the city of Lapa, south Brazil. The animals were fed during the winter with corn silage, cottonseed meal, cracked corn, urea, limestone and mineral salts as sources of protein, as well as an energy supplement, in pasture systems of *Brachiaria decumbens* Stapf. The animal groups were slaughtered at 20 months of age, at 501<0.05) final weight than PUR and PUB bulls. There was no observed difference ($p>0.10$) in moisture, ash, crude protein and total cholesterol contents among the three genetic groups.

Serra *et al.* (2008) reported that sensory characteristics of *longissimus thoracis* muscle from three local Spanish beef breed-production systems and their relationships with chemical and instrumental meat quality traits were studied. Young bulls of Bruna dels Pirineus (BP; $n = 69$), Avilena-Negra Iberica (A-NI; $n = 70$) and Morucha (MO; $n = 70$) breeds were reared in their own production systems. No differences in moisture and protein contents were found among breeds. A-NI showed the highest intramuscular fat (IMF, $p<0.05$) and total collagen ($p<0.001$) contents, whereas BP showed the lowest IMF content ($p<0.05$) and the highest collagen solubility ($p<0.001$).

Brown *et al.* (2007) reported that, steers ($n = 335$) of known genetic background from four fundamentally different growth types were subjected to two production systems to study differences in cooking loss (CL), tenderness and chemical composition. Growth types were animals with genetic potential for large mature weight-late maturing (LL), intermediate mature weight-early maturing (IE), and small mature weight-early maturing (SE). Each year, in a nine-year study, calves of each growth type were weaned and five steers of each growth type were developed on pasture or feedlot and harvested at approximately 20 and 14 mo of age, respectively. Data collected were CL and Warner-Bratzler shear force (WBS) for the *Longissimus dorsi* (LM), *Psoas major* (PS) and *Quadriceps femories* (QF) muscles. Chemical composition was also determined from the right fore-and hindquarter. Data were analyzed using least squares analysis of variance for unequal subclass numbers. The beef growth type $\times$ production system interaction was significant for CL and WBS of the LM and ash in the lean trim of the forequarter. Growth types of LL and IL had greater ($p<0.05$) mean percentage CL in the PS and QF muscles than did IE and SE steers. Growth type LL had the highest ($p<0.05$) mean for both moisture and protein in the fore- and hindquarters; while SE

had the lowest numerical mean value for moisture and protein in the fore- and hindquarters.

Jahan *et al.* (2005) analyzed six different cuts of beef meat like chuck, loin, rib, round and rump to determine their macro and micro nutrient contents, characteristics of meat fat and utilization of each cut for product preparation. Protein contents in different cuts were found within 16-20%, fat 2.8-4.5%, moisture 75-77% and ash remained within $\pm 1.00\%$. Among the cuts of beef analyzed rib portion contains the highest protein while the rump contains the highest fat. This study showed that, beef cuts, despite of saturated fat contents are nutritionally well balanced.

Torre *et al.* (2005) stated that, this study aimed to characterize sensory aspects like appearance and odor, and to estimate the proximate composition values, pH, collagen rate (COL), percentage amount of collagen per total protein (rel COL) from 20 raw beef minced meat samples received for routine laboratorial analysis. The data observed from 20 samples were compared to the physical-chemical results from minced meat prepared from nine distinct beef hind-quarters meat cuttings bought at butcher shop. Beef minced meat samples analyzed for routine laboratorial procedures revealed a wide range of moisture content (61.0%-81.8%), fat (1.2%-21.9%), protein (8.1%- 21.1%), ash (0.5%-1.1%), COL (1.0%-4.9%), rel COL (5%-31%), and pH (5.34-6.55). On the other hand, minced meat samples prepared from meat bought at butcher shop showed smaller ranges of moisture content (64.1%-74.5%), fat (2.8%-16.3%), protein (19.3%-21.8%), ash (0.8%-1.1%), COL (1.0%-3.7%), rel. COL (5%-17%), and pH (5.52-5.80). Beef minced meat samples assayed for routine laboratorial analysis in general revealed acceptable odor and color, although 14 samples (70%) showed sensory appearance alteration due to variable amounts of connective tissue or aponeurosis, present in the meats.

Wu and Shiau (2002) reported that, ten commercial meat essences of chicken, beef, clam and eel contained the moisture ranged from 91.1 to 97.5%, protein from 0.6 to 7.8%, and ash from 0.3 to 1.7%. Freshwater clam and hard clam essences had a much higher level of glycogen than other products. The total amount of free amino acids (FAA) in six chicken essences varied from 150 to 725 mg/100 g. Taurine was the dominant FAA and accounted for 16~30% of the total FAA. Though beef essence had the highest level of total FAA among ten products, its taurine was accounted for only about 2%. Taurine in freshwater clam

essence was also very low, but a high level of ornithine was found. Anserine in six chicken essences, ranging from 36 to 437 mg/100 g, was higher than carnosine, ranging from 8 to 162 mg/100 g. In beef essence, however, anserine was far less than carnosine. These dipeptides in both clam essences were not detectable, and only a small amount of carnosine was present in eel essence. Another dipeptide, balenine, was found only in a chicken essence. The amount of low-molecular-weight peptides in chicken essences, ranged from 1,187 to 3,296 mg/100 g, was more than the level of FAA in each product. Both clam essences contained a much lower amount of small peptides than other products. Consequently, hard clam essence was the only product with lower level of peptides than its FAA.

Jennifer *et al.* (2000) determined the proximate composition of the separable lean of beef retail cuts as influenced by USDA quality grade and external fat trim level. Carcasses (n = 20) were selected from two commercial packing plants, one in the Texas Panhandle and the other in Nebraska, by trained personnel. Ten USDA Choice and 10 USDA Select, yield grade 2 and 3 carcasses were selected to reflect the approximate distribution found in the U.S. beef supply. Thirteen cuts (in sets of four) were fabricated and assigned to one of four treatments: (1) 0.3 cm external fat trim, raw; (2) 0.0 cm external fat trim, cooked; (3) 0.3 cm external fat trim, cooked; and (4) 0.6 cm external fat trim, cooked. Retail cuts assigned to the cooked treatment were braised, broiled or roasted. Proximate analysis on the separable lean was done to determine fat, moisture, protein, and ash content. Trimming cuts of external fat before cooking had few ($p < 0.05$) effects on chemical fat, moisture, protein or ash content within a cut. However, separable lean from the Choice quality grade retail cuts had higher ($p < 0.05$) chemical fat contents than select cuts.

Mills *et al.* (1992) determined meat composition and palatability changes resulting from feeding Holstein (HOL) and crossbred beef (XB) steers diets containing corn silage (CS) or alfalfa haylage (AH) (forage type) and soybean meal (SM) or fish meal (FM) (protein source). Fifty-nine steers (30 HOL and 29 XB) were randomly assigned to diet combinations for a $2 \times 2 \times 2$ (breed $\times$ forage $\times$ protein) factorial arrangement. Steers were fed to a fat-constant end point (fat depth over the longissimus muscle measured by ultrasound: 1.0 cm XB, 0.6 cm HOL). Proximate and fatty acid analysis and sensory evaluation were conducted on a rib eye roast and steaks, respectively, removed from the left side of each carcass at ribs

9 to 12. Proximate analysis of the longissimus muscle showed no significant difference (p greater than 0.05) in moisture, protein, or fat content due to breed, forage, or protein treatment.

2.14 Sensory properties of meat

Kerth *et al.* (2015) reported that, brisket, chuck, plate, flank, and round subcutaneous fat trim were used to produce ground beef patties then evaluated for color, lipid oxidation, fatty acid composition, volatile chemical compounds and consumer sensory evaluation. Color, TBARS, consumer sensory evaluation, and cook/freezer loss did not differ ($p > 0.05$) among carcass fat locations. Percentage stearic acid was lower ($p = 0.044$) in the ground beef using brisket fat than using the chuck and flank fat. Patties made with brisket fat were higher in cis-vaccenic acid ($p = 0.016$) and the saturated to monounsaturated fatty acid ratio ($p = 0.018$) than all other sources of subcutaneous fat. Butanedione was highest ($p = 0.013$) in patties using flank and plate fat. Ground beef with brisket fat was higher ($p = 0.003$) than all other sources for beefy aroma. Altering the profile of non-polar, triglyceride fatty acids had no effect on sensory flavor or major volatile chemical compounds.

Dzomba *et al.* (2014) assessed the quality, shelf-life and sensory properties of beef meat treated with *Cleome gynandra* and *Vigna unguiculata* extracts. Semi trained and untrained panelist were used to assess sensory qualities; color, smell and general acceptability. Shelf life and sensory evaluation results revealed that treating beef meat with *Cleome gynandra* and *Vigna unguiculata* leaf extracts reduces peroxides formation, proliferation of microbes; delays color loss and formation of unpleasant smells. *Cleome gynandra* offered best results for this purpose.

Adhikari and Brooks (2013) stated that USDA quality grade impacted consumer and trained descriptive palatability ratings. Increases in quality grade yield greater consumer ratings for tenderness, juiciness, flavor, and overall liking. Flavor descriptor ratings, for positive flavor attributes (beef identity, initial flavor impact and fat-like), increased with quality grade, while negative flavor descriptors were inversely correlated with quality grade. Standard steaks were characterized by attributes such as liver-like and serummy. The descriptive sensory work presented was correlated with consumer and instrumental measures carried out and it was found that flavor was highly correlated with overall liking.

Relationships between flavor descriptors and consumer ratings revealed consumers were adequately evaluating juiciness independent of flavor and tenderness. Flavor ratings by consumers seemed to be impacted by off-flavors and brown/roasted flavors independent of tenderness.

Bures and Barton (2012) investigated the effects of sex and slaughter age on growth, feed intake, carcass composition and meat quality attributes of *musculus longissimus lumborum* in Charolais × Simmental bulls (n=12) and heifers (n=12) reared and finished under identical management conditions. The animals entered the experiment at similar age (251 days) and were slaughtered at 14 or 18 months of age. The meat from heifers was assessed by the sensory panel as more tender and, when aged for 11 days, more acceptable than the meat from bulls. Older animals obtained higher scores for beef flavor intensity ($p<0.01$), tenderness ($p<0.001$), juiciness ($p<0.05$), and overall acceptance ($p<0.001$).

Dashdorj et al. (2012) evaluated carcass characteristics and meat quality traits as a function of endpoint months of slaughter age (26 vs 32 mon) and chiller ageing (1 vs 10 d) for *m. longissimus* of 26 Hanwoo steers fed with commercial diets including whole crop barley silage. Totally twenty six Hanwoo steers for 6 mon of age that were fed until 26 mon of age constituted the short term-fed group and fed until 32 mon of age constituted long-term fed group. Carcasses were chilled for 24 h and were graded. Strip loin samples were divided into two age groups (1 d and 10 d). The feeding for 32 mon produced tender, juicy meat ($p<0.01$) with lower cooking loss and higher rating score ($p<0.05$) than short term feeding, while other quality traits were not influenced by the length of feeding. Chiller aging reduced instrumental tenderness (WBSF value), improved color, sensory tenderness, acceptability and rating of beef. The results of this study mirrored that Hanwoo steers until 32 mon of age overall improved carcass traits and palatability compared to that for 26 months.

Njisan et al. (2012) evaluated the effect of consumer background on the sensory evaluation of micro-waved Angus loins. The steaks were prepared using a microwave. Only salt was added to taste. Sensory evaluation was done by an untrained panel of 70 participants of different ages, tribes and gender. Pearson's correlation coefficients between sensory characteristics were determined. Age of consumer had no effect on all the sensory characteristics. Gender had an influence ($p<0.05$) on sustained impression of juiciness. Tribe

had an influence ($p < 0.05$) on the amount of connective tissue. Significant correlations ($p < 0.05$) occurred between initial impression of juiciness and first bite, as well as with sustained impression of juiciness ($p < 0.001$), muscle fiber and overall tenderness ($p < 0.001$). First bite correlated positively ($p < 0.001$), with sustained impression of juiciness, as well as with muscle fiber and overall intensity. Micro waved meat has reduced juiciness as well as fat content, thus production of tougher than tender meat. Male consumers preferred the micro waved loins compared to female consumers. Consumer background therefore had an effect on sensory scores of micro waved Angus loins.

Roy *et al.* (2013) investigated the effects of age and breed on growth, feed intake, carcass characteristics and meat quality attributes of longissimus muscle in Pabna cattle ($n=12$), Red Chittagong cattle ($n=15$) and Brahman crossbred bulls ($n=15$) reared on a single plane of nutrition for 125 days. The age groups of bulls were 18 months, 24 months and 30 months. Three bulls from each age group of 3 genotypes except, Brahman crossbred where 7 bulls under 24 months age group were randomly selected for slaughtering. This study revealed that, meat tenderness, beef flavor intensity and overall acceptability score were significantly ($p < 0.05$) influenced by the breed types, and Pabna beef had significantly higher meat tenderness ($p < 0.05$), flavor intensity ($p < 0.05$) and overall acceptability score ($p < 0.05$) than Brahman and RCC with any significant ($p > 0.05$) age impact. Although, meat tenderness were not shown to be affected by the age of animals but the older animals obtained lower scores (less tender) for meat tenderness than younger animals. RCC and Brahman crossbred had almost similar tenderness on acceptance to consumers. However, the sensory panel did not found any significant ($p > 0.05$) effects on age, breed types and age $\times$ breed interactions on meat chewiness, juiciness, fineness, color scores of cooked meat and mouth coating.

San-Julian *et al.* (2012) characterized and compared the organoleptic quality of beef from Uruguay and from three European countries. In Uruguay, 40 Hereford steers were raised exclusively under grazing conditions up to either two or three years old. Meat samples were aged for 20 days, matching commercial conditions. In Europe, one commercial local beef type, with two ageing times (7-20 days), from Germany, Spain and the United Kingdom were compared with Uruguayan beef sample, using 20 animals of each treatment per country. The highest beef odor and flavor scores were for the British beef aged for 7 days followed by the German and Uruguayan meat. Beef from the youngest animals (Spanish)

and especially from the UK, were up to 42 and 62%, respectively, more tender than German beef, all of them aged for 7 days. The highest juiciness scores were for the Uruguayan three years old beef. Long ageing periods (20 days) tended to produce off-aromas in the case of the British beef, which showed the highest scores in abnormal odor flavor intensities. European beef showed a significant variability in its sensory attributes that could be justified only by differences in the ageing time. Uruguayan beef has meat with similar sensory characteristics to some European meats, and because of that it could have good consumer acceptability.

Jenkins *et al.* (2011) reported that whole field peas were fed at 0, 10, 20, and 30% of DM to 139 yearling steers (British cross; 409 ± 31 kg of initial BW) for a 119-d finishing period. Carcass data and Choice grade strip loins ($n = 98$) were collected from a commercial abattoir in Lexington, Nebraska. Consumer sensory and Warner-Bratzler shear force analyses were performed on 2.5-cm strip steaks. Regarding the sensorial analysis, feeding peas linearly increased subjective tenderness ($p < 0.01$) and led to a quadratic response of overall like ratings ($p = 0.01$) and flavor like ratings ($p = 0.12$). Feeding peas did not alter ($p \geq 0.64$) juiciness, but decreased shear force values linearly when quantities were increased ($p = 0.02$). These data suggested that feeding peas did not affect steer performance or carcass characteristics differently from dry-rolled corn, but improved objective and subjective tenderness, overall desirability, and flavor of beef. Field peas could be fed to cattle and give positive attributes to the quality of the meat up to 30% inclusion in the diet.

Brugiapaglia *et al.* (2009) stated that five m. *longissimus thoracis* steaks from different breeds, purchased at retail, were cut into samples and simultaneously photographed under standard shooting conditions. The first photo was taken on samples just arrived at the laboratory, the second one on a freshly cut surface after blooming. Two consumer panels evaluated beef color using respectively photo 1 and photo 2. Each consumer was asked to rank samples in order of preference. Rank sums were evaluated with Friedman's test. Immediately after taking the photos, color was measured with a colorimeter. Regarding photo 1, consumers were able to discriminate one sample, the worst, from all the others. Concerning photo 2, consumers discriminated the worst sample, as in photo 1, but also the best one. Therefore a more accurate color evaluation could be obtained if the assessment was carried out on a fresh cut surface after blooming. In general, consumers preferred

samples with high lightness and a relatively high yellowness. The sensory evaluation of meat color using photographs is a promising tool to overcome the difficulties when the meat is directly evaluated. For this purpose the use of a color target could be useful to check the validity of the adopted parameters.

Steinberg *et al.* (2009) stated that, twenty pasture-fed steers and 10 pasture-fed heifers were evaluated for relationships among daily BW gain, grazing period, frame size, final weight, and carcass traits. Consumers evaluated tenderness, juiciness, flavor, texture and acceptability of cooked steaks from these animals. Cattle were wintered for a weight gain of 0.69 ± 0.03 kg/d for 156 d postweaning and were maintained in adjacent, rotationally-grazed paddocks containing primarily cool-season grasses. Cattle were harvested at a constant age ($532.9 \text{ d} \pm 5.7 \text{ d}$) in 6 harvest groups and carcass data were collected. The longissimus muscle steaks were taken from each of the longissimus muscle. An additional steak from each of the carcasses was thawed, cooked and offered to consumer panelists. A Third steak was used to determine the total lipid, fatty acid, cholesterol composition. Correlations were determined on the relationships among animal, production and carcass traits with the consumer evaluations and the relationships of fatty acids and cholesterol with consumer evaluations. Animal, growth, and carcass traits were generally not strongly related with panelist scores for tenderness, flavor, or overall desirability from pasture-fed cattle harvested at 533 d of age.

Brewer and Novakofski (2008) selected cattle in order to assess consumer quality attributes, to represent a range of quality grades from Utility to Prime. Steaks from these cattle were aged in vacuum bags for 0, 7, or 14 d, cut, and cooked on open hearth grills to 70 degrees C. Sensory evaluation was completed by consumers (n=522). Warner-Bratzler (WB) shear and various physical characteristics were also determined. Shear values decreased with aging time and tenderness increased. Consumers perceived the majority of change in tenderness occurred during the first 7 d of aging while change in WB shear was similar during the first 7 d and the second 7 d of aging. Aging had no effect ($p>0.05$) on juiciness, flavor, pH, lipid content, or water content of steaks.

Serra *et al.* (2008) reported that sensory characteristics of *longissimus thoracis* muscle from three local Spanish beef breed-production systems and their relationships with chemical and instrumental meat quality traits were studied. Young bulls of Bruna dels Pirineus (BP;

n=69), Avilena-Negra Iberica (A-NI; n=70) and Morucha (MO; n=70) breeds were reared in their own production systems. MO breed showed the highest water holding capacity and also the highest thawing loss and haem pigment content ($p<0.001$). Meat from A-NI was rated significantly higher ($p<0.01$) for beef flavor and tenderness than that from BP and MO animals. Furthermore, MO showed the lowest juiciness ($p<0.001$) which could be due to its higher thawing loss. Within the three breeds, thawing loss was negatively correlated with juiciness and, likewise cooking loss with juiciness and tenderness ($p<0.05$). The canonical discriminate analysis showed that the three breeds were significantly different ($p<0.05$) from each other according to sensory attributes, which justifies their involvement in different protected geographical indications (PGI).

Reuter *et al.* (2002) studied the logical point of value change, related to either tenderness or consumer acceptance, at which to separate the beef carcass within the rib/chuck region. Rib/chuck rolls consisting of the rib-eye roll and chuck eye roll subprimals were cut into 22 steaks each and Warner-Bratzler shear force and consumer purchase preference were evaluated for steaks at each rib location. Steaks were offered for sale at a retail supermarket and case time was monitored on each steak to determine consumer purchase preference. Steaks from the 2nd through 4th rib locations required more time to sell ($p<0.01$) than steaks from the 5th through 12th rib locations.

Carmack *et al.* (1995) evaluated twelve muscles from eight USDA Select/Choice grade steers for beef-flavor intensity, tenderness, and juiciness. The *biceps femoris*, *psaos major*, *gluteus medius*, *semimembranosus*, and *triceps brachii* were similar in beef-flavor-intensity ($P>0.05$) and were ranked as the most intensely flavored of all muscles. The *rectus femoris*, *longissimus lumborum*, *serratus ventralis*, *infraspinatus*, *semitendinosus*, *pectoralis profundus*, and *supraspinatus* generally were less intense in beef-flavor than the other muscles and were ranked from highest to lowest intensity in that order. The *psaos major* was the most tender ($P>0.05$) followed by the *infraspinatus*, *longissimus lumborum*, and *rectus femoris*, which were similar ($P>0.05$). Generally, muscles from the chuck and loin were juicier than those from the round.

Casey *et al.* (1990) conducted textural evaluations on the *longissimus thoracis* muscles from carcasses of young Afrikaner, Nguni and Pedi bulls fed intensively and slaughtered at 160, 290, 340 and 390 kg. Carcasses were stimulated electrically (500 V, 12.5 Hz) for 2 min, and

chilled for 19 h at 0-5° C. Rib cut samples (11, 12 and 13th rib cut) were removed 24h post-slaughter and evaluated by a taste panel for tenderness, juiciness, flavor and residue on an unstructured five-point scale, ranging from least to most acceptable. Shear tests were performed on an Instron apparatus. Percentage cooking loss and free water were measured. The Afrikaner was found to be slightly more tender and flavorsome with less residue than the Nguni. The Pedi did not differ from the Afrikaner or the Nguni. No breed differences occurred in juiciness, cooking loss, free water or shear force. Mass affected juiciness ($p<0.05$), residue ($p<0.01$) and free water ($p<0.01$). Shear force correlated highly with tenderness (-0, 61**) and residue (0, 74**). Juiciness correlated negatively with percentage cooking loss (-0, 57**), though poorly with percentage free water (0, 28). Compared with published results of textural evaluation of steer meat, the meat from the young Afrikaner, Nguni and Pedi bulls fell into a superior category.

2.15 Microbial quality of Beef

Jahan *et al.* (2015) conducted an experiment to assess whether elapsed time between slaughter and preservation and storage conditions influence the chemical and microbial changes of locally marketed beef. Meat samples were collected from local markets and divided into two groups, morning and evening beef. Morning beef was collected immediately after slaughtering from healthy cattle while evening one was collected 8 h after slaughtering. The samples were kept either in refrigerator (4° C) or freezer (-20° C). Refrigerated samples were stored for 7 days and analyzed on day 1st, 3rd and 7th while frozen samples were stored for 90 days and analyzed on day 3rd, 45th and 90th. Results showed that there was a significant difference in chemical and microbial parameters between morning and evening beef ($p<0.01$ to 0.05). Moreover, the coliform, yeast and mold counts were also increased with advance of storage time ($p<0.01$ to 0.05), indicating the unhygienic conditions of slaughter house, equipment and water which was giving signal for the possible occurrence of food borne intoxication. In conclusion, it was obvious that the quality of marketed beef degraded with the time elapsed before storage and storage temperature suggesting the importance of early preservation of meat at lower temperature. The findings of increased number of microbial counts were also suggested the necessity to improve the hygienic conditions of slaughterhouse and equipment in developing countries like Bangladesh.

Kumar et al. (2014) analyzed 300 meat samples (50 beef, 50 carabeef, 50 chevon, 50 mutton, 50 pork and 50 chicken) collected from the municipal slaughter houses and the retail meat shops from Hyderabad Karnataka region of Karnataka state, India for the microbiological quality; standard plate count and isolation and confirmation of *Staphylococcus*, *Salmonella*, *E. Coli*, *Listeria* and *Clostridium* by selective plating, microscopic examination and biochemical characterization. As per Food Safety and Standards (FSS) regulations 2011, of the samples analyzed, 89 (29.66%) (21 beef, 26 carabeef, 9 chevon, 7 mutton, 14 pork and 7 chicken) samples exceeded the limit of 10,000 CFU/gram of total viable count. Twenty (6.66%) samples (8 beef, 9 carabeef and 3 pork) exceeded the limit for *Staphylococcus* (100/gram maximum), 15 (5%) samples (9 pork, 4 chicken and 2 mutton) exceeded the limit for *Salmonella* (absent in 25 gram) and 22 (7.33%) samples (11 pork, 4 chicken, 4 beef and 3 carabeef) exceeded the limit for *E. coli* (100/gram maximum). None of the samples were positive for *Listeria* and *Clostridium* spp.

Omorodion and Odu (2014) analyzed three different meat samples namely; beef, chicken and pork obtained from Creek road market, Mile 3 market and Rumokoro market for their microbiological quality using differential, selective and routine media. A total of thirty one bacterial isolates covering six genera and thirteen fungal isolates covering three genera were isolated and characterized as *Bacillus* spp., *Enterobacter* spp., *Escherichia* spp., *Klebsiella* spp., *Pseudomonas* spp. and *Staphylococcus* spp., *Aspergillus* spp., *Mucor* spp. and *Penicillium* spp. From the analysis, it was observed that the total bacteria viable count of the meat samples ranged from 8.6×10^5 CFU/g to 2.6×10^6 CFU/g, while that of fungi ranged from 6.0×10^4 CFU/g to 4.4×10^5 CFU/g. In the detection method for pathogens (*Salmonella* and *Shigella*) after adopting the normal culture procedures of selective enrichment, differential and selective plating; no pathogen was detected.

Bradeeba and Sivakumaar (2013) reported that, in this study 75 meat (Beef, pork and mutton) samples were collected from retail shops in Chidambaram. The bacterial load was assessed on the samples collected at regular 3h (6 am-6 pm) intervals. Meat and Surface swabs from meat processing equipment and the surrounding environment were analyzed for microbiological contamination. In this study, beef showed high general viable counts (5.01-8.61 log cfu g⁻¹), whereas the other two meat products showed comparatively low general population coun. Scientists reported a mean total viable count of 7.47 log g⁻¹ in

minced beef, in pork sausages with the mean total viable count of 4.5 log organism g⁻¹, they also reported a significantly higher mean total viable count in minced sheep meat. However, in the presented study there was significant difference between beef and mutton products as well as between Beef and pork products. coliform count between 3.03-6.15 log₁₀ cfu g⁻¹. In spite of this mean coliform counts of all the products assessed in this study were well within the maximum permissible limit of 2.69 log organism per gram. Moderate count of psychrophilic followed by *Pseudomonas* sp. and *Bacillus* sp. were noted. Significant differences (p>0.05) were observed between samples for total viable counts, coliform and psychophilic from 6: am to 6: pm. The mean of Total Viable Count, Psychrophilic count, *Pseudomonas*, *Staphylococcus* and *Bacillus* count were analyzed in beef, mutton and pork meat. The mean count of Total viable count was not significantly (p>0.05) difference in Beef, Mutton and Pork meat. The temperature and pH of the meat samples ranges from 36.20 to 39.04° C and 5.04 to 6.6. Significantly (p<0.05) decreased the values of physicochemical composition of meat was observed at increase selling time (h).

Rahman (2013) observed the presence of micro-flora (TVC) and food borne pathogens (Coliform and Yeast-Mould) on fresh beef samples stored at -20° C which were subjected to repeated freeze-thaw cycles (1, 2 and 3). The initial value of TVC for fresh beef (not frozen and thawed) was 5.12 log₁₀ CFU/g beef, indicating good quality beef. The TVC was almost similar to fresh beef but slightly vary by thawing methods within and among the cycles. TVC was affected significantly (p<0.01) by thawing methods within and among the cycles. TVC was decreased in cycle 1 but increased in cycle 2 and 3 subsequently in different thawing process which did not cross the initial count. TVC was significantly (p<0.05) changed in different interactions of cycles and thawing methods. Thawing at 40° C in cycle 3 had the highest (5.17 log₁₀ CFU/g) and thawing at 4° C in cycle 1 had the lowest (4.49 log₁₀ CFU/g) TVC among the interactions.

Adzitey et al. (2011) assessed the microbial quality of beef sold in five most popular meat shops in the Tamale Metropolis in order to ascertain its safety. The meat shops were selected from Aboabo, Central (external), Central (internal), Nyohini, and Sakasaka markets. The total bacterial count was used as index of quality. A total of 100 beef samples were collected in two successive visits. The samples were stored under 4° C for transportation to the laboratory. Microbiological analysis was carried out immediately upon arrival in the

laboratory under aseptic conditions. Beef samples from Sakasaka had the highest mean total bacterial count of 1.67×10^6 cfu/cm², followed by Aboabo (5.75×10^5 cfu/cm²), Central Market (internal) (4.325×10^5 cfu/cm²), Nyohini (3.875×10^5 cfu/cm²) and Central Market (internal) (4.325×10^5 cfu/cm²). While their mean log counts were 6.22, 5.76, 5.64, 5.59 and 5.57 for Sakasaka, Aboabo, Central Market (internal), Nyohini and Central Market (internal), respectively. Bacterial species isolated from the beef samples were *Escherichia coli*, *Streptococcus* species, *Salmonella* species and *Staphylococcus* species.

Sethulekshmi and Nanu (2009) stated that bacteriological quality of 40 beef carcasses selected from a meat processing plant and the environmental samples surrounding the plant were assessed during the present investigation. The samples from each carcass were examined for the bacterial quality by estimating the total viable count (TVC), coliform count (CC), *Escherichia coli* count (ECC) and fecal streptococcal count (FSC). Statistical analysis of the data using paired t-test revealed a significant and positive association between the mean total viable count and fecal streptococcal count ($p < 0.05$) of the samples. The samples of air, water, equipment and hand wash of personnel were also collected and the various bacterial loads of these samples were estimated. Highest mean total viable count was observed in pond water. The ice, pond water and tap water had contributed significantly in the contamination of beef carcasses. Only hand wash samples showed the presence of *Escherichia coli* count whereas coliform and fecal streptococcal count was also detected in samples collected from hand washes. Ice samples had a mean TVC of $3.20 \pm 0.11 \log_{10}$ cfu/ml. The coliform count in ice, pond, and tap water were 2.30 ± 0.08 , 1.39 ± 0.77 and $0.50 \pm 0.21 \log_{10}$ cfu/ml, respectively. The study pointed out that the equipment, environment and personnel contributed to the low quality of meat in the processing plant.

Phillips et al. (2001) conducted a survey of the microbiological quality of beef carcasses and boneless beef produced in Australia during the period June to November 1998. Sponge samples were collected from 1,275 carcasses, and meat samples were drilled from 990 cartons of frozen boneless beef. Carcass and boneless beef samples were respectively collected from 21 and 27 establishments that concentrated on export and from 38 and 3 establishments supplying the Australian domestic market of which 31 were very small plants slaughtering no more than 150 cattle equivalents per week. The mean log total viable counts (TVCs) were 2.42/cm² and 2.52/g for carcasses and boneless meat, respectively.

Escherichia coli were detected on 10.3% of carcasses and 5.1% of boneless beef samples and coagulase-positive *Staphylococci* on 24.3% of carcasses and 17.5% of boneless beef. *Salmonella* was detected on 0.2% of carcasses and 0.1% of boneless beef and *E. coli* O157:H7 recovered from 0.1% of carcasses but not detected on 990 boneless beef samples. Mean log TVCs/cm² differed significantly ($p < 0.05$) between establishment types. They were lower on carcasses from export establishments (2.20) compared with domestic (2.61) and very small plants (3.10). There were no significant differences in prevalence of *Salmonella* or *E. coli* O157:H7 between establishment types.

Vanderlinde et al. (1998) reported that two studies were undertaken to determine the microbiological of beef carcass meat and frozen boneless bulk packed beef produced in Australia. Samples were collected from 1,063 beef carcasses and from 929 cartons of frozen boneless bulk packed beef over a period of approximately 12 months. Samples were collected from works processing beef carcasses for the Australian domestic market and from works targeting export markets. On carcasses processed for export markets, where bacterial counts were obtained, the log₁₀ mean of the APC (aerobic plate count) was 3.13 CFU/cm², the geometric mean of the coliform count was 19 MPN/cm², and the geometric mean of *Escherichia coli* was 13 MPN/cm². A small percentage (0.59%) of export samples were found positive for *Listeria monocytogenes*, 0.16% were positive for coagulase-positive for *Campylobacter jejuni/coli*, 0.22% were positive for *Salmonella* spp., and 29% were positive for coagulase-positive *Staphylococcus* spp. Bacterial numbers were lower on carcasses processed for export markets and higher carcasses chilled for more than 24 h. *Escherichia coli* O1:57 was recovered from 4 of 893 export carcasses tested (0.45%). Of the export frozen boneless bulk packed beef samples that tested positive, the log₁₀ mean of the APC was 2.5 CFU/g, the geometric mean of the coliform count was 15 MPN/g, and the geometric mean number of *E. coli* was 15 MPN/g. Three of 787 export frozen samples (0.38%) tested positive for *Salmonella* spp., *E. coli* O1:57 was not isolated from any of the 685 export frozen samples tested for this bacteria. Export samples tested for these bacteria. Export samples on average had lower APCs than domestic samples.

Borch et al. (1996) presented the influence of environmental factors (product composition and storage conditions) on the selection, growth rate and metabolic activity of the bacterial flora for meat (pork and beef) and cooked, cured meat products. The predominant bacteria

associated with spoilage of refrigerated beef and pork, were *Brochothrix thermosphacta*, *Carnobacterium* spp., *Enterobacteriaceae*, *Lactobacillus* spp., *Leuconostoc* spp., *Pseudomonas* spp. and *Shewanella putrefaciens*. The main defects in meat were off-odours and off-flavors, but discoloration and gas production also occurred. Bacteria associated with the spoilage of refrigerated meat products, causing defects such as sour off-flavours, discolouration, gas production, slime production and decrease in pH, consisted of *B. thermosphacta*, *Carnobacterium* spp, *Lactobacillus* spp, *Leuconostoc* spp. and *Weissella* spp.

2.16 Cost and return of cattle fattening

Rashid et al. (2015a) evaluated the growth performance and cost per gain of Brahman × Local crossbred bull calves receiving three diets with varying concentrate to roughage ratio (C : R) of 75 : 25, 65 : 35 and 55 : 45 on dry matter (DM) basis. Twelve bull calves (aging 11.5 ± 1.2 months and 170.8 ± 13 kg live weight) divided into three equal groups were fed on three diets. Animals fed diet with C : R – 55 : 45 had the lowest feed cost (136.8 BDT/kg LW gain), which was increased (147.5 and 153.8 BDT) non-significantly ($p > 0.05$) with the increasing level of concentrate. The diet consisting of 55% concentrate mixture showed similar result with the diet consisting of 75% concentrate mixture, but was comparatively economic. It was concluded that the diet consisting of 55 : 45 C : R may be used for economic beef production.

Rashid et al. (2015b) reported that, twelve local × Brahman (L × B) bulls of average 20 ± 1.5 months of age and 343 ± 20 kg live weight divided into three equal groups were fed a mixed concentrate diet (CON); 1:1 CON and UMS (Urea and Molasses impregnated straw at a ratio of 3:15:82 on dry matter basis; and the UMS diet alone. The feed cost of producing one kg live weight was calculated to be 2.26, 2.04 and 2.60 US\$, respectively for the three diets. Considering feed conversion rate and cost per kg gain, a mixed diet of concentrate and UMS (1:1) is the most appropriate for F₁ Local × Brahman crossbred bulls.

Malole et al. (2014) examined the costs and benefits of indigenous beef cattle fattening schemes in Shinyanga Urban and Kishapu Districts in Tanzania. Specifically, in this study the net profit (NP) for fatteners between beef cattle fattening schemes had been determined. The schemes were divided into two main categories, scheme 1 in which the animals were fed on cottonseed hulls (CSHL) based diets and scheme 2 on cottonseed cake (CSC) based

diets. The survey was carried out using a sample of 144 respondents. The tools for data collection were structured questionnaire, interview, personal observation, communication, documentary reviews (e.g. from internet, libraries) and key informants. Data were analyzed using descriptive statistics and quantitative statistics and standard procedure of the association of official analytical chemists. Results showed that the positive net profit was relatively higher in scheme 2 (Tanzanian shilling (TAS) 119512.87 / USD 76.03 per fed animal per quarter a year) than that in scheme 1 (TAS 92993, 90 / USD 59.17 per fed animal per quarter a year). This implies that the fattening business is more feasible, profitable and efficient for sustainable implementation in scheme 2. Furthermore, the average daily gains (ADG) of 1.5, 1.3 and 1.0 for Tanzania Short Horn Zebu (TSHZ) males, steers and females were higher than the 1.2, 1.0 and 0.9 for TSHZ males, steers and females in scheme 1, respectively. Additionally, the feed conversion ratios (FCRs) of about 5.0, 5.5, 6.3 for TSHZ males, steers and females in scheme 2 were lower than 7.2, 8.6, 8.6 for TSHZ males, steers and females in scheme 1. Therefore, scheme 2 was economically feasible, profitable and therefore is recommended for implementation and monetary support for improved income, livelihoods, poverty reduction and commercialization of the beef industry.

Sarma *et al.* (2014) studied the profitability of beef cattle fattening in the northern char area of Bangladesh. A total of 150 cattle fatteners were randomly selected from two districts representing the highest concentration of fatteners in the char area. Socioeconomic data as well as data on beef fattening were collected from the people selected at Pabna and Sirajgonj district. Descriptive statistics was used to analysis the socioeconomics characteristics of beef producers, the profit function was used to determine the profitability of beef market and regression analysis was used to determine the factor affecting profitability of beef cattle. In spite of beef cattle production was profitable agribusiness most of the farmers adopt traditional beef fattening system for beef fattening target the cattle marketing during the Muslim festival "Eid-ul-Azha". Profitability margin equals BDT 13,350.84 per cattle. The benefit cost ratio of the entire enterprise was 0.52 that means cattle fattening enterprise was profitable and feasible business enterprise. The major problems facing the farmers included high cost of feeds, inadequate credit facilities, disease attack, illegal use of human drugs for cattle fattening, price fluctuation and inadequate extension services.

Dashdorj *et al.* (2012) evaluated carcass characteristics and meat quality traits as a function of endpoint months of slaughter age (26 vs 32 mon) and chiller ageing (1 vs 10 d) for *m. longissimus* of 26 Hanwoo steers fed with commercial diets including whole crop barley silage. Totally twenty six Hanwoo steers for 6 mon of age that were fed until 26 mon of age constituted the short term-fed group and fed until 32 mon of age constituted long-term fed group. Carcasses were chilled for 24 h and were graded. However, from the viewpoints of economical and environmental aspects, cost of the additional feeding for 6 months for value-adding of eating quality was relatively high and the effects in turn were limited.

Sarma and Ahmed (2011) studied the profitability as well as operational economics efficiency of cattle fattening enterprise of Rajbari District. Data used to achieve this objective was obtained from 120 nomadic farmers, which were randomly selected using a multi-stage sampling procedure. Data were generated using a survey schedule as well as direct observation (cost-route method). Descriptive statistics, economics analysis as well as operational efficiency index were used to analyze the data. Results showed that small scale cattle fattening enterprise were profitable and flexible. A net enterprise income of BDT 5559 per cattle was realized by an average enterprise in study area. It was also shown that operational efficiency was not generally high among the entrepreneur. Based on these results, the study advised less efficient entrepreneurs to adopt the practices of the efficient ones in order to make the enterprise more profitable. The study shows that small scale cattle fattening enterprise is profitable due to agribusiness context. Farmers used three years old cattle for beef fattening. Cattle fattening period is 4.5 months in rural study areas of Rajbari district in Bangladesh.

