GROWTH PERFORMANCE AND CARCASS TRAITS
OF BEETAL GOAT REARED UNDER HIGH INPUT
FEEDING SYSTEM

By

Kashif Ishaq
M.Sc. (Hons.) Livestock Management
Regd. No. 1997-ag-1471

A dissertation submitted in the partial fulfillment of the requirements for
the degree of

DOCTOR OF PHILOSOPHY

in

LIVESTOCK MANAGEMENT

INSTITUTE OF DAIRY SCIENCES
FACULTY OF ANIMAL HUSBANDRY
UNIVERSITY OF AGRICULTURE, FAISALABAD
PAKISTAN

2015
In the Name of Allah, the Most Gracious, the Most Merciful
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DECLARATION

I here declare that the contents of the dissertation “Growth performance and carcass traits of Beetal goat reared under high input feeding system” are product of my own research work and no part of this dissertation has been copied from any published source (except the references, standard mathematical or genetic models/equations/formulations/protocols, etc.). I further declare that this work has not been submitted for award of any other degree. The University may take action if the information provided is found inaccurate.

Kashif Ishaq
Regd. No. 1997-ag-1471
To

The Controller of Examinations
University of Agriculture
Faisalabad

We, the Supervisory Committee, certify that the contents and form of dissertation submitted by Mr Kashif Ishaq, Regd. No. 1997-ag-1471, has been found satisfactory and recommended that it be processed for the award of the degree.

Supervisory Committee:

1) Dr Muhammad Younas (Chairman) _________________________

2) Dr Muhammad Riaz (Member) ____________________________

3) Dr Mubarak Ali (Member) ________________________________
DEDICATION

It is with my deepest gratitude and warmest affection that

I dedicate this dissertation to my teacher at the

Institute of Dairy Sciences (IDS), Faculty of Animal Husbandry

Professor Emeritus Dr Bakht Baidar Khan

who has been a constant source of knowledge and inspiration for me.
ACKNOWLEDGEMENTS

I would like to express my special indebtedness and recognitions to my erudite Supervisor, Dr Muhammad Younas, Professor (R) and Ex-Director, Institute of Dairy Sciences, Faculty of Animal Husbandry, University of Agriculture, Faisalabad, Pakistan; who has been a tremendous mentor for me. I thank him for encouraging my research and for allowing me to grow as a research scientist. His advices on both research as well as on my career have been priceless.

I would like to manifest my deep gratitude and have obligation to Dr Muhammad Riaz and Dr Mubarak Ali, from Institute of Animal Sciences, Faculty of Animal Husbandry, for serving as my committee members. I want to thank them for letting my Doctoral research be an enjoyable moment and for their brilliant comments and suggestions.

I am grateful to the honorable Dr Muhammad Sarwar, Professor and Dean, Faculty of Animal Husbandry, for his support and courteousness in time when I required. I am also thankful to Dr Muhammad Iqbal Mustafa, Incharge, Institute of Dairy Sciences, and the staff at the Institute of Dairy Sciences who provided me conducive environment to pursue my degree program. I would especially own up the nice cooperation and edification of my teacher, Dr Muhammad Yaseen (Assistant Professor, Department of Statistics) during the course of my doctoral degree.

I would like to thank the Higher Education Commission (HEC), Islamabad for providing me opportunity to win an indigenous scholarship. I would acknowledge the role of HEC as mentorship in revolutionizing the research and higher education sector in the country. I would pay the special tribute to Dr Abdul Rehman, Director of Small Ruminants especially to Mr Muhammad Arif, Farm Manager, LES, Allahdad, Jahanian, District Khanewal for providing me the facilities to conduct my research. I would like to appreciate the administration and my colleagues at Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi for their support and motivation.

Last but not least, I show my politeness to all my friends and department fellows especially Dr Asim Fraz, Mr Mehboob A Hamid, Mr Muhammad Rafiq and Mr Muhammad Iqbal who facilitated me during the course of study.

I am deeply indebted to my father, Mr Muhammad Ishaq, mother, brothers, sister, brother in laws, mother in law (late) and all family members for providing me the moral support and every help which I required during my study.

I am incomplete without the love of my kids; Umm-e-Hani, Afeef Kashif, Umm-e-Faqeeha and my better half. They helped me by sacrificing their time for my study and really cradled me when I was down and alone.

Kashif Ishaq
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December 6, 2015
ABSTRACT

Livestock sector has been one of the key sector in Pakistan during recent past and is fairly contributing to national economy (11.76 % share in GDP). The country being one of most livestock keeping countries contains 68.4 M goats and ranked 3rd in most goat keeping countries in the world after China (137.68 M) and India (125.45 M). As Pakistan does not possess any beef breed, the spent meat of dairy and draught is cherished as beef. There are some breeds of sheep and goat who have potential for mutton production. There are 28 different breeds of goat and Beetal goat is one of the most popular breed in the Punjab because of its beauty and high growth rate. The goats are reared mostly on the fodder and poor quality roughages. The diet of livestock in the country has deficiency of 29% in TDN and 33% DP. Moreover, the fodder based traditional feeding practices are not suitable especially for rain fed areas because of shortage and uncertainty in the supply of feed and fodder.

Poor feeding management during pre-weaning period is one of the factors resulting in compromised growth of Beetal kids fattened for meat purpose. The main reason for this anomaly may be less milk offered to kids and non-serious efforts for its management. The first study was planned to find the most appropriate protein level suiting the age of the weaning while shifting animals to high input feeding system. Total 42 Beetal male kids having 30 (±10), 60 (±10) and 90 (±10) days of age were selected with 16 in each age group. They were designated as G30, G60 and G90 respectively. The weight of animals were; 8±2 kg (G30), 12±2 kg (G60) and 16±2 kg (G90), respectively. All animals were weaned by introducing the total mix feed gradually and withdrawing the milk during the adjustment period of two weeks. The pelleted starter ration (total mix feed) with three various dietary protein levels designated as R1 (16% CP), R2 (20% CP) and R3 (26% CP) were introduced. The control group was reared on the fodder. The starter rations were iso-caloric and were offered for 6 week duration. All animals were exposed to treatment using 2 factor factorial (3×3) plus control treatment arrangement under completely randomized design. The data were collected on average daily feed intake (ADFI), average daily gain (ADG), gain to intake ratio, Klieber ratio (KR), body measurements and blood metabolites of kids. The statistical analysis showed that starter feed protein levels and age of weaning had significant interaction for ADG (P<0.001), KR (P<0.001), ADFI
(P<0.05) and blood urea nitrogen (P<0.05) while serum creatinine and feed conversion had non-significant interaction. The trend analysis (post-hoc analysis for means comparison) revealed that ADG had shown quadratic trend with protein levels and age of weaning interaction. It was found with R2; the animals weaned at 30 days showed better ADG (46.88 gm/day) while same trend was found for animals (87.06 gm/day) weaned at 60 days of age. The animals weaned at 90 days had ADG (127 gm/day) best with R1. It is extracted from the first study that Beetal kid’s performance may be improved by minimizing the post weaning stress if choosing the appropriate protein level with respect to age of weaning.

The high input feeding system have been found more reliable in fulfilling the requirement of the Beetal goat. It also resulted in improving the growth and meat potential of the animals. However, the investigation about which physical form of feed is better for the Beetal is still awaited. Similarly, use of yeast in the feed for improving the feed efficiency also requires the some experimentation in this breed.

Total 16 kids of Beetal breed having 180 (±10) days of age and 17(±2) kg BW were selected for the study. Fattening ration was formulated and used in two physical forms i.e. mash or pellets. The both rations were iso-caloric and iso-nitrogenous. While they were further divided in two categories with presence or absence of live yeast (Saccharomyces cerevisiae). All animals were exposed to treatments using two factor factorial (2×2) arrangement with two form and two yeast addition groups for seventy days. Average daily gain showed the interaction effects of both the treatments whereas it was found that pellets form of feed supplemented with yeast culture showed the best performance (77.50 gm/day) followed by mash without yeast (61.56 gm/day). However, the animals fed on the mash form showed overall lower ADG performance. The same trend was noticed for Klieber ratio. Overall, pellets with yeast addition (PL) showed significantly better Klieber ratio (8.026) than all other groups. The ADFI was lowest (P<0.05) in MS (mash with yeast added) with (588.30 gm/day) followed by pellets without yeast (PLX) (610.0 gm/day), PL (648.8 gm/day) and MS (863.0 gm/d). Feed conversion ratio (FCR) was significantly affected by the main effects of physical form of feed and yeast addition. Yeast addition resulted in better FCR (9.50) than not added (12.24) while pellets form feed resulted lower FCR than mash (9.67 vs 12.48). Pellets with yeast addition resulted in higher (P<0.05) hue angle, hot carcass weight, dressing percentage, lower cook loss, serum glucose and ether extract in meat. The other carcass traits, sensory evaluation, blood metabolites
were not affected by the treatment groups. It is concluded that the pellets with addition of yeast has improved the growth performance without any bad effect on carcass quality.

High input feeding system results in better growth performance in goats as compared to low input feeding system. Traditionally goats are reared under low input system while to see the effectiveness of high input feeding system, third study project was planned to study the growth performance and carcass quality among various classes of Beetal breed. Total 16 Beetal kids (12 male + 4 female) were selected considering 120 (±10) days average age and weight ranging from 16 (±2) kg for male and 14(±2) kg for female. The kids from various classes were divided into four treatment groups designated as S1 (Entire male or not castrated), S2 (castrated at 4 mo), S3 (castrated at 6 mo) and S4 (female). Animals were castrated during pre-fattening period and managed under same conditions before fattening. The duration of the study was 120 days (60 days pre-fattening + 60 day fattening). Total of 12 animals (randomly 3 from each treatment group) were slaughtered at the end of study for detail carcass quality evaluation. The average daily gain (ADG) was significantly affected (P<0.001) by the treatments. There was higher ADG noticed in S3 group (93.75 gm/d) as compared to S1 (90.42 gm/d), S4 (63.89 gm/d) and S2 (33.75 gm/d). Average daily feed intake was significantly (P<0.05) highest in S3 (878.00 gm/d). The serum cholesterol and serum glucose were also affected (P<0.05) by the treatments. There was non-significant (P>0.05) effect of treatments on the sensory panel score about color, chewability, flavor, tenderness and overall acceptability of the cooked meat. It is concluded from third experiment that sex and castration affected the growth in kids while the carcass traits were not affected. The age of castration need consideration in Beetal kids because castration at early age adversely affected the growth of kids in this study.

It is concluded from this dissertation that the young kids of Beetal goat could be shifted to high input feeds as early as 2 month of age but consideration must be given to CP of the starter ration. The fattening of animals under high input feeding system at 6 month of age showed that age of castration may be more that 6 month. While the class of Beetal kids (meat grade classes) does not affect carcass traits. The fattening ration may be used in pellet form while the addition of live yeast was found beneficial.
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Chapter 1

INTRODUCTION

Livestock sector has been one of the key sector in Pakistan during recent past and is fairly contributing to national economy (11.76 % share in GDP). The country being one of most livestock keeping countries contains 68.4 M goats and ranked 3rd in most goat keeping countries in the world after China (137.68 M) and India (125.45 M) (FAOSTAT, 2014). There were 68.4 M goat, 41.2 M cattle, 35.6 M buffalo, 29.4 M sheep and 1.0 M camel in the country (Pakistan Economic Survey, 2014-2015). As Pakistan does not possess any beef breed, the spent meat of dairy and draught is cherished as beef. There are some breeds of sheep and goat who have potential for mutton production. There are 28 different breeds of goat and Beetal goat is one of the most popular breed in the Punjab because of its beauty and high growth rate (Khan et al., 2005). There were 3.11 M Beetal goats in Punjab. The Figure 1.1 shows the distribution of the Beetal goat in Pakistan (ACO, 2006). The goats are reared mostly on the fodder and poor quality roughages. The livestock sector in the country has deficiency of 29% in TDN and 33% DP (FAO, 2006). Moreover, the fodder based traditional feeding practices are not suitable especially for rain fed areas because of shortage and uncertainty in the supply of feed and fodder. The livestock business requires the continuous supply of feed. The high input feeding has one of advantage for continuous supply of the balance feed to the animals.

Figure 1.1: Distribution of Beetal goat in various provinces of Pakistan
KPK= Khyber Pakhtoon Kha, AJK & NA= Azad Jamu Kashmire and Northern Areas
High input feeding system is based on feeding animals intensively on feed lot using rations free of green fodder where the ration is based on agro-industrial wastes, grains and straws, etc. The system has been found more efficient in sheep and goat than traditional low input feeding system in Pakistan due to better nutrients intake, utilization, N-balance and growth with increased profit margins (Nisa et al., 2013). Cholesterol and triglycerides have also been found significantly higher in lambs reared under high input feeding system fed concentrates than those fed fodder only (Sarwar et al., 2010). Based upon this information, it can be envisaged that the cost/kg live weight of lambs fed concentrates may be significantly lower than those fed diets containing fodder.

However, there are some important questions required to be addressed for use of high input feeding system in Beetal goats. In the field conditions, Beetal kids are naturally weaned however they seldom get milk according to body needs. Early age weaning results in lower body weight at weaning, which ultimately affects carcass characteristics. Live weight gain reduces in relation to feed intake when animal approaches maturity (Thompson and Parks, 1983). However, a good nutritional plan may help improve growth and carcass quality of early weaned animals (Muller et al., 2006). The improvement in growth performance may also be due to improvement in digestibility of the nutrients in response to high level of dietary protein. Therefore, appropriate dietary protein level in relation to the age of weaning is required to be investigated.

Physical form of feed is also known to affect growth performance of goats. It is well documented that animals fed ration in the form of mash showed better performance when compared with traditional fodder based system (Nisa et al., 2013 and Sarwar et al., 2010). Pellets have been used to control the fermentation rate in high grain fed diets to animals. Whereas, animals fed with pelleted concentrates showed better average daily gain (ADG) than the mash form concentrates probably due to efficient nutrient utilization (Gipson et al., 2007). Many techniques have been used to improve the nutrient utilization in rumen, like use of antibiotics, yoghurt, prebiotics, ionospheres and various chemical (Jouany, 1994). Live yeast culture (Saccharomyces cerevisiae) has also been supplemented as probiotic or rumen stimulant in the ration of ruminants (Bugdayci et al., 2014). Improvement in the
growth performance was noticed due to better feed conversion and better ruminal NH₃-N concentration in the animals fed rations with the addition of live yeast culture than the rations with no yeast added (Ozsoy et al., 2013). This information demands study to check which physical form of feed out of mash and pellet is the most suited to Beetal goat and whether addition of live yeast has some interaction with the physical form of the feed, while fattening under high input feeding system.

The castration and gender of animals have a significant effect on carcass characteristics of the fattening animals (Mahgoub et al., 2004; Koyuncu et al., 2007 and Zamiri et al., 2012). However, information available on the comparative carcass characteristics of various classes of Beetal, especially under high input feeding system is scanty and therefore, needs to be addressed.

It is hypothesized that use of pelleted total mix feed at weaning and at fattening phases of life in the Beetal kids will improve the feed efficiency and nutrient utilization. It is expected that the findings of this study will be helpful in improving the quality meat production from Beetal kids under high input system. Keeping in view the aforementioned information, this study has been planned to catch on the aptness of introducing high input feeding system after weaning and at fattening age in different classes of Beetal kids (castrated, entire and female) with an effort to improve the growth performance and carcass characteristics.
Chapter 2
REVIEW OF LITERATURE

Mutton production from the goat is one of the extensively investigated topics now a days in this part of the world. South Asian countries including India, Pakistan and Bangladesh are rich in goat population which are inspiring the scientists of the region to explore the new horizons and to get deeper insight about the potential of local breeds. The neighbor countries of the region like China, Iran, Thailand and Philippines are also working on this specie. Other parts of the world including USA, Middle East, Kenya and South Africa are one of leading countries in research about the dairy and meat type goat breeds. The adaptability, multipurpose, feed efficiently for meat and milk production are extensively found and discussed attributes by the scientists. A few work related to current studies are presented in the ensuing lines indicating its potential and mutton production and efficient growth.

2.1. Performance of Beetal Goat

The performance trials have been conducted to know the growth response of the Beetal breed. In an early study conducted at the University of Agriculture, Faisalabad, Ramzan et al. (1988) found Beetal kids attained higher (P<0.01) weight gain (113.16±3.55 gm/day), consumed more (P<0.01) milk (392.85±10.73 gm/day), green fodder and concentrate and showed better utilized protein efficiency (1.64±0.021) as compared to Barbari kids.

Improving the feeding has resulted in better growth performance. Different feeding regimens have been used by scientists aiming to improve the growth rate. Saikia et al. (1995) studied the effect of various feeding regimens in the Crossbred (Assamese × Beetal) animals in India. They used iso-nitrogenous diets having 12% CP and three energy levels with 2.25, 2.50 and 3.00 Mcal DE/kg. The diet with 12% CP and 3 Mcal DE/kg (DM) produced better results.

Nasrullah et al. (2013) studied the effect of different feeding management systems on 45 female Beetal goats and Lohi sheep. Dry matter and neutral detergent fiber intakes were highest (P<0.05) under the extensive management system compared to semi
intensive or intensive systems. The crude protein intake did not differ (P>0.05) among systems within species, sheep presented a significantly higher (144.43 gm/day) crude protein intake compared to goats (127.92 gm/day) under intensive feeding. The extensive system resulted in the highest (P<0.05) average daily gain and the intensive system in the lowest (P<0.05) for both goats and sheep, with growth higher (P<0.05) in sheep than goats in the respective systems.

Recently, a study conducted to reduce the stress after weaning by improving the body reserves done by the Indian scientists, Mann et al. (2015). They used 24 Beetal kids aging 5 days (3-4 kg body weight) in their experiment. They introduced three treatments i.e. feeding Soybean oil at 3% of concentrate up to 2 months and then bypass fat at 3% thereafter for 3 months (W2:3), Soybean oil up to 3 months and bypass fat for 2 months at same dose (W3:2) and without additional supplementation named as Control (W0:0). Data were collected for 150 days on milk, feed, fodder intake and body weight. Average daily gain was best in W2:3 (22.98 % higher than control) followed by W3:2 (15.53 % higher). They concluded that feeding strategy of improving regime with soybean oil for 2 months and by-pass fat for 3 months from birth at the rate of 3% of feed could be a suitable for kids to negate the post weaning stress.

2.2. Age of Weaning and Dietary Protein Levels

Weaning is cesation of milk to the kids. Weaning early may be a strategic plan of management for getting optimum growth in some breeds. The growth performance in response to two different weaning age groups (45 days and 60 days) in 24 Jonia kids were investigated by Marsico et al. (1993). All the animals were fed commercial weaning diet till 70 days of age and then fattened during 70-107 days of age using commercial fattening ration. The weaning ration contained 17.40% CP while comercial fattening ration contained 16.27% CP. The growth pattern was monitered. The kids weaned at 60 days showed better body weight (BW). However, they showed more weight loss i.e. -25 gm/day vs -14 gm/day in kids weaned at 45 days. The early weaned animals showed better (87 gm/day) gain during 70-107 days period as compare to 71 gm/day in late weaned because of older age. Comparative study of effect of early and late weaning was conducted by Palma and Galina (1995) in Maxico. They used 70 female kids (42 weaned early and 28 weaned one month later)
and kept in confinement. During this period of milk feeding, solids (alfalfa hay and concentrate) were always available. Animal weaned later showed better ADG (138±35 gm/day) than the animals weaned earlier (98±35 gm/day).

Feeding systems affect the growth performance in early stage of life. The intensive system proved to be the best to support the growth performance of early weaned kids. A study was conducted to investigate the effect of weaning age and feeding system on the growth performance in 3 breeds of Indian goats by Nagpal et al. (1995). They used 82 male kids on two rearing systems (intensive and semi intensive) for 60 or 90 days weaning ages. The data were collected for the period of three months. Animal weaned at 3 mo of age showed best ADG (100 gm/day) kept on intensive system followed by the 79 gm/day with same weaning age group reared on semi-intensive system. With regard to weaning age group, both groups animals were not different in ADG while kept on semi intensive system. All breeds showed high feeding intake on intensive feeding system when weaned at 90 days of age.

If the animals are weaned in early age then they require better nutritional plan to compensate the decrease in ADG due to post weaning stress. The dietary protein level in the early age play a key role in improving the growth performance of the small ruminants. Some studies presented are evidence of better growth performance with high protein levels in small ruminants. Mtenga and Kitaly (1990) introduced three protein levels i.e. 11.4% (low), 17.2% (medium) and 20.8% (high) in 24 Tanzanian male kids in Tanzania. The dry matter intake was non-significantly different among the experimental units. Maximum DMI was noticed in the animals fed medium protein diet (551 gm/day) followed by high protein (541 gm/day) and low protein diets (532 gm/day). However, ADG was better (P<0.05) in high protein (62.5 gm/day) followed by medium (52.8 gm/day) and low protein diet (44.6 gm/day). Three levels of protein were studied by Purroy et al. (1993) in 96 intact male using two factor factorial experiment. They used 12%, 15% and 18% CP rations in their study. ADG was highest with 18% CP (208 gm/day) followed by 15% CP (207 gm/day) and 12% CP (180 gm/day). Dry matter intake was 74.1, 74.0 and 70.9 gm/day in 18%, 15% and 12% CP respectively. Feed conversion was 3.83 with 12% CP followed by 3.46 in 18% CP and 3.45 in 15% CP.
Muwalla et al. (1998) used two month weaned Awasi lambs and exposed them to two protein levels i.e. high protein (HP) with 15.8% CP and low protein (LP) ration with 12.6% CP. The feed intake was significantly affected by the treatments. Animals with high protein levels showed better intake (1066gm/day) than LP diet (903 gm/day). The treatment effect was also visible in average daily gain (ADG) response with 230 gm/day in HP vs 183 gm/day on LP over the period of 70 days.

While Indian scientists compared three protein levels in creep ration i.e. 18% (G1), 22% (G2) and 27% (G3) in 30 Avivastra lambs while working in Rajastan, India (Santra and Karim, 1999). They found that ADG was not affected significantly by the levels of CP in creep ration. Highest ADG was noticed in G3 (158 gm/day) and lowest in G2 (153gm/day). In a later study, Karim et al. (2001) assessed the nutrient requirement of the preweaned lambs in 47 Malpura lambs. They introduced the creep rations with high energy and high protein (HEHP) having 21.4% CP, medium energy and medium protein (MEMP) containing 16.9% CP while low energy with low protein (LELP) was having 14.3% CP. Total dry matter intake was higher in LELP (17.3 kg/lamb) followed by MEMP (14.8 kg/lamb) and HEHP (13.8 kg/lamb) while ADG was 123.8 gm/day in HEHP followed by 123.6 gm/day in LELP and than 107 gm/day in MEMP.

Jordanian scientists, Titi et al. (2000) used 40 Awasi lambs and 40 Black goats. They used four rations i.e. with 12% CP (D1), 14% CP (D2), 16% CP (D3) and 18% CP (D4). Animals were selected with 110-150 days of age. ADG was maximum with the diet D3 in both lambs (208 gm/day) and kids (134 gm/day).

While working at Institute of Animal Nutrition, Bonn, Germany, Negesse et al. (2001) introduced four protein levels i.e. 8.7% CP (A), 11.7% CP (B), 14.4% CP (C) and 17.6% CP (D) in growing Sannen kids (weaned at 12 kg weight). The ADG was maximum with ‘D’ ration (181 gm/day) while least with ‘A’ ration. The finding was supported by the significant improvement in the feed intake. DMI was also maximum (608 gm/day/head) with ration ‘D’ and least by the ‘A’ ration.

Atti et al. (2004) while working at National Institute of Agricultural Research (NIAR) of Tunisia, used 15 local male kids with mean weight 23.3 kg and approximately 5 month age in their study. They introduced three diets with variable CP i.e. 100, 130,
160 gm/kg DM. they also introduced oat hay *ad libitum*, while concentrates were offered at 500 gm/day. They found that the hay intake was significantly (P<0.05) affected by the protein levels of the concentrate for over the period of 90 days. The diet with 130 gm/day CP shown better dry mater intake of hay with 605 gm/day over the period of study followed by low protein 481 gm/day. However, ADG was not affected (P>0.05) by the rations. Joy *et al.* (2008) worked on 38 male lambs with 3.6±0.8 kg birth weight. The animals were divided in two groups i.e. grazing and indoor housed. They found that the ADG was better in the animals housed indoor (281 gm/day) from birth to slaughter than the grazing animals (242 gm/day).

The effect of dietary treatment and postmortem aging was determined by Kannan *et al.* (2006) while working on 24 castrated goats (BW = 30.7±6.80 kg, age 10 months) in USA. They used four dietary treatments i.e., T1 (2.5 Mcal/kg DM DE and 12% CP), T2 (2.5 Mcal/kg DM DE and 18% CP), T3 (2.9 Mcal/kg DM DE and 12% CP) and T4 (2.9 Mcal/kg DM DE and 18% CP). There was non-significant effect of dietary treatment and meat aging time on Warner-Bratzler shear force value, cooking loss and collagen solubility in Chevon from goat carcasses. Similarly, the treatments did not affect (P>0.05) the sarcomere length, total collagen content and heated calpastatin activity of *longissimus* muscles in dairy goats. They concluded that meat quality is not influenced by the diet and shear force values of Chevon did not considerably decrease due to aging.

Muscher *et al.* (2010) worked on white Saanen male kids, 2 month of age at University of Hannover, Germany. They formulated three rations with 7% CP, 10% CP and 19% CP. They used 3% urea in the ration to improve CP to 19%. The experiment lasted for 7 weeks. The DMI was higher in animals fed with 10% CP (751 gm/day) ration followed by 19% CP (701 gm/day) and 7% CP (558 gm/day). The ADG was 0.14 kg/day achieved with 10% CP ration followed by 0.10 kg/day (with 19% CP) and 0.06 kg/day (with 7% CP). Plasma urea was 5.8 m/M in animals fed with 19% CP followed by 5.0 m/M in 10% CP and 1.9 m/M in 7% CP. They concluded that goat can adapt their nitrogen homeostasis over a broad range of nitrogen using increased capacity of ruminal transfer.

Recently, Vosooghi-poostindoz *et al.* (2014) conducted a study on 24 male fat tailed Kurdi lambs in Iran while fed with ration having two levels of protein i.e. low (16%
CP) and high (18% CP) for 60 days. Lambs were grown under the dam till 10 days of age. Then they were shifted to individual pens and were allowed to suckle twice in a day. The lambs were given ration ad libitum. The animals with high protein diet showed better growth (388 gm/day) than the low protein diet (275 gm/day). The feed intake also followed the same trend (594 gm/day vs 482 gm/day). Urea nitrogen was significantly affected by the ration’s protein levels (17.7 mg/dl with high protein vs 12.3 mg/dl with low protein). However, the serum glucose was non-significantly affected by the the protein levels of the ration.

2.3. Carcass Traits and Growth in Response to Genotype under Various Feeding Systems

The carcass traits have been investigated in various breeds in many part of the world in order to sort out genotype effect. Similarly, the feedings sytems have been studied for their effect on the carcass as well as on the economies of the enterprize. There are hay based, fodder based, grazing based and concentrate base systems used by the scientists for determining the carcass traits.

Nisa et al. (2013) while comparing the high input feeding system with traditional low input system in 80 Beetal male goat kids at University of Agriculture, Faisalabad (UAF) concluded that the kids grown under high input systems have increased nutrients intake, utilization, N-balance and growth with increased profit margin.

In Argentina, Paez Lama et al. (2013) studied the effect of rearing system and slaughter ages on the growth and economic performance of Criollo kids. They divided 48 kids randomly in three groups (n=16) i.e. G1 (groups of kids were naturally reared with their mothers allowed to suckle till weaning at 30 days), G2 (groups of kids naturally reared with their mothers allowed to suckle till weaning at 45 days of age) and G3 (reared on milk replacer until 45 days). A ration consisted of alfalfa hay and ground corn was offered ad libitum during 30-90 days age to all the animals. Kids were slaughtered at 90 (n=8) and 60 (n=8) days old from each group to explore the growth performance of kids. ADG was not affected by the rearing systems while the age of slaughter was affected (P<0.05) with 115.9 gm/day in 60 days slaughter group and 29.5 gm/day in 90 days slaughter group. The results of economics analysis revealed that it was profitable to raise the kids naturally with goat milk and increase the age of slaughter.
The carcass measurement and meat quality in response to intensive production system in 5 breeds of the sheep were studied by Ekiz et al. (2009) in Turkey. They used 46 lambs of Kivircik, Turkish Merino, Ramlic, Chios and Imroz breeds. The breed was not significantly varied in meat pH, water holding capacity and cooking loss. The shear force using Warner Bratzler was more (P<0.01) in Ramlic and Turkish Merino lambs than Kivircik and Imroz lambs. Kivircik lamb meat showed highest redness values than others. Sensory evaluation was not significantly varied among the breed except tenderness score which was significantly (P<0.01) better in Kivircik than those of Turkish Merino, Ramlic and Imroz lambs. The carcass measure including carcass length, leg length, carcass width, buttock width, internal carcass length, hind limb length and thoracic depth were highly varied among the breeds with Kivircik breed showed the highest values. They concluded indigenous Kivircik breed, which had high carcass quality as those of improved breeds, might be considered for production of better quality meat in Marmara Region of Turkey.

In an other experiment, Ekiz et al. (2012) studied the effect of the feeding system on the carcass measurement and meat quality in 48 Kivircik lambs (45 days age) divided equally (n=12) in four groups. They introduced the four systems as; W-G-S lambs (weaned and then taken to pasture and wheat stubble), W-C lambs (weaned between 45-60 days of age and were fattened with concentrate feed until slaughter), UW-C lambs (fattened with concentrate feed and they suckled their dams until slaughter) and UW-G lamb (kept with their dams and were taken to pasture in the day-time). The dressing percentage was 55.24, 51.77, 57.83 and 55.38% (P<0.001) in W-C, W-G-S, UW-C and UW-G lambs respectively while hot carcass weight were 13.62, 12.52, 14.37 and 13.88 kg (P<0.001).The lambs reared under W-G-S had shown higher shear force value in longissimus dorsi muscle (P<0.05) but decreased meat lightness (P<0.001) than those of other systems. W-G-S got lowest sensory score for tenderness, flavor, texture and overall acceptability except juiciness. In a later study, Ekiz et al. (2013) reported the slaughter characteristics, carcass quality and fatty acid composition of lambs reared under four different production system in 45 Kivircik lambs. The four production systems were same as aforementioned. Animal were slaughtered at 30 kg weight. The average finishing period among groups was recorded as 62 days (W-C), 147 days (W-G-S), 66 days (UW-C) and 98 days (UW-G) days. Average daily gain was lower in W-G-S (87 g) and UW-G lambs (131 g) than W-C
(207 g) and UW-C (197 g). Cold dressing based on empty body weight were 53.45, 50.04, 56.45 and 53.82% while cold carcass weight were found 13.18, 12.10, 14.03 and 13.49 kg from W-C, W-G-S, UW-C and UW-G systems, respectively. Carcass fatness parameters for W-G-S system were found lower than the other production systems. The lambs finished with concentrate feed (W-C and UW-C systems) shown higher carcass fatness and higher lean proportion in pelvic limb than UW-G lambs. Proportions of pelvic and thoracic limb joints were lower in lambs of concentrate based systems than grazed. The profile of fatty acids in intramuscular fat was not significantly different in all four feeding systems except for C14:0 and C18:0. The percentage of C18:0 were found higher in intramuscular fat of W-G-S while C14:0 was the highest in UW-C lambs.

In Iran, Norouzian and Ghiasi (2012) studied the carcass performance in response to feeding of Pistachio by-products (PB) in Balouchi lambs. Total 28 lambs were divided in equally (n=7) 4 groups. The control group was fed on the commercial concentrate. Group 2, 3 and 4 were fed with 30, 20 and 10% PB as partial supplementation of beet pulp and alfalfa hay. The treatments did not affect (P>0.05) the carcass traits and growth performance. Therefore, PB could be used safely upto 30% levels in the fattening lambs. Similarly, the growth performance and carcass traits in pure bred St. Croix White (STX) and its cross with Dorper (DRP) were reported by Dodson et al. (2005) in USA. They managed animals in guinea grass pastures (0.5 ha) in a rotational grazing system. The target weight in lambs was 30 kg and DRP lambs reached the target weight sooner (P<0.0008) than STX lambs (178.2±6.3 days vs 210.9±6.7 day, respectively). Average daily gain was lower (P<0.0002) for STX than for DRP lambs (79.1±2.0 gm/day vs 90.3±1.9 g/d respectively). The STX lambs had carcasses with lower (P<0.01) rib eye area than DRP (8.63±0.21 cm² vs 9.36±0.19 cm², respectively). The same trend was also noticed regarding fat thickness as was greater (P<0.02) in DRP than in STX lambs (1.92±0.10 mm vs 1.57±0.10 mm, respectively). Leg circumference was lower (P<0.03) for STX than for DRP lambs (37.3±0.3 cm vs 38.2±0.3 cm, respectively).

Prezioso et al. (1999) studied the effect of various dietary energy sources on the ADG and carcass characteristics of 36 Apennine male lambs. Three diet plan were used in the study as R1 (lambs fed ad libitum lucerne hay + concentrate supplemented with
5% maize oil cake), R2 (same as R1 except concentrated supplemented with 9% barley flakes) and R3 (received the same only concentrate as in R1 but no hay feeding). The R3 diet resulted in better (P<0.01) ADG (0.28 kg/day) than R2 (0.26 kg) and R1 (0.24 kg/day). The cold carcass weight (CCW) was significantly affected by the diets. The R3 diet produced heavier CCW (17.57 kg) followed by R1 (16.17 kg) and R2 (15.34 kg). Similarly, the dressing percentage was higher in the lambs fed R3 (51.87%) than other groups. Conversely, the R3 diets resulted in significantly (P<0.01) lower lean:fat (3.51) than R2 (4.38) and R1 (4.59).

In India, effect of weaning age and feeding system on the carcass traits and growth performance in three goat breeds was studied by Nagpal et al. (1995). Total 82 kids of Sirohi (S) and Malwari (M) and Kutchi (K) weaned at 90 or 60 days of age were randomly allotted to intensive or semi intensive system to study the post weaning period till the age of 6 months (180 days). ADG showed the interaction between feeding system and weaning age. With the semi intensive system (SIS), the weaning age of 60 days and 90 days resulted in statistically same ADG (71 vs 79 gm/day), however, weaning at 90 days resulted in more ADG (100 gm/day) than the 60 days weaned (63 gm/day) when reared on intensive system (IS). Hot carcass weight (HCW) showed the interaction of the age of weaning and feeding system. There was same HCW (P>0.05) with the 60 days weaned kids on SIS but with 90 days, higher (P<0.05) HCW (11.8 kg) at IS than SIS (9.7 kg). The dressing percentage was not affected by the weaning age but IS resulted in higher (P<0.05) dressing percentage (51.6 %) than SIS (48.2 %). The loin area also followed the same trend.

The genotype is one of important the source of variation in the carcass traits. The following studies showed that the carcass traits should be studied for every good meat breed. Fernandes et al. (2008) found that chemical composition of the body and carcass of 3/4Boer× 1/4Saanen crossbred male kid could be predicted by using the body components like neck, hind leg, fore leg, ribs, loin, 9–11th rib section, visceral fat, kidney fat and non-carcass components (head plus feet, organs plus blood and hide). They found high correlation for chemical composition of organs plus blood and 9–11th rib section with the estimate of percentage of fat, protein and water in the body ($r^2$ of 0.94, 0.82 and 0.90). Meat quality is affected by the breed factor where
muscling and carcass size are important for fatter breeds while fatness measurement was more important in the lean breeds (Lambe et al., 2009).

The comparative live animal production performance and carcass traits of purebred Katahdin (KA; n = 20), 3/4 or 7/8 Dorper (DO; n = 30), purebred St. Croix (SC; n = 17) and purebred Suffolk (SU; n = 10) lambs born were studied by Burke and Apple (2007). The lambs were offered the supplemental ration @ 680 g of a corn-soybean meal besides the grazing on Bermuda grass pastures over seeded with ryegrass. The age of slaughter in the lambs was approximately 210 days. DO lambs showed faster gain (P<0.001) than KA or SC lambs during pre-weaning phase. However, DO and SU wethers had greater (P<0.02) ADG during post weaning till slaughter age. Suffolk lambs were heavier (P<0.001) at slaughter and produced heavier (P<0.001) carcasses than lambs from hair-sheep breeds. Carcasses of KA lambs had higher actual fat thickness (P<0.02) that resulted in higher yield grades (P<0.03) than carcasses of DO, SC, or SU lambs. The kidney fat percentage and weight was more (P<0.001) in carcasses from SC and KA than DO and SU lambs. The longissimus muscle (LM) length was larger (P<0.001) in DO and SU than SC and KA. Lean maturity was not different (P=0.32) among breeds. The color index value showed that LM from DO lambs was redder (higher a* values; P<0.001) than SC and SU and more (P<0.001) yellow than that of the other breed-types while SU lambs was lighter (higher L values; P<0.05) than that of SC and KA. The SU yielded in the carcass with higher shear force values (P<0.007) than other breeds. The growth parameters like ADG and carcass muscularity was not affected by the breed type.

Lee et al. (2008) while working on 36 cross bred (Boer × Spanish) intact male goats (aged = 4 months, body weight = 18±0.8 kg) in USA reported chemical composition and quality characteristics of goat meat in response to three dietary treatments. All animals were divided randomly in equally three groups (n=12) where they were fed using pens with 4 animals per pen and three pens were allotted to each treatment groups. The animals were exposed to three dietary regimens i.e. H (alfalfa hay alone), C (18% CP concentrate diet) and HC (hay diet for the first 45 days + followed by the concentrate diet) The longissimus dorsi (LD) muscle from the goats fed the H diet contained a lower (P<0.05) total lipid (1.32 vs 2.67%) and higher (P<0.05) moisture (77.1 vs 74.7%) than those from goats fed the C diet while the total lipid and
percentages of moisture in the LD muscle from HC group were non-significantly different from those fed either the C or H group. The shear force value and cooking loss (%) was not affected by the treatments. The color index of the meat from the various treatments showed that redness ($a^*$ value) was not statistically different among the dietary treatments while $b^*$ (yellowness) and $L^*$ (lightness) of the C and HC were lower (P<0.05) than H fed goats.

Kadim et al. (2003) conducted a study to determine the growth, carcass and meat quality of three Omani goat breeds. They used total of 42 intact male with equal number (n=14) of Batina, Dhofari and Jabal Akdhar breeds in Oman. The slaughter weight, empty body weight, carcass weights and ADG was significantly higher in Jabal Akdhar than Dhofari and Batina goats. The dressing percentage (based on empty body weight) was found 57 and 53% and was highest in Dhofari goats. Batina and Dhofari resulted in lower longissimus muscle dimensions than Jabal Akdhar having a significantly larger area. Batina and Jabal Akhdar goats produced significantly longer and narrower carcasses than Dhofari goats however, the carcass cuts were significantly heavier in Jabal Akdhar. Muscles from the Dhofari and Jabal Akdhar goats had significantly lower ultimate pH values and higher cooking loss (%) than Batina when 4 muscles (longissimus dorsi, biceps femoris, semitendinosus and semimembranosus) from both sides of each carcass were subjected to two different aging periods (1 day vs 6 day). Aging from 1 to 6 days decreased cooking loss by 5% but increased tenderness significantly (27%).

In Bulgaria, Marinova et al. (2001) studied the effect of the sunflower oil supplementation on the carcass composition and meat quality in white Bugarain goats. Total of ten male kids (~ 3 month age) were divided equally (n=5) in two groups which were fed iso-nitrogenous ration consisted of either addition of sunflower oil @ 2.5% of wet weight of concentrate or no added oil (control). The treatments non significantly affected the growth rate, average daily gain, dressing percentage, body components weights, physiochemical characteristics of the meat, carcass and muscle measurements. Experimental ration resulted in significantly (P<0.01) high fat (10.45%) than the control (7.36%) in the half carcass.

At University of Queensland in Australia, Dhanda et al. (2003) conducted the experiment to determine the effect of the genotype on the growth performance and
carcass traits in 6 genotypes. They selected 110 male kids with the genotypes; Boer×Angora (BA), Boer×Feral (BF), Boer×Saanen (BS), Feral×Feral (FF), Saanen×Angora (SA) and Saanen×Feral (SF). There were two slaughter weight groups, i.e. slaughter at 14-22 kg (Capretto) and at 30-35 kg (Chevon). The animals from BS and SF genotypes reached the required live weight for slaughter earlier than kids from other genotypes due to better growth performance. Capretto kids had a significantly (P<0.05) higher average daily gain (171 g per day) compared to Chevon kids (119 g per day). The kids from FF, SA and SF kids deposited more internal fat in comparison to other genotypes. The dressing percentage ranged from 51 to 54% in between all genotypes. The carcass from SF and BS kids were longer, while eye muscle area was largest in BF (11.6 cm²) compared to other genotypes. Cooking loss, pigment concentration and muscle color parameters (CIE L*, a* and b* values) were significantly (P<0.05) influenced by the genotypes. The BF cooked meat had lower shear force values and better sensory scores compared to other genotypes. The longissimus muscle color was lighter for BS kids than other genotypes. There was no significant difference in hot carcass weight, cold carcass weight and shrinkage % among genotypes. Chevon resulted high hot carcass weight (14.9 vs 8.2 kg). A significant (P < 0.05) increase in muscle tenderness was observed from Chevon to Capretto carcasses and cooked meat from these both slaughter weight groups was accepted equally (P>0.05) by the sensory evaluation panel.

2.4. Effect of Physical Form of Feed

The advances in the feed technology and use of agroindustrial waste resulted in concept of commercial goat production in Pakistan. Ration for fattening could be processed in pellet, mash and textured form for improving the economic of the business due to a number of factors. The effect of the physical form of feed on the growth performance in the ruminants have been studied by scientist. Various other factors like feeding system, formulation factors, ingredient composition and use of straws, etc. have also been reported and presented in the following lines.

A group of Indian scientists, Reddy et al. (2012) studied the effect of the physical form of feed on the growth performance of 32 Osmanabadi goat breed (4-5 month age). There were two forms of feed (mash and pellet) with 35% red gram straw (32% RGS) or 50 % red gram straw (50% RGS). Average daily gain was significantly
(P<0.001) highest with pellets with 35% RGS (73.17 gm/day) followed by pellets with 50% RGS (69.42 gm/day), mash with 35% RGS (53.17 gm/day) and mash with 50% RGS (44.12 gm/day). The voluntary feed intake also followed the same trend with the highest intake (670.69 gm/day) in pellet with 35% RGS and least in mash with 50% RGS (420 gm/day). Apparent digestibility was non-significantly (P>0.05) affected by the addition of straw and physical form of feed.

Pelletization effect on the nutritive value of rice straw based total mix ration was studied in the growing Boer goats by Pi et al. (2005) in China. The feed intake was improved significantly (P<0.01) by pelletization i.e. 914 gm against 608 gm in mash. Daily weight gain was 88.8 gm/day and 87.6 gm/day in two pelleted ration against 40.3 gm/day in un-pelletized form. The carcass quality was also improved by treatment. Cooked muscle ratio was 57.37 (P<0.01) in pelleted ration and 53.67% in un-pelletized form.

Gipson et al. (2007) investigated the effect of physical form of feed on the intake, feeding behaviour and growth performance of Boer goat cross bred with 50% Boer (50B) and 75% Boer (75B) genotype. They used 32 goats with approximately 5 month of age. They used two feeding systems i.e. Calan gate feeder (Calan) and automated feeding system (FIRE). They used two type of feed i.e. Alfalfa hay and concentrate with loose or unpeletted and pellet form for each. The 75B showed better intake than the 50B animals under both feeding systems. In FIRE feeding sytems, there was highest dry matter intake in alfalfa hay fed animals (2282 gm/day in 75B and 2206 gm/day in 50B) followed by concentrate pellets (2021 gm/day in 75B and 1647 gm/day 50B), alfalfa loose form (1887 gm/day in 75B and 1414 gm/day in 50B) and least in concentrate in loose form (1696 gm/day in 75B and 1552 gm/day in 50B). While in Calan feeding system, highest intake was noticed in 75B fed concentrate in pellet form (1927 gm/day) followed by 1858 gm/day (75B) in alfalfa pellets, 1850 gm/day (75B) in concentrate loose, 1812 gm/day (50B) in alfalfa pellets and least with 1552 gm/day (50B) in concentrate-loose form fed animals. However, the average daily gain was highest in concentrate-pellets fed goats (221 gm/day in 75B and 203 gm/day in 50B) followed by concentrate-loose form fed (215 gm/day in 75B and 195 gm/day in 50 B), alfalfa-pellets fed (207 gm/day in 75B and 174 gm/day in 50B) and least in alfalfa-loose form fed animals (167 gm/day in 75B and 147 gm/day in 50B).
The ADG:DMI ratio was highest in concentrate pellets fed goats (127 in 75B and 127 in 50B) followed by loose form concentrate fed (121 in 75B and 119 in 50B) while alfalfa has shown non significant difference (P>0.05) regarding the physical form of feed. The feeding system did not affect (P>0.05) the ADG and ADG:DMI ratio.

Earlier, the effect of form of concentrate on fattening performance of Kamauyruk lambs was studied by Turkish scientists (Yaylak et al., 2003). They fed pelleted and mash form concentrate containing 2.76 Mcal ME /kg and 14.48 % crude protein. Animals were given concentrate ration *ad libitum* while mixture straw (barley + vetch) was given at 150 gm/head/day. There was significant effect of the form of feed on daily gain in the 28-42 day period of experiment, feed to gain ratio in the 28-42 day periods and feed intake during 14-28 day, 28-42 day (P<0.05) and 0-42 day (P<0.01) of the experiment. Pellet form of feed resulted in more daily weight gain (310.8 vs 279.8 gm/day) more feed intake (1568.7 vs 1391.3 gm/day) than those fed with mashed feed and they also had lower feed to gain ratio (5.04 and 5.07).

In Spain, pelleted feed was mixed with raw feed by Fernandez and Sanchez-Seiquer (2003) 3 year old goats with 2, 3 and 4 kg/day dose. They intended to determine the effect of dose rate of total mix ration (TMR) on the feed intake and digestibility under Latin square design. The animals with 2 kg/day TMR showed lower dry matter intake (1634.64) than 3 kg/day TMR (1758.24 gm/day) or 4 kg/day TMR (1737.64). However, there was no significant difference for apparent digestibility among treatments. The goats showed sorting as higher percentage of particles < 0.99 mm were found.

The carcass response is also important variable which must be considered while devising the feeding plan for meat producing animals. Various carcass traits like dressing percentage, hot carcass weight, weight and proportion of whole sale cuts and meat quality factors like meat pH, cooking loss, eye muscle area, etc. have been reported by the scientists while feeding the pellet and mash form of feed. Sensory evaluation was also used as a tool to know the consumer preferences while fattening animals using rations with various physical forms of feed. Recently, pellet form feed was used by Spanish scientists (Blanco et al., 2014) in 40 male Merino lambs (6-8 weeks old and 14.1±0.20 kg body weight, BW). There were four experimental treatments: Control (conventional system: long form barley straw and pelleted
concentrate), F05 (TMR pellet including 50 gm barley straw per kg), F15 (TMR pellet including 150 gm barley straw per kg) and F25 (TMR pellet including 250 gm barley straw per kg). All animals were allocated randomly to the treatments with ten in each group. All animals were slaughtered when reached 27 kg body weight. The average daily gain was affected (P = 0.002) by the treatments with F05 group showed lowest (280 gm/day) ADG and F25 showed the highest (353 gm/day) ADG. However, feed to gain ratio was not significantly affected by the dietary treatments (P= 0.172). Neither meat characteristics (pH, fat and meat color, cooking losses and texture) nor carcass traits (carcass weight, chilling losses, dressing percentage, conformation, measurements, fat thickness or jointing into commercial cuts) was affected by the treatments. It was concluded that the treatments did not impact carcass negatively.

Effect of feed processing on the growth performance and carcass traits was determined by Ustuner et al. (2012) in Awasi lambs. They used 26 male lambs (3 month of age) and exposed to three treatments with group one fed with ground feed (n = 8); group 2 fattened with pelleted feed (n = 9) and group 3 was grown with pellet extruded feed (n = 9). Average daily gain (ADG) was significantly affected by the physical form of the feed (P<0.01). ADG of lambs during the project were highest in group 3 (287.8±23.4 gm/day) followed by group 2 (252.1±21.5 gm/day) and group 1 (180.9±17.7 gm/day). There was non significant difference effect of the feed processing on slaughter weight, cold carcass weight, dressing percentage, fat thickness and eye muscle area.

Effect of pelleted concentrate on the growth performance and carcass traits was studied by Solaiman et al. (2011b) in two goat breeds i.e. Boer and Kiko in USA. Total twelve with equal number (n=6) from both breeds were weaned at 3 month age and then offered pelleted concentrate and hay ad libitum with 80:20 ratio for 85 days period. There was breed difference in ADG (P=0.06) with Boer showed better gain (147 gm/day) than Kiko (103 gm/day) males. There was no difference in DMI (P=0.48) among both breeds while significant (P=0.06) higher gain efficiency (0.123 vs 0.093) was noticed in Boer kids. There were non significant differences (P>0.10) in dressing percentage and various carcass traits except Kiko kids shown lower fat thickness over 12th rib (P= 0.04), lower total % fat (P= 0.001) and higher total % bone
mass (P= 0.05) in carcass whereas no difference in muscle mass (P= 0.22) was noticed among breeds.

In India, Madhavi et al. (2006) determined the effect of the physical form of feed on the growth and carcass traits of the Nellor sheep in Hyderabad. They formulated the ration using detoxified neem (Azadirachta indica) and processed it into mash, expander extruded pellets (EP) and stream pellets (SP). These three forms of ration were compared with the conventional feed in 24 Nellor lambs. ADG was significantly (P<0.05) higher in pellets fed (98.80 gm/day in steam pellets and 96.02 gm/day) vs 76.20 gm/day in mash). The same trend was noticed for DMI (1328 gm/day) in SP, 1310 gm/day in EP vs 975 gm/day in mash. Nutrient intake was better for pellets with ME intake 8.45 MJ/kg in EP, 8.31 MJ/kg in SP vs 7.74 MJ/kg in mash. Fiber and protein digestibility was improved by making ration into pellet from. The dressing percentage proportion of whole sale cuts were not affected by the form of feed (P>0.05). Similarly, the lean percentage, bone percentage and Meat/Bone ratio was not affected by the physical form of feed.

In Australia, Pethick et al. (2005) tested the effects of dietary treatment on sheep meat eating quality as perceived by un-trained consumers. Total of 192 Suffolk × Merino lambs (6 month age) were divided in four groups and exposed to four rations for 60-77 days. Lambs were fed: a mixed ration treatment consisting of a high-energy pelleted diet (40% barley grain, 30% wheat grain, 15% hay and 12% lupin grain); irrigated pasture for 37-51 days followed by a moderate-energy pelleted diet (36% wheat grain, 35% hay and 24.5% lupin grain) for 23-26 days; an irrigated perennial ryegrass-clover-kikuyu sward and irrigated perennial ryegrass-clover-kikuyu pasture for 48-61 days then poor quality straw for the last 12-16 days. The initial live weight was 31.5-35.5 kg and the final hot carcass weight was 19-20 kg. Straw feeding (last 12-16 days) resulted in loss of live-weight during straw feeding period while decreased content of intramuscular fat and glycogen in muscle was also noticed. Sensory evaluation was performed by the Untrained Australian consumers and were asked to rate samples (scale 0-100) of the M. longissimus thoracis et lumborum (LL) from lambs for tenderness, juiciness, liking of flavour and overall liking with the option of classify the meat as unsatisfactory, good everyday or better than everyday.
Straw feeding resulted in significantly lower consumer scores for juiciness (P<0.05) and liking of flavour (P<0.10) with no changes in tenderness and overall liking.

Physical form of feed was studied in 32 Merino Branco (MB) ram lambs by Portuguese scientists (Santos-Silva et al., 2004). They divided lambs in four groups and offered four rations: conditioned lucerne hay (H); conditioned lucerne hay + soybean oil (HO); ground and pelleted lucerne (P) and ground and pelleted lucerne + soybean oil (PO). ADG was best in pellet form (P=323 gm/day; PO = 280 gm/day) and similarly DMI was best in pellet form feed (148 gm/kg W^{0.75} in P and 117 gm/kg W^{0.75}). There was an interaction in the particle size and oil use during the experiments. Pellet form shown better response without oil for ADG and DMI while hay showed better response with oil addition. After slaughtering animals at 6 week of experiment, the data on carcass traits were collected. Hot carcass weight (HCW) also showed interaction effects of the particle size and oil addition with higher HCW (18.2 kg) for pellets without oil addition while hay showed better HCW with oil supplementation (13.4 kg). Kindney knob channel fat (KKCF) showed the main effects of oil addition where oil addition increased KKCF significantly higher (P<0.001) in PO (3 %) followed by HO (2.6 %). Other carcass traits were not affected by the treatment factors.