Umar *et al.* (2008) studied the economics of small-scale cow fattening enterprise in Bama LGA of Borno State. Random sampling was used to select 45 respondents from two districts that have large number of beef fattening enterprise. The analytical tools employed were descriptive statistics and net margin analysis. The average age of the respondents was 41 years. The inputs used for cow fattening were feeder cow, feed, drugs/vaccines, labor, water and potash/salt. The net margin was N40, 528.58 per cow that was, for every one naira invested in cow fattening business; 67 kobo was realized as net margin. The study showed that small scale cow fattening enterprise was profitable.

Begum *et al.* (2007) investigated the cattle fattening programs of rural farmers in Panchagarh district of Bangladesh through field survey. About 56.7% farmers used cattle of 2-3 years of age and 36.7% farmers used cattle of 1-2 years age. About 70% farmers used bulls and 70% farmers had an average of 1-4 cattle for fattening. Fattening period of 3-6 months and 7-12 months were reported by 60% and 30% farmers respectively. Separate houses for cattle were provided by 86.7% of the farmers. About 63.4% farmers washed their cattle in ponds and rivers regularly. About 76.7% farmers had taken short training on livestock rearing from Rangpur, Dinajpur Rural Service (RDRS) and Panchagarh Youth Training Centre and 80% farmers de-wormed their cattle before starting the fattening program. About 96.6% of farmers reported shortages of animal feed and 86.6% reported lack of credit as the major problems of cattle fattening. Average buying and selling prices and net profit were Taka/cattle 7528, 9542 and 2055, respectively. Small scale cattle fattening programs could be recommended as an income generating activity for the rural fainters of Bangladesh.

Okoruwa *et al.* (2005) conducted a study in Ibadan metropolis to determine the profitability of beef cattle fattening. Data were collected from 50 randomly selected cattle fattening operators and were analyzed using descriptive and budgetary analyses. Results showed that 84 percent of the operators sourced capital from personal savings, relatives and friends. The structure of the herd kept typifies more of beef to dairy herds while the average herd size was 26 animals (LU). The cost figures indicate that feed and labor made up 46 and 37 percent of the variable cost respectively, while 84 percent of the total cost was the fixed cost. Cost-benefit analysis revealed a gross margin of N568, 689, and cost-benefit ratio of 1:1.3. Net income was estimated as N142, 735 and N 5, 554 per farm and head of animal respectively. However, the heavy dependence on credit from informal sources could limit the potential for expansion of the enterprise and this could be addressed by adequate funding from formal sources like cooperative societies and community banks.

Ahmed (2002) conducted an experiment on cattle fattening as income generating activity by the farmers. They found that feed cost for 3 involved Tk. 1500 and 2200 for control and treated groups respectively. Average buying price of calves for the control and treated groups was Tk. 3833 and 3733 respectively. The corresponding returns were Tk. 1951.67 and 2050 for the control and treated groups respectively.

Hashem *et al.* (1999) investigated the cattle fattening programs of rural farmers in different districts of Bangladesh through field survey. About 60.4% farmers used cattle of 2-3 years of age and 32.2% farmers used cattle of 1-2 years age. About 70.4% farmers used bulls and only 5.2% used females. About 71.20% farmers had an average of 2 cattle for fattening and 28.80% farmers had an average of 3 cattle. Fattening periods of 3-6 months and 7-12 months were reported by 42% and 30% farmers respectively. About 86.40% farmers financed their cattle fattening business by themselves. Separate houses for cattle were provided by 86% of the farmers. About 61.2% farmers dewormed their cattle before starting the fattening programs. About 72.8% farmers did not vaccinate against infectious diseases for their cattle. For treatment of cattle only 24% of farmers had taken help from a Veterinary Surgeon. About 46.4% of farmers bought their cattle at 2-4 thousand taka per cattle. Average buying and selling prices and net profits (Taka/cattle) were taka 5043, 8360 and 3648, respectively. About 96.8% of farmers reported shortages of animal feed and 84% reported lack of credit as the major problems for cattle fattening.

Hossain *et al.* (1996) conducted a study upon nine selected women of Dhalla village under Singair thana of Manikganj district to evaluate the beef fattening as an income generating source being practiced by the vulnerable group of women. The fattening programme was financed by the local Grameen Bank, Dhalla branch. It was found that each woman borrowed average loan money amounting to Tk 7,333.00 @ 20% interest per annum from the Grameen Bank. The study revealed that the average net income of each women was Tk. 7745.00/season (5.77 months) having 1.78 animals on an average. Individual record showed that two, out of these nine women earned an average net income of Tk. 650.00 where as the other four women had an average income of Tk. 4800.00/season. On the other hand, the remaining three women earned a net income of Tk. 11,700.00, 16,500.00 and 21,000.00/season, respectively. The reasons behind this increased amount of income by these three particular women were that their investment per animal was higher and the overall management of the fattening program was very good.

CHAPTER III

MATERIALS AND METHODS

3.1 Description of survey

To obtain up to date information on cattle fattening, feeding, management and favorable condition of beef fattening system for local and crossbred bull, a survey was conducted in Raiganj upazila of Sirajganj district. The data were collected from January to February, 2013. The primary reasons for selection of Raiganj upazila for the present study were higher concentration of beef fattener, well communication facilities, available feedstuff, high land and trained beef fatteners by local NGOs with the expectation to obtain reliable information.

3.1.1 Description of the study area

The area of Raiganj upazila (Sirajganj district) is of 267.83 sq km, located between 24°25' and 24°34' north latitudes 89°24' to 89°37' east longitudes. It is bounded by Sherpur and Dhunat upazilas (Bogra) on the north, Ullahpara and Kamarkhanda upazilas on the south, Sirajganj sadar and Kamarkhanda upazilas on the east, Tarash upazila on the west. Location of survey area (Raiganj) has been shown in the geographical map of Bangladesh (Fig. 3.1). Raiganj has a population of total 267522; male 137574, female 129948; Muslim 234112, Hindu 33361, Buddhist 30 and others 19. Main sources of income were agriculture 69.27%, non-agricultural laborer 2.93%, industry 4.46%, commerce 11.25%, transport and communication 2.51%, service 3.90%, construction 0.90%, religious service 0.17%, rent and remittance 0.18% and others 5.33%. There are 55.99% landowner and 44.01% landless people in Raiganj upazila where agricultural landowner: urban 35.59% and rural 56.49%. The status of fisheries, dairies and poultries are; fishery 38, dairy 8, poultry 28, hatchery 5 (Cultural Survey Report of Raiganj Upazila 2007).

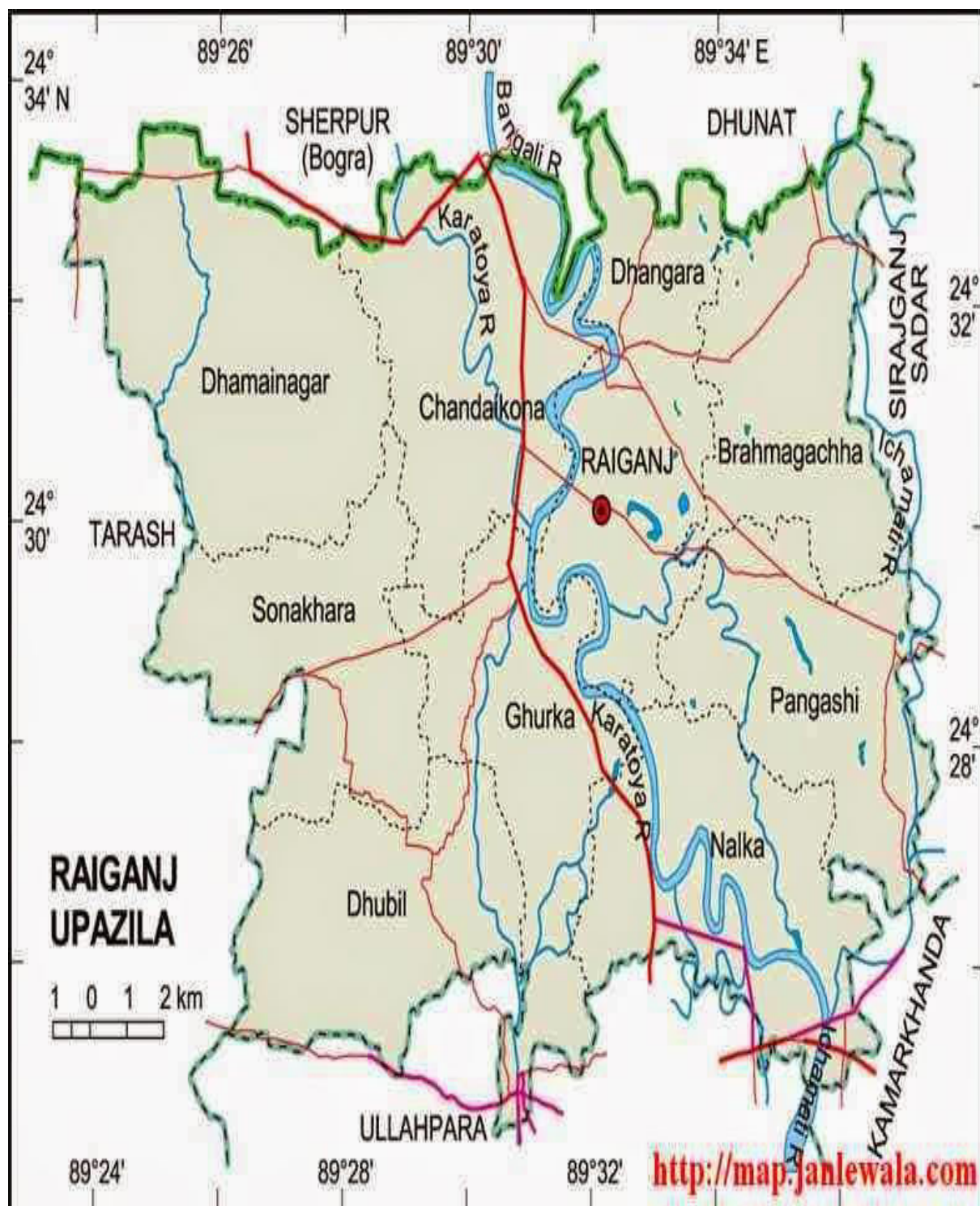


Fig. 3.1 Geographical map of Raiganj upazila, Sirajganj district, Bangladesh

3.1.2 Preparation of questionnaire

A structured questionnaire was carefully prepared keeping the objectives of the study in mind. The questions and statement contained in the questionnaire were simple, direct and easily understandable by the respondents. Some scale was included in the questionnaire, wherever necessary. The draft interview schedule was pre-tested in the study area. The pre-test facilitates the researcher to identify faulty questions in the draft schedule, and necessary corrections and modifications were made on the basis of the pre-test results. The questionnaire contained the following major items of information;

- Socio-economic condition of the selected cattle owners, viz. level of education, gender, occupation, family size, land size, income of households, training and experience on cattle fattening, etc.
- Livestock population and their genetic status
- Purchase time
- Duration of fattening program
- Feed resources and feeding system
- Housing of livestock
- Primary health care and disease management of livestock
- Statement of expenditure and income of the farmers

The questionnaire used in data collection is given in Appendix 1.

3.1.3 Data collection

In order to obtain reliable information, door to door survey was performed and data were collected from the farmers who reared at least one fattening bull throughout the year. Farmers were selected randomly from Kathalbaria and Char Faridpur villages of Raiganj upazila of Sirajganj district for collection of information. The farmers those were more cooperative and interested to provide reliable information voluntarily were interviewed. A good relationship was maintained with respondents during the time of survey work. Before making actual interview, the objectives of the study were explained clearly to the respondents. Then the questions were asked in a very simple manner. In case of respondent failed to understand any question, special care was taken by the researcher to explain it. To collect the necessary information from the respondent both interviewing and observation

were applied. The relevant data for this study were collected without biasness. The farmers were assured that the study was purely academic one and would not likely to have any adverse effect on them. Information given on the above mentioned questionnaire was recorded and kept for analysis.



Fig. 3.2 Collection of data from the respondents

3.1.4 Processing of the primary data

At the end of data collection, the collected data were coded, compiled, tabulated and analyzed. The local units were converted into standard units. The qualitative data were transferred into quantitative data by appropriate scoring technique. The responses of the respondents that were recorded in the interview schedule were transferred to master sheets and compiled to facilitate the needed tabulation.

3.1.5 Data tabulation and analysis

Data were tabulated and analyzed with simple statistical method to fulfill the objectives of the study. Occupation, level of education, family size, land size and annual income of the respondents were considered as independent variables of the study. These variables were subsequently used for statistical analysis and expressed in number, percentage and mean etc.

3.2 Experiment 1

A comparative study on the feeding plans of nutrition, intake, growth and feed conversion efficiency of indigenous and crossbred bulls

The experiment was conducted at Raiganj upazila, Sirajganj district of Bangladesh for a period of 120 days with 10 days of adjustment period at the beginning of the experiment started from May, 2013. Twenty indigenous and twenty crossbred (L×HF) bulls of 24 months age were selected and given to 40 women who were well trained by the local NGOs for beef fattening.

3.2.1 Selection of farmers

A number of 100 households were interviewed from Raiganj upazila. Among them 40 farmers were selected from Kathalbaria and Char Faridpur village for this experiment, who were willing for fattening of indigenous and crossbred cattle. All the selected farmers were female and they were well-trained for beef fattening. They were trained by the local NGOs. The farmers who reared crossbred cattle were given crossbred bull and who reared indigenous cattle were given indigenous bull for beef fattening.



Fig. 3.3 Explanation of the experiment to selected farmers



Fig. 3.4 Napier cutting distribution to the selected farmers

3.2.2 Purchase of cattle

The experimental animals were purchased from local cattle market and from various local dairy farms. Price of the cattle was determined by negotiation with the cattle owner.



Fig. 3.5 Purchasing of cattle from local markets

3.2.3 Cattle selection

Cattle were selected on the basis of breed, age, sex, average body weight, coat color and body condition score. Indigenous and crossbred (Holstein Friesian $\times$ local breed) bulls were selected for beef fattening. The age of the cattle was determined by dentition. Male cattle were selected for beef fattening. Average body weights for indigenous and crossbred bulls were 208.08 ± 13.98 kg and 256.26 ± 26.85 kg, respectively. Various coat color has been chosen for indigenous and crossbred bulls depending on availability.



Fig. 3.6 Some indigenous bulls selected for beef fattening



Fig. 3.7 Some crossbred bulls selected for beef fattening

3.2.4 Housing and management

The houses of cattle were well ventilated and space per animal was adequate. Gunny bags were hanged over the ventilator to protect the bulls from rainfall and cold wind at night. Fresh drinking water was made available in mangers at all time for *ad-libitum* drinking. The animals were identified with ear tag. All the animals were stall fed.

3.2.5 Cleaning and sanitation

Cleaning and hygienic management of the animal house was maintained regularly. The floor, stall, manger, water trough, paddock and drains were washed with water. Every day the floor and mangers were cleaned thoroughly using PPM as antiseptic. The cow dung was removed before washing and then animals were groomed and washed every day.

3.2.6 Health management

3.2.6.1 De-worming

Animals were de-wormed by Endex (Triclabendazole INN 900 mg, Levamisole hydrochloride BP 600 mg) 20 mg per kg live weight before ten days of feeding trial.

3.2.6.2 Vaccination

All the animals were vaccinated during the experimental period according to the following Table 3.2.1.

Table 3.2.1 Name, dose and route of application of vaccine used for preventive measures

Name of vaccine	Dose	Route of application	Work against
Anthrax spore vaccine	1ml/cattle	Subcutaneous	Anthrax disease
FMD vaccine	6ml/cattle	Subcutaneous	Foot and mouth disease

FMD = Foot and Mouth Disease

3.2.7 Adjustment period

After de-worming the experimental animals were allowed for 10 days to adjust with the experimental condition and diet.

3.2.8 Feeding of animals

3.2.8.1 Collection of feedstuffs

For preparation of concentrate mixture, maize crush, wheat bran, rice polish, kheshari bran, mustard oil cake, bone meal, salt and fish meal were purchased from local market. Rice straw was obtained from the farmers' own source. Napier grass and Ipil-ipil leaf fed to the experimental animals were collected by cut and carry system. Local grasses were collected from fallow lands and road side every morning and fed in fresh condition.



Fig. 3.8 Napier grass lands cultivated by the farmers



Fig. 3.9 Ipil ipil leaf around the Napier grass lands



Fig. 3.10 Concentrate feed mixing for the experimental animals

3.2.8.2 Experimental design and dietary treatments

The animals were divided into two major groups, 1) indigenous and 2) crossbred; and each group was divided into four treatment groups (T₀, T₁, T₂ and T₃) each containing five animals. Animals of group T₀ (control group) were treated with conventional feeding method. Whereas, the experimental animals of treatment group T₁ were received *ad libitum* local grasses and rice straw; and animals of group T₂ and T₃ received *ad libitum* Napier grasses (*Pennisetum perpureum*; hybrid) and rice straw as basal diet. Animals of group T₃ were also supplied with small amount of Ipil ipil leaf. They also received a concentrate mixture at the rate of 1.5% of their live weight. Different concentrate mixtures were prepared for the control group and treatment groups.

Samples of green grasses, rice straw, Ipil ipil leaf and concentrate feeds were subjected to chemical analysis for the determination of dry matter, crude protein, crude fiber, ether extract and total ash following the method described by AOAC (2005). Metabolizable energy contents of feedstuffs were determined following *in-vitro* gas production techniques (Menke *et al.*, 1979). Table 3.2.2, 3.2.3 and 3.2.4 showed different chemical compositions of roughages, chemical composition of concentrates and ingredient composition of concentrate mixtures with energy and protein value, respectively.

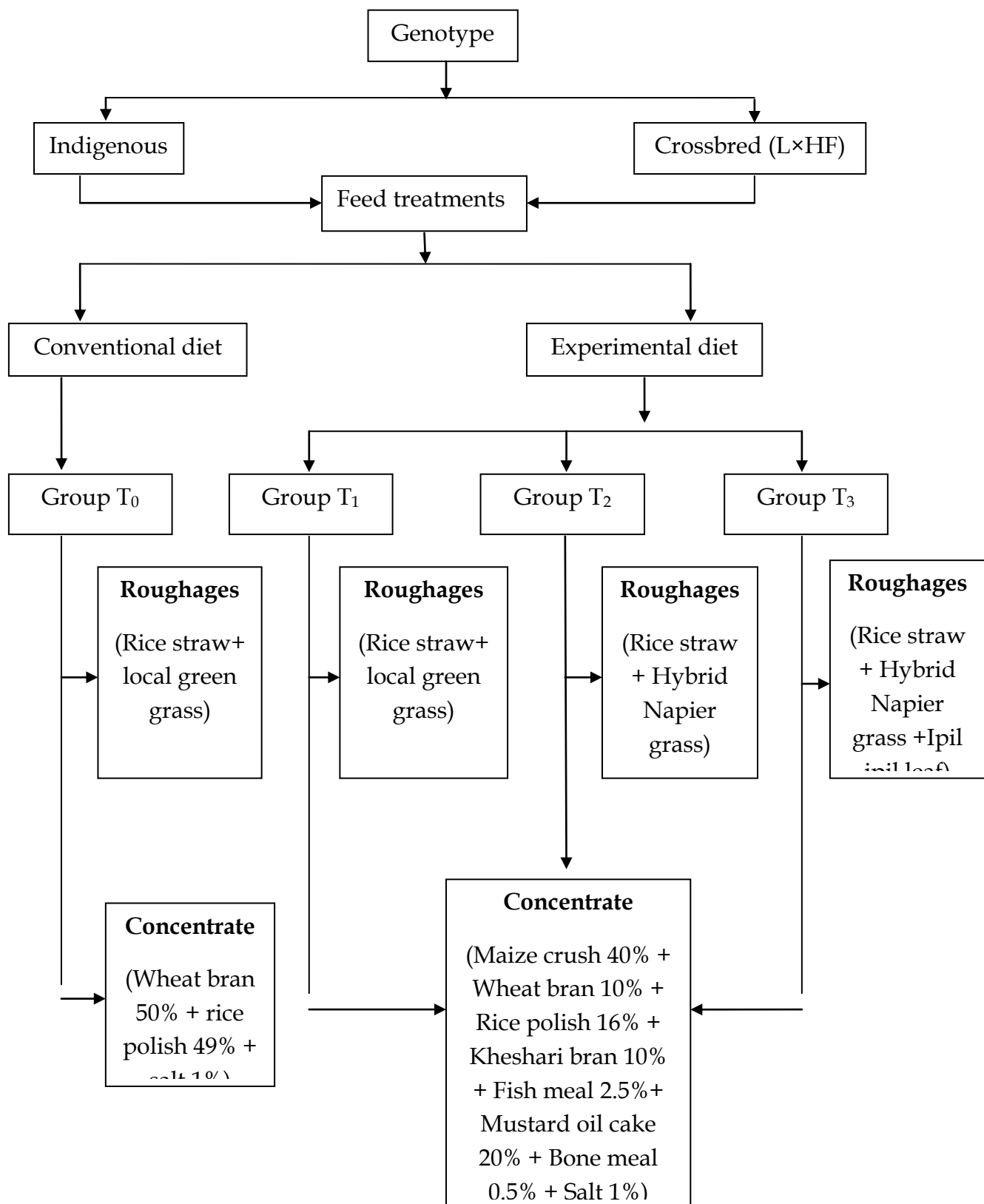


Fig. 3.11 Lay-out for feeding experimental animals

Table 3.2.2 Chemical composition of roughage supplied to experimental animals

Name of ingredients	DM %	DM basis				ME (MJ/kg DM)
		OM%	CP%	EE%	Ash%	
Local grass	18.40	90.91	8.92	2.25	9.87	6.78
Napier grass (hybrid)	14.93	92.42	11.39	1.12	7.36	7.24
Rice straw	91.57	82.98	9.52	1.97	17.02	5.99
Ipil ipil leaf	27.80	92.73	23.12	3.17	7.13	8.7

DM = Dry Matter, OM = Organic Matter, CP = Crude Protein, EE = Ether Extract, ME = Metabolizable Energy

Table 3.2.3 Chemical composition of different ingredients of concentrate mixture fed to experimental animals

Name of ingredients	DM%	DM basis				ME (MJ/kg DM)
		CP%	Ash%	OM%	CF%	
Maize crush	89.5	11.06	13.14	86.86	2.17	13.30
Wheat bran	88.51	17.11	9.04	90.96	17.11	11.50
Rice polish	90.61	13.37	14.96	85.03	13.37	7.00
Kheshari bran	89.12	16.65	7.99	92.00	16.65	7.75
Fish meal	87.69	59.04	27.21	72.79	59.04	13
Mustard oil cake	91.51	35.72	15.03	84.97	12.42	12
Bone meal	-	-	-	-	-	-
Common salt	-	-	-	-	-	-

DM = Dry Matter, CP = Crude Protein, OM = Organic Matter, CF = Crude Fiber, ME = Metabolizable Energy

Table 3.2.4 Ingredient composition of the concentrate mixtures with energy and protein value

Name of ingredients	(kg/100 kg)	
	Conventional Diet (T ₀)	Improved Diets (T ₁ , T ₂ , T ₃)
Maize crush	-	40
Wheat bran	50	10
Rice polish	49	16
Kheshari bran	-	10
Fish meal	-	2.5
Mustard oil cake	-	20
Bone meal	-	0.5
Common salt	1	1
Nutrient composition per kg DM		
ME (MJ)	9.25	11.25
CP (g)	152.28	188.64

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3
DM = Dry matter, ME = Metabolizable energy, CP = Crude protein

3.2.8.3 Feeding method

All animals except control group, received *ad libitum* (at least 15% in excess of requirement) rice straw and chopped hybrid Napier grasses (*Pennisetum perpureum*) harvested at pre-flowering stage as the basal diet. They also received a concentrate mixture at the rate of 1.5% of their live weight. The animals of control group received *ad libitum* rice straw and local grass, and a conventional concentrate mixture at the rate of 1.5% of their live weight. The concentrate allowance was divided into two halves and offered at 9.00 A.M and 4.00 P.M. The supply of concentrate mixture to an animal was adjusted with the increase of its live weight. During the whole 120 days of feeding period, amount of green grass and concentrate offered and residue left by the individual animals were recorded every day.

3.2.9 Measurement of feed intake and live weight changes

Feed intake of individual animal was determined by subtracting the refusal from the amount given. Feed refusals were collected every morning before feeding and weighed out regularly to find out daily feed intake. The average initial and final live weight of each animal were recorded by using a platform digital balance with an weighing range 0.00 kg to 1000 kg and a minimum graduation of ± 0.1 kg. The weight of each experimental animal was also recorded at every fortnight interval in the same way. Initial live weight of each animal was measured before feeding at the beginning day of experiment and final live weight was measured at the end of the feeding period. The daily live weight gain was calculated as the differences between the means of initial and final live weights divided by the number of growing days.

The average daily gain (ADG) of an individual animal was calculated as;

Average daily gain (ADG) = total LWG / total days of the experiment

Feed conversion ratio for each animal was determined by following equation;

Feed conversion ratio (FCR) = Total DMI (kg)/Total LWG (kg)

3.2.10 Data analysis

Significant differences among different treatment means within a breed were determined through completely randomized design (CRD) while comparison of treatment means between two breeds were determined by student t-test using statistical software SPSS version 20 and Microsoft Excel Software for Windows (SPSS Inc. 2007) (Albert *et al.*, 2008). Data were presented as means and standard error of the means (SEM). Significant differences at $p < 0.05$ and $p < 0.01$ were determined among different treatment groups of native and crossbred bulls by pooled analysis.

3.3 Experiment 2

Study on carcass and meat yield characteristics of indigenous and crossbred cattle reared under improved feeding system

After 120 days of feeding trial, all the bulls were slaughtered. For slaughtering, animals were transported from the project area to Pabna Meat, Uttara, Dhaka at three different phases to facilitate data collection.

3.3.1 Pre-slaughter body parameters

Before slaughtering different pre-slaughter body measurements were recorded.



Fig. 3.12 Measurement of pre-slaughter body parameters

- **Body length** - Body length was measured by taking the length from point of elbow to point of pin by using a measuring tape.
- **Heart girth** - Heart girth was taken by measuring circumference of the thorax just behind the point of shoulder using a measuring tape.
- **Wither height** - Wither height was measured with a measuring tape.
- **Hip height** - Hip height was also measured with a measuring tape.



Fig. 3.13 Fasting of animals before slaughter in lairage of Pabna Meat

3.3.2 Slaughtering procedure

After fasted for around 24 hours, bulls were slaughtered in the abattoir of Pabna Meat following 'Halal' method and were bled by cutting throat and then slaughtered by severing the head at its articulation on the occipito-atlantal space.

3.3.3 Yield of non-carcass components

The conventional procedure of flaying was followed after slaughtering an animal. Blood was collected and weighed in a pre-weighed bucket immediately after slaughter. Then the head was removed at the atlanto-occipital joint and feet below the carpals in the fore legs, and tarsals in the hind legs. Head, head meat, hide, spleen, heart with and without fat, kidney, gut, perinephric fat, lung with trachea, liver, gall bladder, bile, testes and penis were removed and weighed using digital scale. The entire digestive tract with and without content, rumen with and without its content were weighed and recorded.



Fig. 3.14 Conventional flaying of beef carcass at Pabna Meat

3.3.4 Yield of primal cuts

Halving and quartering of a carcass, and cutting of different primal cuts following vertebral formula (Cervical₇ Thoracic₃ Lumbar₆ Sacral₅ Caudal₁₃₋₂₁) were done according to FAO (1991).



Fig. 3.15 Halving and quartering of a carcass at Pabna Meat

3.3.5 Carcass yield parameters

3.3.5.1 Slaughter weight

After slaughtering blood was collected and weighed in a pre-weighed bucket. Then the weight of blood was subtracted from the live weight of the animal to determine the slaughter weight.

Slaughter weight = Pre-slaughter weight - weight of blood

3.3.5.2 Warm carcass weight

Hot carcass was prepared by removing head, skin, thoracic cavity contents, abdominal cavity contents, pleural cavity contents, fore and hind canons from slaughtered cattle. Weight of the carcass was taken with the help of weighing balance.

3.3.5.3 Chilled carcass weight

After taking hot carcass weight, the carcass was kept at 4° C in a chiller for 24 hours. Then the chilled carcass weight was taken with the help of weighing balance.



Fig. 3.16 Chilling of carcass at 4° C in chiller of Pabna Meat

3.3.5.4 Dressing percentage

3.3.5.4.1 Dressing percentage of warm carcass

Dressing percentage was calculated on the basis of hot carcass weight. The hot carcass was weighed (kg) by a digital balance. Dressing percentage was calculated as follows:

$$\text{Dressing percentage (DP)} = [\text{Warm carcass weight} / \text{Live weight}] \times 100$$

3.3.5.4.2 Dressing percentage of chilled carcass

Dressing percentage was calculated on the basis of chilled carcass weight. The chilled carcass was weighed (kg) by a digital balance. Dressing percentage was calculated as follows:

$$\text{Dressing percentage (DP)} = [\text{Chilled carcass weight} / \text{Live weight}] \times 100$$

3.3.5.5 Longissimus muscle area (LMA)

For measuring longissimus muscle area the warm carcass was split between 12th and 13th ribs. From the cross section the area was traced five times onto an acetate sheet and from the weight-area relationship of the acetate paper the average area of each single 'eye' was estimated.

$$\text{Longissimus muscle area (cm}^2\text{)} = [\text{Weight of acetate paper for total eye muscle area} / \text{Weight of acetate paper for one cm}^2\text{}]$$

3.3.5.6 Percent Kidney, Pelvic, Heart fat (%KPH)

It is the percentage of total fat found in the body cavity of a carcass specially in the regions of the kidneys, pelvis and heart. It was calculated based on the change in carcass weight following removal of fat from these areas on the carcass.

3.3.5.7 Fat thickness

Fat thickness was taken by a caliper averaging three points between the 12th and 13th ribs, but over the longissimus muscle.

3.3.5.8 Meat to bone ratio of different primal cuts

A sharp knife was used to separate muscle from bone to determine the meat bone ratio of different primal cuts.

3.3.5.9 USDA Yield Grade

The factors used to calculate yield grades include fat covers (FC), hot carcass weight (HCW), rib-eye-area (REA) and percent kidney, pelvic, heart fat (% KPH). The formula is as follows:

$$\text{USDA Yield Grade} = 2.5 + (2.5 \times \text{FC}) + (0.0038 \times \text{HCW}) + (0.2 \times \% \text{KPH}) - (0.32 \times \text{REA})$$

3.3.5.10 Retail Cut (%)

To calculate retail cut percentage the factors need to be used are fat covers (FC), hot carcass weight (HCW), rib-eye-area (REA) and percent kidney, pelvic, heart fat (% KPH). The formula is as follows:

$$\% \text{ Retail Cut} = 51.34 - (5.78 \times \text{FC}) - (0.0093 \times \text{HCW}) - (0.462 \times \% \text{KPH}) + (0.740 \times \text{REA})$$

3.3.6 Data analysis

Analysis of variance was carried out to compare the treatment means and determine level of significance by pooled analysis, completely randomized design (CRD) and Multiple t-test using statistical software SPSS version 20 and Microsoft Excel Software for Windows (SPSS Inc. 2007) (Albert *et al.*, 2008).

3.4 Experiment 3

Study on meat quality of indigenous and crossbred cattle reared under improved feeding system

3.4.1 Collection of meat samples for quality analysis

To determine meat quality and meat nutrients, samples of different cuts were kept at freezer immediately after processing for physical and chemical analyses. Meat samples for physical (pH, drip loss, cooking loss, marbling score and color) and chemical analysis i.e., proximate compositions, microbial quality and sensory evaluation, were taken from same region (*longissimus dorsi* muscle) of slaughtered bulls. Twenty gram of meat sample for proximate analysis, 10 g for pH, 60 g for drip loss, 100 g for cooking loss, 10 g for microbial quality determination and 400 g for sensory evaluation were taken from longissimus muscle of the animals. All the samples were weighed carefully and packed separately after labeling. Physical, chemical and microbial analyses of meat were performed in BLRI (Bangladesh Livestock Research Institute), Savar, Dhaka and sensory evaluation of meat was performed at Animal Science laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.4.2 Physical properties of meat

3.4.2.1 Meat pH determination

The pH of 24 hour postmortem (chilled meat) were recorded with a digital pH meter (Model no. HANNA Instruments, HI 2211 pH/Orp meter) following the method of University of Nebraska-Lincoln (2005). Before, taking reading, pH meter was calibrated with pH 7 and pH 4 standard buffer solutions. Meat samples (*longissimus dorsi* muscle between 12th and 13th ribs) were cut into small pieces and, small amount of 10 gm were weighed in a blender cup. Duplicates on each sample were taken. Ninety milliliter (90 ml) of distilled water was added and blended for 30 seconds on high speed. The sample was then transferred to a beaker and the pH was read as soon as possible.

3.4.2.2 Drip loss measurement

Drip losses of meat sample (*longissimus dorsi* muscle; 12th and 13th rib) were determined on the same day of slaughter. From each sample, a standardized muscle cylinder (weighing about 60 g) was suspended in an inflated plastic box (4° C) for 24 hours (30 hour postmortem). The percentage of drip loss was measured as described by Joo *et al.* (1995), where, drip loss (%) = [(sample weight - sample weight after 24 h)/sample weight] × 100.

3.4.2.3 Cooking loss measurement

Cooking losses of meat samples (*longissimus dorsi* muscle; 11th and 12th rib) were estimated 24 hours post mortem according to the procedures recommended by Yang *et al.* (2006). Meat samples weighing about 100 g were packed in a polyethylene zipper bag and then this bag was covered with another bag tying knot by a piece of string. Samples were cooked at a constant temperature of the water bath to obtain an internal temperature target of 70° C for 1 hour. Cooked samples were cooled into plastic box with two-third of ice-flex and one-third of water for at least 1 hour. Then sample was cooled at 4° C for 24 hours and then removed from the pack, surface dried, blotted with a paper towel and weighed. Cooking loss was determined by expressing cooked sample weight (B) as a percentage of precooked sample weight (A) following the procedure of Yang *et al.* (2006). Cooking loss (%) = [(A-B)/(A)] × 100.

3.4.2.4 Marbling score

Marbling or intramuscular fat is the estimate of the amount of fat present in the loin/rib-eye (*Longissimus dorsi*) muscle. Graders evaluate the amount of intramuscular fat at the cut surface of 12th to 13th ribs. Marbling was estimated by visual observation according to Burson, 2005. Marbling score was done from a 1 to 9 point scale between 12th and 13th rib eye muscle.

The marbling scores (least to greatest) are:

1. Practically Devoid (PD)
2. Traces (TR)
3. Slight (SL)
4. Small (SM)

5. Modest (MT)
6. Moderate (MD)
7. Slightly Abundant (SLAB)
8. Moderately Abundant (MDAB)
9. Abundant (AB)

3.4.2.5 Color

Color of different carcass meat were evaluated by visual appraisal following color score (3 to 5) according to Busboom and Reeves (2002). Where,

5 = very good

4.5 = good

4 = average

3.5 = below average

3 = inferior

3.4.3 Chemical properties of meat

Fresh meat samples (*Longissimus dorsi* muscle) from each experimental animal were analyzed for moisture, crude fat, crude protein and ash content by the standard AOAC procedure (2005).

3.4.3.1 Moisture

Moisture content was determined by placing an accurately weighed known amount sample (5 g) in a pre-weighed porcelain crucible in an electric oven at 105° C for about 24 hours until constant weight was obtained. The loss of moisture was calculated as percent moisture.

$$\text{Moisture content (\%)} = \frac{Y-Z}{S} \times 100$$

Here,

S= Sample weight (g)

Y= Crucible + Sample weight (g)

Z= Crucible + Dry Sample weight (g)

3.4.3.2 Crude protein

Crude protein was determined by the micro-Kjeldahl method. Total nitrogen content of each sample (1g) was determined in triplicate by using Kjeldahl apparatus. In this case total nitrogen was determined by digesting the sample with 20 ml concentrated Sulphuric acid (H_2SO_4) in presence of 100 g Potassium Sulphate (K_2SO_4), 10 g Copper Sulphate (Cu_2SO_4) and 1g Selenium Iodide followed by distillation of Ammonia liberated by alkali (NaOH) into Boric acid (H_3BO_4) and titrated with standard HCl (0.1N). The nitrogen values thus obtained were converted to total crude protein by multiplying with a factor of 6.25.

The formula is mentioned below-

$$\% \text{ of CP} = [\text{Titrated required (ml)} \times 0.014 \text{ (mili equivalent of } \text{N}_2) \times \text{Strength of HCl (0.1N)} \times \text{Conversion factor 6.25} / \text{Weight of sample}] \times 100$$

$$\% \text{ of } \text{N}_2 = [\text{Titrated required (ml)} \times 0.014 \text{ (mili equivalent of } \text{N}_2) \times \text{Strength of HCl (0.1N)} \times \text{Weight of sample}] \times 100$$

$$\text{So, Crude protein (CP \%)} = \% \text{ N}_2 \times \text{Conversion factor (6.25)}$$

3.4.3.3 Ash

Weighed dried samples were taken in porcelain crucibles and pre-ashes at 100°C in an electric oven. The crucibles were then placed in a muffle furnace and heated at 550°C for 6 hours. The crucibles were then cooled in desiccators. The average weight in percentage of each sample of the remaining material was taken as ash.

$$\text{Ash content (\%)} = \text{E/C} \times 100$$

Here,

E= Weight of ash (g)

C= Weight of Sample (g)

3.4.3.4 Ether extracts (EE)

Ether extract was determined by Soxhlet Apparatus using acetone. Meat sample (2 g) was taken in pre-weighed thimbles and was dipped in pre-weighed aluminum cups with 80 ml ether. First boiling then rinsing and finally extraction were done at $40\text{--}45^\circ \text{C}$ which took about 7 hours. After extraction the aluminum cups were taken out and dried in oven for 30 minutes at 100°C . The cup containing ether extract was cooled in a desiccator and weighed.