### 2.5. Addition of Live Yeast as Probiotics

The yeast have been added in the rations of mutton producing animals as probiotics to improve the feed efficiency and economics of venture. The effect of yeast addition on the growth performance depends on type of yeast, level of yeast, NDF content of ration and duration of feeding, etc. Some studies have showed that the yeast addition may affect the carcass traits. Some studies are presented here in ensuing lines for getting better understanding of using yeast culture.

The effect of feeding yeast on the growth performance and carcass traits was investigated by the Hernandez-Garcia et al. (2015). They selected 32 Pelibuey cross bred and exposed them to four treatments i.e. 1) control (no yeast), 2) yeast (1.5 gm/kg DMI per day), 3) Se-Cr mixed (1.5 mg/kg DMI per day and 4) yeast-Se-Cr mixture. They used *Saccharomyces cerevisiae* as yeast culture in their experiment. The DMI was significantly decreased due to Se-Cr supplementation. While carcass characteristics was not affected by the supplementation of the yeast culture.
Ozsoy et al. (2014) investigated the effect of adding the live yeast culture in 48 Saanen crossbred in Turkey. The experimental period was 10 week. There were four treatment groups i.e. 1= control or CON (no yeast supplementation), 2 = yeast supplementation @ 1.5 % lives yeast culture (YC15), 3 = yeast supplementation @ 3.0 % lives yeast culture (YC30) and 4 = yeast supplementation @ 4.5 % lives yeast culture (YC45). The \textit{Saccharomyces cerevisiae} was used in this study. The ADG was highest with YC45 (201.8 gm/day) and lowest in CON (174.8 gm/day). The FCR and DMI was not affected by the supplementation of the yeast. In the rumen fluid, Coliform was least in YC45 group.

In Turkey, Bugdayci et al. (2014) worked out the effect of addition of live yeast culture (LYC) on growth performance of 18 Saanen male goat. There were three dietary treatments with S (-) = no sucrose and LYC, S (+) = added 3%, sucrose and S+LYC = 3% S + LYC. The fattening performance and blood parameters were not significantly (P<0.05) affected by the sucrose and LYC supplementation.

In Brazil, effect of inactive dry yeast (IDY) addition on the growth performance and carcass traits in Santa Ines lambs was studied by Rufino et al. (2013). The soybean meal was substituted for inactive dry yeast (\textit{Saccharomyces cerevisiae}) with 0, 33, 67, 100 % levels of substitution. There was a quadratic relation for levels of substitution with maximum at 67% levels. Apparent digestibility of crude protein was also maximum at 67% level. The ADG was not affected by the levels of the IDY while feed efficiency was lowest at 67% level. Carcass traits were not affected by the levels of the IDY. However, the meat chemical composition was affected by the IDY. There was linear increase (P=0.024) in CP of the meat with maximum (20.46 %) at 100 % level of substitution. While there was quadratic increase (P=0.056) in intramuscular fat with maximum (2.94%) at 67 % levels.

In Brazil, Issakowicz et al. (2013) studied the effect of live yeast (\textit{Saccharomyces cerevisiae}) and concentrate levels in 24 Texel lambs. There were two concentrate levels (80 % and 60%) and two live yeast (Absent or present). Animals were reared in individual pens for 62 days including 10 days adjustment period. There was no effect of addition of live yeast on daily live weight gain, DMI and feed conversion (FC). However, improving the concentrate level to 80% did improve the daily live weight gain or DLWG (326 vs 221 gm/day), DMI (854 vs 728 gm/day) and lower the FC.
Average serum glucose was improved by improving the concentrate level to 80% (80.08 vs 72.15 mg/dL) while not varied by the addition of live yeast. BUN was affected by the addition of live yeast at 60% concentrate level while it was lowered due to absence of live yeast (37.57 vs 50.92 mg/dL) with 80% concentrate level. Cold carcass weight was lowered (P=0.0135) by the absence of yeast (14.6 vs 15.9 kg) while rib eye area was improved due to absence of yeast (13.7 vs 12.3 cm²). Other carcass traits were not affected by the addition of live yeast.

In South Africa, Pienaar et al. (2012) investigated the effects of active live yeast (Saccharomyces cerevisiae) on the growth performance of 60 mutton Merino lambs. The lambs were maintained on four dietary treatments for 47 days i.e. control or C (no additive), live yeast @ 220 gm/ton (SC), ionophore @ 120 gm/ton feed and both live yeast and ionophore (SCG) at the same mentioned levels. The feed intake, daily live weight gain, feed conversion ratio, carcass weight and carcass characteristics were not affected by the dietary treatments. They concluded that the live yeast culture and ionophores should be included in diet with more than 28% NDF/kg DM.

In Poland, the meat quality of Kamieniecka breed lambs was studied by Milewski and Zaleska (2011) in response to supplementation of dried brewer’s yeast (Saccharomyces cerevisiae). They used 24 lambs and fed them for 100 days with the rations i.e. control with concentrate fed (no yeast) and yeast added @ 50 gm/kg of concentrate. The yeast addition improved meat dry matter (0.78%) and intramuscular fat (0.33%) as compared with control lambs (P<0.01). The yeast addition also improved (P<0.01) the meat red color component (a* =12.28 vs 11.14) and lowered water holding capacity of meat (16.25 vs 18.06 cm²). There was higher (P<0.05) concentrations of C14:1, C18:2 and C22:6 fatty acids while C20:4 was lower (P<0.01) in the intramuscular fat of lambs from group with yeast added. The average sensory score was not affected by the yeast addition. The cooking loss was lower (P<0.001) while content of dry matter and protein was higher in longissimus lumborum (LL) than in quadriceps femoris (QF) muscle. The sensory properties were better in QF muscle.

In India, the effect of live yeast culture addition in growing lambs on growth performance and nutrient utilization was investigated by Tripathi and Karim (2010). They used 60 lambs fed them on total mixed feed for 90 days with five yeast groups
i.e. no addition (control), *Kluyveromyces marximanus* (KM), *Saccharomyces cerevisiae* (SC), *Saccharomyces uvarum* (SU) and mixture of all with 1:1:1 ratio. Dry matter intake, nutrient intake and digestibility coefficient were same (P>0.05) for yeast culture addition groups in weaners. Similarly, digestible organic matter and ME intake was not affected by the treatments. However, microbial protein synthesis was best (P<0.05) by SC (50.5 gm/day) followed by KM (39.2 gm/day), Mixed yeast (39.2 gm/day), SU (30.7 gm/day) and control (27.8 gm/day). Average daily gain was significantly (P<0.05) higher in SC fed animals (184 gm/day) followed by mixed yeast (173 gm/day), SU (162 gm/day), control (145 gm/day) and KM (136 gm/day). The feed intake was better (P<0.05) for SC (1040 gm/day) and least by KM (77 gm/day) during 90 days period for Malpura finishers. All the yeast groups resulted in same feed efficiency except control with higher feed efficiency.

The effect of addition of live yeast culture on the slaughter traits were investigated by Tripathi and Karim (2011). They used 60 lambs fed on total mixed feed for 90 days with five yeast groups i.e. no addition (control), *Kluyveromyces marximanus* (KM), *Saccharomyces cerevisiae* (SC), *Saccharomyces uvarum* (SU) and mixture of all yeast with 1:1:1 ratio. The ADG was significantly (P=0.002) affected by the yeast type with highest in SC (184 gm/day) while lowest in KM (136.2 gm/day). Rumen fermentation characteristics was not affected by the yeast addition except pH which highest with SC (6.02) and control (6.16). Ciliate protozoa population (×10⁴). Dasytricha species were lowest (P=0.052) in SC (1.47) Diplodinomorphs were also lower (P=0.023) in SC (13.68). The lower total ciliate was lower in groups with better ADG. The glucosidase enzymes activity was significantly lower in SC groups than others. The carcass characteristics was not affected by the yeast addition.

In Mexico, effect of yeast on production performance and carcass traits was studied by Kawas et al. (2007). They used twenty Pelibuey lambs and exposed them to four treatments i.e. no feed additive (NA), 0.12% yeast culture (YC), 0.5% sodium bicarbonate (SB) and including both YC and SB. There was no effect of feed additive on the dry matter intake, weight gain and feed efficiency. Similarly, carcass measurement, weight of visceral organs, eye muscle area and marbling was also not affected by the treatments.
The addition of live yeast culture was investigated in Black Bangal kids on the growth performance by the Indian scientists (Pal et al., 2010). The concentrate was prepared with same composition but one recipe included the trace minerals while other did not. Total 24 kids were fed on the concentrate for 90 days while yeast + rice distillers gains (DGS) were added @ 0, 15, 30 g DGS/day designated as C, T1 and T2, respectively. There was linear increase (P=0.05) in DMI with the levels of yeast as maximum intake was noticed at 346 gm/day with T2 for without trace minerals while 340.1 gm/day with T2 level for with supplemented trace mineral ration. Similar trend was noticed for crude protein intake and ether extract intake. Balance of zinc, iron, copper and manganese in kids was not affected by the yeast addition.

In Pakistan, the effect of Ionophores and live yeast culture containing probiotic was investigated by Mukhtar et al. (2010) in 24 Lohi sheep. There were three feed treatments i.e. (1) Concentrate, (2) Concentrate + Ionophores and (3) Concentrate + Probiotics. The dry matter (DM), neutral detergent fiber (NDF) crude protein (CP) and acid detergent fiber (ADF) intake of % body weight were not affected by the treatments. Similarly, the digestibility traits were not affected by the treatments. The treatment also did not affect the initial, final and daily weight gains.

In Jordan, growth performance and carcass traits in Awassi (AW) and Shami kids (SH) in response to yeast addition in finishing diet was investigated by Titi et al. (2008). They selected 48 Awassi and 48 Shami male kids and fed on total mix feed for 12 weeks. There were two feed groups i.e. no yeast (C) and yeast added at recommended dose (YC). At the end total of 12 animals per breed was selected randomly for slaughtering and carcass characteristics evaluation. There was interaction in addition of yeast and final body weight. The AW Lambs fed with YC had gain more final body weight than the C (49.9 vs 49.7 kg) while SH fed C gained more weight than YC (32.5 vs 32.1). However, there was no interaction in yeast addition and species for ADG and DMI. The yeast culture addition resulted in significant interaction with species for hot carcass weight (HCW). The AW group showed better HCW with C than YC (23 vs 20.8 kg) while SH kids showed better HCW with YC than C (21.8 vs 21.1 kg). Proportional weight of leg was also affected by the treatments. For AW lambs this was not significant but for SH kids, C resulted better proportion of leg cut weight than YC (0.321 vs 0.302) while same trend was
also noticed for shoulder cut except for SH, YC fed resulted better (P=0.02) proportion of shoulder cut weight proportion than C (0.470 vs 0.449). There was interaction of treatment factors for crude protein and ether extract of meat proportion. There was no effect of yeast addition in SH for meat CP and meat EE proportion while C resulted better (P=0.04) crude protein proportion in AW lambs than YC (0.823 vs 0.794) lower ether extract (0.137 vs 0.171).

The effect of dietary yeast in Awassi lamb was investigated by Abdelrahman and Hunaiti (2008) in Jordan. Total 18 Awasi lambs were used with three diet treatments i.e. (1) Control or C (feed on total mix ration), (2) T1 (C+2 gm cyc-methionine per animal/day) and (3) T2 (C+ 4 gm cyc-methionine per animal/day). The cyc-methionine includes 10 gm methionine and 1.5 × 1111 c.f.u. live cells of S. cervisiae. The final gain was significantly affected by treatments with maximum (P<0.05) in T2. ADG was more in yeast supplemented diet than control, however, the levels did not affect ADG. The FCR was lowest in T1 (6.3). Hot carcass weight highest with T1 (26.7 kg), and dressing percentage was best with T1 (54.8 %) and minimum with T2 (50.9 %).

2.6. Effect of Gender and Growth Performance

The sex of animals has prominent effect on the growth performance and carcass traits. However, this effect varies among the various breeds. There is more fat deposition in some breeds while others have less. It also depends on the duration of fattening and age at fattening. There is not much difference in the growth and carcass traits of some breeds in early stage of life. Similarly, both sex also behave differently under various feeding systems. Some studies are presented in consequent lines from various part of the world.

Recently, in Iraq, effect of sex of kids on growth performance and carcass traits was studied by Alkass et al. (2014). They used 32 weaned (at 90 days) females (16) and males (16) local breed kids with an average live weight of 17.00±0.7 kg for females and 16.22±0.80 kg for males. They divided all animals in two groups and one group was fed on concentrate in individual stalls while the second group was grazed on pasture. They slaughtered animals in two stages: slaughtered till 20 kg or 30 kg BW. There was non-significant effect of the sex, feeding system and slaughter weight on average daily gain (averaged 75.65±5.54 gm/day). Male kids were more able in
converting feed into gain than females and while the kids slaughtered at 30 kg were more efficient than 20 kg regarding feed to gain performance. Kids reared on pasture or slaughtered at 20 kg had shown significantly (P<0.05) lower dressing percentage than kids received concentrate and slaughtered at 30 kg. The kids slaughtered at 20kg had significantly (P<0.05) smaller rib eye area and thinner fat than kids slaughtered at 30kg. Kids raised on concentrate had significantly lower proportion of leg (29.98 vs 31.8 %) and higher proportion of shoulder (19.92 vs 17.72 %) than kids grazed in Pasture.

In Turkey, the effect of the feeding system and sex on the carcass and meat quality was studied by Ozcan et al. (2014) in Gokceada kids. Total 40 kids (both sexes) were subjected equally (n=20) to semi intensive (SIS) and extensive system (ES). The hot carcass weight (HCW) showed the significant (P<0.05) interaction in feeding system (FS) and sex. There was non significant difference (P>0.05) in HCW of both sexes at SIS (5.42 kg in ♂ and 5.82 kg in ♀) while male resulted in higher (P<0.05) HCW (9.72 kg) than female (8.18 kg) at ES. Dressing percentage was affected (P<0.001) by the FS but not by sex. The ES resulted in higher dressing percentage (50.73 in ♂ and 51.63 in ♀) than the SIS (43.85 in ♂ and 45.81 in ♀). Proportion of the various body parts was not affected by the interaction while main effects showed significance. Head % in the body proportion was affected by the FS with SIS resulted in more head proportion than ES. While sex also affected (P<0.05) the head proportion with more in ♂ than ♀. The cold carcass weight (CCW) showed the significant interaction (P<0.05) for FS and sex. At SIS, both sexes resulted in same CCW while at ES resulted in more CCW than SIS and male were having havier (9.40 kg) CCW than female (7.91 kg) at ES. The carcass measurement showed significant interaction of FS and sex for leg length (LL) and carcass compactness (CMP). The males produced the carcass with longer LL (18.86 cm) than female (18.02 cm) at ES while female produced longer (17.35 cm) LL than male (16.91 cm) at SIS system. Similar trend was followed by the animals for CMP response.

In Turkey, effect of sex on carcass characteristics in Hair goat under extensive system was investigated by Toplu et al. (2013). Total 60 Hair goats (30 ♂ and 30 ♀) were reared and slaughtered at 3, 6, 9 and 12 months age. The slaughter weight was significantly (P<0.001) heavier in males than females (22.36 vs 18.44 kg). The males
yielded carcasses with better (P<0.001) hot carcass weight (9.76 kg vs 8.13 kg), cold carcass weight (9.44 kg vs 7.84 kg) and less (P<0.001) kidney knob channel fat contribution to left half (1.44 % vs 0.99% than females). While female animals had produced more (P<0.001) subcutaneous fat (4.86% vs 3.15%), intermuscular fat (5.59% vs 3.46% than males) and total fat (10.39% vs 6.64%) but lower (P<0.001) muscle/total fat (5.31 vs 8.39 %). Regarding carcass measurements, male produced carcass with better measurement i.e. carcass length (31.98 vs 29.23 cm, P<0.01), buttock width (15.70 cm vs 14.82 cm, P<0.001), buttock perimeter (41.21 vs 38.36 cm, P<0.01) while carcass compactness and hind limb compactness was not significantly different between males and females.

In Slovenia, the effect of gender on the growth performance and carcass traits in Boer kids were reported by Kaic et al. (2012). They used 34 kids and fattened using same ration till slaughtering. They slaughtered kids (17 males and 17 females) in two age groups i.e. slaughter age (85±10.14 days (Group 1) and 139±17.55 days (Group 2). The average daily gain was higher in males (203 gm/day) as compare to females (163 gm/day). There was no significant (P>0.05) effect of the sex on dressing percentage with females (47.1%) had yielded slightly more values than male kids (45.2%). Notably, there was significant (P≤0.001) effect of age on the deposition of subcutaneous fatness. The carcass length, shoulder width and hind leg width were significantly higher more with slaughter age.

Effect of ration supplemented with various levels of coconut oil on the carcass traits was studied in 32 Malpura lambs by Bhatt et al. (2011). All animals were divided in four groups with equal no. (n=8) of animals per group (4 ♂ and 4 ♀). All animals were fed on same concentration with aditional supplementation of coconut oil (CO) with various levels i.e. 0 gm/kg (CO-0), 25gm/kg (CO-25), 50gm/kg (CO-50) and 75gm/kg (CO-75). The trend analysis revealed that ADG was not affected by the supplementation of the coconut oil. However, total DMI of the ration showed quadratic trend (P<0.01) with highest (608 gm/day) in CO-0 group and minimum (539 gm/day) in CO-75 group. The blood cholesterol showed the linear trend (P=0.029) with minimum in CO-0 (75 mg/100 ml) and maximum in CO-50 (128 mg/100 ml) followed by CO-75 (121 mg/100 ml). Carcass characteristics and longissimus dorsi composition had showed non-significant effect (P>0.05) of the
treatments except the intramuscular fat (P=0.08). The intramuscular fat of slaughtered animals was highest in CO-50 (73 gm/kg) group and lowest in CO-75 group (49 gm/kg). The higher levels of the coconut supplementation suppressed the rumen protozoa that resulted in lower growth.

The effect of gender and liveweight at slaughter was studied by Bonvillani et al. (2010). Thirty males and thirty females with ~9-15 kg weight and 90-days age were kept under extensive management system. The kids were divided in three weight categories (slaughter weight) i.e. low (<11 kg), medium (≥ 11 <13 kg) and high (≥ 13 kg). Analysis of data revealed that the slaughter live weight (SLW), empty body weight (EBW), hot carcass weight (HCW) and cold carcass weight (CCW) were not affected by the sex of the animals. However, the chilling loss was affected (P<0.05) by the sex of the animals (5.7% in ♂ vs 5.6% in ♀). The weight category did affect the slaughter traits where group ‘high’ yielded significantly higher SLW (13.5 kg), EBW (11.8), HCW (6.8 kg) and CCW (6.7 kg) than other groups. The carcass measurements also followed the same trends as the leg length, internal carcass length, buttock width, thorax width, maximum rib width, chest depth, buttock perimeter, thoracic perimeter, ribeye width and ribeye depth were significantly higher in group ‘high’ but not affected by the sex of the animals. The left-half-carcass weight (kg) and percentage contribution of leg, shoulder, rib, neck and breast was not significantly affected by the sex and live weight of the animals at slaughter.

Dutta et al. (2009) reported the effect of different protein-energy ratio of ration on the growth performance and carcass quality in 32 Barbari kids (5-mo old 10.62±0.09 kg BW, 16 males and 16 females). They used diet consisted Cajanus cajan straw (60%) and concentrate mixture (40%). The different protein-energy ratio in the diets were (i) Diet 1 (CP 12%, TDN 55%), (ii) Diet 2 (CP 12%, TDN 60%), (iii) Diet 3 (CP 14%, TDN 55%) and (iv) Diet 4 (CP 14%, TDN 60%). The kids were fed at 4% of the body weight while oat fodder was offered at the rate of 300-400 g/kid/day on DM basis. The DMI was found higher with Diet 1 (89.5 gm/kg W^{0.75}) and lowest with Diet 4 (86.5 gm/kg W^{0.75}). The ADG and feed efficiency were not significantly different (P>0.05) among the diets. The serum glucose, total protein and BUN was also not significantly different among the treatments groups. The treatments resulted in not significant (P>0.05) in the values of hot carcass weight, dressing percentage, carcass
physical composition, variety meat yield and fat deposition. The breast fat thickness and kidney fat accumulation were significantly (P<0.05) higher in Diet 2. They concluded that pelleted feed of Diet 2 responded with better growth rate, quality of carcass traits and meat quality.

A comparative study was conducted in Norway by Mushi et al. (2008) to find the most suitable meat producing animals among female Norwegian short tail lamb (NL), castrated Norwegian male dairy goat (NG) and castrated Cashmere goat (CG). The animals were fattened using silage and commercial concentrate. The hot carcass weight was affected by the type of the animals where NL produced highest hot carcass weight (14.9 kg) and CG produced the lowest (8.8 kg). The color of raw longissimus dorsi was determined. The lightness was highest (P<0.05) in CG (40.8) and redness was same for NG and CG (15.1 and 15.0) but low in NL (11.2). The chroma also followed the same trend. However, Hue angle was highest in NL (30.8) followed by CG (24.8) and NG (21.4). Sensory evaluation revealed that intensity of the odor was not affected by the type of the animals. While sweet odor got lowest score (3.32) in NL and highest score in CG (3.68). For taste, sensory paneling results showed NG were better than other with 6.56 score. Sensory evaluation for the hardness of heated loin meat revealed lowest score in NL (3.92) than NG and CG (5.58 and 6.08) and contrary to this texture juiciness was highest score in NL (6.14) than NG and CG (5.32 and 5.00).

A group of Spanish scientist, Pena et al. (2005) found the influence of sex, slaughter weight and carcass weight on non-carcass and carcass quality in 100 Segurena lambs. The animals were managed under the same condition till the slaughter weight of 19-25 kg. Animals with slaughter weight below 20 kg were assigned to B class while more than 20 kg were assigned to class A. Slaughter weight (SW) was not affected by the sex, however, class B had lower (P<0.05) SW than the class A. Hot carcass weight (HC) was also affected by slaughter weight where class B show lower HC (9.9 kg) than class A (11.1 kg). Cold carcass weight/empty live weight (CW/EW %) was 54.1% in class B and 55.6% in class A. The sex did not affect the carcass traits. However, fat depots:empty live weight (FD:ELW) was affected by the sex with more (P<0.05) in females (3.1 %) than males (2.4 %). Meat colour was not (P>0.05) affected by the treatment factors. Body measurements were not affected by the
treatment factors. While slaughter weight category did affect the body length (L), buttock perimeter (BG) and hind leg length (F) with body length (L) was more in class A (52.8 cm) than class B (51.7 cm) and BG was also higher in class A (51.9 cm) than class B (49.9 cm). While in the next study, Pena et al. (2007) studied the effect of weight at slaughter and sex in 60 suckling kids of Florida goats on carcass measurements. There was decreasing trend of percentage of blood, skin, head, feet and internal organs with the increase in slaughter weight. The carcass measurements also increased with increasing slaughter weight. The sex showed the non significant effect on carcass traits except internal organ fat.

In Oman, Mahgoub et al. (2004) worked out the effect of sex of animals on the body weight and carcass tissue distribution. They selected 45 youngs of bucks, wethers and does of Jebel Akhdar (JA) with equal numbers (n=15). The animals were reared under intensive feeding systems and slaughtered at three weight categories i.e. at 11, 18 or 28 kg body weights. There was interaction between the sex classes and weight at slaughter for total non-carcass fat. The wethers and does had similar non carcass fat (6.11 % vs 6.63 %, respectively) at 18 kg slaughter weight. Sex has significantly affected the total body fat (TBF %) as does had resulted in higher TBF followed by wether and buck. The highest proportion of fat in the body was found inter-muscularly whereas the omentum had the highest non-carcass fat proportion. About 55% of the musculature in JA goat carcasses was found in muscle groups of the proximal hind leg, around the vertebral column and in the proximal forelimb (expensive muscle groups). Bucks had higher proportions of intrinsic muscles of the neck and musculature in the forequarter (P<0.001) while decreased proportions of muscles at the proximal hind limb (P<0.001) than wethers and does.

For Florida goat breed in the USA, Johnson et al. (1995) conducted experiment to know the effect of gender, castration and genotype. They used 75 goats of three types of Florida breeds i.e. Florida native (FN), Nubian×Florida native (NF) and Spanish×Florida native (SF). There were three sex classes (female, intact male, castrate). They found that breed type had very little effect on carcass quality. There was higher percentages of fat (11.6%) and lower percentages of bone (20.4%) in FN than NF or SF carcasses. The Warner-Bratzler shear (WBS) values for muscles from the leg and loin were not affected by the breed factor. The intact male and castrated
male resulted in higher percentages of feet, pelt, liver, heart and kidney than female. Male carcasses had less marbling (176), softer flank firmness (4.1), but lighter lean color scores of carcass than female or castrate. The shear force values (Warner Bratzler shear values) were less from female carcasses (5.0 kg) so resulted in less tendered muscles than from castrate or intact male carcasses. They concluded that sex class had a greater impact on carcass characteristics than breed type.

2.7. Effect of Castration and Carcass Quality

The males are mostly fattened for meat purpose and females are retained for replacement stock. The males are either used as entire or as castrated. Wethers are mostly castrated after birth. Castration results in better growth and more fat deposition which will enhance the juiciness and taste of the meat. And on the other hand it also helps to eliminate the bad aroma in meat of entire male goats. The aroma problem is not much pronounced in early age but becomes more prominent as animal reached near to sexual maturity and possibly is due to high levels of testosterone. The following studies showed that the age at castration and method of castration are important variables. However, the effect of castration and age at castration varies among different breeds which is further varied due to feeding system and duration of fattening. Below are some studies conducted at various parts of the world and presented to get better insight of the effect of castration on growth performance and carcass traits in small ruminants.

In Sudan, effect of castration and nutrition was investigated by Mudalal et al. (2014) in male desert goats. They used 72 goats aged 4-5 months and weighing 12 kg. There were three feeding groups with equal numbera in each group (n=24) i.e. on grazing (G1), on grazing + concentrate at the rate of 324 gm/head/day (G2) and ad libitum feeding on concentrate (G3). Half of the animals in each group were castrated and half were entire males. The duration of the study was 90 days. Castration did not affect the carcass measurements except distal hind leg length which was lower in entire and higher in castrate males. While in % age of primal cuts; the loin was better in entire than castrate (11.1% vs 8.1% in G1; 10.2 vs 8.8 % in G2, respectively) except the G3 (9.1 vs 9.5 %, respectively). There was an interaction in castration and feeding for muscle to fat ratio (M:F). In G1, castrate were better than entire (24.5 vs 21.5, respectively) and same trend for G2 (17.0 vs 13.0, respectively) while inverse
trend in G3 (13.5 vs 14.1). All the feeds resulted in higher fat % in castrated males than entire.

Boer goat was studied for the effect of castration and level of feeding in USA by Poore et al. (2013). They used 44 males (22 castrated after birth and 22 intact) and were fed commercial concentrate in three groups (hay only or C0, hay + concentrate pellets @ 2% BW named C1 for instance and ad libitum concentrate with hay @ 0.75 % of BW named C2). The feeding was done for 84 days period. Castration resulted in better lower ADG during birth to weaning (0.147 vs 0.167 kg/day) and followed also during finishing (0.105 vs 0.137 kg/day). Intake was also higher in bucks than wethers (799.8 vs 684.6 gm/day). The buck showed better HCW (15.67 vs 12.98 kg), loin eye area (9.42 vs 8.15 cm$^2$) compare to castrate males. Same trend was also noticed for carcass measurements.

In Nigeria, Tsado and Adama (2012) studied the effect of sex and castration on body measurements in Savanna Brown kids. There was two classes of male i.e. castrate and non-castrate with single or twin birth while female was selected with twin birth. The animals were castrated by open method after 2 weeks of birth. All animals were grazed with additional concentrate for 5 months. The height at withers was highest in single male castrate (40.50 cm) and least in female (36.09 cm). The same trend was noticed in height from fore legs. However, the neck length was highest in single non-castrate (14.16 cm) followed by female (13.75 cm) while castrate had resulted in lower neck length.

In Iran, the effect of castration and fattening on growth performance and carcass characteristics of Iranian goats was studied by Zamiri et al. (2012). They selected 66 male goat kids with 3 month of age. They slaughtered 6 kids on first day of experiment and remaining 60 were kept in individual stalls under similar environmental conditions. The castrated male group was castrated using Burdizo method after 10 days of experiment start. There were six fattening period i.e. 1(5 mo), 2 (6 mo), 3 (7 mo), 4(8 mo), 5(9 mo) and 6 (10 mo). There was no difference in dressing percentage till period 4 but castrates yielded higher dressing percentage than intact male at period 5 (50.8 vs 48.5%) and period 6 (50.8 vs 46.6%). The sensory evaluation mean score for meat color before cooking was better (P=0.0007) for castrate goat than intact (2.82 vs 2.52) while aroma score was less (P=0.0199) in
castrate than intact (1.55 vs 1.85). Sensory panel score for cooked meat of castrated male was better for juiciness (2.40 vs 2.05, P=0.0012), tenderness (2.62 vs 2.19, P=0.0002) and flavor (2.18 vs 2.01, P=0.0827) while the results were the same for aroma after cooking (1.54 vs 1.60, P=0.4003).

Growth performance and carcass characteristics in response to castration of Boer males while grazing on Marshall Ryegrass was determined by Solaiman et al. (2011a). They used 14 males and wethers (n=7) with 38 kg weight for males and 34.8 kg for wethers. The ADG was higher (P<0.001) in bucks (146.2 gm/day) than wethers (73.7 gm/day). Hot carcass weight and cold carcass weights were also better (P=0.06), (P=0.04) in bucks (21.2 kg), (20.3) than wethers (18.8 kg), (17.9 kg). Dressing percentage was significantly (P=0.06) affected by castration and wethers had yielded better dressing percentage (51 %) as compared to bucks (47 %). Body wall fat was significantly (P=0.05) more in wethers (0.41 cm) than bucks (0.21 cm).

In Ethiopia, effect of castration in Arsi-Bale kids was investigated by Kebede et al. (2008). They used 36 male kids with initial weight of 10.56±0.39kg and fed for 15 months to determine the effects of age at castration on growth performance and carcass traits. They divided 36 kids equally (n=9) in four groups i.e. entire (T1), castration at 3 month of age (T2), castration at 6 month of age (T3) and castration at 9 month of age (T4). All animals were grazed during day time and supplemented 2.5 % of body weight with concentrate per day. They selected 5 goats from each treatment group slaughtered for carcass evaluation. The age at castration did not affect significantly (P>0.05) on body weight, total weight gain, overall average daily gain and body measurements. The T4 and T1 had resulted in significantly (P<0.05) higher ADG (108.50±5.23 gm/day and 113.73±3.53 gm/day, respectively) than T3 (92.16±5.72 gm/day) and T2 (92.16±6.20 gm/day) at 9-12 months of age. Carcass traits were not significantly affected by the treatments except for fat deposition, which were significantly (P<0.05) lower for entire as compared to castrated groups.

In Turkey, Koyuncu et al. (2007) studied the effect of castration in hair goats. The duration of the study was 56 days. The ADWG in intact and castrated males were not significantly different (102 and 77 gm, respectively). Intact males resulted in lower (P<0.01) dressing percentage based on full weight and empty body weight than castrates. The percentage contributions to the whole carcass of primal cuts, ribs, tissue
distribution in the carcass were not affected by castration. They concluded that castration improves carcass value by increasing dressing percentage, intermuscular fat and eye muscle area.

Effect of various levels of energy on the carcass composition of 30 black goat was studied by Abdullah and Musallam (2007) in Jordan. The energy levels of the rations were 10.44 MJ ME/kg DM (LEL), 11.60 MJ ME/kg DM (MEL) and 12.90 MJ ME/kg DM (HEL). Half of the experimental animals were castrated at 1 week of age and left to be reared with their dams until weaning age of 90 days while remaining were intact male. Different carcass attributes e.g. water holding capacity, cooking loss%, shear force values and muscle color components (CIE: L, a and b) were not affected by the energy content of the ration. Castration had significantly affected the carcass characteristics. The L value, water holding capacity (WHC) and cooking loss% was higher in the castrated animals. The deposition of fat is improved by the castration. Muscularity was noticed higher in the intact males.

In UK, the effect of castration and diet was determined by Mtenga et al. (2005). They purchased 60 kids from farmers at day 2-3 of age after birth. The half of animals were castrated at 11 days of age using rubber ring. While there were two diets i.e. barley based concentrate and lucerne pellets. There were three phases in experiment with arrival to weaning (phase 1), weaning to 24.5 kg weight (phase 2) and 24.5 kg to 36.5 kg weight (phase 3). There was significant effect of castration (P<0.01) and diet (P<0.05) on the age at 24.5 kg weight. The male took lesser days (117 days) than castrated (132 days) while barley concentrate yielded early weight gain (118 days) than lucerne (131 days) during phase 2. Male had better (P<0.001) growth rate (222 gm/day) than castrate (183 gm/day) during phase 2. The same trend was noticed for Feed Conversion Ratio (FCR). However, the growth rate was higher for castrate (234 gm/day) than male (185 gm/day) during phase 3.

Effect of castration on fatty acid profile in male Boer and Australian feral goat was studied by Werdi Pratiwi et al. (2006) in Australia. They found that C18:0 was higher (P<0.01) in entire than castrate with better values for Boer breed (18.1 vs 15.9 at 30 kg slaughter wt., 13.7 vs 10.7 % at 60 kg slaughter wt.). While castrate Boer and feral has higher C18:1 at both 30 kg and 60 kg slaughter weight.
Iraqi scientists, Tahir et al. (1994) determined the distribution of meat, fat and bone in response to castration of Iraqi black goat. The study was conducted on 18 carcasses. The highest fat was found in breast region of castrated males (7.59 %) and 5.87 % in entire male. While lean was highest in leg (71.08 % in entire and 70.08 % in castrated).

In USA, effect of castration and sex on growth performance and carcass traits of fat tailed Karakul, Rambouillet and crossbred lambs was investigated by Shelton et al. (1991). They found that the warm carcass weight was best (P<0.05) in Karakul (25.35 kg) and least in Rambouillet (23.64 kg). While castrates had produced highest warm carcass weight (24.84 kg) followed by males (24.52 kg) and females (24.52 kg). The carcass length was better (P<0.05) in male (129.7 cm) followed by castrate (128.8 cm) and females (127.9 cm). Back fat thickness was highest in females (11.61 mm) followed by castrates (11.02 mm) and males (9.04 mm).
Chapter 3

MATERIALS AND METHODS

3.1. Study Area
The study was conducted at Livestock Experiment Station (LES), Allahdad, 16 km Jahanian-Dillo-mor road, Tehsil Jahanian, District Khanewal, Multan, Pakistan (Plate 1). The area is situated 58 km from Multan, Pakistan. The climate of the region are tropical with longer summer and shorter winter. Average temperature may reach 45°C during May-June. The study was conducted during March to November (8 months during 2013).

3.2. Selection of Beetal
Beetal breed is a dual purpose meat and dairy breed. The breed is characterized by the long stout legs, long ear and may be horned or polled (Khan et al., 2005). Breed description of the Beetal is shown in Plate 2. There are three strains of Beetal breed maintained in the Directorate of the Small Ruminant, Multan under Livestock and Dairy Development Department (L&DD), Lahore. It is observed in the field conditions that the farmers classify these strains as; (a) Faisalabadi (Solid Black/Maroon/Brown or + white in patches (b) Bahawalpuri (Brown/Maroon with white in splashy pattern and (c) Nuqri (whole white/light grey white shade). Faisalabadi strain of Beetal were the main animals at LES, Allahdad, Jahanian. More than 100 animals of this strain were used during the study.

3.3. Housing and Management
The individual stalls were made using bamboo and wire guaze for the experiments. The watering and feeding was done in the bukets made up of tyres (used) and were easily available in the local market of Tehsil, Jahanian. The experimental animals were housed in separate pens while the other animals were housed in the remaing 5 sheds. All the experimental animals were vaccinatied against Contagious Caprine Pleuro-Penomonia (during March-April) and Enterotoximea (during May/June), while animals were injected with Ivermectin at the recommended dose. Animals were offered ration early in the morning (8-10 am). Animals were fed ad libitum with the rule of thumb increase the daily allowence when orts were found 20% or <20%. Clean and fresh water was offered in troughs to experimental animals and changed daily.
after feeding. The castration was done in the experimental animals during second experiment. The local anaesthesia (Lignocane) was used subcutaneously and then Burdizo castrater was used to castrate the animals (Louca et al., 1977).

3.4. Ration Preparation
Ration formulation was done per NRC, 2007 standards using MS-Excel (MS Office 2010) sheets. Feed ingredients were purchased from the open market and experimental feed was prepared at the Feed mill unit, Institute of Animal Nutrition and Feed Technology (IAN&FT), UAF. The feed was further processed for pellets/crumbs making at the Nice Feeds, Sumundri Road, Faisalabad. Then the feed was packed and transported to LES Allahdad, Jahanian.

Plate 1: Location of LES Allahdad Farm

(Courtesy of google maps)
Plate 2:  Beetal Breed Characteristics

<table>
<thead>
<tr>
<th><strong>Home Tract:</strong></th>
<th>Faisalabad</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Colour Shade:</strong></td>
<td>Black, Brown, White, Black splashed, Black with white patch, Brown splashed, Brown with white patch</td>
</tr>
<tr>
<td><strong>Birth weight:</strong></td>
<td>3.55 kg</td>
</tr>
<tr>
<td><strong>Adult weight:</strong></td>
<td>55 kg (♂); 34 kg (♀)</td>
</tr>
<tr>
<td><strong>Purpose:</strong></td>
<td>Milk and meat</td>
</tr>
<tr>
<td><strong>Age at 1st kidding:</strong></td>
<td>761 days</td>
</tr>
<tr>
<td><strong>Kidding interval:</strong></td>
<td>368 days</td>
</tr>
<tr>
<td><strong>Service Period:</strong></td>
<td>160 days</td>
</tr>
<tr>
<td><strong>Litter size (%):</strong></td>
<td>Single = 40.66, Twining = 52.6, Triplet = 6.52 &amp; Quadruplets = 0.22</td>
</tr>
<tr>
<td><strong>Conformation:</strong></td>
<td>Large size animals, mostly brown or black with white spots of differing sizes, coat is lustrous short, typical Roman nose, long drooping and flat ears, both sexes have thick, medium-sized horns, carried horizontally with a slight twist directed backward and upward, small and thin tail, udder is large and well developed, with large conical teats.</td>
</tr>
</tbody>
</table>
3.5. Data Collection

The methodologies used for data collection under different experiments are given below.

3.5.1. Growth Performance and Feed Intake

Growth performance was measured by monitoring the weight gain and feed intake. Weight was measured using spring balance (manufactured by National Pvt. Ltd. Pakistan). The data on weight was collected on weekly basis (Kadim et al., 2003). These weight readings were used to calculate average daily gain (ADG) using Equation 1 while dry matter intake (DMI) was also calculated using Equation 2 given below;

\[ ADG (\text{gm/day}) = \frac{\text{Change in weight during the study period (gm)}}{\text{No. of Days of study period}} \]  
\[ \text{(Equation 1)} \]

\[ DMI (\text{gm/day}) = \frac{\text{Total feed consumed during the study period (DM) in gm}}{\text{No. of Days of study period}} \]  
\[ \text{(Equation 2)} \]

The feed conversion ratio (Equation 3) and gain to intake ratio (Equation 4) were calculated using the protocols by (Sen et al., 2004) and the equation are given below;

\[ \text{Feed conversion ratio} = \frac{\text{Total feed consumed in kg (DM basis)}}{\text{Total weight gain in kg}} \]  
\[ \text{(Equation 3)} \]

\[ \text{Gain to Intake ratio} = \frac{\text{Total weight gain in kg}}{\text{Total feed consumed in kg (DM basis)}} \]  
\[ \text{(Equation 4)} \]

Kleiber ratio (KR) was calculated using the expression (Mohammadi et al., 2010) through Equation 5 and given below;

\[ \text{Kleiber ratio} = \frac{\text{Average daily gain}}{(\text{Weight of animal at finishing of experiment})^{0.75}} \]  
\[ \text{(Equation 5)} \]
3.5.2. **Body Measurements**

Body length, heart girth and height at withers were measured weekly (Adeyinka and Mohammed, 2006) and pictures are shown at Plate 3. Body length was measured as the distance from external occipital protuberance to the base of the pin bone in ‘cm’. Height at withers was the distance from the sole touching ground to the withers in ‘cm’. Heart girth was measured by taking the circumference of the chest in ‘cm’.

3.5.3. **Blood Collection and Analysis**

The blood was collected at the start and at the end of the experiments from the jugular vein using aseptic syringe (without the anticoagulant) (Plate 3). The serum was centrifuged (3000 rpm) to remove the blood cells to avoid the hemolysis and were frozen at -20°C till the final analysis (Nudda et al., 2013). The serum was thawed and used for determination of serum glucose, blood urea nitrogen, serum cholestrole and creatinine kinase. The kits of serum glucose, blood urea nitrogen and creatinine were manufactured by MERCK, France and the details of the kits are given at Annexure 1. Blood urea nitrogen was determined by UV test through GLDH method as described by Newman et al. (2001). Serum glucose was determined by the GOD-PAP method by following Burmin and Price (1985). Serum creatinine was determined by measuring the concentration of dyestuff formed during the reaction of reagents and serum (Vasiliades, 1976). The samples and reagents were run on MICROLAB-300 manufactured by MERCK Pvt. Ltd. The blood analyses were performed in the Clinical Pathology Laboratory, UAF (Plate 4).
Plate 3: Body measurements and blood collection

a. Measuring body length

b. Measuring heart girth

c. Height from front legs

d. Blood collection in a preceptor

e. Blood collection from the jugular vein
Plate 4: Blood analyses

a. Microlib 300
b. Kit for serum glucose
c. Kit for Urea nitrogen
d. Kit for serum cholesterol
e. Kit for serum creatinine
f. Display of readings
g. Blood analysis under process
h. Centrifuge machine
3.5.4.  Feed Analyses

The rations were analyzed for proximate composition using AOAC (2003) with some
modification while samples were also analysed for ADF/NDF by the methods
described by Van Soest et al. (1991). The gross energy of the feed was determined by
procedure outlined by Harris (1970). The brief methodology are given in ensuing
lines while detailed procedures with the principles are discussed at Annexure 2.

3.5.4.1.  Proximate Composition of Feed

Proximate analysis of ingredients and experimental rations for dry matter, crude
protein, ether extract, crude fiber and ash was carried out and given below.

3.5.4.1.1.  Moisture: Moisture contents of sample were determined by drying the
sample in a hot air oven at 100°C to a constant weight. Weight of the sample before
and after drying was recorded. The moisture percentage was calculated according to
the following formula;

\[
\text{Moisture (\%)} = \frac{\text{Weight of sample} - \text{Weight of sample after drying}}{\text{Weight of sample}} \times 100
\]

3.5.4.1.2.  Crude Protein: One gram of dried and ground sample was digested in
Kjeldhal’s digestion flask with 5 gram of digestion mixture containing K$_2$SO$_4$, CuSO$_4$
and FeSO$_4$ (90:10:1) and 30ml of concentrated H$_2$SO$_4$. The contents of the flask were
heated till a light green solution was obtained. After cooling, the contents of the flask
were diluted upto 250 ml in a volumetric flask by adding distilled water. 10 ml of
diluted solution was mixed with 10 ml of 40 percent NaOH solution and the mixture
was distilled with steam in micro distillation apparatus. The ammonia so produced
was collected in 10 ml of 4 percent boric acid solution having two drops of methyl red
as in indicator. The distillate was titrated against 0.1N H$_2$SO$_4$ to determine the volume
of ammonia evolved. Crude protein percentage was calculated by the following
formula:

\[
\text{Nitrogen (\%)} = \frac{X \times A \times 0.0014}{B \times S} \times 100
\]

Where,

\[X = 0.1N \ H_2SO_4 \ \text{used}\]

\[A = \text{Solution prepared (250 ml)}\]
S = Volume of solution (10 ml)

B = Weight of sample (1g)

\[ \text{Crude protein\%} = \text{Nitrogen (\%)} \times 6.25 \]

3.5.4.1.3. Ethereal Extract: Three grams of dried and ground sample was taken in thimble plugged with cotton and placed dried in Soxhlet’s apparatus. Petroleum ether was used as solvent. The rate of condensation of ether was fixed at 90 to 100 drops per minute and process was continued for about four hours. The ether extract was calculated on the drying residue at 60°C. Percentage of each extract was calculated with the following formula:

\[ \text{Ether extract\%} = \frac{\text{Weight of ether extract}}{\text{Weight of the sample}} \times 100 \]

3.5.4.1.4. Crude Fiber: One gram of the dried and fat free sample was digested first with 200 ml of 1.25 percent NaOH solution for 30 minutes and subsequently with 200 ml 1.25 percent H\textsubscript{2}SO\textsubscript{4} for another 30 minutes to dissolve alkali soluble carbohydrates, minerals and proteins. The residue was dried and its weight was recorded. The dried residue was ignited in muffle furnace and the weight of ash was recorded.

\[ \text{Crude Fibre\%} = \frac{\text{Weight of dry residue} - \text{Weight of Ash}}{\text{Weight of dried fat free sample}} \times 100 \]

3.5.4.1.5. Ash: Two grams of dried and ground sample was taken in tare crucibles and ignited in the muffle furnace maintained at about 600°C temperature. After complete ignition the crucible was cooled in a dessicator and the percentage of ash was calculated by the following formula:

\[ \text{Ash\%} = \frac{\text{Weight of Ash}}{\text{Weight of sample}} \times 100 \]

3.5.4.2. Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) in feed
One gram feed sample was taken in conical flask. Sodium sulphite was weighed (0.50 gm) and put in the conical flask with 1 gram sample then NDF reagent was added. The flask was fixed to the air condenser cooling arrangement. The content was heated slowly for 60 min then allow to cool. Now, remove the condenser. Filter the content with the help of suction pump. Wash the residue with hot distilled water (60-70°C) for
4-5 times each time using 5-10 ml of warm distilled water. Then wash the residue twice with the acetone (5 ml). Transfer it to dried crucible. Place it in hot air oven at 105°C for 4 hour. Take it out and put it in desiccator for 5-10 min. The NDF was calculated by following equation;

$$NDF\ (\%) = \frac{\text{Weight of crucible + residue} - \text{wt. of crucible}}{\text{Weight of sample}} \times 100$$

While the residue of NDF was transfer into 500 ml conical flask. Add 100 ml of acid detergent solution in the flask. Fix the air condenser assembly with the flask. Heat the flask slowly till 60 min. Remove the condenser and wash with residue 3-4 time with distilled water. Then wash the residue with 5-10 ml acetone. Transfer the residue to dry crucible and put it in hot air oven at 105°C for 24 hours. Then put it in desiccator for cooling. The ADF is calculated using following expression;

$$ADF\ (\%) = \frac{(\text{Weight of crucible + ADF residue}) - \text{wt. of crucible}}{\text{Weight of sample}} \times 100$$

3.5.4.3. *Gross Energy*

Gross energy of the feed were measured with the help of adiabatic oxygen bomb calorimeter according to the method of Harris (1970) and the procedure described in the manual provided with the bomb calorimeter by Parr Instrument Co., Moline, USA with some modifications. Benzoic acid (GE 6318 Kcal/kg) was used to standardize the bomb calorimeter and to determine the energy equivalent factor. One gram pellet of benzoic acid was used. The energy equivalent factor was calculated by the following factor.

$$E_{\text{Cal}/^\circ\text{C}} = \frac{(HxM) + (2.7 \times W) + A}{T}$$

Where:

- **E** = Energy equivalent of the calorimeter in calories per degree Celsius.
- **H** = Heat of combustion of the standard benzoic acid sample in calories per gram.
- **M** = Mass of the standard benzoic acid sample in grams.
- **W** = Wire in centimeter used in combustion. (2.7 is the Cal/cm of 34 SG fuse wire)
A = Volume of alkali (0.0709 N Na$_2$CO$_3$) in ml used.
T = Temperature

**Calculation of gross energy**

The gross energy of each sample was calculated according to the formula.

**Gross Energy (Kcal/Kg) = ((E \times (FT-IT)-(2.3 \times W+A))/S)-464**

Where

E = Energy equivalent factor (2426)
IT = Initial temperature
FT = Final temperature
A = ml of alkali used in titration
W = length of wire (cm) used in ignition (2.7 is the calories per centimeter of 34 SG fuse wire)
S = Capsule + sample weight
3.5.5. **Slaughtering of Animals and Data Collection about Slaughter/Carcass Traits**

Kids were transported to Livestock Experiment Station (LES), Main Campus, UAF from experimental site at Jahanian. After overnight rest, the kids were off feed (for 12 h) and with free access to water before slaughtering. After weighing (slaughter live weight, SLW), goats were slaughtered during various experiments according to the Muslim (Halal) way by severing the throat and major blood vessels in the neck (*Plate 5-a*).

### 3.5.5.1. Slaughter Traits

Non-carcass components such as trotter weight, head weight, skin weight, pluck weight, liver weight were weighed (*Plate 5-a*) as per the methods described by Bonvillani *et al.* (2010). Dressed carcasses were weighed within 1 hour (hot carcass weight or HCW) and then chilled for 24 hours at 4°C at NIFSAT, University of Agriculture, Faisalabad (UAF) and weighed again (cold carcass weight or CCW). The dressing percentage was calculated on the basis of slaughter weight using hot carcass weight and cold carcass weight (Bonvillani *et al.*, 2010; Kadim *et al.*, 2003) as given below;

\[
Dressing \ percentage \ (\%) = \frac{Hot \ carcass \ weight}{Slaughter \ weight} \times 100
\]

### 3.5.5.2. Carcass Measurements

The carcass measurement were taken while following Bonvillani *et al.* (2010) as shown in *Plate 5-b*. The carcass length (L: length from cranial edge of the symphysis pelvis to the cranial edge of the first rib), leg length (F: length from perineum to distal edge of the tarsus), diaphragm width (Wr: widest carcass measurements at the ribs), buttock width (G: widest buttock measurements in a horizontal plane on the hanging carcass), buttock perimeter (BG: maximum perimeter at G), carcass compactness (HCW/L) and hind limb compactness (G/F) were the reading taken during the experiments.

### 3.5.5.3. Carcass cutting

After chilling, the carcasses were split along the vertebral column in two halves and the left side was used for all measurements. Carcasses left side weights were recorded. The left side of each carcass was divided into five anatomical regions or
cuts (neck, hind leg, loin + ribs, foreleg and breast) using a standard technique (Colomer-Rocher et al., 1987). Weight of the cuts was recorded (Plate 5-c) and expressed as proportion of the left half-carcass weight. After weighing, the loin + ribs cut (containing eye muscle or *longissimus dorsi*) was frozen at -20°C at NIFSAT, UAF for meat and sensory evaluation.
Plate 5: Data collection of slaughter and carcass traits

a. Slaughter, skinning and weighing of non-carcass parts
b. Carcass measurements
c. Preparing the carcass cuts
3.5.5.4. Carcass Traits
Various carcass traits using loin + ribs cut after thawing were determined to find out the quality of the carcass in response to various treatment factors. All the laboratory tests were performed in the Meat Laboratory at the National Institute of Food Science and Technology (NIFSAT), UAF except meat colour index (chromaticity, lightness and Hue angle) which was performed in the Post-Harvest Research Centre, Ayub Agricultural Research Institute (AARI), Faisalabad. The details are given below.

3.5.5.4.1. Eye Muscle/Ribeye Area: The eye muscle or ribeye area was determined between 12-13th rib by Grid-EMA devised by Iowa State University Extension while following Plant and Maden (1996) and by Held (2003). The frozen meat cut was divided into small pieces which were used for further tests. The Grid-EMA is given at Annexure 3. The pictures are given in Plate 5-d.

3.5.5.4.2. pH of Meat: The pH was evaluated by homogenizing 10 gm sample in 100 ml distilled water following the method as described by Arain et al. (2010) and Purchas (1990) with some modifications within the 24 hour of slaughtering. For determination of pH, firstly pH meter was calibrated using pH 7, 4 and 10 standard buffers. Afterword, 10 gm of the minced meat samples were homogenized in 100 ml of distilled water for about 30 seconds at high speed to make slurry. Homogenized samples were transferred into a beaker and pH was noted by placing the pH electrode into the samples (Plate 5-e).