The calculated value for lipid content was obtained as percent of the sample according to following formula:

$$\text{Ether extract content (\%)} = [\text{Weight of lipid} / \text{Weight of the sample}] \times 100$$

3.4.4 Sensory evaluation

Sensory evaluations were conducted on the longissimus muscle of the prime rib cut (9th, 10th and 11th rib) from the left rib cut of the carcasses from bulls slaughter around four months of fattening. After trimming, left side *longissimus dorsi* muscle was labeled, packed with food grade polyethylene sheet, frozen and stored at -80° C until the sensory evaluations were made. Before the sensory evaluation, the longissimus muscles were thawed for 24 hours at a temperature of 4° C. 400 gm meat samples from each group of animals were cut to a uniform size (2cm × 2cm × 2cm cubes). The cubes were cooked along with similar quantities of soybean oil, salt, different spices, onion, garlic, ginger and green piper in a gas burner. However, the intensity of flame in burner was uniformed and cooked for 30 minutes. After cooking, cooked meat were held in a warming oven at 70° C until serve to panelists. A panel of 5 judges using a 5-point scale ranging from 1 to 5 was used to quantitatively determine the overall acceptability of the investigated cooked meat according to the procedure reported by Conte *et al.*, 2009. Moreover, panelists were also asked to judge the tenderness, chewiness, juiciness, fineness, mouth coating, flavor and color of each sample, thus considering their judge of the overall acceptability as an average of seven sensory attributes. During the test sessions, the samples presentation order was randomized.



Fig. 3.17 Uniform sized (2cm × 2cm × 2cm) cubes of meat cooked for sensory evaluation

3.4.5 Microbial analysis

3.4.5.1 Collection and transportation of samples

Beef samples were collected from *Longissimus dorsi* muscle of each bull between 12th and 13th rib. Samples were collected in sterile polythene zipper bags separately. The samples were transported carefully from Pabna Meat to BLRI (Bangladesh Livestock Research Institute), Savar, Dhaka for bacteriological analysis (Total Viable Count).

3.4.5.2 Processing of samples for TVC (Total Viable Count)

Antiseptic measures were undertaken during processing of samples to prevent contamination. A quantity of 10 gm of each raw beef samples were uniformly homogenized in mortar and pastel using a sterile diluent as per recommendation of ISO (1995). About 10 grams of sample was minced and grinded properly with 90 ml of sterile PBS using mortar and pastel. Thus 1:10 dilution of the samples was obtained. After that centrifugation of the mixtures was done at 1500 rpm for 10 minutes and the supernatants were taken in sterile test tubes. Then 0.5 ml supernatant was taken from each tube and a 10 fold serial dilution ranging from 10^{-2} to 10^{-6} of the samples was performed in 1% peptone water.

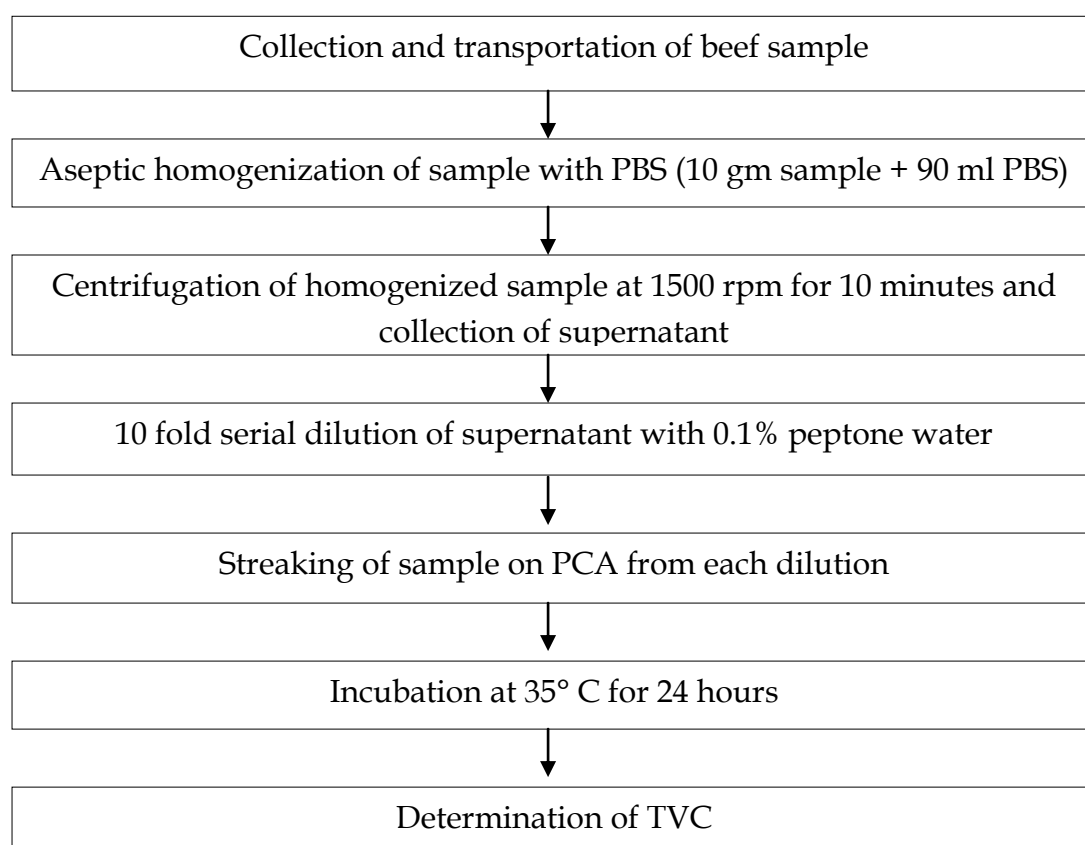


Fig. 3.18 Experimental protocol for determination of total viable count (TVC)

3.4.5.3 Media and reagents employed for TVC

a) Solid media

The media employed for this bacteriological analysis included Plate Count Agar (PCA). The commercial media was prepared according to the direction of the manufacturers. 11.50 gm of PCA was dissolved in 500 ml of cold distilled water in a conical flask and heated to boiling for dissolving the ingredients completely. After boiling the media was sterilized at 121°C (6.795 kg pressure/ sq inch) in an autoclave. The agar was then ready for pouring.

Composition of Plate count agar (PCA)

Casien enzyme hydrolysate	5.0 gm
Yeast extract	2.5 gm
Dextrose	1.0 gm
Agar	15.0 gm
Final pH	7.0 ± 0.2

b) Reagents

The reagents used during the study were 0.1% peptone water and PBS (Phosphate Buffer Saline) solution. The formula

i) Phosphate buffered saline solution

Sodium chloride	8.0	gm
Disodium hydrogen Phosphate	2.8	gm
Potassium chloride	0.2	gm
Potassium dihydrogen phosphate	0.2	gm
Distilled water to make	1000	ml

ii) 0.1% Peptone water

Peptone	1.0 gm
Distilled water	1000 ml

3.4.5.4 Determination of total viable count (TVC)

For the determination of total bacterial count 0.5 ml of each 10 fold dilution was poured and spread on plate count agar (PCA) using a micropipette for each dilution. The diluted samples were spread as quickly as possible on the surface of the plate with sterile glass spreader. The plates were kept in an incubator at 37° C for 24 hrs. After incubation, plates exhibiting 30-300 colonies were counted. The average number of colonies in particular dilution was multiplied by the dilution factor to obtain the total viable count which was expressed in a $\log_{10} \pm \text{SD}$ colony forming unit (CFU) per ml. The total viable count was calculated according to ISO (1995).

3.4.6 Data analysis

Data were presented as means and standard error of the means (SEM). Data of physical, chemical, microbial and sensory quality of meat were analyzed for determining significant differences in treatment response using analysis of variance with statistical software SPSS version 20 and Microsoft Excel Software for Windows (SPSS Inc. 2007) (Albert *et al.*, 2008).

3.5 Experiment 4

Study on cost benefit analysis of indigenous and crossbred cattle reared under improved feeding system

The total cost of rearing an individual animal including cattle, feed, de-worming, vaccination and sale price were recorded properly. Then the economic analysis was performed using the recorded data.

3.5.1 Economic analysis on the basis of feed cost

Economic analyses were done considering the feed cost. The costs of concentrate mixtures, straw and grass were calculated as 19.89 BDT/kg DM, 2.15 BDT/kg DM and 5.94 BDT/kg DM respectively. Thus, the costs of diet were calculated as 8.63 BDT, 9.57 BDT, 10.31 BDT and 10.74 BDT for per kg DM of T₀, T₁, T₂, and T₃, respectively for indigenous bulls; whereas the costs of diets were: 8.24 BDT/kg DM of diet T₀, 9.14 BDT/kg DM of diet T₁, 10.15 BDT/kg DM of diet T₂ and 10.19 BDT/kg DM of diet T₃ for crossbred bulls. The gain cost was calculated according to the following equation:

$$\text{Gain cost (BDT/kg gain)} = [\text{total DMI (kg)} \times \text{cost/kg of diet DM}] / \text{total LWG}$$

3.5.2 Measurement of Costs and Returns

The cost benefit analysis was modeled in terms of direct, indirect cost and returning variables and other factors considering of cattle fattening program in this study. The economic analysis of the determinants was done according to Sarma and Ahmed (2011) by using following equations:

$$\text{Total Cost} = \text{Direct Cost} + \text{Indirect Cost}$$

$$\text{Gross Return} = \text{Direct Return} + \text{Indirect Return}$$

$$\text{Net Return} = \text{Gross Return} - \text{Total Cost}$$

In this study, costs of cattle, feed (grass price, straw price and concentrate price), deworming and vaccination were considered as direct costs; while interest on capital, tax and transportation cost were considered as indirect costs. Total cost was calculated by using direct and indirect costs. Sale price of fattened cattle and sale price of manure were considered as direct return and indirect return respectively, which were used to calculate the gross return. The net return in this study was measured by subtracting the total cost from the gross return.

3.5.3 Data analysis

The data of cost and return of cattle fattening program in the present study were recorded and were subjected to statistical analysis using SPSS software version 20 and Microsoft Excel Software for Windows (SPSS Inc. 2007) (Albert *et al.*, 2008).

CHAPTER IV

RESULT AND DISCUSSION

In this chapter the findings of the study and their logical interpretation have been presented as found to satisfy the objectives of the study and findings have been discussed in relation to other similar studies.

4.1 Survey in Raiganj upazila of Sirajganj district

4.1.1 Socio-economic conditions of the farmers

Information on farmers' occupation, family size, land size, level of education and annual income were recorded and presented as follows.

4.1.1.1 Occupation

Distribution of farmers according to their occupation is presented in Table 4.1.1. It was found that in village Kathalbaria and Char Faridpur average 40.5% respondents considered agriculture as their main occupation. Average 46% respondents in both villages adopted livestock rearing and agriculture for their livelihood. Overall mean respondents of both villages considered business and others were 7% and 6.5%, respectively. Rahman (2012) reported that, out of the 75 respondents from three Upazila (Birganj, Kaharul and Khansama) of Dinajpur district 54.7% were involved in agriculture, 26.7% in business, 13.3% in service and 5.3% in beef fattening. Hossain (2013) found 70% respondents to be involved in agriculture, 23% in business and 7% in government job out of 30 respondents of Shahjadpur upazila of Sirajganj district.

Table 4.1.1 Distribution of the occupation of the farmers (n = 100)

Occupation	% of respondents		
	Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Agriculture	42	39	40.5
Agriculture + Livestock rearing	44	48	46
Business	8	6	7
Others	6	7	6.5

4.1.1.2 Family size

The data on family size of the respondents are presented in Table 4.1.2. On the basis of family member, the families were classified into three categories. Majority of the respondents had small sized family (average 47%) in both villages (Kathalbaria and Char Faridpur) followed by medium (average 38%) and large sized family (average 15%). The result was almost similar to Hossain (2013) who found small (up to 5 members), medium (6-8 members) and large (above 8 members) family size of 43%, 37% and 20% of respondents, respectively.

Table 4.1.2 Distribution of the farmers according to family size (n = 100)

Family size	% of respondents		
	Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Small (up to 4)	50	44	47
Medium (5 to 6)	34	42	38
Large (7 to above)	16	14	15

4.1.1.3 Land size

Table 4.1.3 shows the distribution of farmers according to their land size. Most of the farmers in both villages were small farmers (64%) followed by landless (26%) and medium farmers (10%) in the present study. Similarly, Hossain (2013) found the major category (40%) of the farmers belonged to small class which was also a representative of typical land size of Bangladesh of about 23% marginal, 30% medium and 7% large land size.

Table 4.1.3 Distribution of the farmers according to their land size (n = 100)

Land size (acres)	% of respondents		
	Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Landless (0 to 0.49)	22	30	26
Small (0.5 to 2.49)	66	62	64
Medium (2.5 to 7.49)	12	8	10

4.1.1.4 Annual income

Distribution of the farmers according to their annual income is shown in Table 4.1.4. The farmers were divided into three categories i.e. low income, medium income and high income. Most of the respondents of village Kathalbaria and Char Faridpur (average 76%) were belonged to medium income category followed by low income category (average 18%) and high income category (average 6%).

Table 4.1.4 Distribution of the farmers according to their annual income (BDT) (n = 100)

Annual income (BDT)	% of respondents		
	Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Low income (0 to 50,000)	14	22	18
Medium income (50,000 to 100,000)	82	70	76
High income (> 100,000)	4	8	6

4.1.1.5 Educational level

The farmers were classified into five categories on the basis of their level of education (Table 4.1.5). The results revealed that, the percentage of the respondents for these 5 categories were 14%, 49%, 25%, 9% and 3% for illiterate, can sign only, class V, class X and SSC level of

education, respectively. Begum *et al.* (2007), Rahman (2012) and Hossain (2013) found higher percentage for primary level of education (40%, 47% and 72%, respectively) than the present study. Begum *et al.* (2007) found 20% illiterate respondents which is almost similar to this study. Rahman (2012) and Hossain (2013) found higher percentage of respondents for SSC level of education (26.7% and 33%, respectively); they also found 1.3% and 20% respondents had HSC level of education, which were different from the present study.

Table 4.1.5 Educational level of farmers in two selected village under Raiganj upazila of Sirajganj district (n = 100)

Educational status	% of respondents		
	Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Illiterate	18	10	14
Can sign only	40	58	49
Class V	30	20	25
Class X	8	10	9
S.S.C	4	2	3

4.1.2 Check list of beef cattle production

4.1.2.1 Source of capital

The source of capital for beef cattle production varied from farmers to farmers. Table 4.1.6 showed that most of the respondents of both villages (average 59%) took loan from NGOs, followed by 29% used own capital and 12% respondents took bank loan for beef cattle production. Begum *et al.* (2007) and Hossain (2013) reported that, higher percentage of respondents used their own capital (86.7% and 76%, respectively) than the present study for beef cattle production. Almost similar percentage of respondents (17%) took bank loan and lower percentage of respondents (7%) took loan from NGO for cattle fattening reported by Hossain (2013).

Table 4.1.6 Distribution of respondents according to source of capital, training, training duration and duration of fattening program (n = 100)

Parameter	Categories	% of respondents		
		Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Source of capital	Own capital	34	24	29
	Bank loan	10	14	12
	NGO loan	56	62	59
Training	Yes	100	100	100
	No	0	0	0
Training duration	3 days	64	78	71
	6 days	36	22	29
Duration of fattening	4 months	28	42	35
	6 months	34	22	28
	> 6 months	38	36	37

4.1.2.2 Training

All the respondents from village Kathalbaria and Char Faridpur were trained for cattle fattening (Table 4.1.6). In both villages, 71% of respondents had 3 days training experience while 29% respondents had 6 days training experience on cattle fattening. Whereas, Begum *et al.* (2007) reported that, about 76.7% farmers had short training experience. Unlikely to the present study Hashem *et al.* (1999) reported only 8% farmers had beef fattening training in different districts of Bangladesh. Hossain (2013) also found that, only 7% respondents had short time training experience for 3-7 days.

4.1.2.3 Duration of fattening

Table 4.1.6 showed that 35%, 28% and 37% farmers fattened cattle for 4 months, 6 months and more than 6 months, respectively. Begum *et al.* (2007) reported that, 60% and 30% farmers fattened cattle for 3-6 months and 7-12 months, respectively. Hossain (2013) also reported that, 37% farmers fattened their cattle for 6 months, 53% for 3 months and 10% for more than 6 months.

4.1.2.4 Origin of beef cattle

Two types of genotypes were included in this study, i.e. indigenous and crossbred (L × HF). Table 4.1.7 showed that average 55% farmers used indigenous cattle and 45% farmers used crossbred cattle in both villages for fattening. On the other hand Rahman (2012) reported that, 28% respondents reared indigenous, 12% crossbred and 60% respondents reared both of indigenous and crossbred cattle for fattening. Hossain (2013) also found most of the farmers used crossbred (88%) cattle and only 12% indigenous cattle used for beef cattle production. Table 4.1.7 also showed that, 64% respondents had own source of beef cattle while 36% respondents purchased their cattle occasionally from market or other farmers for fattening. Similarly, Hossain (2013) reported that, 63% farmers used own source of cattle and 37% farmers purchased cattle occasionally for beef cattle production.

4.1.2.5 Livestock breeding

Table 4.1.7 showed that on average majority of the farmers (68%) of both villages used artificial insemination (AI) method for cattle breeding, 13% farmers used natural breeding, 19% farmers used both methods for beef cattle production. Similar result was found by Hossain (2013) who reported that the percentage of farmers applied artificial insemination, natural service and both were 73%, 13% and 14%, respectively for cattle breeding.

Table 4.1.7 Origin, source and breeding method of livestock in two selected village under Raiganj upazila of Sirajganj district (n = 100)

Parameters	Categories	% of respondents		
		Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n= 100)
Origin of cattle	Indigenous	62	48	55
	Crossbred (L×HF)	38	52	45
Source of beef cattle	Own source	68	60	64
	Purchase	32	40	36
Breeding method	Natural	10	16	13
	A.I	72	64	68
	Natural and A.I	18	20	19

4.1.2.6 Livestock feeds and fodder

Table 4.1.8 showed that 51% farmers in village Kathalbaria and Char Faridpur fed cultivated fodder like Napier, Jambo, Maize, Kheshari etc, while 25% farmers supplied roadside grasses and 24% used both cultivated and roadside grass for beef cattle production. Different concentrates including wheat bran, rice polish/bran, Kheshari bran, til oil cake, mustard oil cake and common salt etc. supplied by 97% farmers, whereas only 3% farmers fed compound feed to cattle for fattening. Among them 72% farmers purchased the concentrate ingredients from local market when 28% farmers had own source of production. Vitamin and minerals were provided to the cattle by 63% farmers and 37% farmers did not use vitamin and mineral supplementation. All the farmers of both villages used fertilizer for production of feeds and fodder. Hossain (2013) reported that, most of the farmers (83%) used cultivated fodder like Napier, Jambo, Maize, Kheshari etc. and only 17% farmers used both cultivated and roadside grasses; and almost all farmers used own prepared mixed feed which are in agreement with the present study. Most of the farmers (63%) did not use vitamin and mineral supplements to the animals, which is unlikely to the present study. All the respondents used fertilizer for fodder production in this study. Similar result was reported by Hossain (2013).

Table 4.1.8 Feeds and fodder of livestock in two selected villages under Raiganj Upazilla of Sirajganj district (n = 100)

Parameter	Categories	% of respondents		
		Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Roughage	Roadside grass	28	22	25
	Cultivated fodder	44	58	51
	Both	28	20	24
Concentrate	Compound feed	4	2	3
	Mixed feed	96	98	97
Source of concentrate	Own production	22	34	28
	Buy Locally	78	66	72
Vitamin mineral supplement	Yes	76	50	63
	No	24	50	37
Fertilizer use	Yes	100	100	100
	No	0	0	0

4.1.2.7 Livestock health

Table 4.1.9 showed that about 61% farmers of two villages vaccinated their cattle regularly, while others did not vaccinate their beef cattle. Most of the farmers (88%) did not use hormones and growth promoters, but 12% farmers used hormones and growth promoters for cattle fattening. Most of the farmers (63%) de-wormed their cattle regularly, while 37% farmers did not. Similarly Hashem *et al.* (1999) found 61.2% farmers de-wormed their cattle before starting the fattening program, but unlikely to the present study 72.8% farmers did not vaccinate their beef cattle. Begum *et al.* (2007) also reported that most of the farmers (80%) de-wormed their beef cattle. Unlikely to the present study, Hossain (2013) reported that most of the farmers (70%) used hormones, antibiotic and growth promoters for cattle fattening in Shahjadpur upazila of Sirajganj district and most of the farmers (87%) vaccinated their beef cattle. Rahman (2012) also revealed that higher percentage (90.7%) of farmers vaccinated their cattle in Dinajpur district.

Table 4.1.9 Livestock health in two selected villages under Raiganj upazila of Sirajganj district (n = 100)

Parameter	Categories	% of respondents		
		Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Vaccination	Yes	68	54	61
	No	32	46	39
Hormone, and growth promoter	Yes	10	14	12
	No	90	86	88
Deworming	Yes	60	66	63
	No	40	34	37

4.1.2.8 Record keeping

Table 4.1.10 showed that on average only 6% farmers of Kathalbaria and Char Faridpur villages kept birth record, breeding record, feed record, health record etc. while most of the farmers (94%) did not keep their livestock record. This result was similar to the report of Hossain (2013) who found most of the farmers (97%) did not keep any livestock record.

Table 4.1.10 Record keeping of livestock in two selected villages under Raiganj upazila of Sirajganj district (n = 100)

Parameter	Categories	% of respondents		
		Kathalbaria (n = 50)	Char Faridpur (n = 50)	Overall mean (n = 100)
Record keeping	Yes	7	5	6
	No	93	95	94

4.1.3 Farmer selection

After surveying the above areas 100 farmers were found to perform beef fattening. Among them 40 farmers were selected who were co-operative and interested in improved beef fattening system according to the requirement of the experiment.

4.2 Experiment 1

A comparative study on feeding plans of nutrition, intake, growth and feed conversion efficiency of indigenous and crossbred bull

4.2.1 Nutrient intake

4.2.1.1 Daily feed nutrient intake by indigenous and crossbred bulls under different feed treatment groups

Daily intake of feed nutrients by indigenous and crossbred bulls of different treatment groups is shown in table 4.2.1. Significant difference ($p < 0.01$) in fresh grass intake was found among different feed treatment groups of indigenous and crossbred bulls. Treatment group T₃ of crossbred bulls had the highest fresh grass intake (27.74 kg/d) and control group T₀ of indigenous bulls had the lowest fresh grass intake (9.08 kg/d). Similarly grass DM intake (kg/d) and daily grass DM intake as percent live weight differed significantly ($p < 0.01$) among different treatment groups. Grass DM intake (kg/d) was highest (4.38 kg/d) in T₃ group of crossbred bulls and lowest (1.64 kg/d) in T₀ group of indigenous bulls. The daily grass DM intake as percent live weight was highest (1.32%) in T₁ group of indigenous bulls and lowest (0.55%) in T₀ crossbred bulls. Daily straw intake (kg/d), straw DM intake (kg/d) and the daily straw DM intake as percent live weight were also varied significantly ($p < 0.01$) among different treatment groups. Daily straw intake was highest (3.24 kg/d) in T₃ group of crossbred bulls and lowest (1.40 kg/d) in T₃ group of indigenous bulls; straw DM intake (kg/d) was highest (2.82 kg/d) in T₃ group of crossbred bulls and lowest (1.22 kg/d) in T₃ group of indigenous bulls; and the daily straw DM intake as percent live weight was highest (0.82%) in T₀ group of crossbred bulls and lowest (0.44%) in T₃ group of indigenous bulls. The animals also received a concentrate mixture at the rate of 1.5% of their live weight. Daily concentrate intake (kg/d), concentrate DM intake (kg/d) and daily concentrate DM intake as percent live weight had significant ($p < 0.01$) differences among different feed treatment groups. Daily concentrate intake (kg/d) was highest (4.11 kg/d) in T₃ group of crossbred bulls and lowest (2.28 kg/d) in T₀ group of indigenous bulls; concentrate DM intake (kg/d) was highest (3.79 kg/d) in T₃ group of crossbred bulls and lowest (2.17 kg/d) in T₀ group of indigenous bulls; and daily concentrate DM intake as percent live weight was highest (0.95%) in group T₂ of crossbred bulls and lowest (0.74%) in group T₀ of crossbred bulls.

Table 4.2.1 Daily intake of feed nutrient by indigenous and crossbred bulls under different feed treatment groups

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Fresh grass intake (kg/ d)	9.08 ^d ±1.26	18.09 ^c ±1.24	21.46 ^b ±1.41	21.39 ^b ±1.88	10.36 ^d ±2.68	23.88 ^b ±1.89	26.45 ^a ±1.38	27.74 ^a ±2.88	1.31	**
Grass DMI (kg/ d)	1.64 ^c ±0.23	3.26 ^b ±0.22	3.39 ^b ±0.22	3.38 ^b ±0.30	1.87 ^c ±0.48	4.30 ^a ±0.34	4.17 ^a ±0.22	4.38 ^a ±0.45	0.22	**
Grass DMI (%LW)	0.67 ^c ±0.08	1.32 ^a ±0.07	1.29 ^a ±0.07	1.20 ^{ab} ±0.07	0.55 ^d ±0.14	1.26 ^a ±0.11	1.11 ^b ±0.07	1.08 ^b ±0.11	0.06	**
Straw intake (kg/ d)	1.75 ^{bc} ±0.10	1.92 ^b ±0.25	1.53 ^c ±0.23	1.40 ^c ±0.34	3.21 ^a ±0.12	2.98 ^a ±0.32	3.11 ^a ±0.025	3.24 ^a ±0.46	0.19	**
Straw DMI (kg/ d)	1.52 ^{bc} ±0.09	1.67 ^b ±0.22	1.34 ^c ±0.20	1.22 ^c ±0.29	2.80 ^a ±0.11	2.60 ^a ±0.28	2.71 ^a ±0.21	2.82 ^a ±0.40	0.16	**
Straw DMI (%LW)	0.62 ^c ±0.04	0.68 ^{bc} ±0.10	0.51 ^d ±0.08	0.44 ^d ±0.11	0.82 ^a ±0.03	0.76 ^{ab} ±0.08	0.72 ^{ab} ±0.06	0.70 ^{bc} ±0.10	0.05	**
Conc. Intake (kg/ d)	2.28 ^f ±0.11	2.41 ^{ef} ±0.10	2.46 ^e ±0.03	2.74 ^d ±0.09	2.67 ^d ±0.06	3.41 ^c ±0.09	3.88 ^b ±0.18	4.11 ^a ±0.12	8.54	**

Conc. DMI (kg/ d)	2.17 ^e ±0.11	2.18 ^e ±0.08	2.22 ^e ±0.03	2.48 ^d ±0.08	2.54 ^d ±0.06	3.14 ^c ±0.08	3.57 ^b ±0.16	3.79 ^a ±0.11	0.06	**
Conc. DMI (%LW)	0.89 ^b ±0.07	0.89 ^b ±0.05	0.85 ^c ±0.03	0.88 ^{bc} ±0.02	0.74 ^d ±0.01	0.92 ^{ab} ±0.01	0.95 ^a ±0.02	0.94 ^a ±0.01	0.02	**
Ipil ipil leaf intake (kg/ d)	-	-	-	0.30±0.14	-	-	-	0.30±0.07	-	NS
Ipil ipil leaf DMI (kg/ d)	-	-	-	0.08±0.00	-	-	-	0.08±0.00	-	NS
Total DMI (kg/ d)	5.32 ^d ±0.25	7.11 ^c ±0.08	6.95 ^c ±0.12	7.13 ^c ±0.17	7.20 ^c ±0.62	10.41 ^b ±0.03	10.53 ^b ±0.09	11.07 ^a ±0.20	0.003	**
Total DMI (%LW)	2.19 ^f ±0.12	2.90 ^b ±0.05	2.65 ^{de} ±0.07	2.54 ^e ±0.05	2.10 ^f ±0.17	3.06 ^a ±0.07	2.81 ^{bc} ±0.05	2.73 ^{cd} ±0.03	0.0001	**

LW = Live Weight, DMI = Dry Matter Intake, T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means,

******= Significant at 1% level of probability (p<0.01), **NS** = Not Significant (p>0.05),

Values having different superscripts in the same row differ significantly.

Ipil ipil leaf was received by T₃ groups of both indigenous and crossbred bulls. Ipil ipil leaf intake did not differ significantly ($p>0.05$) between these two groups. Finally, total dry matter intake (kg/d) and daily total DM intake as percent live weight were calculated and the values had significant ($p<0.01$) differences among different treatment groups. Result showed that, daily intake of total DM was highest (11.07 kg/d) in T₃ group of crossbred bulls and lowest (5.32 kg/d) in T₀ group of indigenous bulls; and daily total DM intake as percent live weight was highest (3.06%) in T₁ group and lowest (2.10%) in T₀ group of crossbred bulls.

4.2.1.2 Daily feed nutrient intake by indigenous bulls under different treatment groups

Table 4.2.2 showed that, daily fresh grass intake was significantly ($p<0.01$) higher (21.46 kg/d) in group T₂ and lower (0.08 kg/d) in group T₀; and daily grass DM intake (kg/d) was significantly ($p<0.01$) higher (3.39 kg/d) in group T₂ and lower (1.64 kg/d) in group T₀. However, daily grass DM intake as percent live weight did not differ significantly ($p>0.05$) among different groups. Daily straw intake, daily straw DM intake and daily intake of straw DM as percent live weight had significant ($p<0.01$) differences among the groups of indigenous bulls. Daily straw intake, daily straw DM intake and daily intake of straw DM as percent live weight were highest (1.92 kg/d, 1.67 kg/d and 0.68%, respectively) in T₁ group and lowest (1.40 kg/d, 1.22 kg/d and 0.44%, respectively) in T₃ group. Daily concentrate intake and daily intake of concentrate DM were differed significantly ($p<0.05$) among the groups; and the values were highest (2.74 kg/d and 2.48 kg/d, respectively) in group T₃ and lowest (2.28 kg/d and 2.17 kg/d, respectively) in group T₀. The daily concentrate DM intake as percent live weight was also varied significantly ($p<0.01$) among the groups; and highest value (0.89%) was in group T₀ and T₁, and lowest value (0.85) was in group T₂. Ipil ipil leaf intake (kg/d) and Ipil ipil leaf DM intake (kg/d) had no significant differences. Finally, result showed that daily total DM intake and daily total DM intake as percent live weight differed significantly ($p<0.01$) among different groups of indigenous bulls. The highest daily total DM intake was found in group T₃ (7.13 kg/d) and lowest was found in group T₀ (5.32 kg/d); whereas the highest daily total DM intake as percent live weight was found in group T₁ (2.90%) and lowest value was found in group T₀ (2.19%).

Table 4.2.2 Daily feed nutrient intake by indigenous bulls under different feed treatment groups

Parameters	Indigenous				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Fresh grass intake (kg/d)	9.08 ^c ±1.26	18.09 ^b ±1.24	21.46 ^a ±1.41	21.39 ^a ±1.88	1.04	**
Grass DMI (kg/d)	1.64 ^b ±0.23	3.26 ^a ±0.22	3.39 ^a ±0.22	3.38 ^a ±0.30	0.17	**
Grass DMI (%LW)	0.67±0.08	1.32±0.07	1.29±0.07	1.20±0.07	0.05	NS
Straw intake (kg/d)	1.75 ^{ab} ±0.10	1.92 ^a ±0.25	1.53 ^{bc} ±0.23	1.40 ^c ±0.34	0.17	**
Straw DMI (kg/d)	1.52 ^{ab} ±0.09	1.67 ^a ±0.22	1.34 ^{bc} ±0.20	1.22 ^c ±0.29	0.15	**
Straw DMI (%LW)	0.62 ^{ab} ±0.04	0.68 ^a ±0.10	0.51 ^{bc} ±0.08	0.44 ^c ±0.11	0.06	**
Conc. Intake (kg/d)	2.28 ^c ±0.11	2.41 ^b ±0.10	2.46 ^b ±0.03	2.74 ^a ±0.09	0.06	*
Conc. DMI (kg/d)	2.17 ^b ±0.11	2.18 ^b ±0.08	2.22 ^b ±0.03	2.48 ^a ±0.08	0.06	*
Conc. DMI (%LW)	0.89 ^a ±0.07	0.89 ^a ±0.05	0.85 ^b ±0.03	0.88 ^{ab} ±0.02	0.03	**
Ipil ipil leaf intake (kg/d)	-	-	-	0.30±0.14	-	NS
Ipil ipil leaf DMI (kg/d)	-	-	-	0.08±0.00	-	NS
Total DMI (kg/d)	5.32 ^c ±0.25	7.11 ^a ±0.08	6.95 ^b ±0.12	7.13 ^a ±0.17	0.12	**
Total DMI (%LW)	2.19 ^c ±0.12	2.90 ^a ±0.05	2.65 ^b ±0.07	2.54 ^{bc} ±0.05	0.05	**

LW = Live Weight, DMI = Dry Matter Intake, T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means,

* = Significant at 5% level of probability (p<0.05), ** = Significant at 1% level of probability (p<0.01),

NS = Not significant (p>0.05);

In a row values with dissimilar letter differ significantly.

4.2.1.3 Daily intake of feed nutrient by crossbred bulls under different feed treatment groups

Table 4.2.3 showed daily fresh grass intake, grass DM intake and daily grass DM intake as percent live weight differed significantly ($p<0.01$) among different groups of crossbred bulls. Daily fresh grass intake (kg/d) and daily grass DM intake (kg/d) were highest (27.74 kg/d and 4.38 kg/d, respectively) in group T_3 and lowest (4.38 kg/d and 1.87 kg/d, respectively) in group T_0 ; and daily grass DM intake as percent live weight was highest (1.11%) in group T_2 and lowest (0.55%) in group T_0 . Daily straw intake, daily straw DM intake and daily intake of straw DM as percent live weight did not differ significantly among the groups of crossbred bulls. Daily concentrate intake, daily intake of concentrate DM and daily intake of concentrate DM as percent live weight had significant ($p<0.01$) differences among the groups of animals. Daily concentrate intake and daily intake of concentrate DM were highest in group T_3 (4.11 kg/d and 3.79 kg/d, respectively) and lowest in group T_0 (2.67 kg/d and 2.54 kg/d, respectively); whether the daily concentrate DM intake as percent live weight was highest (0.95%) in group T_2 and lowest (0.74%) in group T_0 . Ipil ipil leaf intake (kg/d) and Ipil ipil leaf DM intake (kg/d) did not differ significantly. Finally daily total DM intake and daily total DM intake as percent live weight differed significantly ($p<0.01$) among different groups of crossbred bulls. The highest daily total DM intake was found in group T_3 (11.07 kg/d) and lowest was found in group T_0 (7.20 kg/d); whereas the highest daily total DM intake as percent live weight was found in group T_1 (3.06%) and lowest value was found in group T_0 (2.10%).

Table 4.2.3 Daily intake of feed nutrient by crossbred bulls under different feed treatment groups

Parameters	Crossbred				SEM	Sig. level
	T_0 (Mean±SD)	T_1 (Mean±SD)	T_2 (Mean±SD)	T_3 (Mean±SD)		
Fresh grass intake (kg/d)	10.36 ^d ±2.68	23.88 ^c ±1.89	26.45 ^b ±1.38	27.74 ^a ±2.88	1.616	**
Grass DMI (kg/d)	1.87 ^b ±0.48	4.30 ^a ±0.34	4.17 ^a ±0.22	4.38 ^a ±0.45	0.274	**
Grass DMI (%LW)	0.55 ^c ±0.14	1.26 ^a ±0.11	1.11 ^b ±0.07	1.08 ^b ±0.11	0.077	**
Straw intake	3.21±0.12	2.98±0.32	3.11±0.0.25	3.24±0.46	0.220	NS

(kg/d)						
Straw DMI (kg/d)	2.80±0.11	2.60±0.28	2.71±0.21	2.82±0.40	0.191	NS
Straw DMI (%LW)	0.82±0.03	0.76±0.08	0.72±0.06	0.70±0.10	0.050	NS
Conc. Intake (kg/d)	2.67 ^d ±0.06	3.41 ^c ±0.09	3.88 ^b ±0.18	4.11 ^a ±0.12	0.087	**
Conc. DMI (kg/d)	2.54 ^b ±0.06	3.14 ^{ab} ±0.08	3.57 ^a ±0.16	3.79 ^a ±0.11	0.077	**
Conc. DMI (%LW)	0.74 ^b ±0.01	0.92 ^a ±0.01	0.95 ^a ±0.02	0.94 ^a ±0.01	0.007	**
Ipil ipil leaf intake (kg/d)	-	-	-	0.30±0.07	-	NS
Ipil ipil leaf DMI (kg/d)	-	-	-	0.08±0.00	-	NS
Total DMI (kg/d)	7.20 ^c ±0.62	10.41 ^b ±0.03	10.53 ^b ±0.09	11.07 ^a ±0.20	0.232	**
Total DMI (%LW)	2.10 ^c ±0.17	3.06 ^a ±0.07	2.81 ^b ±0.05	2.73 ^b ±0.03	0.067	**

LW = Live Weight, DMI = Dry Matter Intake, T₀ = Treatment Group 0, T₁ = Treatment Group 1,

T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means,

****** = Significant at 1% level of probability (p<0.01), **NS** = Not significant (p>0.05);

In a row values with dissimilar letter differ significantly.

4.2.1.4 Comparison of the daily intake of feed nutrients between indigenous and crossbred bulls

Table 4.2.4 showed that, the daily fresh grass intake and daily grass DM intake differed significantly (p<0.05) between the indigenous and crossbred bulls; whereas the daily grass DM intake as percent live weight did not differ significantly (p>0.05). However, the differences of daily straw intake, straw DM intake (kg/d) and the daily intake of straw DM as percent live weight were significant (p<0.01) between these two groups. Daily concentrate intake and concentrate DM intake had significant (p<0.01) differences among indigenous and crossbred bulls. However, difference of daily concentrate DM intake as percent live weight did not differ significantly among these groups. Ipil ipil leaf intake (kg/d) and Ipil ipil leaf DM intake (kg/d) did not differ significantly between these two groups. Daily intake of total DM was significantly (p<0.01) higher (9.80 kg/d) in crossbred

bulls, and lower in indigenous bulls; but daily intake of total DM as percent live weight had no significant difference between two breeds.

Table 4.2.4 Comparison of the daily intake of feed nutrient between indigenous and crossbred bulls considering all treatment groups

Parameters	Breed		P Value	Level of sig.
	Indigenous (Mean±SD)	Crossbred (Mean±SD)		
Fresh grass intake (kg/d)	17.50±5.35	22.11±7.41	0.030	*
Grass DMI (kg/d)	2.91±0.79	3.68±1.13	0.018	*
Grass DMI (%LW)	1.12±0.28	1.00±0.30	0.193	NS
Straw intake (kg/d)	1.65±0.30	3.14±0.30	0.000	**
Straw DMI (kg/d)	1.44±0.26	2.73±0.26	0.000	**
Straw DMI (%LW)	0.56±0.13	0.75±0.08	0.000	**
Conc. Intake (kg/d)	2.48±0.19	3.52±0.58	0.000	**
Conc. DMI (kg/d)	2.26±0.15	3.26±0.50	0.000	**
Conc. DMI (%LW)	0.88±0.05	0.89±0.09	0.625	NS
Ipil ipil leaf intake (kg/d)	0.08±0.00	36.00±0.71	-	NS
Ipil ipil leaf DMI (kg/d)	0.30±0.07	0.08±0.00	-	NS
Total DMI (kg/d)	6.63±0.79	9.80±1.59	0.000	**
Total DMI (%LW)	2.57±0.27	2.68±0.37	0.301	NS

LW = Live Weight, DMI = Dry Matter Intake,

* = Significant at 5% level of probability (p<0.05), ** = Significant at 1% level of probability (p<0.01),

NS = Not significant (p>0.05)

Multiple regression analysis revealed that total DM intake (% LW) was positively correlated with CP intake (g/day) and ME intake (MJ/day) ($R^2 = 0.38$ and 0.43 , respectively), but the correlation was not significant (Fig. 4.1). Similar non-significant correlation between CP intake (g/d) and DM intake (%BW), and between ME intake (MJ/d) and DM intake (%BW) were reported by Islam (2010).