3.5.5.4.3. Tenderness: Tenderness (using TA.XT.PLUS Texture Analyzer) were measured while following the protocols as described by Caneque et al. (2004) and Cavitt et al. (2005). Meat piece from the loin part (1st lumber vertebrae) was used to determine the force (in kg/cm²) with needle puncture shear force Texture Analyzer having a 5-kg load cell using a needle puncture probe with a height of 25 mm and a diameter of 2 mm set to a penetration depth of 20 mm. Crosshead speed was set at 80 mm/min and the test was triggered by a 10-g contact force. Pictures of procedure are given in Plate 5-f.
d. Preparation of meat samples for measuring eye muscle area

e. Measurement of pH after deboning, mincing and homogenization to make slurry
f. Measurement of tenderness using texture analyzer
3.5.5.4.4. **Water holding capacity**: Water Holding Capacity (WHC) was determined according to the procedure described by Wardlaw *et al.* (1973). The frozen right fillets were thawed at 4°C for 8 hrs in a refrigerator. The loin area pieces meat were cut and ground for 1 min in a food processor to achieve the desired particle size of approximately 3 mm of diameter. Five gram portions of the ground meat were weighted and placed in 35 ml assay tubes containing 80 ml of 0.6 M NaCl. The solution was mixed for 30 sec, incubated for 30 min at 4°C and centrifuged at 5000 rpm for 15 min. After centrifugation (*Plate 5-g*), the volume of the supernatant was measured using a 10 ml volumetric cylinder and the results were reported as the proportion of the fluid retained by the sample according to the following equation:

\[
\text{WHC (\%)} = \frac{\text{Initial volume} - \text{Volume of supernatant}}{\text{Initial volume}} \times 100
\]

3.5.5.4.5. **Cooking loss (%):** Meat samples (20 gm) were placed in polyethylene bag and heated in a water bath (*Plate 5-g*). at internal temperature of 72°C. Cook-out was drained and the cooked mass was cooled and weighed to determine the weight loss (Kondaiah *et al.*, 1985).

3.5.5.4.6. **Drip loss (%):** Drip Loss (DL) was determined according to the procedure described by Earl *et al.* (1996) with some modifications. The ground loin region meat was used for determination of WHC was used for this analysis. Three pieces of Whatman 14 # 3 paper (5.5 cm) and one piece of Whatman # 50 filter paper (7.0 cm) were formed into a thimble by shaping the filter papers around the outer round bottom of an inverted 16×150 mm test tube with the # 50 filter paper as the internal surface of the thimble. The filter paper thimble was weighed and approximately 5 gm of ground meat wrapped (*Plate 5-g*) and folded in a 15 cm² piece of 0.1 mm mesh white tulle netting and was placed inside the thimble and then stored at 4°C for 24 hrs. The filter paper with moisture was weighed and expressible moisture was reported as the percentage weight lost from the original samples according to the following equation:

\[
\text{DL (\%)} = \frac{\text{raw meat sample weight} - \text{sample weight after filtering}}{\text{raw meat sample weight}} \times 100
\]

3.5.5.4.7. **Color Index:** Hunter color values or CIE values (L*, a* and b*) were obtained by a ColorTec-PCM colorimeter (Accuracy Microsensor, USA) as shown in
Observations were made of the meat samples from 2nd lumber vetibrea of preserved meat. Meat samples were sliced to make uniform size meat slices and were given time to bloom (Caneque et al., 2004). L* values are a measure of darkness to lightness (larger value indicates a red colour); a* values are measure of redness (larger value indicates a redder colour) and b* values are a measure of yellowness (larger value indicates a more yellow color). These values were used to calculate the chromaticity, lightness and Hue angle using equations given below;

\[ \text{Lightness} = L^* \]

\[ \text{Chromaticity} = \sqrt{(a^*)^2 + (b^*)^2} \]

\[ \text{Hue angle} = \tan^{-1}\left(\frac{b^*}{a^*}\right) \]

3.5.5.4.8. **Meat Chemical Composition:** Moisture, crude protein, fat and ash percentage were estimated from minced muscles following the methods described by AOAC (2003) with some modifications. The materials and methods had already been discussed in feed analysis section while detail are also given at Annexure 2.

3.5.5.4.9. **Sensory Evaluation:** The sensory evaluation of the cooked meat samples was carried out for different attributes like appearance, flavor, juiciness, chewiness and overall acceptability by using nine point hedonic scales (Annexure 4) following the method described by Meilgaard et al. (2007) with some modifications. The meat samples from the loin region cooked using boiling by gas cooker in a pot at 100-160°C for 15 minutes with addition of 0.4% of iodized common salt (Eneji et al., 2012). After cooking the pieces of meat samples were placed in properly sealed plastic containers, labeled according to the meat samples and secured in a cooler for about one hour to ensure that the internal temperature cooled to room temperature. Eight trained panelists within the age range of 25-40 years were served after one hour to prevent possible changes such as the samples drying-out or developing off-flavor which could occur during holding. Post chewing of a sample, panelists were required to chew crackers biscuits and rinse their mouths with water to prevent taste bud carry-over effect (lingering taste from previous sample). The pictures of sensory evaluation are given in Plate 5-i.
g. Water holding capacity, cooking loss and drip loss measurement

h. Meat color index
i. Sensory evaluation
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Chapter 4

*Paper-I*

**EFFECT OF DIETARY PROTEIN LEVELS AND AGE OF WEANING ON THE GROWTH PERFORMANCE OF BEETAL KIDS REARED UNDER HIGH INPUT FEEDING SYSTEM**

4.1. **Abstract**

Poor feeding management during pre-weaning period is one of the factors resulting in compromised growth of Beetal kids fattened for meat purpose. The main reason for this anomaly may be less milk offered to kids and non-serious efforts for its management. This study was planned to find the most appropriate protein level suiting the age of the weaning while shifting animals to high input feeding system.

Total of 42 Beetal male kids having 30 (±10), 60 (±10) and 90 (±10) days of age were selected with 16 in each age group. They were designated as G30, G60 and G90, respectively. The weights of animals were; 8±2 kg (G30), 12±2 kg (G60) and 16±2 kg (G90), respectively. All animals were weaned by introducing the total mix feed gradually and withdrawing the milk during the adjustment period of two weeks. The pelleted starter ration (total mix feed) with three various dietary protein levels designated as R1 (16% CP), R2 (20% CP) and R3 (26% CP) were introduced. The control group was reared on the fodder (Maize). The starter rations were iso-caloric and were offered for 6 week duration. All animals were exposed to treatment using 2 factor factorial (3x3) plus control treatment arrangement under completely randomized design. The data were collected on average daily feed intake (ADFI), average daily gain (ADG), gain to intake ratio, Klieber ratio (KR), body measurements and blood metabolites of kids. The data was analyzed using aov function of R-software. The statistical analysis showed that starter feed protein levels and age of weaning had significant interaction for ADG (P<0.001), KR (P<0.001), ADFI (P<0.05) and blood urea nitrogen (P<0.05) while serum creatinine and feed conversion had non-significant interaction. The trend analysis revealed that ADG had significant quadratic interaction (P<0.05) within protein levels and age of weaning. It
was found that animals weaned at 30 or 60 days, on R2 diet had better ADG (46.8 gm/day and 87.06 gm/day, respectively) weaned at 60 days of age. The animals weaned at 90 days had best ADG (127 gm/day) with R1. It is concluded that animal weaned at 30 or 40 days required 20% CP for better growth performance while animal at 90 days showed better performance with 16% CP.

**Keywords:** Average daily gain, starter protein levels, weaning

**4.2. Introduction**

Efficient raising of the replacement stock is not only required for reproducing the next offsprings but also for continuing the business of ranching (Ahmed, 2008). There is high rate of digestive and respiratory ailments in sheep and goats which are responsible for high mortality in offsprings during early age especially if animals are not managed efficiently during pre-weaning period (Khan et al., 1991). The situation becomes more worsen in developing countries. The main reasons identified in the literature are overfeeding of milk, improper cleaning and sanitation, failure of vaccination, imbalance nutrition after weaning, under feeding and inefficient management (Donkin and Boyazoglu, 2004; Tsegaye et al., 2013 and Mandal et al., 2007)

The main objective of weaning is shifting the animal to consume solids feed to fulfill the requirements of the animals. If the kids could not get their required quantity of the milk at right time during weaning period then the immunity of the animal is impaired. As a result the chances of getting disease is increased and it ultimately results in lower growth (Morand-Fehr, 1981). Protein requirements are high during the early phase of life and the underfeeding results impaired growth of the kids (Ash and Norton, 1987). The pre-weaning loss in growth could be compensated by shifting animals to high plan of nutrition. Recently, Nisa et al. (2013) reported that the high input feeding system resulted in better growth performance than the low input due to better nutrients intake and nutrient utilization resulting in increased profit margin. Ideally, the kids are weaned at 4 months of age. But it is observed in field conditions that in poor managed flocks, kids are weaned at an early age due to shortage of feeding resources and doe’s conditions. The weaning results in post weaning stress which ultimately results in depressed intake and growth performance (Allan and Holst, 1989). These effects of weaning could be worsen if animals are weaned at an early age because the rumen is not developed in these cases. The high plane of nutrition
could decrease the impact of the stress. The most important information about the ration are palatability, digestibility and ration composition especially protein which is required relatively in high levels during the early phase of life. However, there is scanty information available for levels of protein supplementation to early weaned animals, especially in Beetal goats.

Thus, the current study was planned with objective to find out the most appropriate dietary protein levels as per the age of the weaning of Beetal kids. It is hypothesized that there is interaction of the protein levels of ration with the age of weaning. Converting the animals to high plane of nutrition under high input could help the animal to minimize the post weaning stress.

4.3. Materials and Methods

4.3.1. Selection of Animals
Total of 42 Beetal kids (21 ♂ + 21 ♀) of 30, 60 and 90 (±10) days of age were selected for experimentation at LES, Allahdad, Jahanian. The weight of selected animals was in the range of 8±2 kg (30 days age), 12±2 kg (60 days age) and 16±2 kg (90 days age), respectively. All animals were weaned and exposed to treatment during the probation period of two weeks.

4.3.2. Feeding and Management
The animals were managed in individual pens. Three pelleted experimental diets designated as R1 (16% CP), R2 (20% CP) and R3 (26% CP) were offered to three treatments groups. The control group (C) was fed on fodder (Maize) in individual pens. The experimental diets were iso-caloric and were offered for 6 week duration. The treatment plan is given in Table 4.1 and the ration composition is given in Table 4.2. The diets were manufactured at the Feed Mill, Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad (UAF). All the animals were given free access to the fresh and clean water and were reared under similar management conditions.
4.3.3. **Statistical Design**
The experimental units were assigned to treatments using 2 factor factorial (3×3) plus control treatment design (Marini, 2003) under Randomized Complete Block Design (RCBD), where sex of animals was blocking factor.

4.3.4. **Data Collection**
The study consisted of six weeks including 2 weeks of adjustment period. Body weight, body length, body height from the forelegs and heart girth were measured weekly (Kadim et al., 2004). The ADFI was calculated at the end of period (Cameron et al., 2001). Animals were weighed weekly early in the morning with fasting. Average daily gain, gain to intake ratio and Kleiber ratio (Mohammadi et al., 2010) were calculated at the end of trial.

4.3.5. **Blood Collection and Chemical Analyses**
The blood was collected at the start and at the end of the experiment from the jugular vein using the aseptic syringe and was processed and stored at -20°C for the analysis as per Nudda et al. (2013). The serum was thawed and used to determine the blood urea nitrogen and serum creatinine using kits manufactured by MERCK, France (detail given at Plate 3). Blood urea nitrogen was determined by UV test through GLDH method as described by Newman and Price (2001). Serum creatinine was found while measuring dyestuff formed concentration during the reaction of reagents and serum (Vasiliades, 1976. The samples and reagents were run on MICROLAB-300 manufactured by MERCK Pvt. Ltd. The diets were analyzed by proximate composition of feed (AOAC, 2003) while ADF and NDF following Van Soest et al. (1991) with some modifications.

4.3.6. **Statistical Analysis**
The analysis of covariance was performed between initial weight and average daily gain. The Data were analyzed using linear model procedures except the length, width and weekly body weight using *linear mixed effect* procedures in nlme program run in R- software (3.1.1 version). The means were compared by trend analyses to find linear or quadratic trend interaction if the treatment were found significantly affecting the parameters (R Core Team, 2014).
4.4. Results and Discussion

The results after statistical analysis are presented in Table 4.3 and Table 4.4. The trend analysis was performed for only the response factors that showed significant effect of the treatments as given at Annexure 7. ADG showed the significant quadratic interaction between diet and age of weaning. The adjusted means were plotted after fitting linear model in Figure 4.1 whereas section ‘A’ and section ‘C’ are main effects while section ‘B’ and section ‘D’ are interaction effects in this figure. The section ‘B’ shows that diets have significant interaction with age. R1 diet has resulted in the best ADG performance in animals weaned at 90 days age and lower in animals weaned at 30 days of age. The ration with 20% CP resulted in optimum ADG (87.06 gm/day) in animals weaned at 60 days of age. The ration with 26% CP resulted in lower ADG in G60 and G30 but performed better in G90 (93.75 gm/day). The results indicated that the performance of animals affected by protein levels if weaned at various ages. The CP requirement of starter ration is higher in early weaned as compare to late weaned. The animals in control group showed loss in weight (-24.10 gm/day) in G30 age groups. The analysis has shown that the sex (block) has significant effect on ADG (Annexure 7) so this factor was considered while drawing the response surface curve for male and female separately (Figure 4.2 and Figure 4.4 respectively) while contour line were also drawn separately for male and female (Figure 4.3 and Figure 4.5 respectively). These aforesaid diagrams could be used for predicting the CP of diet pertaining to age of weaning while considering the best predicted ADG.

Average daily feed intake (ADFI) also showed the quadratic interaction between age of weaning and dietary protein levels. ADFI was higher in G90 followed by G60 and G30. The highest ADFI was noticed in G90 with R3 (658.1 gm/day) followed by R2 (643.7 gm/day) in same weaning age group. The adjusted mean plot of ADFI is shown in Figure 4.6. The section ‘B’ shows that the dietary protein has non-significant different in G90 group while R2 has resulted in highest feed intake (602.4 gm/day) followed by R1 (452 gm/day) and R3 (417 gm/day). The control group was had least feed intake in all the age groups. The data analysis also showed the significant block effect (sex). This factor was also considered while drawing response surface curve (Figure 4.7 and Figure 4.9) and contour plots (Figure 4.8 and Figure 4.10).
The more meaningful comparison is gain to intake ratio (Table 4.3). The trend analysis showed that there was non-significant interaction of treatment factors for gain to intake ration while ration protein levels showed the significant (P<0.01) quadratic trend with the gain to intake ratio as shown in Figure 4.11. The gain to intake ratio was optimized with R2 (20% CP). Our results are in line with Chobtang et al. (2009) who also noticed the improvement in the average daily gain of Thai indigenous male goats with increase in the dietary protein. They found that the increase in the growth performance in term of ADG showed the linear trend. Earlier, Jia et al. (1995) reported that goat consuming high levels of protein in early age showed 150% more live weight gain than those on lower protein levels. These results are also line with other investigators (Hoffman et al., 2001; Bohnert et al., 2002; Chumpawadee et al., 2006 and Ali et al., 2009). The results are supported by the current studies as there is increase in gain to feed intake ratio and feed intake in the animals showing better gain performance. Muscher et al. (2010) reported that the goats have exceptional wide range of nitrogen homeostasis adaptability. The higher efficiency of utilizing the higher protein levels is due to increase in the efficiency of rumen to utilize the dietary nitrogen for making microbial protein. This would result in decreasing the renal urea secretion. Vosooghi-poostindoz et al. (2014) confirmed that the protein level enhancement in the diets results in the improvement of the feed intake. They further found that ADG was increased in pre-weaning when the dietary protein levels were increased from 16 to 18%. However, it looks that the rumen of animals weaned at 30 and 60 days might not be developed well to utilize the dietary protein levels above the 20% limit. The Control group showed negative gain and that probably is due to premature shifting of animals to fodder because rumen is not developed at early age of 30 days.

The blood serum was analyzed for serum creatinine and blood urea nitrogen. The trend analysis of serum creatinine showed linear trend (P<0.01) with ration dietary protein level (Table 4.3) but showed non-significant interaction. The creatinine decreased with the increase of the dietary crude protein (Figure 4.13). It was maximum (0.787 mg/dl) with R1 in G60 while minimum with R3 (0.449 mg/dl) in G30. The blood urea nitrogen showed significant (P<0.01) quadratic interaction with age of weaning (AG) and dietary protein levels (Trt). The section ‘B’ of Figure 4.12 shows that there was highest BUN with R3 ration in G30 (17.22 mg/dl) followed by
R2 in G30 (13.67 mg/dl). There was minimum BUN in control group. The figure aforementioned clearly shows higher values of BUN within G30 for all rations followed by G60 but at G90, all values seemed same. These results were supported by Muscher et al. (2010) as they found that the fecal and renal urea excretion decreases with increasing the age i.e. the reason of lower BUN. Higher BUN in G30 shows that the rumen may not be efficient in using the high levels of the dietary protein so the blood urea nitrogen trend shows higher rate of BUN increase in G30. While the G60 group also shows the same trend but the level of BUN was lower than G30 that may be due to more efficiency of G60 in utilizing the high level of protein than G30. Wang et al. (2012) reported the linear increase in the ruminal ammonia and plasma urea nitrogen with increase in dietary protein levels. Vosooghi-poostindoz et al. (2014) reported higher levels of the BUN at 18% dietary protein than those of at 16% CP diet during the pre-weaning phase. This might be due to high digestibility of the protein and high intake of N. However, the rumen microbes may not developed to detain the N produced. The serum creatinine decreases with the increase in the BUN due increase in dietary protein levels. Jia et al. (1995) also reported that the PUN was inversely proportional to serum creatinine. The serum creatinine decreased from 0.55 to 0.44 mg/dl and there was also linear increase of BUN as the dietary protein increased from 8% CP to 16 % CP in Angora and Spanish goats.

The body height from the forelegs and body heart girth did not showed significant effect (P>0.05) of the ration dietary protein levels (Table 4.4). However, the both responses showed significant (P<0.05) effect of age of weaning and were higher in G90 group followed by the G60 and G30 simultaneously. The height from fore leg was 54.66 cm in G90 followed by 51.60 cm in G60 and 51.29 cm in G30. Body length showed that main effects significantly affected the response while the interaction of both treatment factor was not significant for this response. Means comparison i.e. Post hoc analysis showed that the body length increase with the increase of dietary protein levels. However, the R2 and R3 have showed non-significant increase in body length. Similarly increasing the age of weaning resulted in increase in body length. There was highest body length with 46.77 cm in G90 followed by G60 with 43.80 cm and G30 with 39.11 cm. The body height and heart girth increases with the age because animals get longer and they deposit more calcium, more bones and more muscles. However, after weaning, the calcium intake
may be decreased which might resulted in lower bones growth rate. Atta et al. (2011) also found that body measurements varies with change in body weight so these measurement could also be used to measure the weight of animals. These trends were also followed in body length response of current studies.

4.5. Conclusion
The dietary protein levels may be selected depending upon the age of weaning. The dietary protein of 20% was better with 60 days weaning while 16% CP was better for 90 days weaning. The early weaning at 30 days resulted in lowering the growth performance. However, the urea level in feed was masked by the dietary protein levels in current study. Therefore, it requires further investigation.

4.6. Acknowledgements
We acknowledge Pakistan Science Foundation (PSF) and Higher Education Commission (HEC), Islamabad, Pakistan for financial support and also thank the Directorate of Small Ruminant Production, Multan for helping us to conduct the studies.

4.7. Conflict of Interest
We announces no conflict of interest in this study.

References


R Core Team. 2014. R: A Language and Environment for Statistical Computing. Vienna, Austria.


### Table 4.1: Treatment plan

<table>
<thead>
<tr>
<th>Groups</th>
<th>Dietary Protein</th>
<th>Weaning Age Groups</th>
<th>Animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>16 % CP</td>
<td>30, 60 and 90</td>
<td>12</td>
</tr>
<tr>
<td>R2</td>
<td>20 % CP</td>
<td>30, 60 and 90</td>
<td>12</td>
</tr>
<tr>
<td>R3</td>
<td>26 % CP</td>
<td>30, 60 and 90</td>
<td>12</td>
</tr>
<tr>
<td>Control</td>
<td>No supplementation</td>
<td>30, 60 and 90</td>
<td>06</td>
</tr>
</tbody>
</table>

### Table 4.2: Ingredient composition and chemical composition of experimental diets

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>22</td>
<td>20.5</td>
<td>14</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>18</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>Rice Polishing</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>30</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Molasses</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Urea</td>
<td>0</td>
<td>1.50</td>
<td>3</td>
</tr>
<tr>
<td>Salt</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wheat Straw</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

**Chemical Composition of Ration**

<table>
<thead>
<tr>
<th>Component</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (%)</td>
<td>92.20</td>
<td>92.60</td>
<td>93.00</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>16.84</td>
<td>19.69</td>
<td>25.57</td>
</tr>
<tr>
<td>Fat by ether extract (%)</td>
<td>5.30</td>
<td>5.35</td>
<td>5.25</td>
</tr>
<tr>
<td>Crude Fiber</td>
<td>15.25</td>
<td>15.10</td>
<td>14.90</td>
</tr>
<tr>
<td>Ash</td>
<td>9.61</td>
<td>9.86</td>
<td>8.28</td>
</tr>
<tr>
<td>NFE</td>
<td>53.00</td>
<td>50.00</td>
<td>46.00</td>
</tr>
<tr>
<td>NDF (%)</td>
<td>27</td>
<td>29</td>
<td>26</td>
</tr>
<tr>
<td>ADF (%)</td>
<td>18</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Gross Energy (Mcal/kg)</td>
<td>3.23</td>
<td>3.19</td>
<td>3.15</td>
</tr>
</tbody>
</table>
Table 4.3: Means table of various response factors and trend analysis in response to dietary protein level and age of weaning (n=4)

<table>
<thead>
<tr>
<th>Trt</th>
<th>AG</th>
<th>ADG (gm/day)</th>
<th>ADFI (gm/day)</th>
<th>Gain to Intake Ratio</th>
<th>BUN (mg/dl)</th>
<th>Creatinine (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>G30</td>
<td>-24.10</td>
<td>235.0</td>
<td>0.109</td>
<td>9.000</td>
<td>0.599</td>
</tr>
<tr>
<td>R1</td>
<td>G30</td>
<td>35.72</td>
<td>366.3</td>
<td>0.078</td>
<td>9.875</td>
<td>0.561</td>
</tr>
<tr>
<td>R2</td>
<td>G30</td>
<td>46.88</td>
<td>276.6</td>
<td>0.184</td>
<td>13.150</td>
<td>0.497</td>
</tr>
<tr>
<td>R3</td>
<td>G30</td>
<td>15.63</td>
<td>283.0</td>
<td>0.057</td>
<td>17.225</td>
<td>0.449</td>
</tr>
<tr>
<td>C</td>
<td>G60</td>
<td>4.17</td>
<td>315.0</td>
<td>0.014</td>
<td>8.600</td>
<td>0.469</td>
</tr>
<tr>
<td>R1</td>
<td>G60</td>
<td>75.89</td>
<td>452.0</td>
<td>0.163</td>
<td>8.475</td>
<td>0.787</td>
</tr>
<tr>
<td>R2</td>
<td>G60</td>
<td>87.06</td>
<td>602.4</td>
<td>0.143</td>
<td>11.225</td>
<td>0.569</td>
</tr>
<tr>
<td>R3</td>
<td>G60</td>
<td>62.50</td>
<td>417.3</td>
<td>0.147</td>
<td>13.675</td>
<td>0.534</td>
</tr>
<tr>
<td>C</td>
<td>G90</td>
<td>20.00</td>
<td>335.0</td>
<td>0.056</td>
<td>9.250</td>
<td>0.617</td>
</tr>
<tr>
<td>R1</td>
<td>G90</td>
<td>127.23</td>
<td>641.6</td>
<td>0.198</td>
<td>8.750</td>
<td>0.690</td>
</tr>
<tr>
<td>R2</td>
<td>G90</td>
<td>89.29</td>
<td>643.7</td>
<td>0.140</td>
<td>8.650</td>
<td>0.494</td>
</tr>
<tr>
<td>R3</td>
<td>G90</td>
<td>93.75</td>
<td>658.1</td>
<td>0.143</td>
<td>9.125</td>
<td>0.524</td>
</tr>
</tbody>
</table>

Standard Error

| Trt  | NA  | NA  | NA  | NA  | NA  | 0.119 |
| AG   | NA  | NA  | NA  | NA  | NA  | NA    |
| Trt × AG | 36.15 | 60.65 | 0.012 | 1.610 | NA  | NA    |

Trend Analysis Significance

| Trt Lin : AG Lin | NS  | *   | NS  | NS  | NS  | NS    |
| Trt Lin : AG Quad | *  | NS  | NS  | *** | NS  | NS    |
| Trt Quad : AG Lin | NS | *** | NS  | NS  | NS  | NS    |
| Trt Quad : AG Quad | NS | *   | NS  | NS  | NS  | NS    |
| Trt Lin Quad | **  | *   | NS  | *** | **  | **    |
| Trt Quad | *** | *** | **  | NS  | NS  | NS    |
| AG Lin | NS  | NS  | NS  | NS  | NS  | NS    |
| AG Quad | *** | *** | NS  | *** | NS  | NS    |

Note: * = P<0.05; ** = P<0.01; *** = P<0.001; Trt = Ration; R1 = Starter with 16% CP; R2 = Starter with 20% CP; R3 = Starter with 26% CP; C = Control (fodder); AG = Age of weaning; G30 = Weaning at 30 days; G60 = Weaning at 60 days; G90 = Weaning at 90 days; ADG = Average daily gain; ADFI = Average daily feed intake; BUN = Blood urea nitrogen
Table 4.4: Effect of dietary protein levels and age of weaning on the body measurement of the Beetal kids

<table>
<thead>
<tr>
<th>Response Variables</th>
<th>Crude Protein Levels of Ration</th>
<th>S.E.</th>
<th>Age of Weaning</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
<td>Control</td>
</tr>
<tr>
<td>Body length (cm)</td>
<td>44.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.77&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>39.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.33&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Body height at forelegs (cm)</td>
<td>52.00</td>
<td>51.80</td>
<td>51.50</td>
<td>51.25</td>
</tr>
<tr>
<td>Body width (Heart girth) cm</td>
<td>52.35</td>
<td>50.30</td>
<td>49.75</td>
<td>49.50</td>
</tr>
</tbody>
</table>

Note: R1 = Starter with 16% CP; R2 = Starter with 20% CP; R3 = Starter with 26% CP; C = Control (on fodder); AG = Age of weaning; G30 = Weaning at 30 days; G60 = Weaning at 60 days; G90 = Weaning at 90 days

Means with same super script shows statistically non-significant difference during Tukey’s HSD test
Figure 4.1: Effect of Dietary Protein Levels and Age of Weaning on ADG

Section A = main effects of Ration CP on ADG (P<0.05)
Section C = main effects of age of weaning on ADG (P<0.05)
Section B = interaction of ration CP with age of weaning on ADG (P<0.05)
Section D = interaction of age of weaning with ration CP on ADG (P<0.05)
Figure 4.2: Response Surface Curve of ADG in Male

Figure 4.3: Contour Plot of ADG in Male
Figure 4.4: Response Surface Curve for ADG in Female

Figure 4.5: Contour Plot of ADG in Female
Figure 4.6: Effect of Dietary Protein Levels and Age of Weaning on ADFI
Figure 4.7: Response Surface Curve for ADFI in Male

Figure 4.8: Contour Plot for ADFI in Male
Figure 4.9: Response Surface Curve for ADFI in Female

Figure 4.10: Contour Plot for ADFI in Female
Figure 4.11: Effect of Dietary Protein Level and Age of Weaning on Gain to Intake Ratio
Figure 4.12: Effect of Dietary Protein Level and Age of Weaning on Blood Urea Nitrogen

Section A = main effects of Ration CP on BUN (P<0.05)
Section C = main effects of age of weaning on BUN (P<0.05)
Section B = interaction of ration CP with age of weaning on BUN (P<0.05)
Section D = interaction of age of weaning with ration CP on BUN (P<0.05)
Figure 4.13: Effect of Dietary Protein Level and Age of Weaning on Serum Creatinine
Chapter 5

Paper-II

EFFECT OF PHYSICAL FORM OF FEED AND ADDITION OF LIVE YEAST CULTURE (*Saccharomyces cerevisiae*) ON THE GROWTH PERFORMANCE AND CARCASS TRAITS OF BEETAL MALE KIDS UNDER HIGH INPUT FEEDING SYSTEM

5.1 Abstract

The high input feeding system have been found more reliable in fulfilling the requirement of the Beetal goat. It also resulted in improving the growth and meat potential of the animals. However, the investigation about which physical form of feed is better for the Beetal is still awaited. Similarly, use of yeast in the feed for improving the feed efficiency also requires the some experimentation in this breed. Total of 16 kids of Beetal breed having age of 180 (±10) days age and 17(±2) kg BW were selected for the study. Fattening ration was formulated and used in two physical forms i.e. mash or pellets (MS or PL). Both rations were iso-caloric and iso-nitrogenous. While they were further divided in two categories with presence or absence of live yeast (or X) (*Saccharomyces cerevisiae*). All animals were exposed to treatments using two factor factorial (2×2) arrangement with two physical form and two yeast addition groups for seventy days. Data was analyzed using *aov* function in R software. Average daily gain showed the interaction effects for both treatments whereas it was found that pellets form of feed supplemented with yeast culture showed the best performance (77.50 gm/day) followed by mash without yeast (61.56 gm/day). However, the animals fed on the mash form showed overall lower ADG performance. The same trend was noticed for Klieber ratio. Overall, PL showed significantly better Klieber ratio (8.026) than all other groups. The ADFI was lowest (P<0.05) in MS with (588.30 gm/day) followed by PLX (610.0 gm/day), PL (648.8 gm/day) and MS (863.0 gm/d). Feed conversion ratio (FCR) was
significantly affected by the main effects of physical form of feed and yeast addition. Yeast addition resulted in better FCR (9.50) than not added (12.24) while pellets form feed resulted lower FCR than mash (9.67 vs 12.48). Pellets with yeast addition resulted in higher (P<0.05) hue angle, hot carcass weight, dressing percentage, lower cook loss, serum glucose and ether extract in meat. The other carcass traits, sensory evaluation and blood metabolites were not affected by the treatment groups. It is concluded that out of all the treatments, the pellet form of feed with the addition of yeast has resulted in best growth performance while there was no detrimental effect of it on the carcass quality.

Keywords: Beetal breed, Pellet, Mash, Saccharomyces cerevisiae, ADG, ADFI and Carcass traits

5.2 Introduction
Total mix feed are commonly used in the high input feeding systems whereas mash form are used in the field conditions of country. The goats are more selective in their feeding behavior which results in the loss of some feed and wastage if kept on mash due to sorting (Issakowicz et al., 2013). Pellets could be used to improve the nutrient digestion and the palatability as well to decrease the sorting. However, there could be some problems of acidosis or even more enterotoxaemia when shifting animals to high input feeding (Issakowicz et al., 2013 and Rufino et al., 2013).

The probiotics have been used to improve the digestion process in the ruminants by improving more residence time, maintaining the ciliates in rumen ecosystem and increase the rumen pH to 6.2 (Tripathi and Karim, 2011). This may result in improving the quality and feed, decreasing the cost by decreasing the chances of acidosis or enterotoxaemia. Live yeast culture of Saccharomyces cerevisiae has been found more beneficial by investigators; Ozsoy et al., (2013); Rufino et al., (2013); Issakowicz et al., (2013); Pienaar et al. (2012) and Tripathi and Karim (2011), etc. The use of lives yeast culture (Saccharomyces cerevisiae) as probiotics to improve the utilization of mash and pellet for Beetal is still to be investigated to rear Beetal goat. It is imperative that such improvisation must improve the growth performance without adverse effect in meat
quality. The aim of current study was to investigate the effect of adding the live yeast culture (*Saccharomyces cerevisiae*) to mash and pellet total mixed fattening ration as a measure to improve the meat quantity and quality in Beetal breed.

5.3 Materials and Methods

5.3.1 Study Area and Selection of Animals
The study was conducted at LES, Allahdad, Tehsil Jahania, District Khanewal. The farm is located 45 km on Khanewal-Bahawalpur road. Total sixteen male kids of Beetal breed having age of 180 (±10) days age and 17(±2) kg BW were selected for study.

5.3.2 Feeding and Management
All animals were fed in the individual stalls. Total duration of the study was 70 days (including 10 days adjustment). A ration was formulated as per NRC, 2007 standards as given in Table 5.1 and processed at Feed Mills, Institute of Animal Science, UAF. The feed was further process for pellets making using steam and sieve (8 mm) in the Nice Feeds, Sumundri Road, Faisalabad. Later, the feed was packed and transported to LES Allahdad, Jahanian. Animals were divided in four groups i.e. MS (Mash form + yeast), MSX (Mash + no yeast), PL (Pellets + yeast), PLX (Pellets + no yeast added). The live yeast (*Saccharomyces cerevisiae*) was procured from market with brand name FIBOCEL® product of Lallemand, France. Yeast was used in feed @ 3 kg/ton before pelleting for PL and MS groups only. Animal were offered *ad libitum* ration for 24 hrs in individual pens. All animals were reared under same husbandry conditions and were given free access to the fresh and clean water. Feeding was done early in the morning after weighing the orts. All the animals were dewormed before the start of actual feeding period.

5.3.3 Statistical Design
The animals were exposed to treatment using 2×2 factorial arrangements. There were two physical forms i.e. Mash and Pellets with addition of live yeast (*Saccharomyces cerevisiae*) added or not added. The CRD design was used to allocated the experimental units.
5.3.4 Data Collection and Chemical Analyses

The data were collected on body weight, fattening ration intake, blood metabolites, slaughter and carcass traits. Body weight were measured weekly. Daily orts were collected to measure feed intake during fattening period. Average daily gain (following Kadim et al., 2003), feed conversion ratio (following Sen et al., 2004) and Kleiber ratio (following Mohammadi et al., 2010) were calculated at the end of the trial. Blood samples were collected at day one and at the end of the fattening period for determining serum glucose, serum creatinine, blood urea nitrogen (BUN) and cholesterol to determine the physiological response in treatment groups (Nudda et al., 2013).

The fattening ration and minced meat sample were analyzed by proximate analyses procedures detailed out by AOAC (2003) for determining the detail chemical composition at Institute of Animal Nutrition and Feed Technology (IAN&FT), UAF. Twelve animals (3 from each group) selected randomly for slaughtering at the end of the experiment, were transported to the University of Agriculture, Faisalabad. The duration of journey was 6 hours. The animals were given rest, water and feed after 3 hours. Final weights of all animals were recorded after 12 hr fasting and then after 24 hr fasting prior to slaughter. Hot carcass weight was recorded after excluding the weight of testes, kidney, pelvic fat and tail and used to calculate the dressing percentage (Bonvillani et al., 2010). The carcasses were chilled for 24 hr at 4°C and weight was recorded. The carcass measurements like carcass length, leg length, buttock perimeter and buttock width were recorded while leg compactness and carcass compactness was calculated using these measurements (Bonvillani et al., 2010). The carcasses were split into two symmetrical parts with the aid of meat saw. Then left side carcasses were divided into five anatomical cuts and these were weighed then converted it into proportions of HCW (Colomer-Rocher et al., 1987), and frozen at -20°C (aged for 30 day). The rib eye muscle from aged carcasses were used for further meat tests and sensory evaluation at National Institute of Food Science and Technology (NIFSAT), UAF, except meat color index which was performed at Ayub Agri Research Institute, Faisalabad. The eye muscle or ribeye area was determined between 12-13th rib by Grid-EMA while following Plant and Maden (1996). The meat was thawed, minced and used for determination of pH by slurry method...
using Hanna Instruments (HI 98107 pHep pH Tester, +/-0.1 Accuracy). The pH of meat was evaluated by taking 10 gm of the minced meat samples and homogenized in 100 ml of distilled water for about 30 seconds at high speed. Homogenized samples were transferred into a beaker and pH was noted by placing the pH electrode into the samples (Arain et al., 2010).

Tenderness (using TA.XT.PLUS Texture Analyzer) were measured while following the protocols as described by Cavitt et al. (2005) with some modifications. Meat piece from the loin part (longissimus dorsi) was used to determine the force (in kg/cm²) with needle puncture shear force Texture Analyzer having a 5-kg load cell using a needle puncture probe with a height of 25 mm and a diameter of 2 mm set to a penetration depth of 20 mm. Crosshead speed was set at 80 mm/min and the test was triggered by a 10-g contact force.

Water Holding Capacity (WHC) was determined according to the procedure described by Wardlaw et al. (1973) with some modifications. The frozen right fillets were thawed at 4°C for 8 hrs in a refrigerator. The loin area meat were cut and ground for 1 min in a food processor to achieve the desired particle size of approximately 3 mm of diameter. Five gram portions of the ground meat were weighted and placed in 35 ml assay tubes containing 80 ml of 0.6 M NaCl. The solution was mixed for 30 sec, incubated for 30 min at 4°C and centrifuged at 5000 RPM for 15 min. After centrifugation, the volume of the supernatant was measured using a 10 ml volumetric cylinder.

Cooking loss (%) was measured following Kondaiah et al. (1985) by placing meat sample (20 gm) in polyethylene bag and heated in a water bath at internal temperature of 72°C. Cook-out was drained and the cooked mass was cooled and weighed to determine the weight loss.

Drip loss (%) was determined according to the procedure described by Earl et al. (1996) with some modifications. Three pieces of Whatman 14 # 3 paper (5.5 cm) and one piece of Whatman # 50 filter paper (7.0 cm) were formed into a thimble by shaping the filter papers around the outer round bottom of an inverted 16×150 mm test tube with the # 50
filter paper as the internal surface of the thimble. The filter paper thimble was weighed and approximately 5 gm of ground meat wrapped and folded in a 15 cm$^2$ piece of 0.1 mm mesh white tulle netting was placed inside the thimble and then stored at 4°C for 24 hrs. The filter paper with moisture was weighed and expressible moisture was reported as the percentage weight lost from the original samples.

The Color index ($L$, $a^*$, $b^*$ values) of meat samples were measured after blooming the meat samples using Minolta Chroma Meter CR-200 (Accuracy Microsensors, Inc., USA). These color index values were used to calculate the chromaticity and hue angle (Caneque et al., 2004). The meat samples were analyzed for chemical composition by proximate analysis procedures (AOAC, 2003). The sensory evaluation of the cooked meat samples (by boiling while following Eneji et al., 2012) was carried out by eight trained panelists (within the age range of 25-40 years) for different attributes like appearance, flavor, juiciness, chewiness and overall acceptability by using nine point hedonic scales following the method described by Meilgaard et al. (2007).

5.3.5 Statistical Analysis
The data were analyzed using linear model procedures run in R-software (3.1.3 version). The means were compared by Tukey’s HSD test during post-hoc analyses (R Core Team, 2014). The ANOVA tables are given at Annexure 8.

5.4 Results and Discussion
The data collected was analyzed to determine the effect of treatments on various response factors. Means comparison are given in Table 5.3 and Table 5.4 for interaction and main effects respectively.

Average daily gain showed the interaction effects (Figure 5.1) for both treatments. However, PL showed the best performance (77.50 gm/day) followed by MSX (61.56 gm/day). However, the animals fed on the mash form showed overall lower ADG performance. Moreover, PLX resulted better ADG performance (55.83 gm/day) as compare to 53.67 gm/day by MS. The same trend was noticed for Klieber ratio (Figure 5.3). Overall, PL showed significantly better Klieber ratio (14.14) than all other groups. The ADFI was lowest ($P<0.05$) in MS (Figure 5.2) with (588.30 gm/day) followed by
PLX (610.0 gm/day), PL (648.8 gm/day) and MS (863.0 gm/d). Feed conversion ratio (FCR) was significantly affected by the main effects of physical form of feed and yeast addition (Figure 5.8). Yeast addition resulted in better FCR (9.50) than not added (12.24) while pellets form feed resulted in lower FCR than mash (9.67 vs 12.48). The Same trend noticed for gain to intake ratio (Figure 5.9)

The improvement in ADG, FCR and KR during current study in response to pellet form was in line with the findings of Reddy et al. (2012); Ustuner et al. (2012); Gipson et al. (2007) and Yaylak et al. (2003). Pellitization increases intake trough decreasing the sorting and the wastage decreases. The steam process during pellet form may improve the feed residence time in the rumen as pelletization make it coarser so particle size increases so the feed utilization improves in this case (Madhavi et al., 2006). The overall ADG was lower in current experiment as compare to Sarwar et al. (2012). Probable reason are captivity and individual feeding that may be resulted in lower gain due to lower feed intake. While the ADFI was seemed affected by the physical form of feed and the yeast addition in feed. These findings are in line with findings of Ozsoy et al. (2014); Issakowics et al. (2013) and Pienaar et al. (2012). These afore said findings also showed that the addition of yeast did not improved the ADG. However, Tripathi and Karim (2010); Tripathi and Karim (2011); Pal et al. (2010) and Titi et al. (2008) contradicted with the findings of current study and showed that the inclusion of yeast in feed resulted in increase in ADG and ADFI and lower FCR. It was noticed that ADFI was not affected by the yeast addition when we fed pellets while the yeast addition has affected the ADFI significantly in mash form feed. Where the non-yeast feed showed higher intake may due to less rumen residence of the mash from which resulted in more intake. This variation in intake was not significant in yeast added in various physical forms. The lower intake could be due to improvement in digestibility, more residence of feed in rumen due to yeast addition, improving the pH to more neutral than acidic and decreasing the ciliates in the rumen (Tripathi and Karim, 2011).

There was significant interaction of (P <0.05) of two treatment factor as shown in Figure 5.4. MS showed cooking loss (37.32 %) than MSX (27.79 %) and conversely PLX
resulted more cooking loss (35.38 %) than PL (30.66 %). Similarly, hue angle also followed the same trends (Figure 5.5) with high value was noticed in PL (35.25) as compare to mash where high values for hue angle as noticed in MSX i.e., without yeast addition group (29.36). Moisture in meat also shown the significant interaction (P <0.05) of treatment factors (Figure 5.6). There was higher moisture in the meat of the animals fed PLX (77.71 %) as compare to those of MS (71.69 %). Blood glucose level in the serum was also affected significantly (P <05) by the interaction of the treatment factors. The glucose (Figure 5.7) was highest in animals fed with pellet ration along with yeast (77.67 mg/dl) followed by mash without yeast (53.67 mg/dl) and mash with yeast (48 mg/dl) and pellets without yeast (41.33 mg/dl). However, statistically three groups were significantly not different except pellet with yeast.

The high cooking loss seems to be linked with the growth performance of animals as better growth rate resulted in lower cooking loss. This may be due to development of muscles so the proteins developed in bigger quantity which help to hold more water so the loss in drip also decreases. Similarly cooking loss will also be decreased (Agnihotri et al., 2006). The moisture in meat is also affected by the mass of muscle. More the growth, more will be muscle mass and higher will fat deposition in the muscles. So, this may resulted in lower moisture contents in mash farm feed (Li et al., 2014). The blood glucose decreased significantly in yeast added feed. These findings are in line with those of reported by Mohammad et al. (2013) while contradicted to the findings of Issakowics et al. (2013) and Payandeh and Kafilzadeh (2007) who reported that the serum glucose was not changed in response to yeast feeding. The hue angle values were higher in pellets may be due to more myoglobin and other proteins which resulted in more ‘a’ values (Milewski and Zaleska, 2011). Similarly the finding were also given by Joo et al. (2013) which also improved the WHC of the meat.

Regarding main effects (Figures 5.8-5.43), there was significant effect of physical form of feed on the dressing % of kids (Figures 5.11). Hot carcass weight was also higher in pellets fed animals (Figures 5.10). Pellets resulted in better (P<0.47) dressing percentage (47.59 %) than mash form feed (42.93 %). The wholesale cuts and carcass measurements
were not affected by the physical form of feed. Leg weight was higher (P<0.05) in pellets fed (1.336 kg) than the mash fed (1.055 kg) (Figures 5.28). While other carcass traits and meat quality was not affected by the physical form of feed or addition of yeast. There was no significant effect of physical form of feed on the sensory evaluation score of the cooked meat and other blood metabolites. The slaughter traits and carcass traits were not affect by the live yeast addition. Similarly, the meat analyses, sensory evaluation and blood metabolites were not affected by the main effect of yeast addition. Drip loss was higher (P=0.012) in kids (Figures 5.32) which were not supplemented with yeast added (4.982 %) feed than yeast added (2.057 %). Similarly, breast weight was higher in yeast not added group (0.820 vs 0.513 kg).

The dressing percentage was same as reported by Agnihotri and Rajkumar (2001) which may be due to better growth performance of pellets fed animals. Similarly high values of hot carcass weight and leg weight noticed were due to better growth performance of the animals (Ozcan et al., 2014; Poore et al., 2013; Titi et al., 2008 and Santos-Silva et al., 2004). However, most of the other carcass traits, blood metabolites and sensory evaluation score were not affected by the addition of yeast culture or by the physical form of feed are in line with those of Blanco et al. (2014); Bugdayci et al. (2014); Pienaar et al. (2012) and Ustuner et al. (2012). The reason could, the iso-caloric feed was used in all groups and the age of animals was also same. However, more drip loss in yeast deprived animals were due to less growth of muscles and muscle protein which decreased the water holding capacity of the meat (Joo et al., 2013).

5.5 Conclusions
The addition of yeast has interaction with the physical form of feed for economics traits like ADG: ADFI, ADG and dressing percentage. Pellets with the addition of live yeast (Saccharomyces cerevisiae) are found best in improving the growth performance while there was not impact on the carcass quality. Therefore, it is concluded that the mash form could be used without addition of yeast while using yeast is beneficial for pellets.
5.6 Acknowledgements
The authors thank and acknowledge the support provided by Meat laboratory, National Institute of Food Science and Technology UAF, Pakistan Science Foundation (PSF) for financial support and Directorate of Small Ruminant Production, Multan for the conduct of current study.

5.7 Conflict of Interest
The authors had not conflict of interest as neither of afore mentioned organization had influence in conduct of the studies or the researchers at any stage.

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Table 5.1: Ingredient and chemical composition of ration (before pelleting)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize (hybrid)</td>
<td>10</td>
</tr>
<tr>
<td>Oats</td>
<td>30</td>
</tr>
<tr>
<td>Corn Gluten Feed (30%)</td>
<td>5</td>
</tr>
<tr>
<td>Rice Polishing</td>
<td>12</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>20</td>
</tr>
<tr>
<td>Molasses</td>
<td>08</td>
</tr>
<tr>
<td>Wheat Straw</td>
<td>12</td>
</tr>
<tr>
<td>Oil</td>
<td>1</td>
</tr>
<tr>
<td>Lime stone</td>
<td>1</td>
</tr>
<tr>
<td>Salt</td>
<td>1</td>
</tr>
</tbody>
</table>

**Chemical composition (%)**

*Proximate composition (%)*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>90.32</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>10.93</td>
</tr>
<tr>
<td>Fat by ether extract</td>
<td>6.44</td>
</tr>
<tr>
<td>Crude Fiber</td>
<td>14.50</td>
</tr>
<tr>
<td>Ash</td>
<td>9.80</td>
</tr>
<tr>
<td>NFE</td>
<td>58.33</td>
</tr>
<tr>
<td><strong>NDF</strong></td>
<td><strong>25.6</strong></td>
</tr>
<tr>
<td><strong>ADF</strong></td>
<td><strong>16.0</strong></td>
</tr>
<tr>
<td><strong>Gross Energy (Mcal/Kg)</strong></td>
<td><strong>3.52</strong></td>
</tr>
</tbody>
</table>

*Note: Formulation derived from NRC (2007)*

Table 5.2: Treatment plan

<table>
<thead>
<tr>
<th>Physical form of feed</th>
<th>Yeast</th>
<th>Group Name</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mash</td>
<td>Present</td>
<td>MS</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>MSX</td>
<td>4</td>
</tr>
<tr>
<td>Pellets</td>
<td>Present</td>
<td>PL</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>PLX</td>
<td>4</td>
</tr>
</tbody>
</table>
Table 5.3: Interaction effects in response to physical form of feed and yeast addition.

<table>
<thead>
<tr>
<th>Response Factors</th>
<th>Mash</th>
<th>Pellets</th>
<th>P-Value</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yeast added</td>
<td>Yeast not added</td>
<td>Yeast added</td>
<td>Yeast not added</td>
</tr>
<tr>
<td>Av. daily gain (gm/day)</td>
<td>53.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>61.56&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>55.83&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Av. daily feed intake (gm/day)</td>
<td>588.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>863.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>648.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>610.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Klieber ratio</td>
<td>9.633&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.82&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cooking loss (%)</td>
<td>37.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27.79&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30.66&lt;sup&gt;b&lt;/sup&gt;</td>
<td>35.38&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hue angle</td>
<td>21.95&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>35.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.33&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Meat moisture (%)</td>
<td>71.69&lt;sup&gt;a&lt;/sup&gt;</td>
<td>71.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>69.69&lt;sup&gt;b&lt;/sup&gt;</td>
<td>77.71&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Blood glucose (mg/dl)</td>
<td>48&lt;sup&gt;b&lt;/sup&gt;</td>
<td>53.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>77.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.33&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
### Table 5.4: Effect of the physical form of feed and live yeast culture addition to the main effects of various responses (n=4)

<table>
<thead>
<tr>
<th>Response Factor</th>
<th>Parameters</th>
<th>Physical form of feed</th>
<th></th>
<th>Lives yeast culture</th>
<th></th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mash</td>
<td>Pellets</td>
<td>Yeast added</td>
<td>Yeast not added</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P – Value</td>
<td></td>
<td>P – Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.081b</td>
<td>0.105a</td>
<td>0.107a</td>
<td>0.083b</td>
<td>0.342</td>
</tr>
<tr>
<td>Growth</td>
<td>Feed Conversion Ratio</td>
<td>12.48b</td>
<td>9.67a</td>
<td>9.50a</td>
<td>12.24b</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>Gain to Intake Ratio</td>
<td>9.38</td>
<td>10.25</td>
<td>10.35</td>
<td>9.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot carcass wt. (kg)</td>
<td>44.42</td>
<td>47.07</td>
<td>47.93</td>
<td>42.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dressing (%)</td>
<td>7.24</td>
<td>6.671</td>
<td>6.84</td>
<td>6.907</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proportion Head wt. to HCW</td>
<td>6.36</td>
<td>6.933</td>
<td>6.773</td>
<td>6.683</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proportion Skin wt. to HCW</td>
<td>3.82</td>
<td>3.567</td>
<td>3.672</td>
<td>3.619</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proportion limbs wt. to HCW</td>
<td>4.48</td>
<td>4.049</td>
<td>4.05</td>
<td>4.482</td>
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<tr>
<td>Slaughter traits</td>
<td>Carcass length (cm)</td>
<td>68.62</td>
<td>70</td>
<td>70.77</td>
<td>68.24</td>
<td></td>
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<tr>
<td></td>
<td>Leg length (cm)</td>
<td>42</td>
<td>44.88</td>
<td>45.73</td>
<td>41.01</td>
<td></td>
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<tr>
<td></td>
<td>Buttock width (cm)</td>
<td>17.5</td>
<td>17.75</td>
<td>18.04</td>
<td>17.48</td>
<td></td>
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<tr>
<td></td>
<td>Buttock Perimeter (cm)</td>
<td>42.5</td>
<td>46.89</td>
<td>45.83</td>
<td>44.33</td>
<td></td>
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<tr>
<td></td>
<td>Thoracic width (cm)</td>
<td>14.80</td>
<td>17.50</td>
<td>16.08</td>
<td>16.83</td>
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<tr>
<td></td>
<td>Carcass compactness</td>
<td>0.135</td>
<td>0.162</td>
<td>0.154</td>
<td>0.152</td>
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<td></td>
<td>Leg compactness</td>
<td>0.401</td>
<td>0.417</td>
<td>0.410</td>
<td>0.399</td>
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<td></td>
<td>Cold carcass wt. (kg)</td>
<td>9.25</td>
<td>10.09</td>
<td>10.15</td>
<td>9.05</td>
<td></td>
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<tr>
<td></td>
<td>Right side weight (kg)</td>
<td>4.855</td>
<td>5.183</td>
<td>5.069</td>
<td>5.082</td>
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<tr>
<td></td>
<td>Left side weight (kg)</td>
<td>4.938</td>
<td>5.131</td>
<td>4.978</td>
<td>5.245</td>
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<tr>
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<td>Neck weight (kg)</td>
<td>0.537</td>
<td>0.453</td>
<td>0.447</td>
<td>0.551</td>
<td></td>
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<tr>
<td></td>
<td>Leg weight (kg)</td>
<td>1.155</td>
<td>1.336</td>
<td>1.382^a</td>
<td>1.07^b</td>
<td>0.047</td>
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<tr>
<td></td>
<td>Loin + Rib weight (kg)</td>
<td>0.972</td>
<td>1.015</td>
<td>1.12</td>
<td>0.941</td>
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<tr>
<td>Carcass traits</td>
<td>Shoulder weight (kg)</td>
<td>0.997</td>
<td>0.965</td>
<td>0.890</td>
<td>1.140</td>
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<tr>
<td></td>
<td>Breast weight (kg)</td>
<td>0.65</td>
<td>0.59</td>
<td>0.51^b</td>
<td>0.82^a</td>
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<tr>
<td></td>
<td>Eye area (sq. In)</td>
<td>1.72</td>
<td>1.86</td>
<td>1.82</td>
<td>1.81</td>
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</tr>
<tr>
<td></td>
<td>pH of meat</td>
<td>5.97</td>
<td>5.6</td>
<td>5.64</td>
<td>5.88</td>
<td></td>
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<tr>
<td></td>
<td>Tenderness/Needle Puncture (kg/cm^2)</td>
<td>0.56</td>
<td>0.71</td>
<td>0.74</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water holding capacity (%)</td>
<td>57.55</td>
<td>58.84</td>
<td>59.24</td>
<td>58</td>
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**Table: 5.4 Contd.**

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\(^{a}\) \(^{b}\) \(^{c}\) Indicates significance at the 0.05 level. SEM values are provided for each comparison.