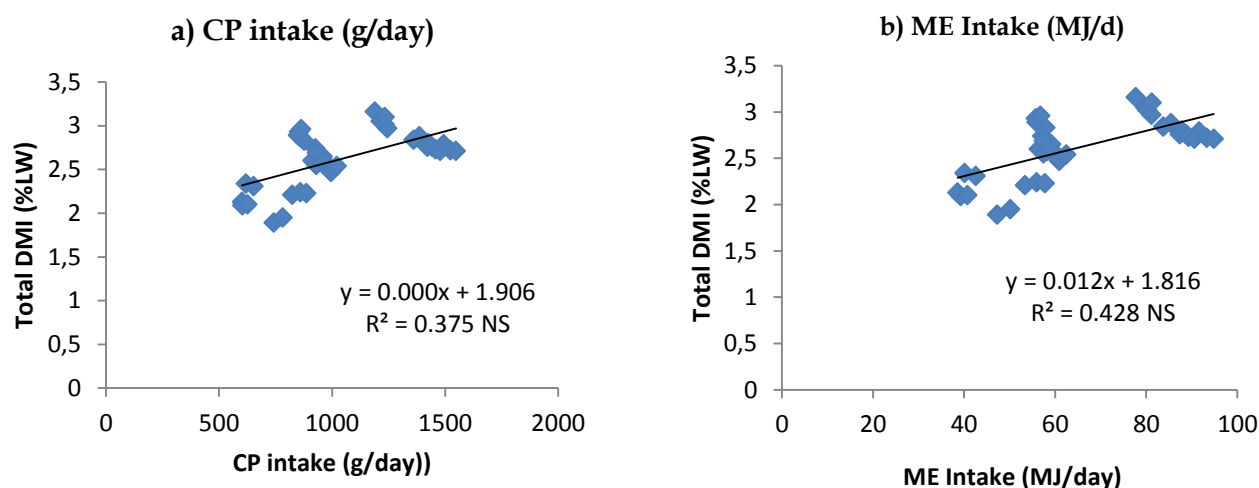


Fig. 4.1 Relationship between total DM intake (% LW) and **a)** crude protein intake (g/ day) and **b)** metabolizable energy intake (MJ/ day)

Feed treatment had significant effect ($p < 0.01$) on daily intake of total dry matter (kg/d) and DM intake as percent live weight both for indigenous and crossbred bulls in this study. Rashid *et al.* (2015b) also reported significant differences ($p < 0.05$) of DM intake per day for three diets of experimental animals, where CON-UMS diet (50% concentrate + 50% Urea Molasses Straw) group showed highest DM intake of 10.2 kg/d or 2.69% of live weight, followed by 100% concentrate diet group (CON) - 7.56 kg/d or 1.99% LW, and 100% UMS diet group - 6.71 kg/d or 1.94% LW respectively. But, Rashid *et al.* (2015a) and Zahradkova *et al.* (2010) did not found any significant difference of DM intake per day among different feed treatment groups could be due to the similar live weights of animals and the diets were iso-nitrogenous and iso-caloric, while animals having different live weights were used in the present study. Total DM intake (kg/d) was significantly ($p < 0.01$) affected by breed type in this study, was in accordance with the result of Roy *et al.* (2013) who found significant ($p < 0.01$) variations of DM intake among Brahman crossbred bulls (6.91 kg/d), Pabna bulls (5.33 kg/d) and Red Chittagong bulls (4.46 kg/d); while unlikely to the present study, total

DM intake (%LW) varied significantly ($p<0.01$) among different breeds (Roy *et al.*, 2013). Fox *et al.* (2001) also found differences of total DM intake among different breeds. But, the findings did not agree with Zahradkova *et al.* (2010). The amount of DM intake (kg/d) by the indigenous bulls in the present study was almost similar to the DM intake (kg/d) reported by Zahradkova *et al.* (2010), while amount of DM intake (kg/d) by crossbred bulls was almost similar to Fox *et al.* (2001) and Bures and Barton (2012). Daily DM intake as percent of live weight for indigenous and crossbred bulls was almost similar to the previous reports of Dung *et al.* (2013) and Rashid *et al.* (2015b) for CON-UMS diet. On the other hand, lower amount of DM intake (kg/d and as %LW) by the animals of 24 months of age reported by Roy *et al.* (2013), may be linked to several factors such as, breed type, live weight and feed ingredients of diet as they fed concentrate mixture at the rate of 1.25% of the live weight of animals which was lower than the present study.

4.2.2 Live weight gain and FCR

4.2.2.1 Daily weight gain and FCR of indigenous and crossbred bulls of different treatment groups fed different plane of nutrition

Initial live weight, final live weight, average daily gain and feed conversion efficiency of the animals of different treatment groups of indigenous and crossbred bulls are mentioned in Table 4.2.5. Initial live weights of the bulls were significantly ($p<0.01$) higher (287.49 kg) in group T_0 of crossbred bulls and lower (191.44 kg) in group T_1 of indigenous bulls. The difference of final live weights of the animals was also significant ($p<0.01$) among different groups of bulls; and the highest final live weight (405.26 kg) was found in group T_3 of crossbred bulls and lowest final live weight (242.85 kg) was found in group T_0 of indigenous bulls. Average daily weight gain (ADG) and feed conversion ratio (FCR) of the animals were affected significantly ($p<0.01$) by breed type and feed treatment interaction. ADG was highest (1.17 kg) in group T_3 of crossbred bulls and lowest (0.27 kg) in group T_0 of indigenous bulls. The highest feed conversion ratio (19.70) of the bulls was found in group T_0 of indigenous bulls and lowest FCR (9.48) was found in group T_3 of crossbred bulls.

Table 4.2.5 Daily weight gain and FCR of indigenous and crossbred bulls of different treatment groups

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Initial live weight (kg)	210.39 ^{cd} ±11.7	191.44 ^e ±6.9	208.45 ^d ±7.9	222.06 ^c ±9.2	287.49 ^a ±9.3	218.77 ^{cd} ±8.01	253.62 ^b ±8.8	265.15 ^b ±10.6	6.23	**
Final live weight (kg)	242.85 ^f ±11.9	245.48 ^f ±6.9	262.42 ^e ±8.2	281.03 ^d ±9.7	341.92 ^c ±9.8	340.26 ^c ±8.9	374.97 ^b ±9.7	405.26 ^a ±10.2	6.47	**
ADG (kg)	0.27 ^e ±0.01	0.45 ^d ±0.00	0.45 ^d ±0.00	0.49 ^c ±0.01	0.45 ^d ±0.04	1.01±0.01	1.01±0.01	1.17 ^a ±0.03	0.01	**
FCR	19.70 ^a ±0.33	15.78 ^b ±0.20	15.45 ^c ±0.15	14.51 ^d ±0.21	15.87 ^b ±0.14	10.28 ^e ±0.09	10.37 ^e ±0.09	9.48 ^f ±0.35	0.15	**

ADG = Average Daily Gain, FCR = Feed Conversion Ratio, T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means

**= Significant at 1% level of probability (p<0.01),

Values having different superscripts in the same row differ significantly

4.2.2.2 Daily weight gain and FCR of indigenous bulls of different treatment groups fed different plane of nutrition

Table 4.2.6 showed that, feed treatment had significant ($p < 0.01$) effect on initial live weight, final live weight, daily weight gain and feed conversion ratio of indigenous bulls. Highest initial live weight (222.06 kg) was found in group T_3 and lowest initial live weight (191.44 kg) was found in group T_1 ; and highest final live weight (281.03 kg) and lowest final live weight (242.85 kg) were found in group T_3 and group T_0 , respectively. ADG and FCR were highest (0.49 kg and 19.70) in group T_3 and group T_0 , respectively, and lowest (0.27 kg and 15.78) in group T_0 and group T_1 , respectively.

Table 4.2.6 Daily weight gain and FCR of indigenous bulls under different feed treatment groups

Parameters	Indigenous				SEM	Sig. level
	T_0	T_1	T_2	T_3		
Initial live weight (kg)	210.39 ^{ab} ±11.66	191.44 ^c ±6.94	208.45 ^b ±7.90	222.06 ^a ±9.19	6.43	**
Final live weight (kg)	242.85 ^c ±11.88	245.48 ^c ±6.94	262.42 ^b ±8.20	281.03 ^a ±9.69	6.61	**
ADG (kg)	0.27 ^c ±0.01	0.45 ^b ±0.00	0.45 ^b ±0.00	0.49 ^a ±0.01	0.007	**
FCR	19.70 ^a ±0.33	15.78 ^b ±0.20	15.45 ^{bc} ±0.15	14.51 ^c ±0.21	0.166	**

ADG = Average Daily Gain, FCR = Feed Conversion Ratio, T_0 = Treatment Group 0, T_1 = Treatment Group 1, T_2 = Treatment Group 2, T_3 = Treatment Group 3, SEM = Standard Error of Means

** = Significant at 1% level of probability ($p < 0.01$), NS = Not significant ($p > 0.05$),

In a row values with dissimilar letter differ significantly.

4.2.2.3 Daily weight gain and FCR of crossbred bulls under different feed treatment groups

Table 4.2.7 showed that, initial live weight, final live weight, daily weight gain and feed conversion ratio of different animals had significant ($p<0.01$) differences among the treatment groups of crossbred bulls. Highest initial live weight (287.49 kg) was found in group T_0 and lowest initial live weight (218.77 kg) was found in group T_1 ; and highest final live weight (405.26 kg) and lowest final live weight (340.26 kg) were found in group T_3 and group T_1 , respectively. ADG was highest (1.17 kg) in group T_3 and lowest (0.45 kg) in group T_0 ; and finally FCR was highest (15.87) in group T_0 and lowest (9.48) in group T_3 .

Table 4.2.7 Daily weight gain and FCR of crossbred bulls under different feed treatment groups

Parameters	Crossbred				SEM	Sig. level
	T_0	T_1	T_2	T_3		
Initial live weight (kg)	287.49 ^a ±9.33	218.77 ^d ±8.01	253.62 ^c ±8.80	265.15 ^b ±10.63	6.53	**
Final live weight (kg)	341.92 ^c ±9.83	340.26 ^c ±8.95	374.97 ^b ±9.73	405.26 ^a ±10.22	6.85	**
ADG (kg)	0.45 ^c ±0.04	1.01 ^b ±0.01	1.01 ^b ±0.01	1.17 ^a ±0.03	0.02	**
FCR	15.87 ^a ±0.14	10.28 ^b ±0.09	10.37 ^b ±0.09	9.48 ^c ±0.35	0.14	**

ADG = Average Daily Gain, FCR = Feed Conversion Ratio, T_0 = Treatment Group 0, T_1 = Treatment Group 1, T_2 = Treatment Group 2, T_3 = Treatment Group 3, SEM = Standard Error of Means

* = Significant at 5% level of probability ($p<0.05$), ** = Significant at 1% level of probability ($p<0.01$), NS = Not significant ($p>0.05$),

Values having different superscripts in the same row differ significantly.

4.2.2.4 Comparison of daily weight gain and FCR of indigenous and crossbred bulls fed different plane of nutrition

Initial live weight, final live weight, average daily gain (ADG) and feed conversion ratio (FCR) were differed significantly ($p<0.01$) between indigenous and crossbred bulls (Table 4.2.8). ADG was significantly higher ($p<0.01$) in crossbred bulls (0.911 kg) than indigenous bulls (0.416); and FCR was significantly lower ($p<0.01$) in crossbred bulls (11.5 kg) than indigenous bulls (16.36).

Table 4.2.8 Comparison of daily weight gain and FCR between indigenous and crossbred bulls considering all treatment groups

Parameters	Breed		P value	Level of sig.
	Indigenous (Mean $\pm$ SD)	Crossbred (Mean $\pm$ SD)		
Initial live weight (kg)	208.08 $\pm$ 13.98	256.26 $\pm$ 26.85	0.000	**
Final live weight (kg)	257.95 $\pm$ 17.89	365.60 $\pm$ 28.86	0.000	**
ADG (kg)	0.416 $\pm$ 0.09	0.911 $\pm$ 0.28	0.000	**
FCR	16.36 $\pm$ 2.05	11.5 $\pm$ 2.62	0.0001	**

ADG = Average Daily Gain, FCR = Feed Conversion Ratio

** = Significant at 1% level of probability ($p<0.01$)

Average daily gain was affected significantly ($p<0.01$) by different feed treatments in this study. Significant ($p<0.05$) variations of ADG among different feed treatment groups were also reported by Rashid *et al.* (2015b), and the reported ADG were 0.954, 0.873, 0.205 kg for 100% concentrate diet group (Con.), Con-UMS diet group and 100% UMS diet group respectively. Rahman (2001) found higher ADG (0.492 kg/d) for UMS treated diet group than the control group (0.365 kg). Malole *et al.* (2014) also found significant ($p<0.001$) difference of ADG between two feed treatment schemes. Unlike the present study, Alberti *et al.* (2014) did not find any significant effect of diet on ADG. Average daily gains of the experimental animals were affected ($p<0.01$) by breed type in the present study. Similar significant ($p<0.01$) variations of ADG for breed type were determined by Roy *et al.* (2013); and the results were 0.709, 0.447, 0.624 kg for Pabna breed, Red Chittagong Cattle (RCC)

and Brahman crossbreds bulls respectively. Fox *et al.* (2001) reported variations in ADG- 2.82, 2.96, 3.09 and 2.86 lb/d for unselected Hereford, selected Hereford, Angus × Hereford × Charolais and Angus × Hereford × Holstein, respectively. Unlikely to the present study, Keane (2010) did not find significant effect of breed on ADG of animals. ADG of indigenous bulls in this study were almost similar to the RCC bulls, but ADG for crossbred bulls (HF × L) were higher than the Brahman crossbred bulls Roy *et al.* (2013). Similarly to the findings of the present study, the differences in ADG among the breed types were also reported by Barton *et al.* (2006) who showed Charolais and Simmental gained more rapidly ($p < 0.05$) than Aberdeen Angus while Hereford showed intermediate. Bonilha *et al.* (2008) also reported a significant variation of daily live weight gain among the *Bos indicus* and tropically adapted *Bos taurus* breed.

Feed conversion ratio in the present study was significantly ($p < 0.01$) affected by different feed treatments which is similar to the results reported by Rashid *et al.* (2015b), Dung *et al.* (2013), and Malole *et al.* (2014). In this study, crossbred bulls (HF × L) showed significantly lower ($p < 0.01$) FCR than the indigenous bulls. But, Roy *et al.* (2013) observed significantly ($p < 0.01$) higher FCR values in Brahman crossbred bulls than the indigenous (Pabna breed and RCC breed) bulls fed single plan of nutrition. Zahradhkova *et al.* (2010) also reported significant ($p < 0.01$) differences of FCR values among different breed types, but he did not find any significant difference of FCR for different diets. Keane (2010) found significantly ($p < 0.01$) lower efficiency of utilization of net energy for carcass weight gain in HF than Belgian Blue × Holstein Friesian. Malole *et al.* (2014) also reported that TSHZ cattle had lower FCR compared to Ankole cattle, which supported the breed effect on FCR of the present study.

Multiple regression analysis was done by taking the ADG (kg/d) and FCR as dependent variable and total DMI intake (kg/day) as independent variable (Fig. 4.2). As expected here high dependency were found to exist, the value of the coefficient of determination ($R^2 = 0.98, 0.95$ for ADG and FCR, respectively) being high. Strongly positive correlation ($p < 0.01$) between ADG (kg/d) and total DMI (kg/d) was found, while negative correlation ($p < 0.01$) was found between FCR and total DMI (kg/d). Roy *et al.* (2013) also reported similar effect of DM intake (kg/d) on average daily gain (kg/d) and feed conversion ratio of native and Brahman crossbred bulls. Multiple regression analysis was also performed to determine the

influence of CP intake (g/d) and ME intake (MJ/d) on average daily gain (kg/d) of experimental animals (Fig. 4.3). CP intake (g/d) and ME intake (MJ/d) influenced the ADG (kg/d) of animals positively and significantly ($R^2 = 0.93, 0.96$ respectively; $p < 0.01$) as expected. Similar significant linear relations of daily weight gain (g/d) with CP intake (g/d) and ME intake (MJ/d) of native male cattle were reported in a research report of BLRI (2005).

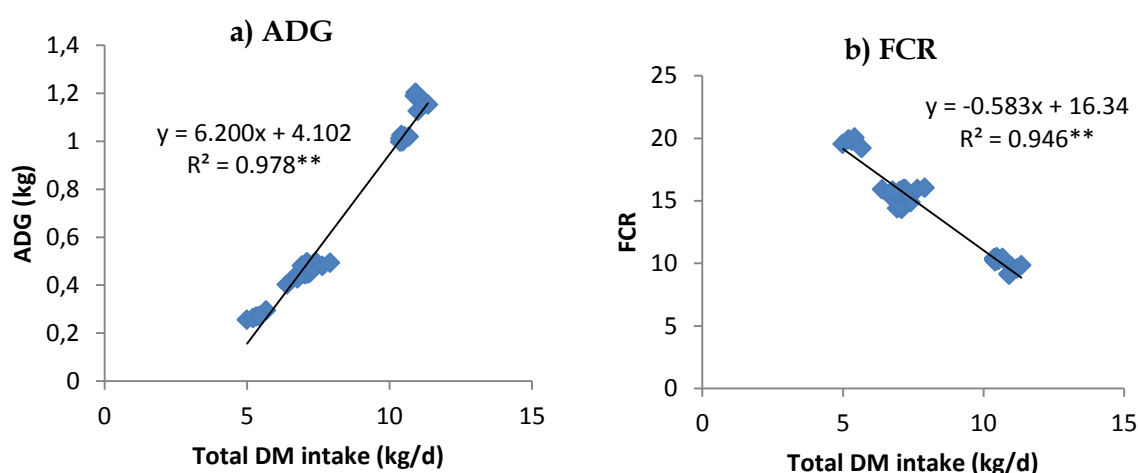


Fig. 4.2 Relationship between total DM intake (kg/d) and a) average daily gain (kg) and b) FCR

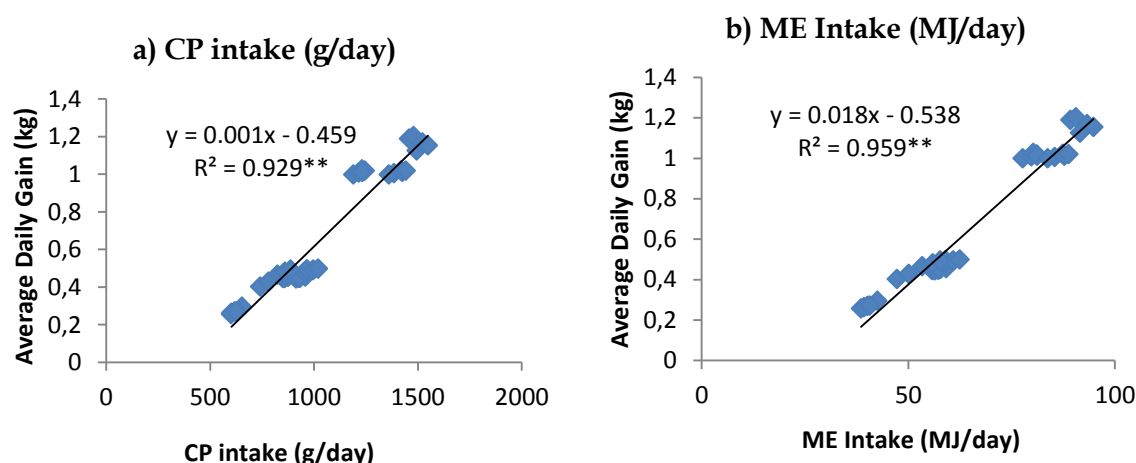


Fig. 4.3 Relationship between average daily gain (kg) and a) CP intake (g/day) and

b) ME Intake (MJ/day)

Cumulative live weight gain of indigenous and crossbred bulls under different feed treatment groups are shown in Fig. 4.4 and Fig. 4.5, respectively.

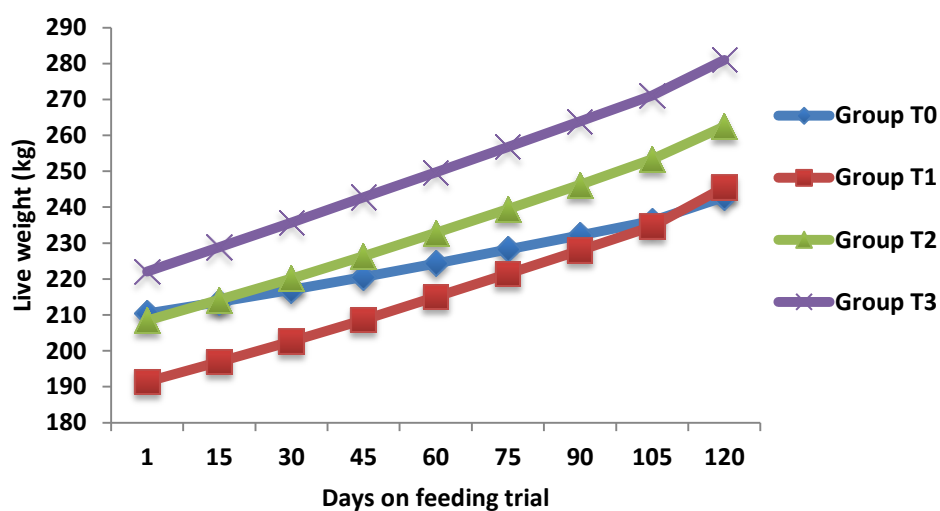


Fig. 4.4 Cumulative live weight gain of indigenous bulls

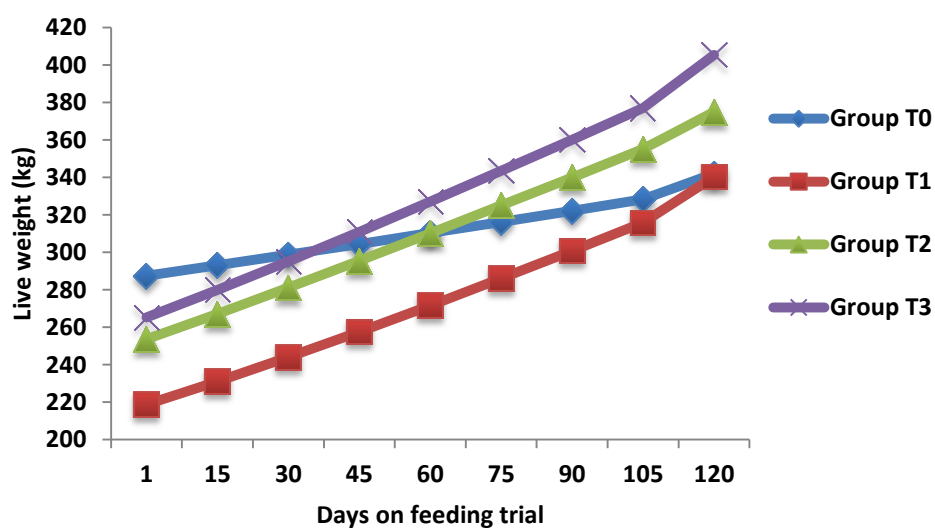


Fig. 4.5 Cumulative live weight gain of crossbred bulls

4.3 Experiment 2

Study on carcass and meat yield characteristics of indigenous and crossbred cattle reared under improved feeding system

4.3.1 Pre-slaughter body measurement

4.3.1.1 Pre-slaughter body measurement parameters of indigenous and crossbred bulls under different treatment groups

The pre-slaughter body measurements of indigenous and crossbred (L × HF) bulls under different feed treatments are presented in Table 4.3.1. The results showed that the interaction of breed and feed treatment had a highly significant ($p < 0.01$) effect on body length, heart girth, wither height and hip height. The body length was highest (134.06 cm) in group T₂ of crossbred bulls and lowest (123.36 cm) in group T₂ of indigenous bulls. Heart girth was highest (181.18 cm) in group T₃ of crossbred bulls and lowest (135.60 cm) in group T₁ of indigenous bulls. Wither height was highest (134.06 cm) in group T₂ of crossbred bulls and lowest (122.28 cm) in group T₀ of indigenous bulls. Finally, the hip height was highest (131 cm) in group T₃ of crossbred bulls and lowest (121.16 cm) in group T₁ of indigenous bulls.

Table 4.3.1 Body measurement parameters of indigenous and crossbred bulls under different treatment groups

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Body length (cm)	128.50 ^{bc} ±1.37	126.22 ^{cd} ±0.71	123.36 ^e ±1.30	125.42 ^{de} ±2.16	129.50 ^b ±2.50	130.36 ^b ±2.06	134.06 ^a ±2.14	133.32 ^a ±1.30	1.21	**
Heart girth (cm)	142.82 ^d ±3.16	135.60 ^e ±7.28	148.18 ^c ±1.10	152.40 ^c ±3.70	169.36 ^b ±1.77	169.50 ^b ±2.82	177.54 ^a ±2.23	181.18 ^a ±1.10	2.34	**
Wither height (cm)	122.28 ^d ±1.89	124.04 ^{cd} ±2.05	123.36 ^d ±1.30	125.42 ^c ±2.16	128.70 ^b ±2.08	130.36 ^b ±2.06	134.06 ^a ±2.14	133.32 ^a ±1.30	1.29	**
Hip height (cm)	121.40 ^{cd} ±1.12	121.16 ^{cd} ±1.40	119.64 ^d ±1.38	121.92 ^c ±1.80	126.94 ^b ±0.82	127.76 ^b ±1.12	130.00 ^a ±2.09	131.00 ^a ±1.37	0.98	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means

**= Significant at 1% level of probability (p<0.01),

Values having different superscripts in the same row differ significantly.

4.3.1.2 Pre-slaughter body measurement parameters of indigenous bulls under different treatment groups

The pre-slaughter body measurements of indigenous bulls under different feed treatments are presented in Table 4.3.2. The results showed that feed treatment had a significant ($p < 0.01$) effect on body length and heart girth, while wither height and hip height were not affected by feed treatment. The body length was highest (128.50 cm) in group T_0 and lowest (125.42 cm) in group T_3 of indigenous bulls. Heart girth was highest (152.40 cm) in group T_3 and lowest (135.60 cm) in group T_1 . Although the differences of wither height and hip height among different feed treatment groups did not differ significantly, the values were higher in group T_3 and lower in group T_0 of indigenous bulls.

Table 4.3.2 Pre-slaughter body measurement parameters of indigenous bulls under different treatment groups

Parameters	Indigenous				SEM	Level of sig.
	T_0 (Mean $\pm$ SD)	T_1 (Mean $\pm$ SD)	T_2 (Mean $\pm$ SD)	T_3 (Mean $\pm$ SD)		
Body length (cm)	128.50 ^a $\pm$ 1.37	126.22 ^b $\pm$ 0.71	123.36 ^c $\pm$ 1.30	125.42 ^{bc} $\pm$ 2.16	1.05	**
Heart girth (cm)	142.82 ^c $\pm$ 3.16	135.60 ^d $\pm$ 7.28	148.18 ^b $\pm$ 1.10	152.40 ^a $\pm$ 3.70	3.12	**
Wither height (cm)	122.28 $\pm$ 1.89	124.04 $\pm$ 2.05	123.36 $\pm$ 1.30	125.42 $\pm$ 2.16	1.33	NS
Hip height (cm)	121.40 $\pm$ 1.12	121.16 $\pm$ 1.40	119.64 $\pm$ 1.38	121.92 $\pm$ 1.80	1.02	NS

T_0 = Treatment Group 0, T_1 = Treatment Group 1, T_2 = Treatment Group 2, T_3 = Treatment Group 3,

SEM = Standard Error of Means;

* = Significant at 1 % level of probability ($p < 0.01$), NS = Not significant ($p > 0.05$),

Values having different superscripts in the same row differ significantly.

4.3.1.3 Pre-slaughter body measurement parameters of crossbred bulls under different treatment groups

The pre-slaughter body measurements of crossbred bulls under different feed treatments are presented in Table 4.3.3. The results showed that the body length, heart girth, wither height and hip height had significant ($p<0.01$) differences among different feed treatment groups of crossbred bulls. The body length was highest (134.06 cm) in group T₂ and lowest (129.50 cm) in group T₀ of crossbred bulls. Heart girth was highest (181.18 cm) in group T₃ and lowest (169.36 cm) in group T₀. Wither height was highest (134.06 cm) in group T₂ and lowest (128.70 cm) in group T₀. Finally, the hip height was highest (131 cm) in group T₃ and lowest (126.94 cm) in group T₀ of crossbred bulls.

Table 4.3.3 Pre-slaughter body measurement parameters of crossbred bulls under different treatment groups

Parameters	Crossbred				SEM	Level of sig.
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Body length (cm)	129.50 ^b ±2.50	130.36 ^b ±2.06	134.06 ^a ±2.14	133.32 ^a ±1.3	1.45	**
Heart girth (cm)	169.36 ^b ±1.77	169.50 ^b ±2.82	177.54 ^a ±2.23	181.18 ^a ±1.1	1.47	**
Wither height (cm)	128.70 ^b ±2.08	130.36 ^b ±2.06	134.06 ^a ±2.14	133.32 ^a ±1.3	1.36	**
Hip height (cm)	126.94 ^b ±0.82	127.76 ^b ±1.12	130 ^a ±2.09	131 ^a ±1.37	1.01	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means;

** = Significant at 1% level of probability ($p<0.01$),

Values having different superscripts in the same row differ significantly.

4.3.1.4 Comparison of pre-slaughter body measurement parameters between indigenous and crossbred bulls considering different treatment groups

Table 4.3.4 shows significant ($p < 0.01$) effect of breed on the pre-slaughter body measurement parameters. The body length, heart girth, wither height and hip height were significantly higher ($p < 0.01$) in crossbred than in the indigenous bulls.

Table 4.3.4 Comparison of pre-slaughter body measurement parameters between indigenous and crossbred bulls considering all treatment groups

Parameters	Breed		P Value	Level of sig
	Indigenous (Mean $\pm$ SD)	Crossbred (Mean $\pm$ SD)		
Body length (cm)	125.88 $\pm$ 2.32	131.81 $\pm$ 2.72	0.001	**
Heart girth (cm)	144.75 $\pm$ 7.61	174.40 $\pm$ 5.60	0.001	**
Wither height (cm)	123.78 $\pm$ 2.08	131.61 $\pm$ 2.85	0.001	**
Hip height (cm)	121.03 $\pm$ 1.59	128.93 $\pm$ 2.13	0.001	**

** = Significant at 1 % level of probability ($p < 0.01$)

The result of the present study for the parameters of pre-slaughter body measurement was almost similar to the result reported by Afolayan *et al.* (2002), Khalafalla *et al.* (2011) and Roy *et al.* (2013) for indigenous and crossbred bulls. Roy *et al.* (2013) observed significant difference ($p < 0.01$) of pre-slaughter body parameters for Pabna breed, Red Chittagong and Brahman crossbred bulls, which is similar to the present study. Bene *et al.* (2007), Alberti *et al.* (2008) and Taiwo *et al.* (2010) also reported significant effect of breed on pre-slaughter body measurements. Bene *et al.* (2007) compared body measurements of beef cows of 9 different breeds (Hungarian Simmental, Hereford, Aberdeen Angus, Red Angus, Lincoln Red, Shaver, Charolais, Limousin and Blonde d' Aquitaine) managed under same feeding and management conditions, and found a significant difference ($p < 0.05$) among breeds in most of the body measurements. Taiwo *et al.* (2010) in their earlier study examined the effects of breed, age, sex and body condition scores on body measurements on White Fulani, Rahji and Sokoto Gudali cattle. They reported that, the breed types ($p < 0.05$) of animals

significantly affected body measurements. However, Alberti *et al.* (2008) reported that the young bulls of Jersey and Limousin breeds had low withers height (112.9 cm and 118.7 cm), Aberdeen Angus, Charolais and Simmental breeds had intermediate values (120.2 cm, 120.6 cm and 126.1 cm, respectively) and Holstein had the greatest (133.1 cm). On the other hand Holstein and Simmental breeds had shorter body length (129.8 cm and 125.9 cm, respectively) while Aberdeen Angus and Charolais breeds had greatest body lengths (142.7 cm and 145.0 cm, respectively).

4.3.2 Carcass yield characteristics

4.3.2.1 Carcass yield characteristics of indigenous and crossbred bulls under different treatment groups

Carcass yield characteristics of indigenous and crossbred bulls of different treatment groups have been presented in Table 4.3.5. Live weight at slaughter and weight after slaughter of indigenous and crossbred bulls were significantly ($p<0.01$) affected by different feed treatments; live weight at slaughter and weight after slaughter were lowest (239.99 kg and 231.84 kg, respectively) in group T₀ of indigenous bulls, and highest (401.97 kg and 387.45 kg, respectively) in group T₃ of crossbred bulls. All the parameters of carcass yield characteristics increased significantly ($p<0.01$) with the increase of live weight among different treatment groups of indigenous and crossbred bulls. This indicated significant effects of breed and feed treatment interaction on carcass yield characteristics. Finally, the calculated USDA yield grade was highest (1.97) in group T₀ of indigenous bulls and lowest (1.00) in group T₃ of crossbred bulls; and calculated % retail cut was highest (54.59%) in group T₃ of crossbred bulls and lowest (52.45%) in group T₀ of indigenous bulls.

Table 4.3.5 Carcass yield Characteristics of indigenous and crossbred bulls under different treatment groups

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Live weight at slaughter (kg)	239.99 ^f ±11.95	242.97 ^f ±6.33	259.89 ^e ±8.02	278.94 ^d ±10.03	339.17 ^c ±9.69	337.10 ^c ±8.85	372.04 ^b ±10.18	401.97 ^a ±9.89	6.449	**
Weight after slaughter (kg)	231.84 ^f ±11.88	234.65 ^f ±6.04	251.18 ^e ±7.57	269.10 ^d ±9.38	328.61 ^c ±9.42	325.82 ^c ±8.06	358.45 ^b ±9.26	387.45 ^a ±9.55	6.139	**
Warm carcass wt (kg)	107.07 ^h ±7.68	124.58 ^g ±3.52	136.13 ^f ±4.28	143.88 ^e ±5.53	157.79 ^d ±5.10	166.06 ^c ±6.2	187.22 ^b ±5.41	200.15 ^a ±5.78	3.776	**
Warm dressing %	44.57 ^f ±1.04	51.27 ^b ±0.32	52.38 ^a ±0.59	51.57 ^{ab} ±0.33	46.87 ^e ±1.06	49.25 ^d ±0.69	50.31 ^c ±0.37	49.79 ^{cd} ±0.61	0.465	**
Chilled carcass wt (kg)	105.01 ^h ±7.63	122.50 ^g ±3.64	133.8 ^f ±4.28	141.81 ^e ±5.55	155.51 ^d ±5.08	163.70 ^c ±6.19	184.97 ^b ±5.50	197.99 ^a ±5.84	3.790	**
Chilled dressing %	43.71 ^g ±1.05	50.41 ^{bc} ±0.33	51.49 ^a ±0.59	50.71 ^{ab} ±0.42	45.84 ^f ±0.50	48.55 ^e ±0.67	49.71 ^{cd} ±0.35	49.41 ^d ±0.92	0.444	**
Meat to bone ratio	3.54 ^f ±0.07	3.80 ^e ±0.07	3.92 ^d ±0.08	3.97 ^{cd} ±0.05	4.02 ^c ±0.09	4.00 ^{cd} ±0.05	4.19 ^b ±0.03	4.35 ^a ±0.05	0.043	**
Bone % chilled carcass wt	22.02 ^a ±0.31	20.81 ^b ±0.29	20.35 ^c ±0.31	20.10 ^{cd} ±0.21	19.93 ^d ±0.35	20.02 ^{cd} ±0.19	19.27 ^d ±0.13	18.69 ^e ±0.18	0.174	**

KPH %	1.73 ^e ±0.03	2.82 ^d ±0.03	2.79 ^d ±0.06	3.30 ^c ±0.07	2.59 ^d ±0.10	3.56 ^b ±0.09	3.84 ^a ±0.03	3.92 ^a ±0.03	0.043	**
Longissimus muscle area (inch ²)	6.11 ^h ±0.33	8.53 ^g ±0.13	9.24 ^f ±0.21	10.17 ^d ±0.35	9.74 ^e ±0.39	12.46 ^c ±0.24	13.47 ^b ±0.19	13.98 ^a ±0.20	0.182	**
Back fat thickness (mm)	1.82 ^h ±0.09	2.82 ^f ±0.08	3.08 ^e ±0.06	3.27 ^d ±0.07	2.48 ^g ±0.15	4.88 ^c ±0.08	5.07 ^b ±0.07	5.24 ^a ±0.07	0.061	**
USDA yield grade	1.97 ^a ±0.03	1.65 ^b ±0.01	1.54 ^c ±0.02	1.43 ^d ±0.05	1.47 ^e ±0.06	1.09 ^f ±0.03	1.02 ^g ±0.01	1.00 ^h ±0.01	0.021	**
% Retail cut	52.45 ^f ±0.07	53.10 ^e ±0.15	53.41 ^d ±0.05	53.65 ^c ±0.10	53.55 ^c ±0.13	54.41 ^b ±0.07	54.54 ^a ±0.03	54.59 ^a ±0.01	0.061	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means,

** = Significant at 1% level of probability (p<0.01);

Values having different superscripts in the same row differ significantly.

4.3.2.2 Carcass yield characteristics of indigenous bulls under different treatment groups

Table 4.3.6 contains the carcass yield parameters of indigenous bulls under different treatment groups. Different feed treatments significantly ($p<0.01$) influenced all the carcass yield characteristics within the same breed. All the carcass yield parameters increased linearly ($p<0.01$) with the increase of live weight of animals (highest in group T_3 and lowest in group T_0). Finally group T_0 showed the highest USDA yield grade (1.97) and lowest % retail cut (52.45%); whereas group T_3 showed the lowest USDA yield grade (1.43) and highest % retail cut (53.65%) among the treatment groups of indigenous bulls.