\(P>0.05 = NS\)
Figure 5.1: Interaction effects on ADG

Figure 5.2: Interaction effects on ADFI

Figure 5.3: Interaction effects on Klieber ratio
Figure 5.4: Interaction effect on the Cooking loss (%)

Figure 5.5: Interaction effect on Hue angle

Figure 5.6: Interaction on Moisture in meat

Figure 5.7: Interaction effects on Serum glucose
Figure 5.8: Main effects of Form of feed and Yeast addition on FCR
Figure 5.9: Main effects of Form of feed and Yeast addition on Gain to intake ratio
Figure 5.10: Main effects of Form of feed and Yeast addition on hot carcass weight
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Figure 5.12: Main effects of Form of feed and Yeast on Head proportion to HCW
Figure 5.13: Main effects of Form of feed and Yeast addition on Proportion of Skin to HCW
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Figure 5.21: Main effects of Form of feed and Yeast addition on Cold carcass wt.
Figure 5.22: Main effects of Form of feed and Yeast addition on Right side weight
Figure 5.23: Main effects of Form of feed and Yeast addition on Left side weight
Figure 5.24: Main effects of Form of feed and Yeast addition on Neck weight

![Box plots showing the main effects of Form of feed and Yeast addition on Neck weight. The plots compare Neck weight (kg) between various conditions of feed form and yeast addition.](image)
Figure 5.25: Main effects of Form of feed and Yeast addition on Foreleg weight
Figure 5.26: Main effects of Form of feed and Yeast addition on Breast weight
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Figure 5.29: Main effects of Form of feed and Yeast addition on Tenderness
Figure 5.30: Main effects of Form of feed and Yeast addition on Eye muscle area

[Box plots showing the effect of Form of feed (Mash vs. Pellets) and Yeast addition (Yeast added vs. Yeast not added) on Eye muscle area in square inches.]
Figure 5.31: Main effects of Form of feed and Yeast addition on pH of meat
Figure 5.32 Main effects of Form of feed and Yeast addition on Drip loss
Figure 5.33: Main effects of Form of feed and Yeast addition on Chromaticity
Figure 5.34: Main effects of Form of feed and Yeast addition on Lightness
Figure 5.35: Main effects of Form of feed and Yeast on Sensory score of meat color
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Figure 5.39: Main effects of Form of feed and Yeast on Sensory score of meat Chewiness
Figure 5.40: Main effects of Form of feed and Yeast on Sensory score of meat
Overall acceptability
Figure 5.41: Main effects of Form of feed and Yeast addition on BUN

Blood Urea Nitrogen (mg/dl)

Mash
Pellets
Physical Form of Feed

Blood Urea Nitrogen (mg/dl)

Yeast Added
Yeast not Added
Yeast Addition
Figure 5.42: Main effects of Form of feed and Yeast addition on Serum cholesterol
Figure 5.43: Main effects of Form of feed and Yeast addition on Serum creatinine
Chapter 6

Paper-III

GROWTH PERFORMANCE AND CARCASS TRAITS OF VARIOUS CLASSES OF BEETAL KIDS UNDER HIGH INPUT FEEDING SYSTEM

6.1 Abstract

High input feeding system results in better growth performance in goats as compared to low input feeding system. Traditionally goats are reared under low input system while to see the effectiveness of high input feeding system, current project was planned to study the growth performance and carcass quality among various classes of Beetal breed. Total 16 Beetal kids (12 male + 4 female) were selected considering 120 (±10) days average age and weight ranging 16 (±2) kg for male and 14(±2) kg for female. The kids from various classes were divided into four treatment groups designated as S1 (Entire male or not castrated), S2 (castrated at 4 mo), S3 (castrated at 6 mo) and S4 (female). Animals were castrated during pre-fattening period and managed under same conditions before fattening. The duration of the study was 120 days (60 days pre-fattening + 60 day fattening). Total of 12 animals (randomly 3 from each treatment group) were slaughtered at the end of study for detail carcass quality evaluation. The average daily gain (ADG) was significantly affected (P<0.001) by the treatments. There was higher ADG noticed in S3 group (93.75 gm/d) as compared to S1 (85.42 gm/d), S4 (63.89 gm/d) and S2 (33.75 gm/d). Average daily feed intake was significantly (P<0.05) highest in S3 (878.00 gm/d). The serum cholesterol and serum glucose were also affected (P<0.05) by the treatments. There was non-significant (P>0.05) effect of treatments on the sensory panel score about color, chewability, flavor, tenderness and overall acceptability of the cooked meat. It is concluded that sex and castration affected the growth in kids while the carcass traits were not affected. The age of castration need consideration in Beetal kids because castration at early age adversely affected the growth of kids in this study.
**Key words:** Beetal kids, castration, growth, carcass, sensory evaluation and blood metabolites.

### 6.2 Introduction

Improvement of the meat quality and quantity cannot be overemphasized to meet the international nutritional standards for the people in Pakistan who are deficient in animal protein by consuming 18 gm/capita/year (Ali and Khan, 2013). The meat from goat has better demand and price in the local market because of more preference by majority of people (Arain *et al.*, 2010). The Beetal is one of the most popular breed of goat in the local soois due to its beauty, better growth rate and meat demand especially at eve of Eid-ul-Adha (Khan *et al.*, 2005).

Traditionally, the small ruminants are raised on the low input feeding system, which results in lower growth of the animals (Sarwar *et al.*, 2010). In some recent studies, high input-feeding system has been found to be more efficient in enhancing the growth performance of Beetal by improving the nutrient availability (Nisa *et al.*, 2013; Sarwar *et al.*, 2012 and Mukhtar *et al.*, 2010). Many studies showed that the carcass quality are imperative to figure out growth performance in goats (Oramari, *et al.*, 2014; Najafi *et al.*, 2012; Limea *et al.*, 2009 and Titi *et al.*, 2008). The scanty information is available about the carcass characteristics of Beetal goat. The current study is a step forward to explore the effectiveness of high input feeding system while considering about the growth and carcass quality analysis simultaneously.

The meats available in the markets are from the various classes i.e. castrated male, entire or non-castrated male and female animals. There are fair amount of studies which depicts about the consideration of various factors like sex, castration, age of castration, type and breed while studying the growth, carcass traits and attributes of meat (Alkass *et al.*, 2014; Ozcan *et al.*, 2014; Mudalal *et al.*, 2014; Poore *et al.*, 2013; Ekiz *et al.*, 2009 and Lambe *et al.*, 2009). The information on aforementioned factors is flimsy regarding Beetal breed especially while raising them under high input feeding system. The aim of the study was validating the high input feeding system aforementioned variables and also to compare the carcass attributes of various meat grade classes of Beetal kids.
6.3 Materials and Methods
The details of the tests used have been discussed in Chapter 3. The brief methodology of the study is given below.

6.3.1 Selection of Animals
The study was conducted at Livestock Experiment Station (LES), Allahdad, Tehsil Jahanian, District Khanewal. Total of 16 Beetal kids (12 ♂ + 4 ♀) were selected. The age of all the animals was 120 (±10) days while the weight of the animals was 16 (±2) kg for males and 14(±2) kg for females group. All animals were grouped into four animal class types designated as S1 (4 male entire), S2 (4 male castrated at 4 mo), S3 (4 male castrated at six mo) and S4 (4 female).

6.3.2 Pre-fattening Management
The S2 group was castrated at 120 days of age while S3 group was castrated at 180 days of age. All the animals were grown on Maize fodder (Zea mays) for two months (60 days) and managed on same conditions before fattening.

6.3.3 Fattening
After completion of growing period at 180 days of age, all the experimental units were fattened on the pelleted feed under high input feeding systems (Table 6.1). Animals were offered ad libitum feeding and watering for 24 hrs in individual pens. The duration of this phase was 60 days including 7 days adjustment period at start of fattening.

6.3.4 Statistical Design
The animals were exposed to treatment under completely randomized design. The model equation is given below.

\[ Y_{i,j} = \mu + \text{(Class of Animal)}_i + \epsilon_{i,j} \]

6.3.5 Data Collection and Chemical Analyses
The data were collected on body weight, fattening ration intake, blood metabolites, slaughter and carcass traits. Body weight was measured weekly. Daily orts were collected to measure feed intake during fattening period. Average daily gain (following Kadim et al., 2003), feed conversion ratio (following Sen et al., 2004) and Kleiber ratio (following Mohammadi et al., 2010) were calculated at the end of the trial. Blood
samples were collected at day one and at the end of the fattening period for determining serum glucose, serum creatinine, blood urea nitrogen (BUN) and cholesterol to know the physiological response in treatment groups (Nudda et al., 2013).

The fattening ration and minced meat samples were analyzed by proximate analyses procedures detailed out by AOAC (2003) for determining the detail chemical composition at Institute of Animal Nutrition and Feed Technology (IAN&FT), UAF. Twelve animals (3 from each group) selected randomly for slaughtering at the end of the experiment, were transported to the University of Agriculture, Faisalabad, through vehicle. The duration of journey was 6 hours. The animals were given rest, water and feed after 3 hours. Final weights of all animals were recorded after 12 hr fasting and then after 24 hr fasting prior to slaughter. Hot carcass weight was recorded after excluding the weight of testes, kidney, pelvic fat and tail and used to calculate the dressing percentage (Bonvillani et al., 2010). The carcasses were chilled for 24 hr at 4°C and weight was recorded. The carcass measurements like carcass length, leg length, buttock perimeter, buttock width were recorded while leg compactness and carcass compactness was calculated using these measurements (Bonvillani et al., 2010). The carcasses were split into two symmetrical parts with the aid of meat saw. Then left side carcasses were divided into five anatomical cuts and these were weighed then converted it into proportions of HCW (Colomer-Rocher et al., 1987) frozen at -20°C (aged for 30 day). The rib eye muscle from aged carcasses were used for further meat tests and sensory evaluation at National Institute of Food Science and Technology (NIFSAT), UAF, except meat color index which was performed at Ayub Agri Research Institute, Faisalabad. The eye muscle or ribeye area was determined between 12-13th rib by Grid-EMA while following Plant and Maden (1996). The meat was thawed, minced and used for determination of pH by slurry method using Hanna Instruments (HI 98107 pHep pH Tester, +/-0.1 Accuracy). The pH of meat was evaluated by taking 10 gm of the minced meat samples and homogenized in 100 ml of distilled water for about 30 seconds at high speed. Homogenized samples were transferred into a beaker and pH was noted by placing the pH electrode into the samples (Arain et al., 2010).
Tenderness (using TA.XT.PLUS Texture Analyzer) were measured while following the protocols as described by Cavitt *et al.* (2005) with some modifications. Meat piece from the loin part (*longissimus dorsi*) was used to determine the force (in kg/cm²) with needle puncture shear force Texture Analyzer having a 5-kg load cell using a needle puncture probe with a height of 25 mm and a diameter of 2 mm set to a penetration depth of 20 mm. Crosshead speed was set at 80 mm/min and the test was triggered by a 10-g contact force.

Water Holding Capacity (WHC) was determined according to the procedure described by Wardlaw *et al.* (1973) with some modifications. The frozen right fillets were thawed at 4°C for 8 hrs in a refrigerator. The loin area meat were cut and ground for 1 min in a food processor to achieve the desired particle size of approximately 3 mm of diameter. Five gram portions of the ground meat were weighted and placed in 35 ml assay tubes containing 80 ml of 0.6 M NaCl. The solution was mixed for 30 sec, incubated for 30 min at 4°C and centrifuged at 5000 RPM for 15 min. After centrifugation, the volume of the supernatant was measured using a 10 ml volumetric cylinder.

Cooking loss (%) was measured following Kondaiah *et al.* (1985) by placing meat sample (20 gm) was placed in polyethylene bag and heated in a water bath at internal temperature of 72°C. Cook-out was drained and the cooked mass was cooled and weighed to determine the weight loss.

Drip loss (%) was determined according to the procedure described by Earl *et al.* (1996) with some modifications. Three pieces of Whatman 14 # 3 paper (5.5 cm) and one piece of Whatman # 50 filter paper (7.0 cm) were formed into a thimble by shaping the filter papers around the outer round bottom of an inverted 16×150 mm test tube with the # 50 filter paper as the internal surface of the thimble. The filter paper thimble was weighed and approximately 5 gm of ground meat wrapped and folded in a 15 cm² piece of 0.1 mm mesh white tulle netting was placed inside the thimble and then stored at 4°C for 24 hrs. The filter paper with moisture was weighed and expressible moisture was reported as the percentage weight lost from the original samples.
The Color index \((L, a^*, b^*\) values) of meat samples were measured after blooming the meat samples using Minolta Chroma Meter CR-200 (Accuracy Microsensors, Inc., USA). These color index values were used to calculate the chromaticity and hue angle (Caneque \textit{et al.}, 2004). The meat samples were analyzed for chemical composition by proximate analysis procedures (AOAC, 2003). The sensory evaluation of the cooked meat samples (by boiling while following Eneji \textit{et al.}, 2012) was carried out by eight trained panelists (within the age range of 25-40 years) for different attributes like appearance, flavor, juiciness, chewiness and overall acceptability by using nine point hedonic scales following the method described by Meilgaard \textit{et al.} (2007).

6.3.6 \textbf{Statistical Analysis}

The data were analysed using linear model procedures run in R-software (3.0.3 version). The means were compared by Tukey’s HSD test during post-hoc analyses (R Core Team, 2014). The ANOVA tables for this experiment are given in Annexure 9.

6.4 \textbf{Results and Discussion}

The statistical analysis of data (Table 6.2) showed that the ADG of Beetal kids were significantly \((P<0.001)\) affected by the class of the animals. The detail post hoc analysis showed that overall males showed better ADG than female group (Figure 6.1). Within the males, S3 (93.75 gm/d) showed highest ADG followed by S1 (85.42 gm/d) and S2 (33.75 gm/d). However, Tukey’s HSD test revealed that S3 had non-significant \((P>0.05)\) difference with S1. Similarly, the Klieber ratio calculations also validated that the S3 group had shown better performance \((P<0.05)\) than other classes (Figure 6.3). Average daily feed intake (ADFI) was significantly \((P<0.05)\) affected by the treatment groups (6.2). S2 group had showed lowest average feed intake (307.50 gm/d) than rest of the groups. Feed conversion (FCR) was affected by treatments \((P=0.005)\). The lowest FCR was noticed in S3 (8.74) followed by S2 (9.24), S1 (9.00) and S4 (11.6).

The age of castration affected significantly the ADG and ADFI. The animals castrated at 4 month of age (S2) showed less ADG and ADFI as compare to animals castrated at 6 month of age (S3). The reason could be the more average daily feed intake which resulted in more nutrient available for growth. The early age castration might have affected the intake and overall lower the metabolism which resulted in the lower ADG in S2.
(Schanbacher et al., 1980). The Kleiber ratio followed the same trend as of ADG with higher the ratio shows better feed conversion (Talebi, 2012). FCR is affected by sex and male kids are efficient converter of feed. Castrate animal shows poor FCR than entire but better than female. The female animals are poor converter of feed (Louca et al., 1977).

The slaughter traits also showed the effect of the treatments significantly varied among the groups. Class of animals significantly (P<0.001) affected the dressing percentage. S3 and S4 had shown better dressing percentage 51.51 % and 58.38% respectively followed by S1 (48.96 %) and S2 (39.89 %).The hot carcass showed significant effect of the treatments. It was least in S2 (7 kg) and highest in S3 (12.61 kg) also obvious by Figure 6.4.

The age of castration and sex significantly affected the dressing percentage and hot carcass weight. Females showed better dressing percentage than males. Overall the dressing percentage and carcass length was not affected by the castration rather age of castration was responsible for lower dressing percentage in S2 while S2 and S1 were same when Tukey’s HSD was used to compare the means. It was because of depressed growth performance of the S2 group due to early age castration (Zamiri et al., 2012). This early age castration could result in decrease IGF-1 as there has been strong relation between the testosterone and IGF-1 reported by Bani Ismail et al. (2009). The weight of none-carcass parts were also significantly affected by the class of the animals (Figure 6.5 to Figure 6.8). The S2 group showed higher proportional weights of head (8.66%), skin (8.98%) and limbs (4.57%) to HCW. These afore said responses are least in females showed that the sex also affected the responses. The carcass length was also higher (P<0.05) in S3 (71.00 cm) followed by 67.67 cm in S1 and 65.15 cm in S4 group and 57 cm in S2. The leg length, buttock perimeter and leg compactness were not significantly affected by the class of animals (Figure 6.9 to Figure 6.14). Carcass compactness is directly affected by the carcass length therefore; the S1 showed higher carcass compactness because of higher carcass length. These findings are in line with the Shelton et al., (1991) and Toplu et al., (2013) while contradicted to the findings of Kaic et al., (2012) and Bonvillani et al., (2010). These parameters showed that non-carcass parts are responsible for lower dressing percentage moreover they don’t more economic importance (Assan, 2015).
It is clear that the weight of parts were higher in S3 (6 month castration) except neck weight which higher in females as given in Figure 6.15 to Figure 6.19. The drip loss was highest (P<0.05) in S2 (2.32%) and lowest in S1 and S4 groups (Figure 6.24). However, the detailed carcass analyses showed that except the hot carcass weight, cold carcass weight, hue angle and drip loss all other parameters were not significantly different (P>0.05) among treatment groups (Figures 6.21 to 6.28). It was also proved by the outcomes during meat composition and sensory evaluation by the expert panel where carcasses were found not different while fattened using iso-caloric and iso-nitrogenous fattening ration.

Hot and cold carcass weights were more in S3 groups mainly due to better ADG performance (Gokdal, 2013). However, hue angle was less in S2 as compared to other classes which showed statistically same hue angle values when the means were compared by Tukey’s HSD test. The castration at 4 mo age resulted in lower glycogen content which may be responsible for lower hue angle value (Ripoll et al., 2008). Higher value of drip loss in S2 group was due to lower water holding capacity of meat as water holding capacity was decreased because of lower growth performance of the S2 (Hwangbo et al., 2009).

Other carcass attributes showed the non-significant effect of the class of animals because the sex and castration did not result in fat deposition at this age of animals and could be due to fattening period was less than 5 months (Zamiri et al., 2012). Similarly, the sensory evaluation score by the expert panels also showed the non-significant effect of the class of the animals on the meat color, chewability, tenderness, flavor and over all acceptability could be due to aforementioned reasons.

The class of Beetal kids affected (P<0.05) the serum glucose levels. Within the male the serum glucose was non-significantly different while female group (S4) had least serum glucose (38.25 mg/dl). Blood urea nitrogen (BUN) was not affected (P>0.05) by the class of animals. The serum creatinine and cholesterol were significantly affected by the treatments. The S3 group showed higher serum cholesterol (90.50 mg/dl) followed by S1 (71 mg/dl), S2 (64 mg/dl) and S4 (55.50 mg/dl). Serum creatinine was least in S2 group.
(0.174 mg/dl) while S2 showed highest level of serum creatinine (0.278 mg/dl) during current studies.

Serum glucose was lower in female animals as compared to male which showed that the more nutrient intake for male as evident in ADFI (Turner et al., 2005). While BUN was not significantly different among the treatment groups because of iso-nitrogenous fattening ration (Kadzere and Charama, 1992; Karnezos et al., 1994). The serum cholesterol was highest in S1 and S4 mainly due to better growth performance as better ADG performance of these groups might be responsible for higher levels of the cholesterol in serum (Tripathi et al., 2012). High creatinine shows high muscle mass metabolism and this is obvious as S3 group has better ADG and ADFI (Sun and Zhou, 2010; Wellington et al., 2003).

6.5 Conclusions
From this current study it can be extracted that growth performance was affected by the class of kids while the carcass evaluation, chemical composition and sensory evaluation showed non-significant effect of the class of Beetal kids. Therefore, all the classes of Beetal kids are suitable for rearing under high input feeding system below 8 month age. The effect of classes after 8 month age on carcass traits are future exploitable research area. Castration at 4 month age resulted in lower growth as well as lower quality meat. Therefore, early castration i.e., below 6 months may be avoided.

6.6 Acknowledgements
We acknowledge Pakistan Science Foundation (PSF) and Higher Education Commission (HEC), Islamabad, Pakistan for financial support and also thank the Directorate of Small Ruminant Production, Multan for helping us to conduct the studies.

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R Core Team. 2014. R: A Language and Environment for Statistical Computing. Vienna, Austria.


Table 6.1: Ingredient and chemical composition of ration

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**Chemical composition (%)**

*Proximate composition*

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*Note: Derived from NRC (2007)*
Table 6.2: Growth performance and carcass characteristics of various classes of Beetal kids under high input feeding system

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<th>Classes of Beetal Kids (Treatment)</th>
<th>Classes of Beetal Kids (Treatment)</th>
<th>P – Value</th>
<th>SEM</th>
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<td>S1*</td>
<td>S2**</td>
<td>S3***</td>
<td>S4****</td>
<td></td>
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<td>Growth Performance</td>
<td>Av. daily gain (gm/d)</td>
<td>85.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33.75&lt;sup&gt;b&lt;/sup&gt;</td>
<td>93.75&lt;sup&gt;a&lt;/sup&gt;</td>
<td>63.89&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>Klieber ratio</td>
<td>8.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.87&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.56&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>P&lt;0.002</td>
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<td></td>
<td>Av. daily feed intake (gm/d)</td>
<td>743.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>307.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>878&lt;sup&gt;a&lt;/sup&gt;</td>
<td>739&lt;sup&gt;a&lt;/sup&gt;</td>
<td>P&lt;0.01</td>
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<tr>
<td></td>
<td>FCR</td>
<td>9.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.24&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.74&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.6&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Slaughter Traits</td>
<td>Hot carcass wt. (kg)</td>
<td>9.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.25&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>P&lt;0.05</td>
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<td>Dressing (%)</td>
<td>48.96&lt;sup&gt;b&lt;/sup&gt;</td>
<td>39.89&lt;sup&gt;c&lt;/sup&gt;</td>
<td>51.51&lt;sup&gt;b&lt;/sup&gt;</td>
<td>58.38&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Proportion Head wt. to HCW</td>
<td>8.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.39&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.66&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.05&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Proportion Skin wt. to HCW</td>
<td>8.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.64&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Proportion limbs wt. to HCW</td>
<td>4.57&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>4.27&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.09&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Proportion pluck wt. to HCW</td>
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<td>4.81&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NS</td>
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<tr>
<td>Carcass Traits</td>
<td>Cold carcass wt.(kg)</td>
<td>67.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>57.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>71.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>65.15&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>Leg length (cm)</td>
<td>41.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>46.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.34&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NS</td>
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<tr>
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<td>Buttock width (cm)</td>
<td>17.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>19.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.27&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Buttock Perimeter (cm)</td>
<td>46.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>42.43&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Thoracic width (cm)</td>
<td>17.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>17.82&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Carcass compactness</td>
<td>0.133&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.123&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.176&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Leg compactness</td>
<td>0.421&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.382&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.426&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.409&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.752&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Cold carcass wt.(kg)</td>
<td>8.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>P&lt;0.001</td>
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<td>Right side weight (kg)</td>
<td>4.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.98&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Left side weight (kg)</td>
<td>4.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.61&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Neck weight (kg)</td>
<td>0.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.37&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.25&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>Leg weight (kg)</td>
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<td>1.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.94&lt;sup&gt;b&lt;/sup&gt;</td>
<td>P&lt;0.001</td>
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<td>Loin + Rib weight (kg)</td>
<td>1.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.75&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.89&lt;sup&gt;b&lt;/sup&gt;</td>
<td>P&lt;0.001</td>
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<td></td>
<td>Shoulder weight (kg)</td>
<td>0.96&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.23&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.89&lt;sup&gt;b&lt;/sup&gt;</td>
<td>P=0.002</td>
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<tr>
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<td>Breast weight (kg)</td>
<td>0.56&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.94&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.78&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>Eye area (sq. In)</td>
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<td>1.20</td>
<td>2.20</td>
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<td></td>
<td>pH of meat</td>
<td>5.63</td>
<td>5.60</td>
<td>5.47</td>
<td>5.50</td>
<td>NS</td>
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Table 6.2 Contd
Table 6.2 Contd

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<td>S1*</td>
<td>S2**</td>
<td>S3***</td>
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<td>Tenderness/Needle Puncture (kg/cm)</td>
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<td>0.73</td>
<td>0.38</td>
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<td>Water holding capacity</td>
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<td>Cooking loss (%)</td>
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<td>33.60</td>
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<td>Drip loss (%)</td>
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<td>2.15&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Hue angle</td>
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<td>19.09&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>44.18</td>
<td>44.03</td>
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<td>Chromaticity</td>
<td></td>
<td>29.41</td>
<td>28.40</td>
<td>32</td>
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</table>

Meat Composition (% of Fresh meat)

|                 | Moisture (%) | 72.61 | 76.32 | 75.68 | 74.50 | NS | 3.190 |
|                 | Fat by Ether extract method (%) | 5.67 | 5.33 | 5.83 | 5.67 | NS | 0.499 |
| CP (%) | | 17.94 | 18.32 | 18.20 | 18.00 | NS | 0.165 |
| Ash (%) | | 1.70 | 1.50 | 1.50 | 1.33 | NS | 0.996 |

Sensory Evaluation (Average Panel Score)

|                 | Color | 7.04 | 6.75 | 7.08 | 7.17 | NS | 0.254 |
|                 | Texture | 6.92 | 7.00 | 6.92 | 5.83 | NS | 0.556 |
|                 | Flavor | 6.75 | 6.79 | 6.46 | 6.50 | NS | 0.661 |
|                 | Juiciness | 6.54 | 6.88 | 6.96 | 6.58 | NS | 0.406 |
|                 | Chewability | 6.83 | 7.04 | 7.17 | 7.17 | NS | 0.312 |
|                 | Overall acceptability | 6.76 | 6.94 | 6.97 | 6.30 | NS | 0.273 |

Blood Metabolites

|                 | Serum glucose (mg/dl) | 42.50<sup>ab</sup> | 52.25<sup>ab</sup> | 59.25<sup>a</sup> | 38.25<sup>b</sup> | P<0.05 | 5.885 |
|                 | Blood urea nitrogen (mg/dl) | 7.68 | 9.75 | 10.05 | 8.84 | NS | 1.121 |
|                 | Serum cholesterol (mg/dl) | 71.00<sup>ab</sup> | 64<sup>b</sup> | 90.50<sup>a</sup> | 55.50<sup>b</sup> | P<0.01 | 7.530 |
|                 | Serum creatinine (mg/dl) | 0.235<sup>b</sup> | 0.174<sup>c</sup> | 0.279<sup>a</sup> | 0.238<sup>ab</sup> | P<0.001 | 0.014 |

Note: Superscript of means (a, b, c) shows the means comparison by Tukey’s HSD test. Where same alphabet means no difference.