4.3.6 Carcass yield characteristics of indigenous bulls under different treatment groups

Parameters	Indigenous				SEM	Sig. level
	T_0 (Mean $\pm$ SD)	T_1 (Mean $\pm$ SD)	T_2 (Mean $\pm$ SD)	T_3 (Mean $\pm$ SD)		
Live weight at slaughter (kg)	239.99 ^c $\pm$ 11.95	242.97 ^c $\pm$ 6.33	259.89 ^b $\pm$ 8.02	278.94 ^a $\pm$ 10.03	6.59	**
Weight after slaughter (kg)	231.84 ^c $\pm$ 11.88	234.65 ^c $\pm$ 6.04	251.18 ^b $\pm$ 7.57	269.10 ^a $\pm$ 9.38	6.35	**
Warm carcass wt (kg)	107.07 ^d $\pm$ 7.68	124.58 ^c $\pm$ 3.52	136.13 ^b $\pm$ 4.28	143.88 ^a $\pm$ 5.53	3.87	**
Warm dressing %	44.57 ^c $\pm$ 1.04	51.27 ^b $\pm$ 0.32	52.38 ^a $\pm$ 0.59	51.57 ^{ab} $\pm$ 0.33	0.45	**
Chilled carcass wt (kg)	105.01 ^d $\pm$ 7.63	122.50 ^c $\pm$ 3.64	133.8 ^b $\pm$ 4.28	141.81 ^a $\pm$ 5.55	3.88	**
Chilled dressing %	43.71 ^c $\pm$ 1.05	50.41 ^b $\pm$ 0.33	51.49 ^a $\pm$ 0.59	50.71 ^{ab} $\pm$ 0.42	0.47	**
Meat to bone ratio	3.54 ^c $\pm$ 0.07	3.80 ^b $\pm$ 0.07	3.92 ^a $\pm$ 0.08	3.97 ^a $\pm$ 0.05	0.05	**
Bone % chilled carcass wt	22.02 ^a $\pm$ 0.31	20.81 ^b $\pm$ 0.29	20.35 ^c $\pm$ 0.31	20.10 ^d $\pm$ 0.21	0.19	**
KPH %	1.73 ^c $\pm$ 0.03	2.82 ^b $\pm$ 0.03	2.79 ^b $\pm$ 0.06	3.30 ^a $\pm$ 0.07	0.03	**
Longissimus muscle area (inch ²)	6.11 ^d $\pm$ 0.33	8.53 ^c $\pm$ 0.13	9.24 ^b $\pm$ 0.21	10.17 ^a $\pm$ 0.35	0.19	**
Back fat thickness (mm)	1.82 ^d $\pm$ 0.09	2.82 ^c $\pm$ 0.08	3.08 ^b $\pm$ 0.06	3.27 ^a $\pm$ 0.07	0.05	**
USDA yield grade	1.97 ^a $\pm$ 0.03	1.65 ^b $\pm$ 0.01	1.54 ^c $\pm$ 0.02	1.43 ^d $\pm$ 0.05	0.02	**
% Retail cut	52.45 ^d $\pm$ 0.07	53.10 ^c $\pm$ 0.15	53.41 ^b $\pm$ 0.05	53.65 ^a $\pm$ 0.10	0.07	**

T_0 = Treatment Group 0, T_1 = Treatment Group 1, T_2 = Treatment Group 2, T_3 = Treatment Group 3,

SEM = Standard Error of Means, ** = Significant at 1% level of probability ($p<0.01$),

Values having different superscripts in the same row differ significantly

4.3.2.3 Carcass yield characteristics of crossbred bulls under different treatment groups

Table 4.3.7 revealed that different feed treatments significantly ($p<0.01$) influenced all the carcass yield characteristics within the crossbred bulls. Live weight at slaughter, weight after slaughter, meat to bone ratio and bone% chilled carcass weight were highest in group T₃ and lowest in group T₁. Warm and chilled carcass weight, KPH%, longissimus muscle area and back fat thickness were highest in group T₃ and lowest in group T₀. So, group T₀ showed relatively higher USDA yield grade (1.47) and lower % retail cut (53.55%); and group T₃ showed relatively lower USDA yield grade (1.00) and higher % retail cut (54.59%) among the treatment groups of crossbred bulls.

4.3.7 Carcass yield characteristics of crossbred bulls under different treatment groups

Parameters	Crossbred				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Live weight at slaughter (kg)	339.17 ^c ±9.69	337.10 ^c ±8.85	372.04 ^b ±10.18	401.97 ^a ±9.89	6.83	**
Weight after slaughter (kg)	328.61 ^c ±9.42	325.82 ^c ±8.06	358.45 ^b ±9.26	387.45 ^a ±9.55	6.42	**
Warm carcass wt (kg)	157.79 ^d ±5.10	166.06 ^c ±6.20	187.22 ^b ±5.41	200.15 ^a ±5.78	3.99	**
Warm dressing %	46.87 ^c ±1.06	49.25 ^b ±0.69	50.31 ^a ±0.37	49.79 ^{ab} ±0.61	0.51	**
Chilled carcass wt (kg)	155.51 ^d ±5.08	163.70 ^c ±6.19	184.97 ^b ±5.50	197.99 ^a ±5.84	4.01	**
Chilled dressing %	45.84 ^c ±0.50	48.55 ^b ±0.67	49.71 ^a ±0.35	49.41 ^{ab} ±0.92	0.46	**
Meat to bone ratio	4.02 ^c ±0.09	4.00 ^c ±0.05	4.19 ^b ±0.03	4.35 ^a ±0.05	0.05	**
Bone % chilled carcass wt	19.93 ^a ±0.35	20.02 ^a ±0.19	19.27 ^b ±0.13	18.69 ^c ±0.18	0.161	**
KPH %	2.59 ^c ±0.10	3.56 ^b ±0.09	3.84 ^a ±0.03	3.92 ^a ±0.03	0.050	**
Longissimus muscle area (inch ²)	9.74 ^d ±0.39	12.46 ^c ±0.24	13.47 ^b ±0.19	13.98 ^a ±0.20	0.190	**
Back fat thickness (mm)	2.48 ^d ±0.15	4.88 ^c ±0.08	5.07 ^b ±0.07	5.24 ^a ±0.07	0.071	**
USDA yield grade	1.47 ^a ±0.06	1.09 ^b ±0.03	1.02 ^c ±0.01	1.00 ^c ±0.01	0.022	**
% Retail cut	53.55 ^c ±0.13	54.41 ^b ±0.07	54.54 ^a ±0.03	54.59 ^a ±0.01	0.055	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means

** = Significant at 1% level of probability ($p<0.01$),

Values having different superscripts in the same row differ significantly.

4.3.2.4 Comparison of carcass yield characteristics between indigenous and crossbred bulls reared under improved feeding system

Table 4.3.8 has shown the comparison of carcass yield characteristics between indigenous and crossbred bulls. Carcass yield characteristics were significantly ($p < 0.01$) varied between indigenous and crossbred bulls, except the warm and chilled dressing percentage. Warm and chilled dressing% were not affected significantly ($p > 0.05$) by breed type. All the carcass yield parameters were higher for crossbred bulls, whereas bone % chilled carcass weight and USDA yield grade were higher for indigenous bulls. Finally, this table revealed that, breed had a significant ($p < 0.01$) effect on carcass yield characteristics of beef cattle.

Table 4.3.8 Comparison of Carcass yield Characteristics between indigenous and crossbred bulls considering all treatment groups

Parameters	Breed		P value	Level of sig.
	Indigenous (Mean $\pm$ SD)	Crossbred (Mean $\pm$ SD)		
Live weight at slaughter (kg)	255.45 $\pm$ 18.09	362.57 $\pm$ 28.73	0.000	**
Weight after slaughter (kg)	246.69 $\pm$ 17.37	350.08 $\pm$ 27.05	0.000	**
Warm carcass wt (kg)	127.91 $\pm$ 15.08	177.8 $\pm$ 17.98	0.000	**
Warm dressing %	49.95 $\pm$ 3.26	49.06 $\pm$ 1.51	0.274	NS
Chilled carcass wt (kg)	125.79 $\pm$ 15.05	175.54 $\pm$ 18.04	0.000	**
Chilled dressing %	49.08 $\pm$ 3.26	48.38 $\pm$ 1.67	0.396	NS
Meat to bone ratio	3.81 $\pm$ 0.18	4.13 $\pm$ 0.16	0.000	**
Bone % chilled carcass wt	20.82 $\pm$ 0.80	19.48 $\pm$ 0.59	0.000	**
KPH %	2.66 $\pm$ 0.59	3.48 $\pm$ 0.55	0.000	**
Longissimus muscle area (inch ²)	8.51 $\pm$ 1.56	12.41 $\pm$ 1.7	0.000	**
Back fat thickness (mm)	2.75 $\pm$ 0.58	4.42 $\pm$ 1.16	0.000	**
USDA yield grade	1.65 $\pm$ 0.21	1.15 $\pm$ 0.19	0.000	**
% Retail cut	53.15 $\pm$ 0.47	54.27 $\pm$ 0.44	0.000	**

** = Significant at 1 % level of probability ($p < 0.01$), NS = Not significant;

Values having different superscripts in the same row differ significantly.

Analysis of available data on back fat thickness and rib-eye-area of experimental animals gave a significant ($p < 0.01$) linear relation having high value of the coefficient of determination ($R^2 = 0.93$) (Fig. 4.6). In the present study, bulls with an increased amount of 12-13th rib fat had larger rib-eyes, which is similar to the findings of Minick *et al.* (2000).

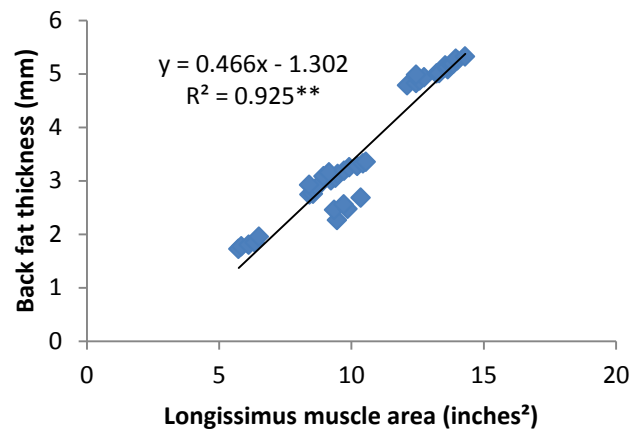


Fig. 4.6 Relationship between rib-eye-area and 12-13th fat thickness of beef carcass

Multiple regression analysis revealed negative correlation ($p < 0.01$) between yield grade with retail cut percentage (cutability) of beef carcass of the experimental animals (Fig. 4.7) as expected. This relation agreed with the expected retail cut percentages for certain yield grades reported by Burson (2005).

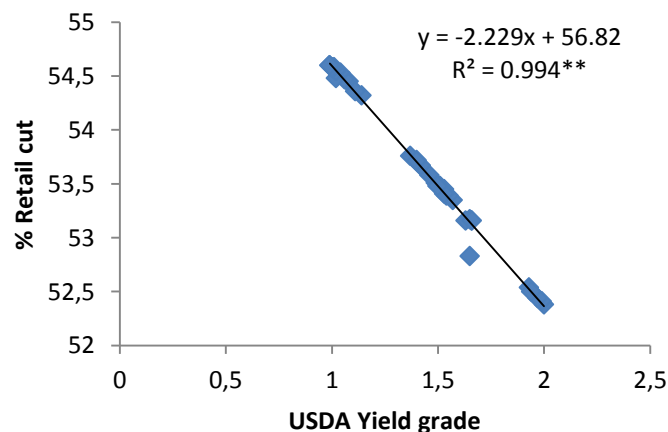


Fig. 4.7 Relationship between USDA Yield Grade and % Retail Cut of beef carcass

In the present study, feed treatment showed significant ($p<0.01$) effect on carcass yield parameters of both indigenous and crossbred bulls. Similarly Ozluturk *et al.* (2008), Dashdorj *et al.* (2012) and Stickel (2012) reported significant effect of diet on carcass weight. In contrast, Arnett (2010) and Zahradkova *et al.* (2010) did not find significant differences in carcass yield for different dietary treatments. Feed treatment had significant effect ($p<0.01$) on dressing percentage, as dressing % were higher in group T₂ and lower in group T₀ in the present study. Rashid *et al.* (2015c) also reported that, the hot dressing percentage increased linearly ($p<0.01$) with the increased level of concentrate in diets. Unlikely to the present study Zahradkova *et al.* (2010) and Sestari *et al.* (2012) did not find significant effect of diet ($p>0.05$) on dressing percentage. Dolezal *et al.* (1982) reported that effect of diet on meat to bone ratio, which is similar to this study, but Zahradkova *et al.* (2010) and Sestari *et al.* (2012) did not agree with this. Ozluturk *et al.* (2008) and Rashid *et al.* (2015c) reported significant effect of diet on KPH% which is similar to the present study. Similar significant effect of diet on back fat thickness found in this study was reported by Stickel (2012) and Rashid *et al.* (2015c). Longissimus muscle area was significantly ($p<0.01$) affected by different feed treatments, similar results were reported by Stickel (2012) and Dashdorj *et al.* (2012); but Rashid *et al.* (2015c) and Zahradkova *et al.* (2010) did not find significant effect of diet on REA.

Significant ($p<0.01$) differences in live weight (LW) and carcass weight (warm and chilled) among the breed types used in this study are in general agreement with results from previous studies that the larger frame-sized breed types attain heavier carcass than the smaller frame-sized breed type. Heavier ($p<0.05$) live weight and carcass weights have been reported for large-framed steers than for small-framed steers at a constant age (Wheeler *et al.*, 1996; Camfield *et al.*, 1999; Plessis and Hoffman, 2007). Roy *et al.* (2013) and Islam (2013) reported almost similar live weight (261.3 kg and 237.33 kg) and warm carcass weight (139.5 kg and 126.77 kg) for indigenous bulls of 24 months of age (average LW 255.45 kg; WCW 127.91 kg). But, the average live weight (362.57 kg) and warm carcass weight (177.80 kg) of crossbred bulls of this study were less than the live weight (374.5 kg) and warm carcass weight (208.6 kg) of Brahman crossbred bulls (Roy *et al.*, 2013). In the present study, crossbred (L × HF) bulls had heavier ($p<0.01$) warm carcass weight, greater ($p<0.01$) longissimus muscle area and thicker ($p<0.01$) back fat thickness than the indigenous bulls. Similarly, significant breed differences in carcasses (Plessis and Hoffman 2007; Zahradkova *et al.*, 2010; Keane 2010), longissimus muscle area (Marshall, 1994; Zahradkova *et al.*, 2010;

Roy *et al.*, 2013) and back fat thickness (Wheeler *et al.*, 1996; Zahradkova *et al.*, 2010; Keane 2010) were reported in previous studies. The findings of the present study also in line with Dolezal *et al.* (1982) and Orrellana *et al.* (2009) Zahradkova *et al.* (2010), who found significant effect of breed on meat to bone ratio. Camfield *et al.* (1999) observed higher kidney pelvic heart fat percentage (KPH%) for steers of smaller framed breed types compared to steers of larger framed breed types, but unlikely to the present study Marshal (1994) did not observe breed differences in KPH fat percentage. The dressing percentage obtained in the current study was not influenced by genotype, which did not agree with Dolezal *et al.* (1993) who reported higher ($p<0.05$) dressing percentage in large-framed steers than in small-framed ones. Barton *et al.* (2006) and Zahradkova *et al.* (2010) also found significant effect ($p<0.05$ and $p<0.01$) of breed on dressing percentage. The USDA yield grade was better for crossbred bulls than the indigenous bulls in the present study. Camfield *et al.* (1999) also observed significant effect of frame size of cattle ($p<0.05$) on yield grade.

4.3.3 Yield of primal cut

4.3.3.1 Yield of primal cut of indigenous and crossbred bulls under different treatment groups

The proportion of different primal cuts in the forequarter and hindquarter of indigenous and crossbred (L × HF) bulls under different treatment groups are shown in Table 4.3.9. The results of primal cuts were expressed as percent of chilled carcass weight. Bullar blade, rib, short plate, brisket, chuck, fore shank and neck comprises in the forequarter. The hind quarter consists of round (top side, silver side and knuckle), loin (tender loin, sirloin and striploin), hind shank, flank and hill muscle. All the parameters for different primal cuts varied significantly ($p<0.01$) among different treatment groups of indigenous and crossbred bulls except strip loin and hill muscle. Forequarter was heavier than the hindquarter in the treatment groups. So, the breed × feed treatment interactions had significant ($p<0.01$) effect on yield of primal cuts of forequarter and hindquarter of carcasses.

Table 4.3.9 Yield of primal cut (% of chilled carcass wt) of indigenous and crossbred bulls under different treatment groups

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Forequarter	53.42 ^a ±0.46	49.26 ^{bc} ±1.99	50.94 ^{abc} ±2.35	51.12 ^{abc} ±0.89	51.64 ^{ab} ±0.56	48.59 ^c ±3.03	49.25 ^{bc} ±1.92	51.02 ^{abc} ±1.76	1.24	**
Bullar blade	16.17 ^a ±0.14	14.91 ^{bc} ±0.61	15.42 ^{abc} ±0.71	15.47 ^{abc} ±0.27	15.63 ^{ab} ±0.17	14.67 ^c ±0.92	14.90 ^{bc} ±0.58	15.44 ^{abc} ±0.54	0.38	**
Rib	5.92 ^a ±0.05	5.46 ^{bc} ±0.22	5.64 ^{abc} ±0.26	5.66 ^{abc} ±0.10	5.72 ^{ab} ±0.06	5.37 ^c ±0.34	5.45 ^{bc} ±0.21	5.65 ^{abc} ±0.20	0.14	**
Short plate	6.14 ^a ±0.05	5.66 ^{bc} ±0.23	5.86 ^{abc} ±0.27	5.88 ^{ab} ±0.10	5.94 ^{ab} ±0.06	5.57 ^c ±0.34	5.66 ^{bc} ±0.22	5.87 ^{abc} ±0.20	0.14	**
Brisket	4.76 ^a ±0.04	4.39 ^{bc} ±0.18	4.54 ^{abc} ±0.21	4.56 ^{abc} ±0.08	4.61 ^{ab} ±0.05	4.33 ^c ±0.27	4.39 ^{bc} ±0.17	4.55 ^{abc} ±0.16	0.11	**
Chuck	8.03 ^a ±0.07	7.41 ^{bc} ±0.30	7.66 ^{abc} ±0.35	7.69 ^{abc} ±0.13	7.77 ^{ab} ±0.08	7.29 ^c ±0.45	7.41 ^{bc} ±0.29	7.67 ^{abc} ±0.26	0.19	**
Fore shank	2.16 ^a ±0.02	1.99 ^{bc} ±0.08	2.06 ^{abc} ±0.10	2.06 ^{abc} ±0.03	2.08 ^{ab} ±0.02	1.96 ^c ±0.13	1.99 ^{bc} ±0.08	2.06 ^{abc} ±0.07	0.05	**
Neck	10.24 ^a ±0.09	9.44 ^{bc} ±0.38	9.76 ^{abc} ±0.45	9.80 ^{abc} ±0.17	9.89 ^{ab} ±0.11	9.29 ^c ±0.58	9.44 ^{bc} ±0.37	9.78 ^{abc} ±0.34	0.24	**
Hind quarter	44.23 ^b ±0.19	48.62 ^a ±2.17	47.55 ^a ±2.33	47.25 ^a ±1.17	46.68 ^a ±0.53	48.22 ^a ±2.45	49.17 ^a ±1.96	47.61 ^a ±1.93	1.21	**
Hind shank	2.53 ^b ±0.15	2.71 ^a ±0.12	2.66 ^{ab} ±0.15	2.63 ^{ab} ±0.06	2.59 ^{ab} ±0.03	2.61 ^{ab} ±0.03	2.72 ^a ±0.12	2.63 ^{ab} ±0.11	0.07	**
Top side	5.67 ^c ±0.02	6.24 ^{ab} ±0.28	6.10 ^{ab} ±0.30	6.05 ^{ab} ±0.15	5.98 ^b ±0.07	6.37 ^a ±0.34	6.28 ^{ab} ±0.26	6.08 ^{ab} ±0.26	0.16	**
Silver side	5.00 ^c ±0.02	5.51 ^{ab} ±0.25	5.38 ^{ab} ±0.27	5.35 ^{ab} ±0.13	5.28 ^b ±0.06	5.62 ^a ±0.30	5.55 ^{ab} ±0.23	5.37 ^{ab} ±0.22	0.15	**

Knuckle	5.03 ^c ±0.21	5.43 ^{ab} ±0.25	5.31 ^{abc} ±0.26	5.26 ^{abc} ±0.13	5.20 ^{bc} ±0.06	5.53 ^a ±0.29	5.46 ^{ab} ±0.23	5.29 ^{abc} ±0.22	0.15	**
Sirloin	9.81 ^c ±0.04	10.81 ^{ab} ±0.49	10.56 ^{ab} ±0.52	10.49 ^{ab} ±0.26	10.37 ^b ±0.12	11.02 ^a ±0.58	10.88 ^{ab} ±0.45	10.53 ^{ab} ±0.44	0.28	**
Tender loin	0.76 ^c ±0.03	0.73 ^c ±0.02	0.77 ^c ±0.11	0.78 ^c ±0.05	0.77 ^c ±0.03	0.90 ^b ±0.05	0.98 ^a ±0.04	0.97 ^a ±0.02	0.04	**
Strip loin	6.28±0.03	6.92±0.31	6.76±0.33	6.72±0.17	5.43±2.71	7.05±0.37	6.96±0.29	6.74±0.28	0.67	NS
Flank	1.27 ^c ±0.01	1.40 ^{ab} ±0.07	1.38 ^{ab} ±0.06	1.36 ^{ab} ±0.03	1.34 ^b ±0.02	1.44 ^a ±0.08	1.41 ^{ab} ±0.06	1.36 ^{ab} ±0.06	0.04	**
Hill muscle	2.58±0.15	2.77±0.13	2.70±0.13	2.69±0.06	2.65±0.03	2.83±0.15	2.79±0.12	2.70±0.11	0.08	NS

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means

****** = Significant at 1% level of probability (p<0.01); **NS** = Not Significant (p>0.05);

Values having different superscripts in the same row differ significantly.



Fig. 4.8 Some primal cuts of beef carcass

4.3.3.2 Yield of primal cut of indigenous bulls under different treatment groups

Table 4.3.10 shows different primal cuts as percent of chilled carcass weight of indigenous bulls under different treatment groups. This result revealed that, feed treatment had significant ($p<0.01$) influence on the weight of most of the different primal cuts as percent of chilled carcass weight in the indigenous breed. Among them percentage of tender loin, knuckle, hill muscle and hind shank were not influenced by feed treatment. All the values for different primal cuts of forequarter were highest in group T_0 and the parameters for the hindquarter were lowest in group T_0 . But, the parameters for the forequarter and hindquarter did not differ much among group T_1 , T_2 and T_3 .

Table 4.3.10 Yield of primal cut (% chilled carcass weight) of indigenous bulls under different treatment groups

Parameters	Indigenous				SEM	Sig. level
	T_0 (Mean $\pm$ SD)	T_1 (Mean $\pm$ SD)	T_2 (Mean $\pm$ SD)	T_3 (Mean $\pm$ SD)		
Forequarter	53.42 ^a $\pm$ 0.46	49.26 ^b $\pm$ 1.99	50.94 ^b $\pm$ 2.35	51.12 ^b $\pm$ 0.89	1.145	**
Bullar blade	16.17 ^a $\pm$ 0.14	14.91 ^b $\pm$ 0.61	15.42 ^b $\pm$ 0.71	15.47 ^b $\pm$ 0.27	0.347	**
Rib	5.92 ^a $\pm$ 0.05	5.46 ^b $\pm$ 0.22	5.64 ^b $\pm$ 0.26	5.66 ^b $\pm$ 0.10	0.126	**
Short plate	6.14 ^a $\pm$ 0.05	5.66 ^b $\pm$ 0.23	5.86 ^b $\pm$ 0.27	5.88 ^b $\pm$ 0.10	0.132	**
Brisket	4.76 ^a $\pm$ 0.04	4.39 ^b $\pm$ 0.18	4.54 ^b $\pm$ 0.21	4.56 ^b $\pm$ 0.08	0.102	**
Chuck	8.03 ^a $\pm$ 0.07	7.41 ^b $\pm$ 0.30	7.66 ^b $\pm$ 0.35	7.69 ^b $\pm$ 0.13	0.173	**
Fore shank	2.16 ^a $\pm$ 0.02	1.99 ^b $\pm$ 0.08	2.06 ^b $\pm$ 0.10	2.06 ^b $\pm$ 0.03	0.045	**
Neck	10.24 ^a $\pm$ 0.09	9.44 ^b $\pm$ 0.38	9.76 ^b $\pm$ 0.45	9.80 ^b $\pm$ 0.17	0.220	**
Hind quarter	44.23 ^b $\pm$ 0.19	48.62 ^a $\pm$ 2.17	47.55 ^a $\pm$ 2.33	47.25 ^a $\pm$ 1.17	1.201	**
Hind shank	2.53 $\pm$ 0.15	2.71 $\pm$ 0.12	2.66 $\pm$ 0.15	2.63 $\pm$ 0.06	0.089	NS
Top side	5.67 ^b $\pm$ 0.02	6.24 ^a $\pm$ 0.28	6.10 ^a $\pm$ 0.30	6.05 ^a $\pm$ 0.15	0.155	**

Silver side	5.00 ^b ±0.02	5.51 ^a ±0.25	5.38 ^a ±0.27	5.35 ^a ±0.13	0.138	**
Knuckle	5.03±0.21	5.43±0.25	5.31±0.26	5.26±0.13	0.153	NS
Sirloin	9.81 ^b ±0.04	10.81 ^a ±0.49	10.56 ^a ±0.52	10.49 ^a ±0.26	0.270	**
Tender loin	0.76±0.03	0.73±0.02	0.77±0.11	0.78±0.05	0.045	NS
Strip loin	6.28 ^b ±0.03	6.92 ^a ±0.31	6.76 ^a ±0.33	6.72 ^a ±0.17	0.173	**
Flank	1.27 ^b ±0.01	1.40 ^a ±0.07	1.38 ^a ±0.06	1.36 ^a ±0.03	0.032	**
Hill muscle	2.58±0.15	2.77±0.13	2.70±0.13	2.69±0.06	0.087	NS

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means,

** = Significant at 1% level of probability (p<0.01), NS = Not significant,

Values having different superscripts in the same row differ significantly

4.3.3.3 Yield of primal cut of crossbred bulls of different treatment groups

Table 4.3.11 shows different primal cuts as percent of chilled carcass weight of crossbred bulls under different treatment groups. The result shows that, feed treatments had no significant (p>0.05) effect on different primal cuts as percent of chilled carcass weight of crossbred bulls, except fore shank. All the values for different primal cuts of forequarter were highest in group T₀ and the parameters for the hindquarter were lowest in group T₀.

Table 4.3.11 Yield of primal cut (% chilled carcass weight) of crossbred bulls under different treatment groups

Parameters	Crossbred				SEM	Level of sig.
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Forequarter	51.64±0.56	48.59±3.03	49.25±1.92	51.02±1.76	1.425	NS
Bullar blade	15.63±0.17	14.67±0.92	14.90±0.58	15.44±0.54	0.432	NS
Rib	5.72±0.06	5.37±0.34	5.45±0.21	5.65±0.20	0.158	NS

Short plate	5.94±0.06	5.57±0.34	5.66±0.22	5.87±0.20	0.163	NS
Brisket	4.61±0.05	4.33±0.27	4.39±0.17	4.55±0.16	0.126	NS
Chuck	7.77±0.08	7.29±0.45	7.41±0.29	7.67±0.26	0.214	NS
Fore shank	2.08 ^a ±0.02	1.96 ^b ±0.13	1.99 ^b ±0.08	2.06 ^a ±0.07	0.059	**
Neck	9.89±0.11	9.29±0.58	9.44±0.37	9.78±0.34	0.273	NS
Hind quarter	46.68±0.53	48.22±2.45	49.17±1.96	47.61±1.93	1.314	NS
Hind shank	2.59±0.03	2.61±0.03	2.72±0.12	2.63±0.11	0.059	NS
Top side	5.98±0.07	6.37±0.34	6.28±0.26	6.08±0.26	0.176	NS
Silver side	5.28±0.06	5.62±0.30	5.55±0.23	5.37±0.22	0.155	NS
Knuckle	5.20±0.06	5.53±0.29	5.46±0.23	5.29±0.22	0.153	NS
Sirloin	10.37±0.12	11.02±0.58	10.88±0.45	10.53±0.44	0.304	NS
Tender loin	0.77±0.03	0.90±0.05	0.98±0.04	0.97±0.02	0.022	NS
Strip loin	5.43±2.71	7.05±0.37	6.96±0.29	6.74±0.28	0.978	NS
Flank	1.34±0.02	1.44±0.08	1.41±0.06	1.36±0.06	0.039	NS
Hill muscle	2.65±0.03	2.83±0.15	2.79±0.12	2.70±0.11	0.077	NS

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means,

** = Significant at 1% level of probability (p<0.01), NS = Not significant,

Values having different superscripts in the same row differ significantly.

4.3.3.4 Comparison of yield of primal cut between indigenous and crossbred bulls

Comparison of yield of different primal cuts of fore and hindquarter of animals as percent of chilled carcass weight between indigenous and crossbred bulls has been presented in Table 4.3.12. This table shows the yield of different primal cuts as percent of chilled carcass

weight did not vary significantly between indigenous and crossbred bulls. So, the type of breed had no significant effect on yield of primal cuts of beef cattle.

Table 4.3.12 Comparison of yield of primal cut (% chilled carcass weight) between indigenous and crossbred bulls considering all treatment groups

Parameters	Breed		P Value	Level of sig
	Indigenous (Mean±SD)	Crossbred (Mean±SD)		
Forequarter	51.18±2.13	50.13±2.25	0.135	NS
Bullar blade	15.49±0.64	15.16±0.69	0.128	NS
Rib	5.67±0.24	5.55±0.25	0.127	NS
Short plate	5.88±0.24	5.76±0.26	0.123	NS
Brisket	4.57±0.19	4.47±0.20	0.131	NS
Chuck	7.70±0.32	7.53±0.34	0.128	NS
Fore shank	2.07±0.09	2.02±0.09	0.111	NS
Neck	9.81±0.41	9.60±0.43	0.125	NS
Hind quarter	46.91±2.29	47.92±1.94	0.143	NS
Hind shank	2.63±0.13	2.64±0.09	0.778	NS
Top side	6.01±0.30	6.18±0.28	0.085	NS
Silver side	5.13±0.26	5.45±0.24	0.084	NS
Knuckle	5.26±0.25	5.37±0.24	0.152	NS
Sirloin	10.42±0.52	10.70±0.48	0.083	NS

Tender loin	0.76±0.06	0.90±0.09	0.000	**
Strip loin	6.67±0.33	6.54±1.44	0.708	NS
Flank	1.35±0.07	1.39±0.07	0.113	NS
Hill muscle	2.69±0.13	2.74±0.12	0.175	NS

** = Significant at 1% level of probability ($p < 0.01$), NS = Not significant

In the present study, feed treatments affected ($p < 0.01$) the yield of primal cut of indigenous bulls, but did not affect the parameters of crossbred bulls. Almost similar result was found by Nour *et al.* (1983), who reported that, weight of trimmed primal cuts at a given shrunk live weight was not affected by diet for Angus steers. However, Holstein steers fed the low-silage diet yielded 6.73 kg more of trimmed primal cuts than high-silage Holstein steers when compared at a constant shrunk live weight. The trimmed primal cut yield of low-silage Holstein steers was better than either Angus-diet combination, while the yield for the high-silage Holstein steers was less than for either Angus-diet combination. Results for yield of primal cut as percent of chilled carcass weight in the present study were similar to the results of Roy *et al.* (2013), as they also found heavier forequarter than the hindquarter. Average percentage of fore and hindquarter in this study were 51.18 and 46.91, respectively for indigenous bulls; and 50.13 and 47.92, respectively for crossbred bulls. Similar to the present study Roy *et al.* (2013) also reported that, the fore- or hindquarter did not vary significantly among the breed types; and the average percent of the former was 55.5, 55.4 and 56.4, respectively and the later was 44.8, 44.6 and 43.6, respectively for Pabna, Red Chittagong and Brahman crossbred bulls. Yield of primal cut as percent of chilled carcass weight was not affected significantly ($p > 0.05$) by breed type in this study. Roy *et al.* (2013) also reported that breed of bulls had no influence ($p > 0.05$) on the weight of most of the primal cuts (% chilled carcass weight) except that of fore shank, silverside and knuckle.

4.3.4 Yield of non carcass component

4.3.4.1 Yield of non carcass component of indigenous and crossbred bulls under different treatment groups

The weight of blood, hide and head and conversion of their weight as percent of live weight shows significant ($p < 0.01$) variations among different treatment groups of indigenous and crossbred (L $\times$ HF) bulls. The weight of gall bladder and bile differed significantly ($p < 0.01$) among different treatment groups, the percent of live weight of gall bladder also differed ($p < 0.05$) among different treatment groups, but the weight of bile (%LW) among different treatment groups was non-significant ($p > 0.05$). Weight of liver differed significantly ($p < 0.01$) while its percent of live weight did not differ among different treatment groups. The weight of spleen, lung and trachea, testes, penis and tail and their conversion as percent of live weight varied significantly ($p < 0.01$) among different treatment groups. The difference of weight of heart among different treatment groups was significant ($p < 0.01$) while its percentage of live weight was non-significant. Heart fat, kidney knob, kidney, kidney fat, visceral fat, pelvis fat and their conversion as percent of live weight were significantly ($p < 0.01$) varied among different treatment groups. Finally, the weight of GI tract and their components, and their conversion as percent of live weight varied significantly ($p < 0.01$) among different treatment groups of indigenous and crossbred (L $\times$ HF) bulls (Table 4.3.13).

Table 4.3.13 Yield of non carcass component of indigenous and crossbred bulls under different treatment groups

Parameters		Indigenous				Crossbred				SEM	Sig. level
		T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Blood	kg	8.15 ^e ±0.21	8.32 ^e ±0.59	8.71 ^e ±0.51	9.64 ^d ±0.62	10.41 ^{cd} ±0.28	11.27 ^c ±1.01	13.60 ^b ±1.01	14.67 ^a ±0.70	0.46	**
	%LW	3.40 ^b ±0.16	3.42 ^{ab} ±0.21	3.35 ^b ±0.11	3.45 ^{ab} ±0.15	3.07 ^c ±0.11	3.34 ^b ±0.23	3.55 ^{ab} ±0.16	3.65 ^a ±0.11	0.11	**
Hide	kg	14.80 ^e ±0.56	15.13 ^e ±0.46	15.93 ^{de} ±0.49	17.43 ^{cd} ±0.60	18.77 ^c ±2.53	20.52 ^b ±1.88	23.52 ^a ±1.16	23.91 ^a ±1.51	0.92	**
	%LW	6.17 ^a ±0.11	6.23 ^a ±0.01	6.13 ^a ±0.14	6.25 ^a ±0.04	5.52 ^b ±0.61	6.08 ^a ±0.46	6.32 ^a ±0.27	5.94 ^a ±0.23	0.21	**
Head	kg	12.51 ^d ±0.50	12.95 ^d ±0.34	14.08 ^{cd} ±0.64	15.84 ^c ±1.26	18.30 ^b ±2.24	18.32 ^b ±1.23	22.24 ^a ±2.62	23.69 ^a ±2.17	1.08	**
	%LW	5.22 ^c ±0.16	5.33 ^c ±0.01	5.42 ^{bc} ±0.11	5.67 ^{abc} ±0.29	5.39 ^c ±0.53	5.43 ^{bc} ±0.25	5.97 ^a ±0.54	5.89 ^{ab} ±0.40	0.23	**
Gall bladder	kg	0.19 ^d ±0.026	0.20 ^d ±0.019	0.23 ^{cd} ±0.036	0.28 ^{ab} ±0.046	0.26 ^{bc} ±0.033	0.26 ^{bc} ±0.032	0.32 ^a ±0.033	0.31 ^a ±0.013	0.02	**
	%LW	0.08 ^{bc} ±0.004	0.07 ^c ±0.024	0.09 ^{ab} ±0.012	0.10 ^a ±0.012	0.08 ^{bc} ±0.007	0.08 ^{bc} ±0.007	0.08 ^{bc} ±0.005	0.08 ^{bc} ±0.00	0.01	*
Bile	kg	0.051 ^c ±0.006	0.053 ^c ±0.007	0.060 ^{bc} ±0.009	0.069 ^b ±0.012	0.07 ^b ±0.013	0.067 ^b ±0.010	0.082 ^a ±0.01	0.09 ^a ±0.007	0.007	**
	%LW	0.020±0.000	0.022±0.004	0.024±0.005	0.022±0.004	0.018±0.004	0.020±0.000	0.020±0.000	0.020±0.000	0.007	NS
Liver	kg	3.13 ^d ±0.28	3.15 ^d ±0.25	3.54 ^{cd} ±0.22	3.75 ^c ±0.29	4.37 ^b ±0.64	4.39 ^b ±0.58	5.05 ^a ±0.44	5.15 ^a ±0.12	0.27	**
	%LW	1.30±0.07	1.29±0.08	1.36±0.08	1.34±0.06	1.29±0.16	1.30±0.14	1.35±0.08	1.28±0.00	0.06	NS
Spleen	kg	0.79 ^d ±0.10	0.81 ^d ±0.07	0.92 ^{cd} ±0.14	0.99 ^{cd} ±0.16	0.86 ^d ±0.09	1.12 ^{bc} ±0.25	1.36 ^a ±0.21	1.22 ^{ab} ±0.03	0.10	**

	%LW	0.33 ^{ab} ±0.03	0.33 ^{ab} ±0.02	0.35 ^{ab} ±0.05	0.35 ^{ab} ±0.04	0.25 ^c ±0.02	0.32 ^{ab} ±0.07	0.37 ^a ±0.05	0.30 ^{bc} ±0.00	0.03	**
Lung & Trachea	kg	3.77 ^d ±0.18	3.93 ^d ±0.26	4.42 ^c ±0.30	4.56 ^c ±0.28	4.71 ^c ±0.33	4.53 ^c ±0.30	6.02 ^a ±0.49	5.22 ^b ±0.25	0.21	**
	%LW	1.57 ^b ±0.09	1.61 ^{ab} ±0.07	1.70 ^a ±0.12	1.64 ^{ab} ±0.05	1.39 ^c ±0.08	1.34 ^c ±0.06	1.62 ^{ab} ±0.09	1.30 ^c ±0.03	0.05	**
Testes	kg	0.46 ^c ±0.05	0.47 ^c ±0.05	0.54 ^{bc} ±0.08	0.58 ^b ±0.10	0.60 ^b ±0.08	0.62 ^b ±0.05	0.86 ^a ±0.09	0.92 ^a ±0.05	0.05	**
	%LW	0.19 ^{bc} ±0.01	0.19 ^{bc} ±0.02	0.21 ^{ab} ±0.03	0.21 ^{ab} ±0.03	0.18 ^c ±0.02	0.18 ^c ±0.01	0.23 ^a ±0.02	0.23 ^a ±0.01	0.01	**
Penis	kg	0.36 ^d ±0.02	0.35 ^d ±0.04	0.40 ^d ±0.03	0.55 ^b ±0.09	0.48 ^c ±0.04	0.54 ^b ±0.03	0.77 ^a ±0.06	0.83 ^a ±0.03	0.03	**
	%LW	0.15 ^{bc} ±0.01	0.15 ^{bc} ±0.01	0.15 ^{bc} ±0.01	0.20 ^a ±0.03	0.14 ^c ±0.01	0.16 ^b ±0.01	0.21 ^a ±0.01	0.21 ^a ±0.01	0.01	**
Tail	kg	0.47 ^c ±0.04	0.50 ^c ±0.05	0.56 ^c ±0.03	0.60 ^{bc} ±0.06	0.72 ^b ±0.06	0.71 ^b ±0.11	0.99 ^a ±0.08	1.06 ^a ±0.18	0.06	**
	%LW	0.20 ^b ±0.02	0.21 ^b ±0.02	0.21 ^b ±0.01	0.21 ^b ±0.02	0.21 ^b ±0.01	0.21 ^b ±0.03	0.26 ^a ±0.02	0.26 ^a ±0.04	0.01	**
Organs and fat											
Heart	kg	0.92 ^d ±0.07	0.94 ^d ±0.09	1.03 ^{cd} ±0.06	1.20 ^{bc} ±0.15	1.44 ^{ab} ±0.32	1.20 ^{bc} ±0.10	1.56 ^a ±0.27	1.57 ^a ±0.24	0.13	**
	%LW	0.38±0.02	0.39±0.03	0.39±0.02	0.43±0.04	0.42±0.08	0.35±0.03	0.41±0.06	0.39±0.05	0.03	NS
Heart fat	kg	0.37 ^d ±0.03	0.37 ^d ±0.04	0.40 ^{cd} ±0.02	0.48 ^{cd} ±0.06	0.53 ^{bc} ±0.09	0.67 ^{ab} ±0.19	0.81 ^a ±0.20	0.81 ^a ±0.12	0.08	**
	%LW	0.15 ^c ±0.01	0.15 ^c ±0.01	0.16 ^c ±0.01	0.17 ^{bc} ±0.01	0.16 ^c ±0.02	0.20 ^{ab} ±0.05	0.22 ^a ±0.05	0.20 ^{ab} ±0.03	0.02	**
Kidney knob	kg	0.34 ^f ±0.04	0.33 ^f ±0.06	0.38 ^{ef} ±0.05	0.47 ^{de} ±0.06	0.56 ^{cd} ±0.07	0.60 ^{bc} ±0.13	0.73 ^a ±0.11	0.66 ^{ab} ±0.06	0.05	**
	%LW	0.14 ^e ±0.02	0.13 ^f ±0.02	0.15 ^d ±0.02	0.17 ^b ±0.02	0.16 ^c ±0.02	0.18 ^{ab} ±0.03	0.20 ^a ±0.02	0.17 ^b ±0.02	0.02	**

Kidney	kg	0.46 ^d ±0.02	0.47 ^d ±0.04	0.52 ^{cd} ±0.02	0.56 ^c ±0.03	0.71 ^b ±0.07	0.71 ^b ±0.07	0.85 ^a ±0.11	0.79 ^a ±0.02	0.04	**
	%LW	0.19 ^c ±0.01	0.19 ^c ±0.01	0.20 ^b ±0.00	0.20 ^b ±0.01	0.21 ^{ab} ±0.01	0.21 ^{ab} ±0.02	0.23 ^a ±0.02	0.20 ^b ±0.00	0.01	**
Kidney fat	kg	1.18 ^g ±0.13	2.17 ^f ±0.18	2.46 ^e ±0.20	3.50 ^d ±0.44	2.21 ^{ef} ±0.07	4.80 ^c ±0.10	5.22 ^b ±0.11	5.65 ^a ±0.18	0.14	**
	%LW	0.49 ^e ±0.03	0.89 ^c ±0.06	0.94 ^c ±0.07	1.25 ^b ±0.12	0.65 ^d ±0.02	1.42 ^a ±0.03	1.40 ^a ±0.01	1.41 ^a ±0.04	0.04	**
Visceral fat	kg	0.55 ^f ±0.07	1.14 ^d ±0.09	0.86 ^e ±0.33	1.12 ^d ±0.07	2.70 ^a ±0.26	1.37 ^d ±0.17	2.08 ^c ±0.10	2.40 ^b ±0.26	0.13	**
	%LW	0.23 ^e ±0.02	0.47 ^c ±0.03	0.33 ^d ±0.13	0.40 ^{cd} ±0.04	0.80 ^a ±0.07	0.41 ^{cd} ±0.05	0.56 ^b ±0.02	0.60 ^b ±0.05	0.04	**
Pelvis fat	kg	2.08 ^g ±0.08	3.18 ^f ±0.09	3.56 ^e ±0.25	4.12 ^d ±0.10	3.36 ^{ef} ±0.29	5.16 ^c ±0.04	6.20 ^b ±0.13	6.88 ^a ±0.06	0.11	**
	%LW	0.87 ^e ±0.04	1.31 ^c ±0.04	1.37 ^c ±0.07	1.48 ^b ±0.05	0.99 ^d ±0.07	1.53 ^b ±0.05	1.67 ^a ±0.02	1.71 ^a ±0.03	0.03	**
GI tract and components											
GI tract with fills	kg	82.55 ^e ±2.98	63.75 ^g ±1.53	65.37 ^g ±2.60	71.04 ^f ±1.91	106.1 ^b ±3.07	90.64 ^d ±3.23	96.42 ^c ±1.04	110.08 ^a ±2.5	1.67	**
	%LW	34.42 ^a ±0.68	26.25 ^{cde} ±0.7	25.15 ^e ±0.54	25.48 ^e ±0.79	31.32 ^b ±1.51	26.89 ^{cd} ±0.62	25.93 ^{dc} ±0.6	27.40 ^c ±0.94	0.58	**
Intestine with content	kg	13.51 ^e ±0.49	10.44 ^g ±0.25	10.70 ^g ±0.43	11.63 ^f ±0.31	17.38 ^b ±0.50	14.84 ^d ±0.53	15.79 ^c ±0.17	18.02 ^a ±0.40	0.27	**
	%LW	5.63 ^a ±0.11	4.30 ^{cde} ±0.11	4.12 ^d ±0.09	4.17 ^d ±0.13	5.13 ^a ±0.25	4.40 ^{bc} ±0.10	4.25 ^{cd} ±0.11	4.49 ^b ±0.16	0.10	**
Stomach with content	kg	69.03 ^e ±2.50	53.31 ^g ±1.28	54.66 ^g ±2.17	59.40 ^f ±1.59	88.74 ^b ±2.57	75.80 ^d ±2.70	80.63 ^c ±0.87	92.05 ^a ±2.05	1.40	**
	%LW	28.78 ^a ±0.57	21.95 ^{cd} ±0.59	21.03 ^d ±0.45	21.3 ^d ±0.66	26.19 ^b ±1.26	22.90 ^c ±0.76	21.68 ^d ±0.53	22.91 ^c ±0.79	0.50	**

Rumen content	kg	58.64 ^e ±2.12	45.29 ^g ±1.09	46.44 ^g ±1.85	50.46 ^f ±1.35	75.39 ^b ±2.19	64.39 ^d ±2.29	68.50 ^c ±0.74	78.20 ^a ±1.74	1.19	**
	%LW	24.45 ^a ±0.48	18.63 ^{de} ±0.52	17.87 ^e ±0.38	18.10 ^e ±0.56	22.25 ^b ±1.07	19.10 ^{cd} ±0.44	18.12 ^{de} ±0.5	19.46 ^c ±0.67	0.41	**
Rumen without content	kg	6.64 ^b ±0.24	5.13 ^c ±0.12	5.26 ^c ±0.21	5.71 ^c ±0.15	8.53 ^a ±0.25	7.29 ^b ±0.26	7.05 ^b ±1.24	8.85 ^a ±0.20	0.33	**
	%LW	2.77 ^a ±0.06	2.11 ^c ±0.06	2.03 ^{cd} ±0.04	2.05 ^{cd} ±0.06	2.52 ^b ±0.12	2.16 ^c ±0.05	1.90 ^d ±0.35	2.20 ^c ±0.08	0.09	**
Empty stomach	kg	10.83 ^e ±0.39	8.36 ^g ±0.20	8.57 ^g ±0.34	9.32 ^f ±0.25	13.92 ^b ±0.40	11.89 ^d ±0.42	12.65 ^c ±0.14	14.44 ^a ±0.32	0.22	**
	%LW	4.51 ^a ±0.09	3.44 ^{de} ±0.09	3.30 ^e ±0.07	3.34 ^e ±0.10	4.11 ^b ±0.20	3.53 ^{cd} ±0.08	3.40 ^{de} ±0.08	3.60 ^c ±0.12	0.07	**
Empty intestine	kg	7.19 ^e ±0.26	5.55 ^g ±0.13	5.69 ^g ±0.23	6.19 ^f ±0.17	9.25 ^b ±0.27	7.90 ^d ±0.28	8.40 ^c ±0.09	9.59 ^a ±0.21	0.15	**
	%LW	3.00 ^a ±0.06	2.29 ^{cde} ±0.06	2.19 ^e ±0.05	2.22 ^e ±0.07	2.73 ^b ±0.13	2.34 ^{cd} ±0.05	2.26 ^{de} ±0.06	2.39 ^c ±0.08	0.05	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means, LW = Live Weight,

*= Significant at 5% level of probability (p<0.05), **= Significant at 1% level of probability (p<0.01), NS = Not Significant (p>0.05),

Values having different superscripts in the same row differ significantly.



Fig. 4.9 Non-carcass components

4.3.4.2 Yield of non carcass component of indigenous bulls under different treatment groups

Yield of non-carcass component as percent of live weight of indigenous bulls under different feed treatment is shown in table 4.3.14. The weight of blood, hide and head shows significant ($p < 0.01$) variations among different treatment groups and conversion of their weight as percent of live weight were non-significant except the head proportion (%LW). The weight of gall bladder and bile differed significantly ($p < 0.01$) among different treatment groups, the percent of live weight of gall bladder also differed ($p < 0.05$) among different treatment groups, while the weight of bile (%LW) among different treatment groups was non-significant ($p > 0.05$). The weight of liver, spleen, lung and trachea, testes, penis and tail varied significantly ($p < 0.01$), while their conversion as percent of live weight were non-significant among different treatment groups except the weight of penis as percent of live weight. The difference of weight of heart, heart fat, kidney knob, kidney among different treatment groups was significant ($p < 0.01$) while their percentage of live weight was non-significant. Kidney fat, visceral fat, pelvis fat and their conversion as percent of live weight were significantly ($p < 0.01$) varied among different treatment groups. Finally, the weight of GI tract and their components, and their conversion as percent of live weight varied significantly ($p < 0.01$) among different treatment groups of indigenous bulls.

Table 4.3.14 Yield of non carcass component of indigenous bulls under different treatment groups

Parameters		Indigenous				SEM	Sig. level
		T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Blood	kg	8.15 ^b ±0.21	8.32 ^b ±0.59	8.71 ^b ±0.51	9.64 ^a ±0.62	0.360	**
	% LW	3.40±0.16	3.42±0.21	3.35±0.11	3.45±0.15	0.114	NS
Hide	kg	14.80 ^c ±0.56	15.13 ^b ±0.46	15.93 ^b ±0.49	17.43 ^a ±0.60	0.363	**
	% LW	6.17±0.11	6.23±0.01	6.13±0.14	6.25±0.04	0.067	NS
Head	kg	12.51 ^b ±0.50	12.95 ^b ±0.34	14.08 ^a ±0.64	15.84 ^a ±1.26	0.543	**
	% LW	5.22 ^b ±0.16	5.33 ^b ±0.01	5.42 ^b ±0.11	5.67 ^a ±0.29	0.124	**
Gall bladder	kg	0.19 ^b ±0.026	0.20 ^b ±0.019	0.23 ^b ±0.036	0.28 ^a ±0.046	0.022	**
	% LW	0.08 ^{ab} ±0.004	0.07 ^b ±0.024	0.09 ^{ab} ±0.012	0.10 ^a ±0.012	0.007	*
Bile	kg	0.051 ^b ±0.006	0.053 ^b ±0.007	0.060 ^a ±0.009	0.069 ^a ±0.012	0.007	**
	% LW	0.020±0.000	0.022±0.004	0.024±0.005	0.022±0.004	0.007	NS
Liver	kg	3.13 ^b ±0.28	3.15 ^b ±0.25	3.54 ^a ±0.22	3.75 ^a ±0.29	0.184	**
	% LW	1.30±0.07	1.29±0.08	1.36±0.08	1.34±0.06	0.050	NS
Spleen	kg	0.79 ^b ±0.10	0.81 ^b ±0.07	0.92 ^a ±0.14	0.99 ^a ±0.16	0.087	**
	% LW	0.33±0.03	0.33±0.02	0.35±0.05	0.35±0.04	0.022	NS
Lung & Trachea	kg	3.77 ^b ±0.18	3.93 ^b ±0.26	4.42 ^a ±0.30	4.56 ^a ±0.28	0.182	**
	% LW	1.57±0.09	1.61±0.07	1.70±0.12	1.64±0.05	0.059	NS
Testes	kg	0.46 ^b ±0.05	0.47 ^b ±0.05	0.54 ^a ±0.08	0.58 ^a ±0.10	0.055	**
	% LW	0.19±0.01	0.19±0.02	0.21±0.03	0.21±0.03	0.022	NS
Penis	kg	0.36 ^b ±0.02	0.35 ^b ±0.04	0.40 ^b ±0.03	0.55 ^a ±0.09	0.039	**
	% LW	0.15 ^b ±0.01	0.15 ^b ±0.01	0.15 ^b ±0.01	0.20 ^a ±0.03	0.007	**

Tail	kg	0.47 ^b ±0.04	0.50 ^b ±0.05	0.56 ^a ±0.03	0.60 ^a ±0.06	0.039	**
	% LW	0.20±0.02	0.21±0.02	0.21±0.01	0.21±0.02	0.007	NS
Organs and fat							
Heart	kg	0.92 ^b ±0.07	0.94 ^b ±0.09	1.03 ^a ±0.06	1.20 ^a ±0.15	0.071	**
	% LW	0.38±0.02	0.39±0.03	0.39±0.02	0.43±0.04	0.022	NS
Heart fat	kg	0.37 ^b ±0.03	0.37 ^b ±0.04	0.40 ^a ±0.02	0.48 ^a ±0.06	0.022	**
	% LW	0.15±0.01	0.15±0.01	0.16±0.01	0.17±0.01	0.007	NS
Kidney knob	kg	0.34 ^b ±0.04	0.33 ^b ±0.06	0.38 ^a ±0.05	0.47 ^a ±0.06	0.039	**
	% LW	0.14±0.02	0.13±0.02	0.15±0.02	0.17±0.02	0.007	NS
Kidney	kg	0.46 ^b ±0.02	0.47 ^b ±0.04	0.52 ^a ±0.02	0.56 ^a ±0.03	0.022	**
	% LW	0.19±0.01	0.19±0.01	0.20±0.00	0.20±0.01	0.007	NS
Kidney fat	kg	1.18 ^b ±0.13	2.17 ^b ±0.18	2.46 ^a ±0.20	3.50 ^a ±0.44	0.190	**
	% LW	0.49 ^c ±0.03	0.89 ^b ±0.06	0.94 ^b ±0.07	1.25 ^a ±0.12	0.055	**
Visceral fat	kg	0.55 ^b ±0.07	1.14 ^a ±0.09	0.86 ^b ±0.33	1.12 ^a ±0.07	0.126	**
	% LW	0.23 ^c ±0.02	0.47 ^a ±0.03	0.33 ^b ±0.13	0.40 ^{ab} ±0.04	0.050	**
Pelvis fat	kg	2.08 ^c ±0.08	3.18 ^b ±0.09	3.56 ^a ±0.25	4.12 ^a ±0.10	0.105	**
	% LW	0.87 ^c ±0.04	1.31 ^b ±0.04	1.37 ^b ±0.07	1.48 ^a ±0.05	0.039	**
GI tract and components							
GI tract with fills	kg	82.55 ^a ±2.98	63.75 ^b ±1.53	65.37 ^b ±2.60	71.04 ^a ±1.91	1.643	**
	% LW	34.42 ^a ±0.68	26.25 ^b ±0.70	25.15 ^c ±0.54	25.48 ^{bc} ±0.79	0.483	**
Intestine with content	kg	13.51 ^a ±0.49	10.44 ^b ±0.25	10.70 ^b ±0.43	11.63 ^b ±0.31	0.268	**
	% LW	5.63 ^a ±0.11	4.30 ^b ±0.11	4.12 ^c ±0.09	4.17 ^c ±0.13	0.081	**
Stomach with	kg	69.03 ^a ±2.50	53.31 ^b ±1.28	54.66 ^b ±2.17	59.40 ^b ±1.59	1.373	**

content	% LW	28.78 ^a ±0.57	21.95 ^b ±0.59	21.03 ^c ±0.45	21.31 ^{bc} ±0.66	0.404	**
Rumen content	kg	58.64 ^a ±2.12	45.29 ^b ±1.09	46.44 ^b ±1.85	50.46 ^a ±1.35	1.167	**
	% LW	24.45 ^a ±0.48	18.63 ^b ±0.52	17.87 ^c ±0.38	18.10 ^{bc} ±0.56	0.346	**
Rumen without content	kg	6.64 ^a ±0.24	5.13 ^b ±0.12	5.26 ^b ±0.21	5.71 ^a ±0.15	0.132	**
	% LW	2.77 ^a ±0.06	2.11 ^b ±0.06	2.03 ^c ±0.04	2.05 ^{bc} ±0.06	0.039	**
Empty Stomach	kg	10.83 ^a ±0.39	8.36 ^b ±0.20	8.57 ^b ±0.34	9.32 ^a ±0.25	0.215	**
	% LW	4.51 ^a ±0.09	3.44 ^b ±0.09	3.30 ^c ±0.07	3.34 ^{bc} ±0.10	0.063	**
Empty intestine	kg	7.19 ^a ±0.26	5.55 ^b ±0.13	5.69 ^b ±0.23	6.19 ^a ±0.17	0.143	**
	% LW	3.00 ^a ±0.06	2.29 ^b ±0.06	2.19 ^c ±0.05	2.22 ^{bc} ±0.07	0.045	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

LW = Live Weight, SEM = Standard Error of Means,

** = Significant at 1% level of probability (p<0.01), * = Significant at 5% level of probability (p<0.05),

NS = Not significant;

Values having different superscripts in the same row differ significantly.

4.3.4.3 Yield of non carcass component of crossbred bulls under different treatment groups

Table 4.3.15 shows yield of non-carcass component of crossbred bulls as percent of live weight under different feed treatment groups. The weight of blood, hide and head varied significantly (p<0.01) among different treatment groups, while the conversion as percent of live weight of blood (p<0.01) and hide (p<0.05) showed significant variations and the proportion of head related to percent of their live weights was non-significant among different treatment groups. The difference of weights of gall bladder, bile and liver was significant (p<0.01), but their proportion related to percent of live weight was non-significant. The weights of spleen, lungs and trachea, testes, penis and tail and their conversion as percent of live weight varied significantly (p<0.01) among different treatment groups. The weights of heart, heart fat, kidney knob, kidney, kidney fat, visceral fat, pelvis fat and their percentage of live weight varied significantly (p<0.01) among the treatment groups except the proportion (%live weight) of heart, heart fat, kidney knob and kidney.

Finally the variations of the values for digestive tract and its components were significant ($p<0.01$) among different feed treatment groups of crossbred bulls.

Table 4.3.15 Yield of non carcass component of crossbred bulls under different treatment groups

Parameters		Crossbred				SEM	Sig. level
		T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Blood	Kg	10.41 ^b ±0.28	11.27 ^b ±1.01	13.60 ^a ±1.01	14.67 ^a ±0.70	0.572	**
	%LW	3.07 ^c ±0.11	3.34 ^b ±0.23	3.55 ^{ab} ±0.16	3.65 ^a ±0.11	0.114	**
Hide	Kg	18.77 ^b ±2.53	20.52 ^b ±1.88	23.52 ^a ±1.16	23.91 ^a ±1.51	1.301	**
	%LW	5.52 ^b ±0.61	6.08 ^{ab} ±0.46	6.32 ^a ±0.27	5.94 ^{ab} ±0.23	0.297	*
Head	Kg	18.30 ^b ±2.24	18.32 ^b ±1.23	22.24 ^a ±2.62	23.69 ^a ±2.17	1.502	**
	%LW	5.39±0.53	5.43±0.25	5.97±0.54	5.89±0.40	0.314	NS
Gall bladder	Kg	0.26 ^b ±0.033	0.26 ^b ±0.032	0.32 ^a ±0.033	0.31 ^a ±0.013	0.022	**
	%LW	0.08±0.007	0.08±0.007	0.08±0.005	0.08±0.000	0.007	NS
Bile	Kg	0.069 ^b ±0.013	0.067 ^b ±0.010	0.082 ^a ±0.010	0.085 ^a ±0.007	0.007	**
	%LW	0.018±0.004	0.020±0.000	0.020±0.000	0.020±0.000	0.007	NS
Liver	Kg	4.37 ^b ±0.64	4.39 ^b ±0.58	5.05 ^a ±0.44	5.15 ^a ±0.12	0.347	**
	%LW	1.29±0.16	1.30±0.14	1.35±0.08	1.28±0.00	0.084	NS
Spleen	Kg	0.86 ^b ±0.09	1.12 ^b ±0.25	1.36 ^a ±0.21	1.22 ^a ±0.03	0.120	**
	%LW	0.25 ^c ±0.02	0.32 ^{ab} ±0.07	0.37 ^a ±0.05	0.30 ^{bc} ±0.00	0.032	**
Lung & Trachea	Kg	4.71 ^b ±0.33	4.53 ^b ±0.30	6.02 ^a ±0.49	5.22 ^a ±0.25	0.251	**
	%LW	1.39 ^b ±0.08	1.34 ^b ±0.06	1.62 ^a ±0.09	1.30 ^b ±0.03	0.050	**
Testes	Kg	0.60 ^b ±0.08	0.62 ^b ±0.05	0.86 ^a ±0.09	0.92 ^a ±0.05	0.050	**
	%LW	0.18 ^b ±0.02	0.18 ^b ±0.01	0.23 ^a ±0.02	0.23 ^a ±0.01	0.007	**
Penis	Kg	0.48 ^b ±0.04	0.54 ^b ±0.03	0.77 ^a ±0.06	0.83 ^a ±0.03	0.032	**

	%LW	0.14 ^c ±0.01	0.16 ^b ±0.01	0.21 ^a ±0.01	0.21 ^a ±0.01	0.007	**
Tail	Kg	0.72 ^b ±0.06	0.71 ^b ±0.11	0.99 ^a ±0.08	1.06 ^a ±0.18	0.084	**
	%LW	0.21 ^b ±0.01	0.21 ^b ±0.03	0.26 ^a ±0.02	0.26 ^a ±0.04	0.022	**
Organs and fat							
Heart	Kg	1.44 ^b ±0.32	1.20 ^b ±0.10	1.56 ^a ±0.27	1.57 ^a ±0.24	0.173	**
	%LW	0.42±0.08	0.35±0.03	0.41±0.06	0.39±0.05	0.039	NS
Heart fat	Kg	0.53 ^b ±0.09	0.67 ^b ±0.19	0.81 ^a ±0.20	0.81 ^a ±0.12	0.109	**
	%LW	0.16±0.02	0.20±0.05	0.22±0.05	0.20±0.03	0.032	NS
Kidney knob	Kg	0.56 ^b ±0.07	0.60 ^b ±0.13	0.73 ^a ±0.11	0.66 ^a ±0.06	0.067	**
	%LW	0.16±0.02	0.18±0.03	0.20±0.02	0.17±0.02	0.022	NS
Kidney	Kg	0.71 ^b ±0.07	0.71 ^b ±0.07	0.85 ^a ±0.11	0.79 ^a ±0.02	0.050	**
	%LW	0.21±0.01	0.21±0.02	0.23±0.02	0.20±0.00	0.007	NS
Kidney fat	Kg	2.21 ^c ±0.07	4.80 ^b ±0.10	5.22 ^a ±0.11	5.65 ^a ±0.18	0.087	**
	%LW	0.65 ^b ±0.02	1.42 ^a ±0.03	1.40 ^a ±0.01	1.41 ^a ±0.04	0.022	**
Visceral fat	Kg	2.70 ^a ±0.26	1.37 ^b ±0.17	2.08 ^b ±0.10	2.40 ^a ±0.26	0.148	**
	%LW	0.80 ^a ±0.07	0.41 ^b ±0.05	0.56 ^b ±0.02	0.60 ^b ±0.05	0.039	**
Pelvis fat	Kg	3.36 ^c ±0.29	5.16 ^b ±0.04	6.20 ^a ±0.13	6.88 ^a ±0.06	0.116	**
	%LW	0.99 ^c ±0.07	1.53 ^b ±0.05	1.67 ^a ±0.02	1.71 ^a ±0.03	0.032	**
GI tract and components							
GI tract with fills	Kg	106.13 ^a ±3.07	90.64 ^b ±3.23	96.42 ^b ±1.04	110.08 ^a ±2.45	1.834	**
	%LW	31.32 ^a ±1.51	26.89 ^b ±0.62	25.93 ^c ±0.63	27.40 ^{bc} ±0.94	0.483	**
Intestine with content	Kg	17.38 ^a ±0.50	14.84 ^b ±0.53	15.79 ^b ±0.17	18.02 ^a ±0.40	0.301	**
	%LW	5.13 ^a ±0.25	4.40 ^b ±0.10	4.25 ^c ±0.11	4.49 ^{bc} ±0.16	0.081	**
Stomach with	Kg	88.74 ^a ±2.57	75.80 ^b ±2.70	80.63 ^b ±0.87	92.05 ^a ±2.05	1.534	**

content	%LW	26.19 ^a ±1.26	22.90 ^b ±0.76	21.68 ^c ±0.53	22.91 ^{bc} ±0.79	0.404	**
Rumen content	Kg	75.39 ^a ±2.19	64.39 ^b ±2.29	68.50 ^b ±0.74	78.20 ^a ±1.74	1.304	**
	%LW	22.25 ^a ±1.07	19.10 ^b ±0.44	18.12 ^c ±0.45	19.46 ^{bc} ±0.67	0.346	**
Rumen without content	Kg	8.53 ^a ±0.25	7.29 ^b ±0.26	7.05 ^b ±1.24	8.85 ^a ±0.20	0.462	**
	%LW	2.52 ^a ±0.12	2.16 ^b ±0.05	1.90 ^c ±0.35	2.20 ^{bc} ±0.08	0.039	**
Empty stomach	Kg	13.92 ^a ±0.40	11.89 ^b ±0.42	12.65 ^a ±0.14	14.44 ^a ±0.32	0.241	**
	%LW	4.11 ^a ±0.20	3.53 ^b ±0.08	3.40 ^c ±0.08	3.60 ^{bc} ±0.12	0.063	**
Empty intestine	Kg	9.25 ^a ±0.27	7.90 ^b ±0.28	8.40 ^b ±0.09	9.59 ^a ±0.21	0.160	**
	%LW	2.73 ^a ±0.13	2.34 ^b ±0.05	2.26 ^c ±0.06	2.39 ^{bc} ±0.08	0.045	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

LW = Live Weight, SEM = Standard Error of Means,

** = Significant at 1% level of probability (p<0.01), * = Significant at 5% level of probability (p<0.05),

NS = Not significant;

Values having different superscripts in the same row differ significantly.

4.3.4.4 Comparison of yield of non carcass component (as percent live weight) between indigenous and crossbred bulls

Table 4.3.16 shows the comparison of yield of non carcass component and their percent of live weight between indigenous and crossbred bulls. The weight of blood, hide and head varied significantly (p<0.01), while the proportion of blood was non-significant, proportion of hide and head were significant (p<0.05) related to percent of live weight between indigenous and crossbred bulls. The weights of gall bladder and bile were higher (p<0.01) for crossbred bulls; while the proportion of gall bladder was non-significant but proportion of bile was significant (p<0.05) as percent of live weight between indigenous and crossbred bulls. The weights of liver and spleen were greater (p<0.01) for crossbred bulls, but difference of their weights as percent of live weight were non-significant between these two breeds. The average weight of lungs and trachea was higher (p<0.01) for crossbred bulls, but the proportion as percent of live weight was higher (p<0.01) for indigenous bulls. The differences of weights of testes, penis and tail were significant (p<0.01), while their percentage of live weight were non-significant (except tail) between indigenous and

crossbred bulls. The weights of heart, heart fat, kidney knob and kidney and their weights as percent of live weight were significantly ($p<0.01$) higher for crossbred bulls except the heart proportion related to percent of live weight. The weights of kidney fat, visceral fat and pelvis fat and the percentage of live weight were significantly higher ($p<0.01$) except the pelvis fat ($p<0.05$) for crossbred bulls than the indigenous bulls. Finally the total digestive tract with its components were significantly heavier ($p<0.01$) for crossbred bulls, while their proportion related to percent of live weight did not differ significantly between indigenous and crossbred bulls.

Table 4.3.16 Comparison of yield of non carcass component (as percent live weight) between indigenous and crossbred bulls considering all treatment groups

Parameters		Breed		P Value	Level of sig
		Indigenous (Mean $\pm$ SD)	Crossbred (Mean $\pm$ SD)		
Blood	Kg	8.705 $\pm$ 0.753	12.487 $\pm$ 1.912	0.0001	**
	%LW	3.408 $\pm$ 0.154	3.403 $\pm$ 0.272	0.949	NS
Hide	Kg	15.825 $\pm$ 1.144	21.680 $\pm$ 2.763	0.0001	**
	%LW	6.196 $\pm$ 0.099	5.968 $\pm$ 0.488	0.047	*
Head	Kg	13.844 $\pm$ 1.496	20.637 $\pm$ 3.125	0.0001	**
	%LW	5.409 $\pm$ 0.237	5.669 $\pm$ 0.487	0.039	*
Gall bladder	Kg	0.225 $\pm$ 0.047	0.286 $\pm$ 0.039	0.0001	**
	%LW	0.086 $\pm$ 0.017	0.081 $\pm$ 0.006	0.226	NS
Bile	Kg	0.058 $\pm$ 0.011	0.076 $\pm$ 0.012	0.0001	**
	%LW	0.022 $\pm$ 0.004	0.020 $\pm$ 0.002	0.022	*
Liver	Kg	3.392 $\pm$ 0.362	4.739 $\pm$ 0.583	0.0001	**
	%LW	1.326 $\pm$ 0.072	1.305 $\pm$ 0.111	0.482	NS
Spleen	Kg	0.881 $\pm$ 0.140	1.141 $\pm$ 0.245	0.0001	**

	%LW	0.341±0.037	0.311±0.058	0.056	NS
Lung & Trachea	Kg	4.169±0.414	5.119±0.679	0.0001	**
	%LW	1.631±0.090	1.411±0.142	0.000	**
Testes	Kg	0.510±0.085	0.749±0.157	0.0001	**
	%LW	0.200±0.022	0.205±0.027	0.486	NS
Penis	Kg	0.417±0.095	0.654±0.157	0.0001	**
	%LW	0.162±0.025	0.179±0.030	0.055	NS
Tail	Kg	0.532±0.067	0.868±0.196	0.0001	**
	%LW	0.207±0.016	0.238±0.037	0.001	**
Organs and fat					
Heart	Kg	1.022±0.145	1.443±0.271	0.0001	**
	%LW	0.398±0.032	0.395±0.061	0.872	NS
Heart fat	Kg	0.405±0.057	0.705±0.186	0.0001	**
	%LW	0.158±0.011	0.194±0.043	0.001	**
Kidney knob	Kg	0.379±0.076	0.639±0.112	0.0001	**
	%LW	0.148±0.023	0.176±0.026	0.001	**
Kidney	Kg	0.503±0.050	0.762±0.091	0.0001	**
	%LW	0.198±0.010	0.212±0.018	0.006	**
Kidney fat	Kg	2.325±0.886	4.466±1.379	0.0001	**
	%LW	0.893±0.289	1.221±0.339	0.002	**
Visceral fat	Kg	0.916±0.294	2.139±0.542	0.0001	**
	%LW	0.357±0.111	0.591±0.150	0.000	**
Pelvis fat	Kg	3.232±0.778	5.410±1.374	0.0001	**

	%LW	1.256±0.244	1.475±0.299	0.015	*
GI tract and components					
GI tract with fills	Kg	70.680±7.857	100.816±8.246	0.0001	**
	%LW	27.826±3.977	27.884±2.294	0.955	NS
Intestine with content	Kg	11.571±1.285	16.508±1.351	0.0001	**
	%LW	4.557±0.650	4.566±0.377	0.955	NS
Stomach with content	Kg	59.101±6.569	84.304±6.895	0.0001	**
	%LW	23.268±3.326	23.421±1.896	0.859	NS
Rumen content	Kg	50.208±5.582	71.620±5.858	0.0001	**
	%LW	19.761±2.828	19.808±1.630	0.949	NS
Rumen without content	Kg	5.682±0.632	7.931±0.995	0.0001	**
	%LW	2.238±0.320	2.196±0.284	0.663	NS
Empty stomach	Kg	9.272±1.031	13.226±1.081	0.0001	**
	%LW	3.650±0.521	3.660±0.301	0.941	NS
Empty intestine	Kg	6.157±0.684	8.784±0.718	0.0001	**
	%LW	2.425±0.346	2.430±0.199	0.960	NS

* = Significant at 5% level of probability ($p < 0.05$), ** = Significant at 1% level of probability ($p < 0.01$), NS = Not significant, LW = Live Weight

The result of the present study for yield of non-carcass component of indigenous and crossbred bulls is almost similar to the values of different parameters of non-carcass component of Roy *et al.* (2013). They also reported similar significant ($p < 0.01$) effect of breed on yield of non-carcass component observed in the present study. Zahradkova *et al.* (2010) observed significantly ($p < 0.001$) higher kidney fat as percent of slaughter weight in Limousin than Charolais heifers. Ozbeyaz *et al.* (1997) also found different weights of hide for Brangus × Jersey, Simmental × Jersey, limousine × Jersey crossbreds (36.5, 37.8, and 39.3 kg, respectively). Nour *et al.* (1983) reported kidney, pelvic and heart fat percentage to be similar

for Holstein and Angus steers in the carcass weight range of 250-350 kg, but at heavier weights there were apparently exponential increases in this fat depot compared to Angus steers. Unlikely to the present study Sestari *et al.* (2012) found no significant difference ($p>0.05$) between treatments for the evaluated parameters for non-carcass component of Nellore cattle fed with different corn hybrids.

4.4 Experiment 3

Study on meat quality of indigenous and crossbred cattle reared under improved feeding system

4.4.1 Physical properties of meat

4.4.1.1 Physical properties of meat of indigenous and crossbred bulls under different treatment groups

The physical properties of meat in indigenous and crossbred (L × HF) bulls under different feed treatments are presented in Table 4.4.1. The pH values of meat after 24h of postmortem did not differ ($p>0.05$) among different treatment groups of indigenous and crossbred bulls. The breed and feed treatment interaction had no significant ($p>0.05$) effect on drip loss, but had a significant ($p<0.01$) effect on cooking loss of meat. There were significant differences of marbling score ($p<0.05$) and color score ($p<0.01$) among different treatment groups of indigenous and crossbred bulls.



Fig. 4.10 Marbling in muscle of rib-eye-area of bull carcass

Table 4.4.1 Physical properties of meat from indigenous and crossbred bulls under different treatment groups

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
pH (24 h postmortem)	5.62±0.04	5.62±0.03	5.63±0.03	5.64±0.03	5.64±0.03	5.62±0.03	5.62±0.04	5.63±0.04	0.02	NS
Drip loss (g 100 g ⁻¹)	1.74±0.04	1.74±0.03	1.76±0.03	1.74±0.02	1.71±0.04	1.73±0.03	1.73±0.05	1.74±0.04	0.02	NS
Cooking loss (g 100 g ⁻¹)	23.72 ^b ±0.47	23.40 ^b ±0.61	23.66 ^b ±0.35	24.26 ^b ±0.48	28.84 ^a ±0.27	29.82 ^a ±0.33	29.00 ^a ±0.38	28.54 ^a ±0.38	0.29	**
Marbling Score	3.55 ^a ±0.022	3.51 ^b ±0.013	3.54 ^a ±0.038	3.53 ^{ab} ±0.036	3.57 ^a ±0.036	3.55 ^a ±0.021	3.54 ^a ±0.021	3.57 ^a ±0.036	0.02	*
Color Score	4.378 ^{ab} ±0.042	4.440 ^a ±0.048	4.384 ^{ab} ±0.054	4.424 ^a ±0.034	4.430 ^a ±0.042	4.290 ^b ±0.024	4.356 ^{ab} ±0.031	4.424 ^a ±0.03	0.03	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means,

* = Significant at 5% level of probability (p<0.05), ** = Significant at 1% level of probability (p<0.01), NS = Not significant;

Values having different superscripts in the same row differ significantly.

4.4.1.2 Physical properties of meat of indigenous bulls under different treatment groups

Table 4.4.2 shows the physical properties of meat of indigenous bulls under different feed treatments. There were no significant ($p>0.05$) effect of feed treatments on pH, drip loss, cooking loss, marbling score and color score of meat of indigenous bulls.

Table 4.4.2 Physical properties of meat of indigenous bulls under different treatment groups

Parameters	Indigenous				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
pH (24 h postmortem)	5.62±0.04	5.62±0.03	5.63±0.03	5.64±0.03	0.022	NS
Drip loss (g 100 g ⁻¹)	1.74±0.04	1.74±0.03	1.76±0.03	1.74±0.02	0.022	NS
Cooking loss (g 100 g ⁻¹)	23.72±0.47	23.40±0.61	23.66±0.35	24.26±0.48	0.344	NS
Marbling Score	3.55±0.022	3.51±0.013	3.54±0.038	3.53±0.036	0.022	NS
Color Score	4.378±0.042	4.440±0.048	4.384±0.054	4.424±0.034	0.032	NS

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means, NS = Not Significant ($p>0.05$).

4.4.1.3 Physical properties of meat of crossbred bulls under different treatment groups

Table 4.4.3 shows the physical properties of meat of crossbred bulls under different feed treatments. pH, drip loss and marbling score of meat did not differ significantly among the dietary treatment groups in crossbred bulls, but the cooking loss and color score varied significantly ($p<0.01$) among different treatment groups.

Table 4.4.3 Physical properties of meat of crossbred bulls

Parameters	Crossbred				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
pH (24 h postmortem)	5.64±0.03	5.62±0.03	5.62±0.04	5.63±0.04	0.022	NS
Drip loss (g 100 g ⁻¹)	1.71±0.04	1.73±0.03	1.73±0.05	1.74±0.04	0.032	NS
Cooking loss (g 100 g ⁻¹)	28.84 ^b ±0.27	29.82 ^a ±0.33	29.00 ^a ±0.38	28.54 ^b ±0.38	0.242	**
Marbling Score	3.57±0.036	3.55±0.021	3.54±0.021	3.57 ^a ±0.036	0.022	NS
Color Score	4.430 ^a ±0.042	4.290 ^b ±0.024	4.356 ^b ±0.031	4.424 ^a ±0.027	0.022	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means

** = Significant at 1% level of probability (p<0.01), NS = Not Significant (p>0.05),

Values having different superscripts in the same row differ significantly

4.4.1.4 Comparison of physical properties of meat between indigenous and crossbred bulls

The comparisons of different physical properties of meat between indigenous and crossbred bulls are shown in table 4.4.4. The pH values of meat after 24 hours of postmortem and drip loss did not differ (p>0.05) between the breed types. But cooking loss of meat was significantly (p<0.01) higher in crossbred bulls. Marbling score was also higher (p<0.05) for meat of crossbred bulls. Color score of meat was not affected by breed type.

Table 4.4.4 Comparison of physical properties of meat between indigenous and crossbred bulls considering all treatment groups

Parameters	Breed		P Value	Level of sig
	Indigenous (Mean±SD)	Crossbred (Mean±SD)		
pH (24 h postmortem)	5.63±0.031	5.63±0.035	0.962	NS
Drip loss (g 100 g ⁻¹)	1.74±0.030	1.73±0.040	0.205	NS
Cooking loss (g 100 g ⁻¹)	23.76±0.550	29.05±0.579	0.000	**
Marbling Score	3.53±0.030	3.56±0.032	0.014	*
Color Score	4.41±0.049	4.38±0.065	0.094	NS

* = Significant at 5% level of probability ($p < 0.05$), ** = Significant at 1% level of probability ($p < 0.01$), NS = Not Significant ($p > 0.05$)

The pH values of meat after 24 hours postmortem was not affected ($p > 0.05$) by feed treatment and breed type in the present study. Unlikely to the present study, Sestari *et al.* (2012) found significant difference ($p < 0.05$) of pH after 24 hours of slaughter between feed treatments. Drip loss of meat was not affected by feed treatment in this study, which is similar to the result of Sestari *et al.* (2012). Marbling score of meat was not affected significantly ($p > 0.05$) by different feed treatments in the present study. Similar non-significant effect of feed treatment was reported by Sestari *et al.* (2012). On the other hand, Tschida (2013) found greater marbling ($p < 0.01$) for meat of purebred Jersey fed diet with 85% concentrate than diet with 70% concentrate. Blomander (2015) reported that, vitamin A restriction had positive effect on marbling. In the present study color score of indigenous bulls did not affected by feed treatment, which is similar to the result of Arnett *et al.* (2010). But, color score of meat of crossbred bulls was affected by feed treatment. Yang *et al.* (2002) also found, better meat color for grain-fed cattle than grass-fed cattle.

The result reported by Plessis and Hoffman (2007), Andrade *et al.* (2010) and Roy *et al.* (2013) were similar to that found in the present study, as they did not observe any significant ($p > 0.05$) difference in pH value measurements taken at 24 hrs in meat of different breeds. Plessis and Hoffman (2007), Jama *et al.* (2008) reported that, drip loss of meat was not affected by breed type which is similar to this study. In the contrary Roy *et al.* (2013) found

significant ($p < 0.05$) effect of breed on drip loss of meat. Cooking loss of meat was higher ($p < 0.01$) for the crossbred bulls than the indigenous bulls in the present study. Similar breed effects on cooking loss were reported by Roy *et al.* (2013), who found higher ($p < 0.05$) cooking loss in meat of Brahman crossbred bulls than Pabna and Red Chittagong bulls of 24 months of age. Unlikely to the present study, Plessis and Hoffman (2007) and Jama *et al.* (2008), Andrade *et al.* (2010) reported non-significant ($p > 0.05$) effect of breed on cooking loss of meat. Marbling score was higher ($p < 0.05$) for meat of crossbred bulls than the indigenous bulls in the present study. Similar significant ($p < 0.05$) effect of breed on marbling was reported by Marshall (1994) and Wheeler *et al.* (1996). According to Ritchie (2005) British breeds have a greater ability to marble than Continental and Brahman-influenced breeds. Among British breeds, Angus, Red Angus, and Shorthorn have a greater propensity to marble than most other breeds that originated in the British Isles. The only breed excelling these breeds in marbling is the Japanese Wagyu. Although, the difference was non-significant, the RCC bulls had the lowest marbling score (2.78) than Pabna (3.56) and Brahman crossbred (3.56) beef (Roy *et al.*, 2013). Color score was not affected ($p > 0.05$) by breed type, and average color score found for meat of indigenous and crossbred bulls (4.41 and 4.38, respectively) was almost similar to the non-significant effect of breed reported by Roy *et al.*, 2013 (4.47 for Pabna breed, 4.77 for RCC and 4.30 for Brahman crossbred bulls).

4.4.2 Chemical properties of meat

4.4.2.1 Chemical properties of meat of indigenous and crossbred bulls under different treatment groups

Table 4.4.5 shows different chemical properties of meat of indigenous and crossbred bulls under different treatment groups. The breed and feed treatment interaction had significant ($p < 0.01$) effect on moisture, protein, fat and ash content of meat. The highest moisture content (75.26 g 100 g⁻¹) was found in group T₁ of crossbred bulls and lowest moisture content (72.72 g 100 g⁻¹) was found in group T₁ of indigenous bulls. The protein content was highest (22.30 g 100 g⁻¹) in group T₁ of indigenous bulls and lowest (18.34 g 100 g⁻¹) in group T₂ of crossbred bulls. Intramuscular fat content was highest (4.67 g 100 g⁻¹) in group T₀ of indigenous bulls and lowest (3.24 g 100 g⁻¹) in group T₂ of crossbred bulls. Finally the highest value (5.30 g 100 g⁻¹) for ash content was found in group T₀ and T₁ of indigenous bulls and lowest (3.61 g 100 g⁻¹) in group T₀ and T₂ of crossbred bulls.

Table 4.4.5 Chemical properties of indigenous and crossbred bulls under different treatment groups

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Moisture (g 100 g ⁻¹)	73.44 ^{ab} ±1.07	72.72 ^b ±0.59	73.88 ^{ab} ±0.93	73.68 ^{ab} ±0.85	75.08 ^a ±0.95	75.26 ^a ±0.44	75.00 ^a ±0.70	75.04 ^a ±0.93	0.57	**
Protein (g 100 g ⁻¹)	21.92 ^b ±0.30	21.92 ^b ±0.30	22.30 ^b ±0.51	21.82 ^b ±0.51	18.74 ^a ±0.63	19.00 ^a ±0.51	18.34 ^a ±0.67	18.74 ^a ±0.63	0.36	**
Fat (IM) (g 100 g ⁻¹)	4.67 ^a ±0.30	4.66 ^a ±0.07	4.65 ^a ±0.31	4.42 ^b ±0.41	3.30 ^b ±0.10	3.34 ^b ±0.24	3.24 ^b ±0.15	3.30 ^b ±0.10	0.16	**
Ash (g 100 g ⁻¹)	5.30 ^a ±0.12	5.30 ^a ±0.12	5.20 ^a ±0.11	5.28 ^a ±0.17	3.61 ^b ±0.12	3.74 ^b ±0.05	3.70 ^b ±0.06	3.61 ^b ±0.12	0.08	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means,

**= Significant at 1% level of probability (p<0.01),

Values having different superscripts in the same row differ significantly.

4.4.2.2 Chemical properties of meat of indigenous bulls under different treatment groups

Table 4.4.6 shows the chemical properties of meat of indigenous bulls under different treatment groups. The result revealed that, the moisture, protein, intramuscular fat and ash content of meat of indigenous bulls did not differ significantly ($p>0.05$) among different treatment groups.

Table 4.4.6 Chemical properties of meat of indigenous bulls under different treatment groups

Parameters	Indigenous				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Moisture (g 100 g ⁻¹)	73.44±1.07	72.72±0.59	73.88±0.93	73.68±0.85	0.621	NS
Protein (g 100 g ⁻¹)	21.92±0.30	21.92±0.30	22.30±0.51	21.82±0.51	0.298	NS
Fat (IM) (g 100 g ⁻¹)	4.67±0.30	4.66±0.07	4.65±0.31	4.42±0.41	0.211	NS
Ash (g 100 g ⁻¹)	5.30±0.12	5.30±0.12	5.20±0.11	5.28±0.17	0.095	NS

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

NS = Not significant, SEM = Standard error of means

4.4.2.3 Chemical properties of meat of crossbred bulls under different treatment groups

Table 4.4.7 shows the chemical properties of meat of crossbred bulls under different treatment groups. The result revealed that, feed treatment did not have significant ($p>0.05$) effect on moisture, protein, intramuscular fat and ash content of meat of crossbred bulls.

Table 4.4.7 Chemical properties of meat of crossbred bulls under different treatment groups

Parameters	Crossbred				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Moisture (g 100 g ⁻¹)	75.08±0.95	75.26±0.44	75.00±0.70	75.04±0.93	0.554	NS
Protein (g 100 g ⁻¹)	18.74±0.63	19.00±0.51	18.34±0.67	18.74±0.63	0.435	NS
Fat (IM) (g 100 g ⁻¹)	3.30±0.10	3.34±0.24	3.24±0.15	3.30±0.10	0.112	NS
Ash (g 100 g ⁻¹)	3.61±0.12	3.74±0.05	3.70±0.06	3.61±0.12	0.063	NS

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

NS = Not significant, SEM = Standard error of means

4.4.2.4 Comparison of chemical properties of meat between indigenous and crossbred bulls under different treatment groups

Table 4.4.8 shows the comparison of different chemical compositions of *longissimus dorsi* muscle between indigenous and crossbred bulls. Result revealed significant ($p < 0.01$) effect of breed on chemical compositions of meat. Moisture content was significantly ($p < 0.01$) higher for meat of crossbred bulls, while protein content, intramuscular fat and ash contents were significantly ($p < 0.01$) higher for meat of indigenous bulls.

Table 4.4.8 Comparison of chemical properties of meat of indigenous and crossbred bulls considering all treatment groups

Parameters	Breed		P Value	Level of sig
	Indigenous (Mean±SD)	Crossbred (Mean±SD)		
Moisture (g 100 g ⁻¹)	73.43±0.924	75.10±0.727	0.000	**
Protein (g 100 g ⁻¹)	21.99±0.430	18.71±0.614	0.000	**
Fat (IM) (g 100 g ⁻¹)	4.60±0.294	3.30±0.151	0.000	**
Ash (g 100 g ⁻¹)	5.27±0.132	3.66±0.101	0.000	**

** = Significant at 1% level of probability ($p < 0.01$)

The proximate compositions (moisture, protein, fat and ash) of meat did not affected ($p>0.05$) by feed treatment in the present study. Mills *et al.* (1992) also did not find any effect ($p>0.05$) of forage and protein treatment on moisture, protein, fat and ash content of meat. Moisture, protein, intramuscular fat and ash content of meat differed significantly ($p<0.01$) between indigenous and crossbred bulls. Unlikely to the present study, Ivanor *et al.* (2008) did not observe any difference ($p>0.01$) in moisture, ash, crude protein and total cholesterol contents among three genetic groups. Serra *et al.* (2008) also did not find any breed effect on moisture and protein content of meat, but found significant ($p<0.05$) differences of intramuscular fat among breeds. Roy *et al.* (2013) reported that RCC beef meat had significantly ($p<0.01$) lower IM fat (1.90 g/100 g) than other two genetic groups, and Pabna beef meat had the highest levels of IM fat (4.65 g/100 g) followed by Brahman crossbred beef meat (3.04 g/100 g). But, breed types did not influence on moisture, protein and ash contents in meat.

4.4.3 Sensory properties of meat



Fig. 4.11 Panel test for sensory evaluation of beef samples

Table 4.4.9 shows that the comparison of sensory properties of meat between indigenous and crossbred bulls. Meat tenderness, chewiness, juiciness, fineness, mouth coating, Beef flavor intensity and color of meat did not differ significantly ($p>0.05$) between indigenous and crossbred bulls. But, overall acceptability of meat was affected ($p<0.05$) by breed type.

Table 4.4.9 Comparison of sensory properties of meat between indigenous and crossbred bulls

Parameters	Indigenous (Mean $\pm$ SD)	Crossbred (Mean $\pm$ SD)	P value	Sig. level
Tenderness	3.72 $\pm$ 0.45	3.35 $\pm$ 0.74	0.367	NS
Chewiness	3.30 $\pm$ 0.48	3.01 $\pm$ 0.39	0.325	NS
Juiciness	3.25 $\pm$ 0.56	3.50 $\pm$ 0.40	0.438	NS
Fineness	3.55 $\pm$ 0.37	3.30 $\pm$ 0.48	0.384	NS
Mouth coating	3.00 $\pm$ 0.40	3.25 $\pm$ 0.25	0.266	NS
Beef flavor intensity	3.70 $\pm$ 0.48	3.40 $\pm$ 0.29	0.264	NS
Color	3.30 $\pm$ 0.33	3.15 $\pm$ 0.42	0.545	NS
Overall acceptability	3.80 $\pm$ 0.33	3.30 $\pm$ 0.33	0.042	*

* = Significant at 5% level of probability ($p < 0.05$), NS = Not significant

In the present study, the panelists did not find any significant ($p > 0.05$) effects of breed on sensory properties of meat, but overall acceptability was affected ($p < 0.05$) by breed type. Almost similar result was reported by Roy *et al.* (2013), who found significant ($p < 0.05$) effect of breed on tenderness, beef flavor intensity and overall acceptability, but did not find any breed effect ($p > 0.05$) on chewiness, juiciness, fineness, mouth coating and color of meat. Although the differences were non-significant, the tenderness, chewiness, fineness, beef flavor intensity and color of beef from native bulls were higher than the crossbred bulls, which was in accordance with Roy *et al.* (2013) and possibly the reason for higher overall acceptability for indigenous beef meat in this study. Casey *et al.* (1990) also found no breed differences in juiciness. But the Afrikaner bulls were found to be more tender and flavorsome than Nguni bulls, and Pedi bulls did not differ from Afrikaner and Nguni bulls. Unlikely to the present study, Serra *et al.* (2008) reported that the three Spanish local beef breeds (Bruna dels Pirineus, Avilena-Negra Iberica and Morucha) were significantly different ($p < 0.05$) from each other according to sensory attributes, which justifies their involvement in different protected geographical indications (PGI). Wheeler *et al.* (1996) also found little effect of breed on palatability traits of meat.

4.4.4 Microbial quality of meat

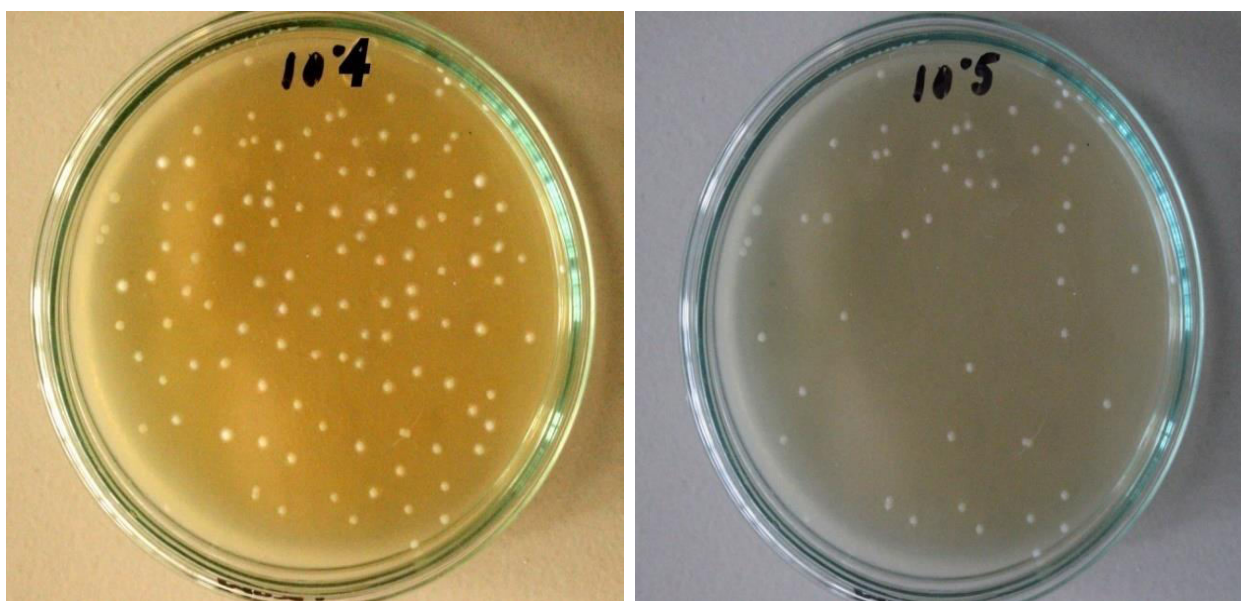


Fig. 4.12 Bacterial colony in Plate Count Agar for different dilutions

4.4.4.1 Total Viable Count of raw meat samples collected from different treatment groups of indigenous and crossbred bulls

Table 4.4.10 shows significant variation ($p < 0.01$) of microbial loads of raw meat samples of indigenous and crossbred bulls among different treatment groups. The highest ($\log 4.90$ cfu/g) and lowest ($\log 3.63$ cfu/g) total viable count were found in group T_0 and group T_1 of indigenous bulls, respectively. The TVC values did not exceed the acceptable limit recommended by ICMSF (1986).

Table 4.4.10 Total Viable Count of raw meat samples collected from different treatment groups of indigenous and crossbred bulls

Breed	Treatments	TVC (Mean log CFU $\pm$ SD/g)	SEM	Level of sig.	Permeable bacterial load in raw meat
Indigenous	T ₀	4.90 ^a $\pm$ 0.36	0.23	**	10 ⁶ $\leq$ TVC $\leq$ 10 ⁷ cfu/g (ICMSF 1986)
	T ₁	3.63 ^f $\pm$ 0.31			
	T ₂	4.71 ^{ab} $\pm$ 0.23			
	T ₃	4.12 ^{cd} $\pm$ 0.53			
Crossbred	T ₀	4.62 ^{ab} $\pm$ 0.25			
	T ₁	4.27 ^{bc} $\pm$ 0.48			
	T ₂	3.70 ^{de} $\pm$ 0.19			
	T ₃	3.71 ^{de} $\pm$ 0.23			

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

TVC = Total Viable Count, CFU = Colony Forming Unit, SEM = Standard error of means

** = Significant at 1% level of probability (p<0.01)

4.4.4.2 Total Viable Count of raw meat samples collected from different treatment groups of indigenous bulls

Table 4.4.11 shows significant variation (p<0.01) of microbial loads of raw meat samples of indigenous bulls among different treatment groups. The highest (log 4.90 cfu/g) and lowest (log 3.63 cfu/g) total viable count were found in group T₀ and group T₁ of indigenous bulls, respectively. The TVC values did not exceed the acceptable limit recommended by ICMSF (1986).

Table 4.4.11 Total Viable Count of raw meat samples collected from different treatment groups of indigenous bulls

Breed	Treatment	TVC (Mean log CFU±SD/g)	SEM	Level of sig.	Permeable bacterial load in raw meat
Indigenous	T ₀	4.90 ^a ±0.36	0.15	**	10 ⁶ ≤ TVC ≤ 10 ⁷ cfu/g (ICMSF 1986)
	T ₁	3.63 ^b ±0.31			
	T ₂	4.71 ^a ±0.23			
	T ₃	4.12 ^b ±0.53			

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

TVC = Total Viable Count, CFU = Colony Forming Unit, SEM = Standard error of means

** = Significant at 1% level of probability (p<0.01)

4.4.4.3 Total Viable Count of raw meat samples collected from different treatment groups of crossbred bulls

Table 4.4.12 shows significant variation (p<0.01) of microbial loads of raw meat samples of crossbred bulls among different treatment groups. The highest (log 4.62 cfu/g) and lowest (log 3.70 cfu/g) total viable count were found in group T₀ and group T₂ of crossbred bulls, respectively. The TVC values did not exceed the acceptable limit recommended by ICMSF (1986).

Table 4.4.12 Total Viable Count of raw meat samples collected from different treatment groups of crossbred bulls

Breed	Treatments	TVC (Mean log CFU±SD/g)	SEM	Level of sig.	Permeable bacterial load in raw meat
Crossbred	T ₀	4.62 ^a ±0.25	0.17	**	10 ⁶ ≤ TVC ≤ 10 ⁷ cfu/g (ICMSF 1986)
	T ₁	4.27 ^a ±0.48			
	T ₂	3.70 ^b ±0.19			
	T ₃	3.71 ^b ±0.23			

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means, CFU = Colony Forming Unit, TVC = Total viable count,

** = Significant at 1% level of probability (p<0.01).

4.4.4.4 Comparison of microbial load of raw meat between indigenous and crossbred bulls

Table 4.4.13 shows the comparison of microbial load of raw meat between indigenous and crossbred bulls. There was no significant difference ($p>0.05$) of total viable count between this two breeds.

Table 4.4.13 Comparison of microbial load of raw meat between indigenous and crossbred bulls considering all treatment groups

Breed	TVC (Mean log CFU $\pm$ SD/g)	P value	Sig. Level	Permeable bacterial load in raw meat
Indigenous	4.34 $\pm$ 0.62	0.144	NS	$10^6 \leq \text{TVC} \leq 10^7$ cfu/g (ICMSF 1986)
Crossbred	4.08 $\pm$ 0.49			

TVC = Total viable count, CFU = Colony Forming Unit, NS = Not Significant

The total viable count in the present study ranged from log 3.63 CFU/g to log 4.90 CFU/g. But the TVC values did not exceed the safety limit recommended by ICMSF (1986) for chilled raw meat. Rahman (2013) found almost similar TVC values for different freeze-thaw cycles ranged from 4.49 log₁₀ CFU/g to 5.17 log₁₀ CFU/g; and slightly higher TVC value (5.12 log₁₀ CFU/g) for fresh beef (stored at -20°C) than the present study. Adzitey *et al.* (2011), Bradeeba and Sivakumaar (2013) and Omorodion and Odu (2014) also reported higher TVC values (5.57 to 6.22 log₁₀ CFU/g, 5.01 to 8.61 log₁₀ CFU/g and 8.6×10^5 to 2.6×10^6 CFU/g, respectively) for meat than the present study, may be due to contamination of beef for unhygienic market condition. Vanderlinde *et al.*, 1998 (2.42 log₁₀ CFU/g and 2.52 log₁₀ CFU/g for carcass and boneless meat) and Philips *et al.*, 2001 (3.13 log₁₀ CFU/g) reported lower TVC values and than the present study. The microbial loads of raw meat samples did not vary significantly ($p>0.05$) between indigenous and crossbred bulls, but varied significantly ($p<0.01$) among different treatment groups in this study, can be linked to a number of factors such as improper handling and processing, use of contaminated water, cross contamination from dirty processing utensils like knife and trays in the meat processing plant. Sethulekshmi and Nanu (2009) also reported that, the equipment, environment and personnel contributed to the low quality of meat due to bacterial contamination in the processing plant.

4.5 Experiment 4

Study on cost benefit analysis of indigenous and crossbred cattle reared under improved feeding system

4.5.1 Economic analysis on the basis of feed cost

4.5.1.1 Feed cost of different feed treatments for indigenous and crossbred bulls

Table 4.5.1 shows significant ($p < 0.01$) effect of breed and feed treatment interaction (breed $\times$ feed treatment) on daily feed cost and feed cost for 1 kg live weight gain of the experimental animals. Daily feed cost was highest (112.9 BDT) in group T₃ of crossbred bulls, while the lowest daily feed cost (45.99 BDT) was found in group T₁ of indigenous bulls. As well as, feed cost for 1 kg live weight gain ranged from 93.96 BDT (group T₁ of crossbred bulls) to 169.94 BDT (group T₀ of indigenous bulls) among different feed treatments of indigenous and crossbred bulls.

Table 4.5.1 Feed cost of different feed treatments for indigenous and crossbred bulls

Parameters	Indigenous				Crossbred				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₀ (Mean±SD)	T ₃ (Mean±SD)	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Feed cost (BDT/d)	45.99 ^g ±4.7	68.04 ^e ±2.1	71.64 ^e ±1.4	76.66 ^d ±4.7	59.26 ^f ±3.6	95.13 ^c ±2.2	106.9 ^b ±3.3	112.9 ^a ±3.9	2.14	**
Feed cost (BDT/kg LWG)	169.94 ^a ±13.6	151.04 ^c ±3.6	159.26 ^b ±2.3	156 ^{bc} ±4.9	130.86 ^d ±3.6	93.96 ^f ±1.7	105.71 ^e ±2.5	96.78 ^f ±5.1	3.99	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, LWG = Live Weight Gain,

SEM = Standard Error of Means,

**= Significant at 1% level of probability (p<0.01),

In a row figures with same superscripts do not differ significantly whereas figures with dissimilar superscripts differ significantly.

4.5.1.2 Feed cost of different feed treatments for indigenous bulls

Daily feed cost and feed cost for 1 kg live weight gain varied significantly ($p < 0.01$) for different feed treatments within the indigenous bulls (Table 4.5.2). The highest daily feed cost (76.66 BDT) was found in group T_3 and lowest (45.99 BDT) in group T_0 . On the other hand feed cost for 1 kg live weight gain was highest (169.94 BDT) in group T_0 and lowest (151.04 BDT) in group T_1 .

Table 4.5.2 Feed cost (BDT) of different feed treatments for indigenous bulls

Parameters	T_0 (Mean $\pm$ SD)	T_1 (Mean $\pm$ SD)	T_2 (Mean $\pm$ SD)	T_3 (Mean $\pm$ SD)	SEM	Sig. level
Feed cost (BDT/d)	45.99 ^c $\pm$ 4.7	68.04 ^b $\pm$ 2.1	71.64 ^b $\pm$ 1.4	76.66 ^a $\pm$ 2.7	2.11	**
Feed cost (BDT/kg LWG)	169.94 ^a $\pm$ 13.6	151.04 ^b $\pm$ 3.6	159.26 ^b $\pm$ 2.3	156 ^b $\pm$ 4.9	5.33	**

T_0 = Treatment Group 0, T_1 = Treatment Group 1, T_2 = Treatment Group 2, T_3 = Treatment Group 3,

LWG = Live Weight Gain, SEM = Standard Error of Means

** = Significant at 1% level of probability ($p < 0.01$),

In a row figures with dissimilar superscripts differ significantly.

4.5.1.3 Feed cost of different feed treatments for crossbred bulls

Table 4.5.3 shows significant ($p < 0.01$) effect of feed treatment on daily feed cost and feed cost for 1 kg live weight gain for the crossbred bulls. Daily feed cost was highest (112.9 BDT) in group T_3 , while the lowest daily feed cost (59.26 BDT) was found in group T_0 . As well as, feed cost for 1 kg live weight gain ranged from 93.96 BDT (group T_1) to 130.86 BDT (group T_0) among different feed treatments of crossbred bulls.

Table 4.5.3 Feed cost (BDT) of different feed treatments for crossbred bulls

Parameters	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)	SEM	Sig. level
Feed cost (BDT/d)	59.26 ^d ±3.6	95.13 ^c ±2.2	106.91 ^b ±3.3	112.9 ^a ±3.9	2.35	**
Feed cost (BDT/kg LWG)	130.86 ^a ±3.6	93.96 ^c ±1.7	105.71 ^b ±2.5	96.78 ^c ±5.1	2.46	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

LWG = Live Weight Gain, SEM = Standard Error of Means,

** = Significant at 1% level of probability (p<0.01),

In a row figures with dissimilar superscripts differ significantly.

4.5.1.4 Comparison of average feed cost between indigenous and crossbred bulls

Table 4.5.4 shows that, the average feed cost per day is higher (p<0.01) for crossbred bulls (93.55 BDT) than the indigenous bulls (65.58 BDT). Whereas, the average feed cost for 1 kg LWG is higher (p<0.01) for indigenous bulls (159.06 BDT) than the crossbred bulls (106.83 BDT).

Table 4.5.4 Comparison of average feed cost (BDT) between indigenous and crossbred bulls considering all treatment groups

Parameters	Indigenous (Mean±SD)	Crossbred (Mean±SD)	P value	Sig. level
Feed cost (BDT/d)	65.58±12.3	93.55±21.6	0.001	**
Feed cost (BDT/kg LWG)	159.06±9.9	106.83±15.3	0.001	**

LWG = Live Weight Gain,

** = Significant at 1% level of probability (p<0.01)

The result of economic efficiency shows, conventional diet group (T₀) had significantly lower (p<0.01) daily feed cost and higher feed cost per kg live weight gain which may due to poor quality of concentrate in diet. On the other hand improved diet groups showed higher (p<0.01) daily feed cost and lower feed cost per kg live weight gain. Rashid *et al.* (2015a)

reported significantly higher ($p < 0.05$) daily feed cost for higher level of concentrate in diets, and the feed cost required for 1kg LWG increased with the increase of concentrate level in diet. Rashid *et al.* (2015b) also found replacing 50% of an all-concentrate diet with urea-molasses impregnated straw (UMS) reduced feed cost per kg LWG, while 100% UMS diet had the lowest ($p < 0.05$) daily feed cost. Parvez *et al.* (2001) reported reduction of daily feed cost with the decreased level of energy and protein in the diet.

4.5.2 Cost-benefit analysis

4.5.2.1 Cost-benefit analysis of indigenous and crossbred bulls under different treatment group

Breed and feed treatment interaction showed significant ($p < 0.01$) effect on the parameters for direct cost (Table 4.5.5). Cattle purchase price, straw price, grass price and concentrate price were lowest (24340, 314.60, 1089.60 and 4114.60 BDT, respectively) in group T₀ of indigenous bulls and highest (37880, 777.80, 3328.60 and 9441 BDT, respectively) in group T₃ of crossbred bulls. De-worming and vaccination cost was highest (154 BDT) in group T₀ of crossbred bulls and lowest (102 BDT) in group T₁ of indigenous bulls. Among the indirect costs tax and transportation cost were fixed for each animal. But, interest on capital was significantly ($p < 0.01$) higher (4641.60 BDT) in group T₃ of crossbred bulls and lower (2956 BDT) in group T₁ of indigenous bulls. Total cost, total cost without grass price and total cost without loan interest varied significantly ($p < 0.01$) among different treatment groups of indigenous and crossbred bulls; and they were highest (56563, 53234 and 51921 BDT, respectively) in group T₃ of crossbred bulls and lowest (33305.20, 32215.60 and 30326.80 BDT, respectively) in group T₀ of indigenous bulls. Between the gross returns sale price of fattened cattle varied significantly ($p < 0.01$) among different treatment groups, while sale price of manure was same (200 BDT). Total gross return was highest (63246 BDT) in group T₃ of crossbred bulls and lowest (33928 BDT) in group T₀ of indigenous bulls. Net returns also varied significantly ($p < 0.01$) among different treatment groups. Net return, net return without grass price and net return without loan interest were highest (6683, 10011.60 and 11324.60 BDT, respectively) in group T₃ of crossbred bulls and lowest (622.80, 1712.40 and 3601.20 BDT, respectively) in group T₀ of indigenous bulls.

4.5.5 Cost-benefit analysis of rearing indigenous and crossbred bulls under different treatment groups

Parameters (BDT)	Indigenous				Crossbred				SEM	Sig. Level
	T ₀	T ₁	T ₂	T ₃	T ₀	T ₁	T ₂	T ₃		
Direct cost										
Cattle purchase price	24340 ^e ±1718.4	24640 ^e ±1105.9	27160 ^d ±971.08	29200 ^c ±1151.09	35680 ^b ±1527	30340 ^c ±1689.08	35500 ^b ±1133.6	37880 ^a ±1530.4	937.6	**
Straw price	314.6 ^d ±18.3	460.6 ^c ±61.2	368.6 ^d ±54.5	337.4 ^d ±81.3	578.60 ^b ±22.2	716 ^a ±77.9	746 ^a ±58.9	777.80 ^a ±109.2	45.3	**
Grass price	1089.6 ^d ±151.3	2170.2 ^c ±149.3	2574.6 ^b ±168.8	2566.4 ^b ±225.2	1243.2 ^d ±321.3	2864.8 ^b ±227.3	3173.8 ^a ±165.5	3328.6 ^a ±345.3	156.7	**
Concentrate price	4114.6 ^f ±447.3	5533.6 ^e ±220.2	5653.2 ^e ±70.1	6295.2 ^d ±203.5	5289.6 ^e ±121.4	7834.8 ^c ±199.2	8909.4 ^b ±409.7	9441 ^a ±277.4	185.04	**
De-worming and vaccination	118 ^c ±8.5	102 ^d ±4.5	120 ^c ±12.3	120 ^c	154 ^a ±5.5	118 ^c ±4.5	136 ^b ±5.5	144 ^b ±5.5	4.491	**
Indirect cost										
Interest on capital	2978.4 ^e ±154.5	2956.8 ^e ±132.7	3288 ^d ±109.6	3700.8 ^c ±248.2	4281.6 ^b ±183.3	3640.8 ^c ±202.7	4276.8 ^b ±131.9	4641.6 ^a ±305.5	131.6	**
Tax	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	-	NS
Transportation	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	-	NS
Total cost										
Total cost	33305.2 ^g ±2300.2	36213.2 ^f ±1316.3	39514.4 ^e ±1109.3	42569.8 ^d ±1626.4	47577 ^c ±1937.5	45864.4 ^c ±2084.7	53092 ^b ±1626.7	56563 ^a ±2220.7	1237.6	**

Total cost (Without grass price)	32215.6 ^g ±2216.5	34043 ^g ±1192.01	36939.8 ^f ±1020.1	40003.4 ^e ±1450.9	46333.8 ^c ±1809.1	42999.6 ^d ±2117.9	49918.2 ^b ±1654.6	53234.4 ^a ±2073.6	1182.7	**
Total cost (Without loan interest)	30326.8 ^g ±2164.8	33256.4 ^f ±1186.4	36226.4 ^e ±1016.8	38869 ^d ±1395.9	43295.4 ^c ±1758.4	42223.6 ^c ±1882.9	48815.2 ^b ±1503.03	51921.4 ^a ±1919.6	1117.2	**
Gross return										
Sale price of fattened cattle	33728 ^h ±2418.7	39241.2 ^g ±1108.6	42875.8 ^f ±1342.6	45321.4 ^e ±1741.5	49701.8 ^d ±1608.04	52309.4 ^c ±1953.6	58974.6 ^b ±1704.6	63046 ^a ±1821.06	1189.2	**
Sales of manure	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	-	NS
Total Gross return	33928 ^h ±2418.7	39441.2 ^g ±1108.6	43075.8 ^f ±1342.6	45521.4 ^e ±1741.5	49901.8 ^d ±1608.04	52509.4 ^c ±1953.6	59174.6 ^b ±1704.6	63246 ^a ±1821.06	1189.2	**
Net Return										
Net Return	622.8 ^d ±750.03	3228 ^b ±546.1	3561.4 ^b ±450.08	2951.6 ^b ±281.7	2324.8 ^c ±523.02	6645 ^a ±677.7	6082.6 ^a ±790.4	6683 ^a ±997.9	448.9	**
Net Return (without grass price)	1712.4 ^d ±778.09	5398.2 ^b ±420.01	6136 ^b ±584.30	5518 ^b ±375.8	3568 ^c ±557.29	9509.8 ^a ±773.66	9256.4 ^a ±773.3	10011.6 ^a ±788.93	442.3	**
Net Return (without loan interest)	3601.2 ^d ±721.07	6184.8 ^c ±503.9	6849.4 ^c ±469.02	6652.4 ^c ±458.2	6606.4 ^c ±413.6	10285.8 ^b ±627.9	10359.4 ^b ±755.6	11324.6 ^a ±831.8	418	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3, SEM = Standard Error of Means

** = Significant at 1% level of probability (p<0.01), NS = Not Significant,

In a row figures with dissimilar superscripts differ significantly.

4.5.2.2 Cost-benefit analysis of indigenous bulls under different treatment groups

Table 4.5.6 shows significant ($p < 0.01$) variations of direct costs among different feed treatment groups of indigenous bulls. Cattle purchase price was highest (29200 BDT) in group T_3 and lowest (24340 BDT) in group T_0 . Straw price was highest (460.60 BDT) in group T_1 and lowest (314.60 BDT) in group T_0 . Grass price was significantly higher ($p < 0.01$) in group T_2 (2574.60 BDT) and T_3 (2566.40 BDT) than group T_0 (1089.60 BDT) and group T_1 (2170.20 BDT). Concentrate price was highest (6295.20 BDT) in group T_3 and lowest (4114.60 BDT) in group T_0 . De-worming and vaccination cost was significantly lower ($p < 0.01$) in group T_1 (102.00 BDT) than the other groups. Among the indirect costs tax and transportation costs were fixed for each animal (250 BDT and 100 BDT, respectively), while interest on capital varied significantly ($p < 0.01$) among different treatment groups, and was highest in group T_3 (3700.80 BDT) and lowest in group T_1 (2956.80 BDT). Total cost also varied significantly ($p < 0.01$) among different treatment groups. The total cost, total cost without grass price and total cost without loan interest were highest in group T_3 (42569.80, 40003.40 and 38869 BDT, respectively) and lowest in group T_1 (33305, 32215 and 30326.80 BDT, respectively). The gross return and net return also varied significantly ($p < 0.01$) among different treatment groups, but return from sales of manure was non-significant ($p > 0.05$). Sale price of fattened cattle and total gross return were highest (45321.40 and 45521.40 BDT, respectively) in group T_3 and lowest (33728 and 33928 BDT, respectively) in group T_0 . Net return, net return without grass price and net return without loan interest were varied significantly ($p < 0.01$) among different treatment groups; and were lowest (622.80, 1712.40 and 3601.20 BDT, respectively) in group T_0 , and comparatively higher (3561.40, 6136 and 6849.40 BDT, respectively) in group T_2 , but did not differ significantly with T_1 and T_3 groups.

Table 4.5.6 Cost-benefit analysis of indigenous bulls under different treatment groups

Parameters (BDT)	Indigenous				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Direct cost						
Cattle purchase price	24340 ^c ±1718.4	24640 ^c ±1105.9	27160 ^b ±971.08	29200 ^a ±1151.09	896.9	**
Straw price	314.6 ^d ±18.3	460.60 ^a ±61.2	368.6 ^b ±54.5	337.4 ^c ±81.3	41.28	**
Grass price	1089.6 ^b ±151.3	2170.2 ^b ±149.3	2574.6 ^a ±168.8	2566.4 ^a ±225.2	124.61	**
Concentrate price	4114.6 ^c ±447.3	5533.6 ^b ±220.2	5653.2 ^b ±70.1	6295.2 ^a ±203.5	191.89	**
De-worming and vaccination	118 ^a ±8.4	102 ^b ±4.5	120 ^a ±12.2	120 ^a ±0.00	5.47	**
Indirect cost						
Interest on capital	2978.4 ^c ±154.5	2956.8 ^c ±132.7	3288 ^b ±109.6	3700.8 ^a ±248.2	119.87	**
Tax	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	-	NS
Transportation	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	100.00 ±0.00	-	NS
Total cost						
Total cost	33305.2 ^d ±2300.2	36213.2 ^c ±1316.3	39514.4 ^b ±1109.3	42569.8 ^a ±1626.4	1166.5	**
Total cost (Without grass price)	32215.6 ^d ±2216.5	34043 ^c ±1192.01	36939.8 ^b ±1020.07	40003.4 ^a ±1450.9	1087	**
Total cost (Without loan interest)	30326.8 ^d ±2164.8	33256.4 ^c ±1186.4	36226.4 ^b ±1016.8	38869 ^a ±1395.9	1064	**

Gross return						
Sale price of fattened cattle	33728 ^d ±2418.7	39241.2 ^c ±1108.6	42875.8 ^b ±1342.6	45321.4 ^a ±1741.5	1219.6	**
Sales of manure	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	-	NS
Total gross return	33928 ^b ±2418.7	39441.2 ^b ±1108.6	43075.8 ^a ±1342.6	45521.4 ^a ±1741.5	1219.6	**
Net Return						
Net Return	622.8 ^c ±750.03	3228 ^a ±546.1	3561.4 ^a ±450.08	2951.6 ^a ±281.7	377.7	**
Net Return (without grass price)	1712.4 ^b ±778.09	5398.2 ^a ±420.01	6136 ^a ±584.3	5518 ^a ±375.8	397.3	**
Net Return (without loan interest)	3601.2 ^b ±721.07	6184.8 ^a ±503.9	6849.4 ^a ±469.02	6652.4 ^a ±458.2	387.7	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means

** = Significant at 1% level of probability (p<0.01), NS = Not Significant,

In a row figures with dissimilar superscripts differ significantly.

4.5.2.3 Cost-benefit analysis of crossbred bulls under different treatment groups

Feed treatment showed significant (p<0.01) effect on the parameters for direct cost of crossbred bulls (Table 4.5.7). Cattle purchase price was highest (37880 BDT) in group T₃ and lowest (30340 BDT) in group T₁. Straw price, grass price and concentrate price were lowest in group T₀ (578.60, 1243.20 and 5289.60 BDT, respectively) and highest in group T₃ (777.80, 3328.60 and 9441 BDT, respectively). De-worming and vaccination cost was lowest in group T₁ (118 BDT) and highest in group T₃ (144 BDT). Among the indirect costs tax and transportation costs were fixed for each animal (250 BDT and 100 BDT, respectively), while interest on capital varied significantly (p<0.01) among different treatment groups, and was highest in group T₃ (4641.60 BDT) and lowest in group T₁ (3640.80 BDT). Total cost varied significantly (p<0.01) among different treatment groups. The total cost, total cost without grass price and total cost without loan interest were highest for group T₃ (56563, 53234.40

and 51921 BDT, respectively) and lowest for group T₁ (45864.40, 42999.60 and 42223.60 BDT, respectively). The gross return and net return also varied significantly ($p<0.01$) among different treatment groups, but return from sales of manure was non-significant ($p>0.05$). Sale price of fattened cattle and total gross return were highest (63046 and 63246 BDT, respectively) in group T₃ and lowest (49701.80 and 49901.80 BDT, respectively) in group T₀. Net return, net return without grass price and net return without loan interest were varied significantly ($p<0.01$) among different treatment groups, and were highest (6683, 10011.60 and 11324.60 BDT, respectively) in group T₃ and lowest (2324.80, 3568 and 6606.40 BDT, respectively) in group T₀.

Table 4.5.7 Cost-benefit analysis of crossbred bulls under different treatment groups

Parameters (BDT)	Crossbred				SEM	Sig. level
	T ₀ (Mean±SD)	T ₁ (Mean±SD)	T ₂ (Mean±SD)	T ₃ (Mean±SD)		
Direct cost						
Cattle purchase price	35680 ^b ±1527	30340 ^c ±1689.08	35500 ^b ±1133.6	37880 ^a ±1530.4	1048.8	**
Straw price	578.6 ^b ±22.2	716 ^a ±77.9	746 ^a ±58.9	777.8 ^a ±109.2	52.34	**
Grass price	1243.2 ^c ±321.3	2864.8 ^b ±227.3	3173.8 ^a ±165.53	3328.6 ^a ±345.3	194.00	**
Concentrate price	5289.6 ^d ±121.4	7834.8 ^c ±199.2	8909.4 ^b ±409.7	9441 ^a ±277.4	193.27	**
De-worming and vaccination	154 ^a ±5.5	118 ^d ±4.5	136 ^c ±5.5	144 ^b ±5.5	3.71	**
Indirect cost						
Interest on capital	4281.6 ^b ±183.3	3640.8 ^c ±202.7	4276.8 ^b ±131.9	4641.6 ^a ±305.5	152.13	**
Tax	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	250.00 ±0.00	-	NS
Transportation	100.00	100.00	100.00	100.00	-	NS

	±0.00	±0.00	±0.00	±0.00		
Total cost						
Total cost	47577 ^c ±1937.5	45864.4 ^d ±2084.7	53092 ^b ±1626.7	56563 ^a ±2220.7	1398.9	**
Total cost (Without grass price)	46333.8 ^c ±1809.07	42999.6 ^d ±2117.9	49918.2 ^b ±1654.6	53234.4 ^a ±2073.6	1359.03	**
Total cost (Without loan interest)	43295.4 ^c ±1758.4	42223.6 ^c ±1882.9	48815.2 ^b ±1503.03	51921.4 ^a ±1919.6	1253.2	**
Gross return						
Sale price of fattened cattle	49701.8 ^c ±1608.04	52309.4 ^b ±1953.6	58974.6 ^b ±1704.6	63046 ^a ±1821.06	1255.4	**
Sales of manure	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	200.00 ±0.00	-	NS
Total return	49901.8 ^b ±1608.04	52509.4 ^b ±1953.6	59174.6 ^a ±1704.6	63246 ^a ±1821.06	1255.4	**
Net return						
Net return	2324.8 ^c ±523.02	6645 ^a ±677.7	6082.6 ^b ±790.4	6683 ^a ±997.9	542.01	**
Net return (without grass price)	3568 ^c ±557.3	9509.8 ^b ±773.7	9256.4 ^b ±773.3	10011.6 ^a ±788.9	515.6	**
Net return (without loan interest)	6606.4 ^c ±413.6	10285.8 ^b ±627.9	10359.4 ^b ±755.6	11324.6 ^a ±831.8	477.7	**

T₀ = Treatment Group 0, T₁ = Treatment Group 1, T₂ = Treatment Group 2, T₃ = Treatment Group 3,

SEM = Standard Error of Means

** = Significant at 1 % level of probability (p<0.01), NS = Not Significant,

In a row figures with dissimilar superscripts differ significantly.

4.5.2.4 Comparison of cost-benefit analysis between indigenous and crossbred bulls under different treatment groups

Table 4.5.8 shows significant ($p<0.01$) variations of all the parameters for direct cost, indirect cost, total cost, gross return and net return between indigenous and crossbred bulls. Average cattle purchase price, straw price, grass price, concentrate price, de-worming and vaccination cost were significantly higher for crossbred bulls (34850, 704.60, 2652.60, 7868.70 and 138 BDT respectively) than the indigenous bulls (26335, 370.30, 2100.20, 5399.15 and 115 BDT respectively). Among the indirect costs tax and transportation costs were non-significant, while the interest on capital was significantly ($p<0.01$) higher for crossbred bulls (4210.20 BDT) than the indigenous bulls (3231 BDT). Total cost, total cost without grass price and total cost without loan interest were also higher for crossbred bulls (50774, 48121.50 and 46563.90 BDT respectively) than the indigenous bulls (37900.65, 35800.45 and 34669.65 BDT respectively). Total gross return was higher ($p<0.01$) for crossbred bulls (56207.95 BDT) than the indigenous bulls (40491.60 BDT). Finally, the net return, net return without grass price and net return without loan interest were also higher for crossbred bulls (5433.85, 8086.45 and 9644.05 BDT respectively) than the indigenous bulls (2590.95, 4691.15 and 5821.95 BDT respectively).

Table 4.5.8 Comparison of cost-benefit analysis between indigenous and crossbred bulls considering all treatment groups

Parameters (BDT)	Breed		P Value	Level of sig
	Indigenous (Mean±SD)	Crossbred (Mean±SD)		
Direct cost				
Cattle purchase price	26335±2345.05	34850±3149.02	0.001	**
Straw price	370.3±78.24	704.60±103.41	0.001	**
Grass price	2100.2±642.39	2652.60±888.71	0.001	**
Concentrate price	5399.15±854.02	7868.70±1658.11	0.001	**
De-worming and vaccination	115±10.51	138.00±14.36	0.001	**

Indirect cost				
Interest on capital	3231±346.04	4210.20±419.33	0.001	**
Tax	250±0E-7a	250.00±0E-7a	0.001	**
Transportation	100.00±0.000000a	100.00±0.000000a	0.001	**
Total cost				
Total cost	37900.65±3876.06	50774.10±4750.41	0.001	**
Total cost (Without grass price)	35800.45±3343.75	48121.50±4311.43	0.001	**
Total cost (Without loan interest)	34669.65±3560.62	46563.90±4393.70	0.001	**
Gross return				
Sale price of fattened cattle	40291.60±4748.76	56007±5663.40	0.001	**
Sales of manure	200.00±0.000000a	200.00±0.000000a	0.001	**
Total gross return	40491.60±4748.76	56207.95±5663.40	0.001	**
Net Return				
Net Return	2590.95±1284.06	5433.85±1986.60	0.001	**
Net Return (without grass price)	4691.15±1860.65	8086.45±2773.03	0.001	**
Net Return (without loan interest)	5821.95±1430.10	9644.05±1949.21	0.001	**

**= Significant at 1% level of probability (p<0.01)

According to the present study, small scale cattle fattening was found to be profitable on the aspect of Bangladesh. Begum *et al.* (2007), Umar *et al.* (2008), Sarma and Ahmed (2011) and Sarma *et al.* (2014) also found small scale cattle fattening enterprise as profitable and feasible. In the present study average cattle purchase price, selling price and net return for indigenous bulls were 26335 BDT, 40291.60 BDT and 2590.95 BDT, respectively, while average buying price, selling price and net return for crossbred bulls were 34850 BDT, 56007.95 BDT and 5433.85 BDT, respectively. Hashem *et al.* (1999) reported average buying and selling prices were 5043 BDT and 8360 BDT, respectively, while average net profit (3648 BDT) was higher than the indigenous bulls and lower than the crossbred bulls of the present study. Begum *et al.* (2007) reported lower average buying price (7528 BDT), selling price (9542 BDT) and net profit (2055 BDT) than the present study. Feed treatment had significant ($p < 0.01$) effect on the net return from this cattle fattening program, where feed treatment T₃ (with Ipil ipil leaf supplementation) proved to be economically feasible and profitable. Ahmed *et al.* (2002) found higher return (2050 BDT) for treated groups than the control groups (1951.67 BDT). Malole *et al.* (2014) also reported similar effect of diet, where cattle fed on cottonseed cake based diets showed higher profit than cattle fed on cottonseed hulls based diet.

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

With the aim of finding an appropriate and cost effective feeding system for improving performance and meat quality of indigenous and crossbred (L × HF) cattle four experiments were carried out in field level during the period of May 2013 to August 2013. Initially a baseline survey was conducted to observe the existing feeding and management systems of indigenous and crossbred (L × HF) cattle during January to February, 2013. The data were collected through a structured pretested interview schedule involving 100 respondents (50 respondents in each village) from two villages (Kathalbaria and Char Faridpur) of Raiganj upazila of Sirajganj district.

The findings of the baseline survey for socio-economic condition of the farmers revealed that, among all the respondents of two villages 40.5% considered agriculture as their main occupation while 46% considered both agriculture and livestock rearing as their main source of income. Overall mean respondents of both villages considered business and other occupations as their income source were 7% and 6.5%, respectively. Majority of the respondents (average 47%) of both villages had small sized family followed by medium (average 38%) and large sized family (average 15). On average most of the farmers in both villages were small farmers (64%) followed by landless (26%) and medium farmers (10%) in the present study. The findings of the survey also revealed that most of the respondents (average 76%) were belonged to medium income category followed by low income category (average 18%) and high income category (average 6%). Average 14% of the farmers were illiterate, 49% farmers could sign only, 25% farmers had primary, 9% had class X and 3% farmers had SSC level of education.

The survey report for beef fattening status in the study area revealed that, most of the respondents (average 59%) took loan from NGOs, 29% used own source of capital and 12% respondents took bank loan for beef cattle production. All the respondents were well-trained for cattle fattening and, average 35% of the farmers fattened cattle for 4 months, 28% farmers

for 6 months and 37% farmers for more than 6 months in both villages. Average 55% farmers used indigenous cattle and 45% farmers used crossbred cattle in both villages for fattening and; on average majority of the farmers (68%) of both villages used artificial insemination (AI) method for cattle breeding, 13% farmers used natural breeding and 19% farmers used both methods for beef cattle production. About 12% farmers used hormones and growth promoters for cattle fattening in the study area; about 61% farmers of two villages vaccinated their beef cattle and 39% farmers did not vaccinate their beef cattle regularly; and most of the farmers (63%) de-wormed their cattle regularly, while 37% farmers did not. Only 6% farmers of Kathalbaria and Char Faridpur villages kept birth record, breeding record, feed record, health record etc. while most of the farmers (94%) did not keep their livestock record in the study area. Finally, after surveying 40 female farmers who were interested in fattening of bulls by improved feeding system were selected for the fattening program.

Result showed that, all the parameters for daily feed nutrient intake were significantly affected ($p < 0.01$) by feed treatment and breed interaction, except Ipil ipil leaf intake ($p > 0.05$). Daily intake of total DM was highest (11.07 kg/d) in group T_3 of crossbred bulls and lowest (5.32 kg/d) in group T_0 of indigenous bulls; and daily total DM intake as percent live weight was highest (3.06%) in T_1 group and lowest (2.10%) in T_0 group of crossbred bulls. Daily total DM intake and daily total DM intake as percent live weight were differed significantly ($p < 0.01$) among different treatment groups of indigenous bulls. The highest daily total DM intake was found in group T_3 (7.13 kg/d) and lowest was found in group T_0 (5.32 kg/d); whereas the highest daily total DM intake as percent live weight was found in group T_1 (2.90%) and lowest value was found in group T_0 (2.19%). The result also revealed that, the parameters for daily intake of feed nutrient by crossbred bulls under different treatment groups varied significantly ($p < 0.01$) except straw intake and Ipil ipil leaf intake ($p > 0.05$). The highest daily total DM intake was found in group T_3 (11.07 kg/d) and lowest was found in group T_0 (7.20 kg/d); whereas the highest daily total DM intake as percent live weight was found in group T_1 (3.06%) and lowest value was found in group T_0 (2.10%). Finally, daily intake of total DM (kg/d) was found to be significantly higher ($p < 0.01$) for crossbred bulls (9.80 kg/d) than indigenous bulls (6.63 Kg/d), but daily intake of total DM as percent live weight did not vary significantly ($p > 0.05$) between these two breeds.

Initial live weight, final live weight, average daily weight gain (ADG) and feed conversion ratio (FCR) of the animals varied significantly ($p < 0.01$) among different treatment groups of indigenous and crossbred bulls. ADG was highest (1.17 kg) in group T₃ of crossbred bulls and lowest (0.27 kg) in group T₀ of indigenous bulls. The highest feed conversion ratio (19.70) of the animals was found in group T₀ of indigenous bulls and lowest FCR (9.48) was found in group T₃ of crossbred bulls. Average daily gain and feed conversion ratio also varied significantly ($p < 0.01$) among different treatment groups both for indigenous and crossbred bulls. ADG was highest in group T₃ both for indigenous (0.49 kg) and crossbred (1.17 kg) bulls; and lowest in group T₀ both for indigenous (0.27 kg) and crossbred (0.45 kg) bulls. Among the feed treatment groups of indigenous bulls, group T₀ showed the requirement of highest amount of feed per kg body weight gain (19.70) and group T₁ showed lowest FCR (15.78). Whereas, among the feed treatment groups of crossbred bulls, highest (15.87) and lowest (9.48) FCR were found in group T₀ and group T₃, respectively. ADG was significantly higher ($p < 0.01$) for crossbred bulls (0.911 kg) than indigenous bulls (0.416); while crossbred bulls showed significantly ($p < 0.01$) superior feed conversion efficiency (11.5 kg/kg LWG) than indigenous bulls (16.36/kg LWG).

The results showed that the interaction of breed and feed treatment had a significant ($p < 0.01$) effect on pre-slaughter body measurement parameters. Feed treatment had significant ($p < 0.01$) effect on body length and heart girth, while wither height and hip height of indigenous bulls did not affected by feed treatment. Pre-slaughter body measurement parameters of crossbred bulls were also affected ($p < 0.01$) by feed treatments. The average body length, heart girth, wither height and hip height were significantly higher ($p < 0.01$) in crossbred bulls (131.81, 174.40, 131.61 and 128.93 cm, respectively) than in the indigenous bulls (125.88, 144.75, 123.78 and 121.03 cm, respectively).

The result also showed that, carcass yield characteristics of experimental animals were affected ($p < 0.01$) by the interaction of breed and feed treatment. All the parameters of carcass yield characteristics increased significantly ($p < 0.01$) with the increase of live weight among different treatment groups of indigenous and crossbred bulls. The warm and chilled carcass weights, meat to bone ratio, KPH%, REA and fat thickness were significantly ($p < 0.01$) lower (107.07 kg, 105.01 kg, 3.54, 1.73%, 6.11 inch² and 1.82 mm, respectively) in group T₀ of

indigenous bulls and higher (200.15 kg, 197.99 kg, 4.35, 3.92%, 13.98 inch² and 5.24 mm, respectively) in group T₃ of crossbred bulls. The calculated retail cut percentage was highest (54.59%) with yield grade 1.00 in group T₃ of crossbred bulls and lowest (52.45%) with yield grade 1.97 in group T₀ of indigenous bulls. Different feed treatments significantly ($p<0.01$) influenced all the carcass yield characteristics within the same breed (both for indigenous and crossbred bulls). The warm and chilled carcass weights, meat to bone ratio, KPH%, REA and fat thickness were significantly ($p<0.01$) lower in group T₀ of indigenous bulls (107.07 kg, 105.01 kg, 3.54, 1.73%, 6.11 inch² and 1.82 mm, respectively) and in group T₀ of crossbred bulls (157.79 kg, 155.51 kg, 4.02, 2.59%, 9.74 inch² and 2.48 mm, respectively); and higher in group T₃ of indigenous bulls (143.88 kg, 141.81 kg, 3.97, 3.30%, 10.17 inch² and 3.27 mm, respectively) and in group T₃ of crossbred bulls (200.15 kg, 197.99 kg, 4.35, 3.92%, 13.98 inch² and 5.24 mm, respectively). Group T₀ showed the highest USDA yield grade (1.97) and lowest % retail cut (52.45%); whereas group T₃ showed the lowest USDA yield grade (1.43) and highest % retail cut (53.65%) among the treatment groups of indigenous bulls. As well as group T₀ showed relatively higher USDA yield grade (1.47) and lower % retail cut (53.55%); and group T₃ showed relatively lower USDA yield grade (1.00) and higher % retail cut (54.59%) among the treatment groups of crossbred bulls. Finally breed type showed significant ($p<0.01$) effect on carcass yield characteristics of experimental animals, except the warm and chilled dressing percentage. The carcass yield parameters such as warm and chilled carcass weights, meat to bone ratio, KPH%, REA and fat thickness were significantly ($p<0.01$) higher (177.8 kg, 175.54 kg, 4.13, 3.48%, 12.41 inch² and 4.42 mm, respectively) for crossbred bulls and lower (127.91 kg, 125.79 kg, 3.81, 2.66%, 8.51 inch² and 2.75 mm, respectively) for indigenous bulls. However, indigenous bulls yielded relatively higher value (1.65) than that of crossbred bulls (1.15), and % retail cut was relatively higher (54.27%) for crossbred bulls than the indigenous bulls (53.15%).

The breed $\times$ feed treatment interactions had significant ($p<0.01$) effect on proportion of different primal cuts in the forequarter and hindquarter of experimental animals, except strip loin and hill muscle. Forequarter was heavier than the hindquarter in the treatment groups. Feed treatment had significant ($p<0.01$) influence on the weight of most of the different primal cuts as percent of chilled carcass weight in the indigenous breed. Among them

percentage of tender loin, knuckle, hill muscle and hind shank were not influenced by feed treatment. All the values for different primal cuts of forequarter were highest and the parameters for the hindquarter were lowest in group T_0 , while the parameters for the forequarter and hindquarter did not differ much among group T_1 , T_2 and T_3 . But, feed treatments had no significant ($p>0.05$) effect on different primal cuts as percent of chilled carcass weight of crossbred bulls, except fore shank. All the values for different primal cuts of forequarter were highest in group T_0 and the parameters for the hindquarter were lowest in group T_0 of crossbred bulls. The type of breed had no significant effect ($p>0.05$) on yield of primal cuts of experimental animals.

The weights of different non-carcass components (kg) and their percentage of live weight (except gall bladder- $p<0.05$; bile, liver and heart- $p>0.05$) varied significantly ($p<0.01$) among different feed treatment groups of indigenous and crossbred bulls. Feed treatment had significant effect ($p<0.01$) on different parameters of yield of non-carcass components of indigenous bulls except, the weight of blood, hide, bile, liver, spleen, lung and trachea, testes, tail, heart, heart fat, kidney and kidney knob as percent of live weight ($p>0.05$). Yield of non-carcass component of crossbred bulls under different treatment groups also varied significantly ($p<0.01$), except the weight of gall bladder, bile, liver, heart, heart fat, kidney knob and kidney as percent of live weight ($p>0.05$). The result also showed that, the weights of different non-carcass components were significantly ($p<0.01$) higher for crossbred bulls than the indigenous bulls. Breed also had significant effect ($p<0.01$) on the weights of different non-carcass components as percent of live weight of animals except, hide, head, bile, pelvis fat ($p<0.05$); but blood, gall bladder, liver, spleen, testes, penis, heart and parameters for GI tract and components did not affected ($p>0.05$) by breed type. However, the weights of non-carcass components were higher for crossbred bulls than the indigenous bulls in this study.

Among the physical properties of meat breed and feed treatment interaction showed non-significant effect ($p>0.05$) on meat pH and drip loss, but significant effect on cooking loss ($p<0.01$), color score ($p<0.01$), and marbling score ($p<0.05$). Cooking loss, marbling score and color score were ranged from 23.40 to 29.82 g 100 g⁻¹, 3.51 to 3.57 and 4.29 to 4.44, respectively. There were no significant ($p>0.05$) effect of feed treatments on pH, drip loss,

cooking loss, marbling score and color score of meat of indigenous bulls. On the other hand, the cooking loss and color score varied ($p < 0.01$) among different treatment groups of crossbred bulls, but no significant ($p > 0.05$) effect of feed treatments on pH, drip loss and marbling score of meat were found. Result also showed that, cooking loss ($p < 0.01$) and marbling score ($p < 0.05$) of meat was significantly higher in crossbred bulls (29.05 g 100 g⁻¹ and 3.56, respectively) than the native bulls (23.76 g 100 g⁻¹ and 3.53, respectively), while the pH values of meat after 24 hours of postmortem, drip loss and color score of meat were not affected ($p > 0.05$) by breed type. Breed and feed treatment interaction showed significant effect ($p < 0.01$) on proximate compositions (moisture, protein, fat and ash) of meat. Moisture, protein, fat and ash content were ranged from 72.72 to 75.26 g 100 g⁻¹, 18.34 to 22.30 g 100 g⁻¹, 3.24 to 4.67 g 100 g⁻¹, 3.24 to 4.67 g 100 g⁻¹ and 3.61 to 5.30 g 100 g⁻¹, respectively. But feed treatment had no significant effect ($p > 0.05$) on the proximate compositions of meat both for indigenous and crossbred bulls. Moisture content was significantly ($p < 0.01$) higher for meat of crossbred bulls (75.10 g 100 g⁻¹) than the indigenous bulls (73.43 g 100 g⁻¹). But protein, fat and ash content of meat was lower ($p < 0.01$) in crossbred bulls (18.71, 3.30 and 3.66 g 100 g⁻¹, respectively) than the indigenous bulls (21.99, 4.60 and 5.27 g 100 g⁻¹, respectively). Meat tenderness, chewiness, juiciness, fineness, mouth coating, beef flavor intensity and color of meat did not differ significantly ($p > 0.05$) between indigenous and crossbred bulls. But, overall acceptability of meat by the panelists was higher ($p < 0.05$) for indigenous bulls (3.80) than the crossbred bulls (3.30). The total viable count in the present study ranged from log 3.63 cfu/g to log 4.90 cfu/ g among different feed treatment groups of indigenous and crossbred bulls, can be linked to a number of factors such as improper handling and processing, use of contaminated water, cross contamination from dirty processing utensils like knife and trays in the meat processing plant. But the TVC values did not exceed the safety limit recommended by ICMSF (1986) for chilled raw meat.

Result for economic analysis showed significant ($p < 0.01$) effect of breed × feed treatment interaction on daily feed cost, and feed cost for 1 kg live weight gain of the experimental animals. Daily feed cost was highest (112.9 BDT) for group T₃ of crossbred bulls, while the lowest daily feed cost (45.99 BDT) was found in group T₁ of indigenous bulls. As well as, feed cost for 1 kg live weight gain ranged from 93.96 BDT (group T₁ of crossbred bulls) to

169.94 BDT (group T₀ of indigenous bulls) among different feed treatments of indigenous and crossbred bulls. Feed treatment and breed type also had significant effect ($p<0.01$) on daily feed cost and feed cost per kg live weight gain of the experimental animals. Feed cost per day was found to be lowest for conventional diet (group T₀), and highest for diet containing Ipil ipil leaf supplementation (group T₃) both for native and crossbred bulls. On the other hand, feed cost per kg live weight gain was highest for conventional diets and significantly ($p<0.01$) lower for improved diets. However, the average feed cost per day was higher ($p<0.01$) for crossbred bulls (93.55 BDT) than the indigenous bulls (65.58 BDT); while the average feed cost for 1 kg LWG was higher ($p<0.01$) for indigenous bulls (159.06 BDT) than the crossbred bulls (106.83 BDT).

Result also revealed that, breed and feed treatment interaction had significant ($p<0.01$) effect on total cost, gross return and net return of organic beef fattening. Highest total cost, total gross return and net return (56563, 63246 and 6683 BDT, respectively) were found for group T₃ of crossbred bulls, and lowest for group T₀ (33305.2, 33928 and 622.8 BDT, respectively) of indigenous bulls. Net return without grass price and net return without loan interest ranged from 1712.4 to 10011.6 BDT and 3601.2 to 11324.6 BDT, respectively. Feed treatment also had significant ($p<0.01$) effect on total cost, gross return and net return of cattle fattening program. Conventional diet showed lowest total costs and lowest net returns both for indigenous and crossbred bulls, while total costs and net returns were higher for improved diets for cattle fattening. Crossbred bulls showed significantly higher ($p<0.01$) average total cost, gross return and net return (50774.10, 56207.95 and 9644.05 BDT, respectively) than the native bulls (34669.65, 40491.60 and 5821.95 BDT, respectively). The net return was much higher without considering grass price and loan interest. So, if the farmers cultivate their own fodder and can use their own source of capital for cattle fattening with appropriate ration and breed type, the highest profit can be achieved on the aspect of Bangladesh.

5.2 Conclusion

Lower cooking loss and marbling, prime color, higher protein, fat, ash content, and higher meat tenderness, flavor intensity, fineness and consumer acceptability made more acceptable beef meat of indigenous bulls than that of crossbred (HF × L) bulls. But, beef carcass from crossbred bulls ((HF × L) with improved diet (T₃) had higher average daily gain (ADG), lower feed conversion ratio (FCR); and superior USDA yield grade and cutability than the indigenous bulls. Improved diet with Ipil ipil leaf supplementation performed more effectively and economically than the diets without Ipil ipil leaf, and the conventional diet found to be inappropriate for profitable beef fattening. So on the aspect of Bangladesh, the crossbred (Holstein Friesian × local) bulls treated with improved diet (containing, Rice straw + Napier grass + concentrate + Ipil ipil leaf) were proved to be more effective and profitable for fattening than the indigenous bulls.

5.3 Recommendations

1. Improving productive performance of indigenous and crossbred (HF × L) cattle is possible through feeding improved diet instead of feeding conventional diet.
2. Supplementation of *ad libitum* roughage (Rice straw + Napier grass + Ipil ipil leaf), and concentrate mixture (maize crush + wheat bran + rice polish + Kheshari bran + fish meal + Mustard oil cake + bone meal + salt) at the rate of 1.5% of the live weight of animals is recommended for economic rearing.
3. Very limited research has been conducted on indigenous and Holstein Friesian × local crossbred bulls for the development of economic feeding system which demands further investigation in this area.

CHAPTER VI

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APPENDICES

Appendix 1. Questionnaire followed to collect information

Department of General Animal Science and Nutrition
Faculty of Veterinary and Animal Science
Hajee Mohammad Danesh Science and Technology University
Dinajpur, Bangladesh

Date:.....

Sl No.....

1. General Information

- a) Farmer's name
- b) Father's/Mother's/Husband's name.....
- c) Address: (i) Village (ii) Union
- (iii) Upazila..... (iv) District.....

2. Socio-economic condition of farmers

a) Gender

☐

Male

☐

Female

b) Age: How old are you?.....Years.

c) Educational level: Please tell your level of education.

☐

Illiterate

☐

Can sign only

☐

Class V

☐

Class X

☐

SSC

d) Household size: How many people do live together in your family?

☐

Small (up to 4)

☐

Medium (5 to 6)

☐

Large (7 to above)

e) **Occupation:** What is your main occupation?

- | | |
|--------------------------------------|--|
| ☐ Agriculture | ☐ Agriculture + Livestock rearing |
| ☐ Business | ☐ Others |

f) **Land size:** Have your land? If yes; total lands.....

- | | |
|--|---|
| ☐ Landless
(0 to 0.49 acres) | ☐ Small land size
(0.5 to 2.49 acres) |
| ☐ Medium land size
(2.5 to 7.49) | |

g) **Annual income:** What is the amount of your annual income?

- | | |
|--|---|
| ☐ Low income
(Up to 50000 BDT) | ☐ Medium income
(50000 to 100000 BDT) |
| ☐ High income
(Above 100000 BDT) | |

3. Check list of organic beef cattle production

a) **Source of Capital:** What is the source of capital for purchasing cattle?

- | | | |
|--------------------------------------|------------------------------------|-----------------------------------|
| ☐ Own capital | ☐ Bank loan | ☐ NGO loan |
|--------------------------------------|------------------------------------|-----------------------------------|

b) **Training:** Do you have any training on organic beef cattle production?

- | | |
|------------------------------|-----------------------------|
| ☐ Yes | ☐ No |
|------------------------------|-----------------------------|

If yes, duration of training and where were you trained.....

c) **Duration of the fattening:**

- | | | |
|-----------------------------------|-----------------------------------|---|
| ☐ 4 Months | ☐ 6 Months | ☐ More than 6 months |
|-----------------------------------|-----------------------------------|---|

d) **Source of Livestock**

- What is the origin of your fatten cattle?

- | | |
|-------------------------------------|------------------------------------|
| ☐ Indigenous | ☐ Crossbred |
|-------------------------------------|------------------------------------|

- Do you Purchase cattle?

☐

Yes

☐

No

If yes, cattle are purchased from

a) Livestock feed

- What type of feed do you use?

i) Roughage

☐

Cultivated fodder

☐

Roadside grass

☐

Both

ii) Concentrate

☐

Mixed feed

☐

Compound feed/pellet

- Do you provide vitamin and mineral supplement?

☐

Yes

☐

No

- What is the source of your feed?

☐

Produce it themselves

☐

Buy locally

- Do you use fertilizer for fodder cultivation?

☐

Yes

☐

No

If yes, what types of fertilizer are used

b) Livestock breeding

- What type of breeding methods you follow?

☐

Natural breeding

☐

Artificial insemination

☐

Natural breeding and AI

c) Health care

- Do you use hormones, antibiotics and synthetic growth promoters?

☐

Yes

☐

No

- Do you vaccinate your cattle?

☐

Yes

☐

No

- Do you de-worm your cattle?

☐

Yes

☐

No

d) Record keeping

- Do you keep your record?

☐

Yes

☐

No

What are the problems you faced in organic beef cattle production?

1.
2.
3.
4.

Suggestions to improve organic beef cattle production

1.
2.
3.
4.

Thanks for your kind cooperation.

Place.....

Date:.....

Name of Interviewer.....

Signature.....

Appendix 2. Daily energy intake and protein intake of indigenous and crossbred bulls during the feeding trial

Items	Experimental animals																			
	T _{0a}	T _{0b}	T _{0c}	T _{0d}	T _{0e}	T _{1a}	T _{1b}	T _{1c}	T _{1d}	T _{1e}	T _{2a}	T _{2b}	T _{2c}	T _{2d}	T _{2e}	T _{3a}	T _{3b}	T _{3c}	T _{3d}	T _{3e}
ME Intake/day (MJ/kg DM)																				
Indigenous Bulls	40.12	38.57	42.55	39.26	40.7	55.8	55.9	56.68	57.88	56.76	56.39	59.16	57.16	57.43	57.53	58.29	59.08	60.93	60.93	62.43
	47.29	53.35	50.13	55.91	57.72	77.69	79.79	80.26	81.15	81.23	85.45	83.75	87.78	87.41	88.78	91.59	89.28	90.55	93.32	47.29
CP intake/day (g/kg DM)																				
Crossbred Bulls	618.83	602.01	652.99	603.44	626.04	853.39	850.42	859.63	876.28	863.57	914.03	958.17	926.64	930.45	932.66	954.45	966.34	997.45	996.19	618.83
	741.75	824.51	782.08	860.33	887.28	1190.06	1215.56	1231.54	1245.24	1232.8	1386.03	1360.69	1425.27	1421.1	1443.06	1494.43	1458.34	1478.98	1523.37	1548.32

Appendix 3. Live weight (kg) of indigenous bulls after each 15 days during the feeding trial

Days on feeding trial	Experimental animals																			
	T _{0a}	T _{0b}	T _{0c}	T _{0d}	T _{0e}	T _{1a}	T _{1b}	T _{1c}	T _{1d}	T _{1e}	T _{2a}	T _{2b}	T _{2c}	T _{2d}	T _{2e}	T _{3a}	T _{3b}	T _{3c}	T _{3d}	T _{3e}
Day 1	195.48	203.51	210.03	217.68	225.24	186.22	191.65	195.27	200.70	183.36	206.97	213.34	198.72	218.99	204.21	210.91	214.11	224.48	228.84	231.98
Day 15	198.70	206.73	213.25	220.90	228.46	191.75	197.18	200.80	206.23	188.89	212.52	219.19	204.57	224.84	210.06	217.69	220.89	231.26	235.62	238.76
Day 30	202.10	210.13	216.65	224.30	231.86	197.44	202.87	206.49	211.92	194.58	218.30	225.13	210.51	230.78	216.00	224.61	227.81	238.18	242.54	245.68
Day 45	205.65	213.68	220.2	227.85	235.41	203.44	208.87	212.49	217.92	200.58	224.27	231.38	216.76	237.03	222.25	231.59	234.79	245.16	249.52	252.66
Day 60	209.41	217.44	223.96	231.61	239.17	209.79	215.22	218.84	224.27	206.93	230.54	237.94	223.32	243.59	228.81	238.59	241.79	252.16	256.52	259.66
Day 75	213.29	221.32	227.84	235.49	243.05	216.24	221.67	225.29	230.72	213.38	237.10	244.62	230.00	250.27	235.49	245.64	248.84	259.21	263.57	266.71
Day 90	217.25	225.28	231.8	239.45	247.01	222.78	228.21	231.83	237.26	219.92	243.73	251.41	236.79	257.06	242.28	252.76	255.96	266.33	270.69	273.83
Day 105	221.24	229.27	235.79	243.44	251	229.43	234.86	238.48	243.91	226.57	252.15	258.23	243.61	263.88	249.10	259.97	263.17	273.54	277.90	281.04
Day 120	227.84	234.23	245.43	249.12	257.64	239.74	245.41	249.15	255.06	238.08	260.37	267.94	252.48	273.23	258.09	268.63	273.51	283.64	287.64	291.74

Appendix 4. Live weight (kg) of crossbred (L × HF) bulls after each 15 days during the feeding trial

Days on feeding trial	Experimental animals																			
	T _{0a}	T _{0b}	T _{0c}	T _{0d}	T _{0e}	T _{1a}	T _{1b}	T _{1c}	T _{1d}	T _{1e}	T _{2a}	T _{2b}	T _{2c}	T _{2d}	T _{2e}	T _{3a}	T _{3b}	T _{3c}	T _{3d}	T _{3e}
Day 1	288.64	273.08	295.5	284.57	295.66	208.99	219.75	221.53	229.98	213.61	241.73	248.62	254.82	258.44	264.51	258.40	256.48	258.66	271.16	281.06
Day 15	294.16	278.6	301.02	290.09	301.18	221.32	232.08	233.86	242.31	225.94	255.19	262.08	268.28	271.90	277.97	273.16	271.24	273.42	285.92	295.82
Day 30	299.8	284.24	306.66	295.73	306.82	234.19	244.95	246.73	255.18	238.81	269.16	276.05	282.25	285.87	291.94	288.41	286.49	288.67	301.17	311.07
Day 45	305.55	289.99	312.41	301.48	312.57	247.72	258.48	260.26	268.71	252.34	283.58	290.47	296.67	300.29	306.36	304.15	302.23	304.41	316.91	326.81
Day 60	311.43	295.87	318.29	307.36	318.45	261.70	272.46	274.24	282.69	266.32	298.23	305.12	311.32	314.94	321.01	320.32	318.4	320.58	333.08	342.98
Day 75	317.35	301.79	324.21	313.28	324.37	276.21	286.97	288.75	297.20	280.83	313.08	319.97	326.17	329.79	335.86	336.67	334.75	336.93	349.43	359.33
Day 90	323.34	307.78	330.2	319.27	330.36	290.97	301.73	303.51	311.96	295.59	328.07	334.96	341.16	344.78	350.85	353.26	351.34	353.52	366.02	375.92
Day 105	329.34	313.78	336.2	325.27	336.36	305.94	316.7	318.48	326.93	310.56	343.15	350.04	356.24	359.86	365.92	370.15	368.23	370.41	382.91	392.81
Day 120	336.88	328.88	346.86	342.17	354.82	328.75	340.71	344.65	352.14	335.05	362.33	368.53	376.26	380.96	386.79	393.52	399.16	402.89	411.32	419.41

Appendix 5. Sensory test of Meat

Expert Name:

Date:

Marking Criteria (Out of 5 point scale):

Types of Meat	Tenderness	Chewiness	Juiciness	Fineness	Mouth coating	Beef flavor intensity	Color	Overall acceptability
Crossbred								
Native								

Signature of Expert