*Entire male, **Castrated at 4 month age, ***Castrated at 6 month age, ****Female.
Figure 6.1: Avg. daily gain of various Beetal classes

Figure 6.2: Avg. daily feed intake of various Beetel classes

Figure 6.3: Klieber ratio under various Beetal classes

Figure 6.4: Hot carcass wt. under Beetal classes
Figure 6.5: Dressing (%) under various classes

Figure 6.6: Skin proportion under Beetal classes

Figure 6.7: Limbs proportion of various Beetal classes

Figure 6.8: Pluck proportion of various Beetal classes
Figure 6.9: Carcass length under various Beetal class

Figure 6.10: Leg length of various classes of Beetal

Figure 6.11: Buttock width of various classes of Beetal

Figure 6.12: Buttock perimeter of various classes of Beetal
Figure 6.13: Thoracic width under various classes of Beetal

Figure 6.14: Carcass compactness under various classes of Beetal

Figure 6.15: Neck wt. under various classes of Beetal

Figure 6.16: Foreleg wt. under various classes of Beetal
Figure 6.17: Breast wt. under various classes of Beetal

Figure 6.18: Loin wt. under various classes of Beetal

Figure 6.19: Leg wt. under various classes of Beetal

Figure 6.20: Right side wt. under various classes of Beetal
Figure 6.21: Tenderness under various classes of Beetal

Figure 6.22: Eye muscle area of meat and Beetal classes

Figure 6.23: Cooking loss of meat from various Beetal type

Figure 6.24: Drip loss of meat from various Beetal type
Figure 6.25: Chromaticity of Meat from Beetal classes

Figure 6.26: Lightness of Meat from Beetal classes

Figure 6.27: Hue angle of Meat from Beetal classes

Figure 6.28: Moisture in mince of Beetal classes
Figure 6.29: Cooked meat Overall acceptability in Beetal classes

Figure 6.30: Cooked meat Juiciness in Beetal classes

Figure 6.31: Cooked meat chewiness in Beetal classes

Figure 6.32: Cooked meat color in Beetal classes
Figure 6.33: Serum creatinine in various class of Beetal

Figure 6.34: Serum cholesterol in various class of Beetal

Figure 6.35: Serum glucose in various classes of Beetal

Figure 6.36: BUN under various classes of Beetal
CONCLUSIONS

Experiment 1

- The outcomes of the first experiment showed that the animals could be shifted as early as 2 month of age with no detrimental effect on the growth performance.

- If animals are weaned after 4 month of age, then the starter total mix feed with 16% CP was found best for performance when fed pelleted ration. However, the animals performed better with increased CP (20%) at weaning age of 2 month and 1 month. Weaning at 1 month resulted in lower ADG than the weaning at 2 month age. The post weaning stress was also more prominent while weaning at one month age.

Experiment 2

- The outcomes of the second experiments proved that the animals had resulted better performance with the pellets form of diet.

- The pellet form feed resulted in better ADG and lower FCR. There was positive interaction in the physical form of feed and addition of live yeast culture in the ration. The pellet form of ration resulted better in ADG, better ADFI and may improve digestibility of ration due to addition of live yeast (Saccharomyces cerevisiae) while the mash form feed performed better without the addition of yeast culture.

- The carcass measurement and weights were affected by the physical form of feed and addition of the live yeast. However, the carcass traits, meat characteristics and sensory evaluation confirmed no effect of the physical form of feed and lives yeast addition. So, we can safely conclude that the use of pellet form of feed with
addition of live yeast may be helpful improving the gain and ultimately the economics of the venture without any effect on the carcass and meat quality.

**Experiment 3**

- The results of the third experiment showed the quality of meat is not affected by sex and castration.
- The growth performance, carcass measurement and wholesale cuts affected by the sex and castration. The male produced better aforesaid attributes than the female. Within the male, castrated at 6 of month age and entire have produced better results than the castration at 4 month of age.
- The sensory evaluation score revealed that the carcasses from two sexes and castration have no different in this stage of fattening. It may be concluded the animals did not differ regarding the carcass quality attributes and sensory evaluation upto 6 month age. We recommend some more research for the development of industrial goat farming concept including the best age and duration of fattening, using the fodders or total mixed feed from weaning till fattening, etc., etc. for this breed.
- The urea addition masked the dietary protein levels in first experiment so this factor requires future investigation to find out whether the performance was affected by the dietary protein levels or urea addition.
- The age of fattening in the Beetal require future investigation. As there was not much effect of treatments on the carcass traits that may be due to lower age of animals. Therefore the age of fattening in Beetal requires further study.
- The animals were fed in the individual pens. The performance evaluation under high put feeding using different feeding techniques also requires investigation
ANNEXURES
Annexure 1

Kits used for the Blood Analyses

a) Glucose PAP (Phenol Animoantipyrine)

**Principle:**
Determination of glucose after enzymatic oxidation by glucose oxidase. The colorimeter indicator is quinoneimine, which is generated from 4-aminoantipyrine and phenol by hydrogen peroxide under the catalytic action of peroxidase.

\[
\text{Glucose} + O_2 \rightarrow \text{Gluconic Acid} + H_2O_2
\]

\[
2H_2O_2 + \text{Aminoantipyrine} + \text{Phenol} \rightarrow \text{Quinoneimine} + 4H_2O
\]

**Sample Material:**
Serum, heparanized or EDTA plasma. Avoid hemolysis, separate latest 1hr after blood collection from cellular contents, stability after addition of a glycolytic inhibitor (NaF, KF) and store at:

- 24 hrs AT 15-25°C
- 7 Days AT 4-8°C

**Reagent:**
Reagent standard 2.5 ml

**Preparation:**
The reagent is ready to use and stable until expiry date if stored at +2 to +8°C and contamination is avoided.

**Test Concentrations:**
- Phosphate buffer (pH 7.5) 13.8 mmol/L
- Phenol 10 mmol/L
- 4-Aminoantipyrine 0.3 mmol/L
- Glucose Oxidase (GOD) 10000 U/L
- Peroxidase (POD) ≥ 700 U/L
- Standard: 100 mg/dl
  5.55 mmol/l
  1 gm/L

**Procedure:**
- Reagent temperature: +25 + 30 or + 37°C
- Wavelength: 500 nm, Hg 546nm
- Light path: 1 cm
- Measuring temperature: +25, + 30 or + 37°C
Measurement Against reagent blank

**Sample Start:**

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<tr>
<th>Sample/standard</th>
<th>Blank</th>
<th>Sample/Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagent Solution</td>
<td>1000µl</td>
<td>1000µl</td>
</tr>
</tbody>
</table>

Mix. Incubate 10 min, at 20-25°C or 5 min at 37°C. Read absorbance against the blank within 60 mins.

**Calculation:**

\[
\text{Glucose concentration} = \frac{\text{Standard concentration}}{\Delta F_{st}} \times \Delta F_{sa} \text{(mg/dl)}
\]

**Dilution limit:**

If concentration exceed 400 mg/dl (22.2 mmol/l). Dilute 1 part of sample with 4 parts of 0.9% NaCl solution. Multiply the result by 5.

**Normal range fasting:**

55-115 mg/dl
b) Urea UV (UV test, GLDH method)

**Principle:**
Urea reacted enzymatically according to following equations:

\[ \text{UREA} + 2\text{H}_2\text{O} \rightarrow \text{NH}_4^+ + 2\text{HCO}_3^- \]

\[ 2 - \text{OXOGLUCORATE} + \text{NH}_4^+ + \text{NADH} \rightarrow \text{L-Glutamate} + \text{NAD}^+ + \text{H}_2\text{O} \]

The decrease in NADH absorbance per unit time is proportional to the Urea concentration.

**Specimen:**
Serum, Plasma

Don’t use any lipemic, icteric or hemolytic serum or plasma.

**Stability in Plasma or serum:**
7 days at +4°C, 2 days at +20 to +25°C

**Preparation:**

*Substrate start*

The reagent are ready to use and stable up to the end of the indicated month of expiry, if contamination is avoided.

*Sample Start*

Mix 4 parts of R₁ with 1 part of R₂ = monoreagent leave the monoreagent for at least 15 min at 15-25°C before use.

**Stability after mixing:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature</th>
</tr>
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<tbody>
<tr>
<td>4 weeks</td>
<td>2-8°C</td>
</tr>
<tr>
<td>5 days</td>
<td>15-25°C</td>
</tr>
</tbody>
</table>

Protect the mono-reagent from direct light

**Test concentrations:**

*R₁:*

- 2-Oxaloglutarate: 9 mmol/L
- ADP: 0.7 mmol/L
- Urease: \( \geq \) 30 KU/L
- GLDH: \( \geq \) 1 KU/L
- NADH: 0.3 mmol/L

*R₂:*

- Tris (pH 7.7): 100 mmol/L

**Standard:**

50 mg/dl
Notes:

For BUN, multiply Urea UV with the 0.47

Procedure:

Wavelength: 340 nm, Hg 334 nm, Hg 365 nm
Optical path: 1 cm
Temperature: 25°C/30°C/37°C
Measurement: Against reagent blank, 2-point kinetic

Substrate Start:

<table>
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<tr>
<th>Sample/standard</th>
<th>Blank</th>
<th>Sample/standard</th>
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<tbody>
<tr>
<td>Reagent 1</td>
<td>1000µl</td>
<td>1000µl</td>
</tr>
<tr>
<td>Mix. Inoculate 0-5 Min</td>
<td></td>
<td>Then add.</td>
</tr>
<tr>
<td>Reagent 2</td>
<td>250µl</td>
<td>250µl</td>
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Sample Start:

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<tbody>
<tr>
<td>Mono reagent</td>
<td>1000µl</td>
<td>1000µl</td>
</tr>
</tbody>
</table>

Reading for both procedures:
Mix. Include for approx. 60 sec at 25°C / 30°C or approx. 30-40 sec. at 37°C, then read absorbance A1.
After exactly 60 sec. read absorbance A2
\[\Delta A = [(A1 - A2) \text{ Sample or Standard}] / [(A1 - A2) \text{ Blank}]\]

Calculations:

With standard or calibrator

\[\text{Urea (mg/dl)} = \frac{-\Delta A \text{ sample}}{\Delta A \text{ Standard}} \times \text{Conc. of Standard (mg/dl)}\]

Dilution limit:
If concentration exceed 300 mg/dl (50 mmol/L) Urea in serum/plasma or 30 gm/dl (5 mmol/L), dilute 1 part of sample with 2 parts of 0.9% NaCl solution.
Multiply the result by 3

Normal range:
Serum/Plasma: 10-50 mg/dl
Urine: 20-35 gm/24 hr (333-583 mmol/L 24 hr)
c) **Cholesterol**

**Principle:**
The cholesterol is determined after enzymatic hydrolysis and oxidation. The indicator quinoneimine is formed from hydrogen peroxide and 4-aminophenazone in the presence of phenol and peroxidase.

\[
\text{Cholesterol ester} + H_2O \rightarrow \text{Cholesterol} + \text{Fatty acid}
\]

\[
\text{Cholesterol} + O_2 \rightarrow \text{Cholest-4-en-3-one} + H_2O_2
\]

\[
H_2O_2 + 4 \text{ Aminoantipyrine} + \text{Phenol} \rightarrow \text{Quinoneimine} + 4 H_2O
\]

**Reagents composition:**

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes buffer</td>
<td>50 mmol/L</td>
</tr>
<tr>
<td>Phenol</td>
<td>24 mmol/L</td>
</tr>
<tr>
<td>Sodium cholate</td>
<td>5 mmol/L</td>
</tr>
<tr>
<td>4- Aminoantipyrine</td>
<td>0.5 mmol/L</td>
</tr>
<tr>
<td>Cholesterol esterase</td>
<td>≥ 180 U/L</td>
</tr>
<tr>
<td>Cholesterol oxidase</td>
<td>≥ 200 U/L</td>
</tr>
<tr>
<td>Peroxidase</td>
<td>≥ 1000 U/L</td>
</tr>
</tbody>
</table>

**Standard:**

<table>
<thead>
<tr>
<th>Cholesterol</th>
<th>200 mg/dl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 gm/L</td>
</tr>
<tr>
<td></td>
<td>5.17 mmol/L</td>
</tr>
</tbody>
</table>

**Sample Material:**

Serum or heparinised plasma or EDTA plasma.

The total cholesterol in the sample is stable for about 7 days at +2 to +8°C

**Normal range:**

<table>
<thead>
<tr>
<th>mg/dl</th>
<th>mmol/dl</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 200</td>
<td>&lt; 5.17</td>
</tr>
</tbody>
</table>

**Procedure:**

Wave length: 500 nm, 546 nm

Light path: 1 cm

Measuring temperature: +25, +30 or +32°C

**Sample Start:**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 μl</td>
</tr>
</tbody>
</table>

176
Serum or plasma 10 µl
Reaction Solution 1000µl 1000µl

Mix well and incubate for 10 min at +20 to 25 °C for 5 min at +37°C, Then measure the absorbance of sample (As) and the standard (Ast) against the reagent blank value. The absorbance remain stable for 45 min.

**Calculations:**
Calculation with standards

\[
\text{Concentration of cholesterol} = \frac{\Delta A \text{ sample}}{\Delta A \text{ Standard}} \times \text{Conc. of Standard (mg/dl)}
\]

**Dilution limit:**

600 mg/dl or 15: 5 mmol/L
d) Creatinine Jaffé

**Principle:**
Creatinine forms a yellow-orange compound in alkaline solution with Picric acid. At the low picric acid concentration used in this method a prescription of protein does not take place. The concentration of the dyestuff formed over a certain reaction times is a measure of the creatinine concentration.

As a result of the rapid reaction between creatinine and picric acid, later secondary reactions do not cause an interference.

**Sample Material:**
Serum, heparin plasma, urine

Stable for 24 hrs at +2 to +8°C or several months at -18 to -20°C

**Reagents**
Reagent 1: R1
- Picric acid 8.73 mmol/L

Reagent 2: R2
- Sodium hydroxide 312.5 mmol/L
- Disodium phosphate 12.5 mmol/L

Standard: Std
- Creatinine 2.0 mg/dl
  - 20 mg/L

**Procedure:**
Since the reaction is highly temperature sensitive, care must be taken to ensure that the solution are preheated to an exact temperature and the reaction must be taken to ensure that the solution are preheated to an exact temperature and the reaction must proceed at constant temperature. The reaction temperature of the standard and that of the sample must be identical. Provided these conditions are fulfilled, the determination can be performed at any chosen temperature between +20 and 37°C.

Wavelength: 492, 509
Light Path: 1 cm
Temperature: 37°C
Prepare one or two standards for each test series.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reagent 1</td>
<td>500 µl</td>
</tr>
<tr>
<td>Reagent 2</td>
<td>500 µl</td>
</tr>
<tr>
<td>Serum or 1:99 diluted urine</td>
<td>100 µl</td>
</tr>
<tr>
<td>Standard</td>
<td>--------</td>
</tr>
</tbody>
</table>

Calculations:

\[
\text{Serum creatinine (mg/dl)} = \frac{A_{s2} - A_{s1}}{A_{st2} - A_{st1}} \times 2.00
\]

Dilution limit:
If the creatinine is higher than 15 mg/dl in serum repeat the determination with sample diluted 1:5 with isotonic saline (9 gm/l NaCl) and multiply result by 6.
Annexure 2

Detailed Procedures of the Proximate Analysis

a) Determination of moisture/dry matter (DM) in a feed samples

Apparatus: Electric weighing balance, desiccator, electric oven, petri-dish, electric grinder, forceps/tong

Procedure:

1. Take a petri dish, already washed and dried in an electric oven for two hours at 100°C and record the weight of petri dish after cooling in a desiccator.
2. Put the feed sample in the already weighed Petri dish and record the weight of feed samples.
3. Then place the Petri-dish along with sample in an electric oven (100-105°C) for 24 hours.
4. Take out Petri-dish containing sample and place in a desiccator for 3-5 minutes and record the weight. Again put the Petri-dish along with sample in an electric oven for 2-4 hours. Take out the Petri-dish with sample in electric oven for 2-4 hours. Take out the Petri-dish with sample and place in the desiccator (3-5 minutes) and record the loss in weight at step 4 will give the loss in weight (moisture). Calculate the % age of moisture in the feed sample.

Precaution:

Never hold the Petri-dish at any stage with uncovered finger. Always use clean, dried paper or forceps to hold the Petri-dish.

\[
\text{Moisture} \% = \frac{\text{Loss of Wt.}}{\text{Wt. of sample}} \times 100
\]

or

\[
\text{Moisture} \% = \frac{\text{Wt. of dry matter}}{\text{Wt. of sample}} \times 100
\]
b) Determination of Crude Protein

Principle:
Conversion of nitrogenous compound of the samples into ammonium sulphate \((\text{NH}_4)_2\text{SO}_4\) by boiling with sulphuric acid \((\text{H}_2\text{SO}_4)\) and subsequent decomposition of the ammonium sulphate with fixed alkali \((40\% \text{ NaOH})\) and collection of ammonia in an acid solution is titrated against an acid of known strength and the N of the sample is computed.

Apparatus:
Kjeldahl flask 500ml/300ml, volumetric flash (250ml), micro Kjeldahal distillation apparatus, pipette 10 ml, micro burette 10 ml (auto), beakers (500ml, 100ml), digital weighing balance, glass funnel, heating arrangement, cold water circulation, measuring cylinder (100ml), etc.

Reagents:
N/10 \(\text{H}_2\text{SO}_4\), 2% boric acid, 40% sodium hydroxide, methyl red indicator, distilled water, digestion mixture \((\text{K}_2\text{SO}_4, \text{FeSO}_4, \text{CuSO}_4)\), feed sample, commercial \(\text{H}_2\text{SO}_4\) ethanol

Preparation of digestion mixture:
\[
\begin{align*}
\text{K}_2\text{SO}_4 & : 90 \text{ parts to raise the boiling point of the acid} \\
\text{FeSO}_4 & : 3 \text{ parts to check the bumping} \\
\text{CuSO}_4 & : 7 \text{ parts to act as catalyst}
\end{align*}
\]

Digestion:
Take 1 gram of the dried feed sample, add 5 gm digestion mixture in Kjeldahal digestion flask (500 ml) add 25-30 ml commercial \(\text{H}_2\text{SO}_4\) and provide heat till light green or colorless content appeared (2-3 hours).

Dilution:
Transfer the digested content in a 250ml volumetric flask and add distilled water to make 250 ml volume.

Distillation
Take 10 ml sample solution in micro Kjeldahal distillation apparatus flask and add 10 ml 40% \(\text{NaOH}\) solution, take another flask or beaker containing 10ml 4% boric acid solution, add 1 drop
of methyl red as an indicator, provide steam, ammonia gas fumes produce, ammonia gas is trapped in 4% boric acid solution. The end point will be yellow color, after this wait for 2 minute and remove the flask containing boric acid and then remove the steam unit.

**Titration:**
Titratar the boric acid solution with N/10 H<sub>2</sub>SO<sub>4</sub> till golden yellow color appear, record the volume of acid used.

**Calculation:**

\[
N\% = \frac{Volume \ of \ \frac{N}{10} \ H_2SO_4 \ used \times vol.\ of \ sample \ dilution}{Wt.\ of \ sample \times volume\ of\ sample\ solution\ used\ (10\ ml)} \times 100
\]

CP % = N% × 6.25
c) Determination of ether extract or crude fat

**Principle:**
Ether or petroleum ether or diethyl ether or any other fat solvent is volatilized and then condensed; the condensed solvent is dropped on the sample containing fat. The repeated volatilization and condensation extracts the fat from the feed samples. It is then measured by weighing the ether extract or by calculating the decrease in weight of the sample.

**Apparatus:**
Soxhlet apparatus, desiccator, hot air oven, digital weighing balance, porous thimble, heating arrangement, glass dish/china dish, cold water arrangement

**Reagent:**
Feed sample
Fat soluble solvent e.g. ether, alcohol, acetone, hexane, chloroform, carbon tetrachloride, etc.

**Procedure:**
2 gm oven dried feed sample is placed in a fat free asbestos, porous thimble (made up of cellulose) and is covered with a cotton plug (fat free) and is placed in the jacket. If thimble is not available, then feed sample may wrapped in filter paper and is placed in the soxhlet jacket which is attached with condenser having cold water circulation at the top for condensation and a receiving flask at the bottom containing fat solvent.

The flask which contains fat solvent is connected to the Soxhelt apparatus and is heated, the solvent is volatilized and the fumes go up via a tube in the upper part, where these are condensed due to cold water circulation. These condensed solvent drops are trickled down on the thimble, containing the feed sample, fat is dissolved and when a definite volume is attained, the solvent comes back (siphoned back) in the receiving flask containing the fat solvent via a siphon tube. This volatilization and condensation is repeated until the color of the fat solvent around the thimble becomes colorless. This color is always due to fat solvent around the thimble becomes colorless. The color is always due to fat soluble pigments (chlorophyll, xanthophylls and carotene, etc.).
Calculation:
The flask containing the dissolved fat is then removed and the contents are transferred in a dry clean already weighed glass dish/flask/beaker and place it in a hot air oven for 10-20 minutes for fat solvent evaporation, then the dish is taken out, place in the desiccator for 2-3 minutes and it is again weighed. Continue this procedure until constant weight is attained. The difference in weight would be residue of ether extract.

\[ \text{Ether extract} \% = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100 \]

OR

\[ \text{Ether extract} \% = \frac{\text{loss of weight of the sample}}{\text{Weight of sample}} \times 100 \]
d) **Determination of Crude Fiber**

In the feed sample, the CH$_2$O are present as crude fiber (cellulose, hemicelluloses and other complex polysaccharides) and as nitrogen free extract (NFE). After removal of moisture and fatty material from the given sample, it is boiled with weak acid and then with a weak alkali for the same time for the removal of protein, sugar and starches and then crude fiber can be determined along with some mineral material.

**Apparatus:**
Beakers, thick linen cloth for filtration, heating apparatus, crucible, weighing balance, muffle furnace, watch, electric oven, filtration flask (1 liter) and Buckner funnel

**Reagents:**
1.25% H$_2$SO$_4$ and 1.25 % NaOH

**Procedure:**
Take 2 gm of oven dried feed sample, remove the fat contents with soxhelt apparatus. Then digest the fat free sample in 1.25% H$_2$SO$_4$ solution (200 ml) at simmering temperature for 30 minutes, filter the contents through thick linen cloth and wash the residue with DW. Transfer the residue in another beaker containing 1.25 % NaOH solution (200ml) and digest the sample for 30 minutes at simmering temperature. Filter the contents and wash the residue with distilled water. Transfer residue in an already weighed crucible, dry it in a hot air oven for 24 hours at 100°C. Record the dry weight of the sample, then ignite the sample in a muffle furnace at 600°C till grey or white ash is obtained (3-4 hours) again record the weight of the ash.

**Calculation:**
\[ CF\% = \frac{Wt.\ of\ dried\ residue - Wt.\ of\ the\ ash}{Wt.\ of\ the\ sample} \times 100 \]
e) Determination of Crude Ash in the feed sample

Total Ash:
Total mineral element as a group are determined in a sample by igniting the sample and weighing the residue, which is called ash. Such determination tells noting about a specific element and the ash may include carbon from organic matter as carbonate when base forming minerals are in excess. This determination in used in the conventional feed analysis to provide a figure to arrive at the determination of nitrogen free extract (NFE) by difference. However, this ash may be used as a starting point for the determination of a specific element present in the feed sample.

Procedure:
Take 2 gm feed sample in a cleaned, dried, already weighed crucible ignite the sample in a muffle furnace at 550-650°C till white grey ash is obtained, cool the residue in a desiccator and record the weight.

Calculation:

\[
\text{Ash} \% = \frac{\text{Wt. of ash} + \text{Wt. of crucible} - \text{Wt. of empty crucible}}{\text{Weight of sample}} \times 100
\]
f) **Determination of nitrogen free extract (NFE) in a feed sample**

The NFE which comprises of sugar, starch and hemicelluloses is determined by difference. It is represented by the figure obtained, the sum is water, crude protein ether extract crude fiber and ash of feed sample is subtracted from 100. Since the figure is determined by difference therefore it includes the cumulative error of other determinations and thus is not an extract value.

*Calculations:*

\[ \text{NFE} \% = 100 - (\%\text{CP} + \%\text{EE} + \%\text{CF} + \%\text{ash}) \]
Annexure 3

Determination of Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF)

a) Determination of neutral detergent fiber (NDF) in a feed sample

**Apparatus:**
Electric weighing balance, conical flask (500 ml) with air condenser, graduated jar, heating apparatus, filtration apparatus, suction pump, crucible, gas, hot air oven, desiccator.

**Reagents:**
*Neutral detergent solution ingredients:*
- Sodium laural sulphate 30 gm
- Disodium EDTA dehydrate 18.60 gm
- Sodium tetra borate 6.80 gm
- Ethoxy ethanol 10 ml
- Disodium hydrogen phosphate 4.56 gm

Make 1 liter solution using distilled water. Adjust the pH of solution (6.90 to 7.0) with 0.1 N NaOH and H2SO4, Acetone reagent grade, sodium sulphite reagent grade

**Procedure:**
Take 1 gm of feed sample in conical flask. Weigh 0.50 gm sodium sulphite and put into the conical flask having 1gm of feed sample and add 100 ml of the NDF reagent solution, fix an air condenser cooling arrangement with it. Heat the content slowly for 60 minutes then allow it to cool and remove the condenser. Filter the contents with the help of suction pump. Wash the residue with hot distilled water (60-70°C) for 4-5 times each using 5-10 ml of warm water. Wash the residue twice with acetone using 5 ml, then allow it to stand for a few minutes to dry. Transfer the residue into a dried crucible. Then place it in the hot air oven at 105°C for 4 hour. Take it out and put in the desiccator for 5-10 minutes.

**Calculation:**

\[
NDF \% = \frac{Wt.\ of\ crucible+residue-Wt.\ of\ crucible}{Weight\ of\ sample} \times 100
\]
b) **Determination of acid detergent fiber in a feed sample**

Electric weighing balance, heating arrangement, hot air oven, graduated jar, conical flask (500 ml), filtration apparatus, crucible, air condenser, beakers, filtration flask (1 liter)

**Reagents:**

Acid detergents solution, add 20.0 gm of cetyl trim ethyl ammonium bromide (Lab grade), add 1 N H2SO4 solution (already standardized) to make volume one liter. acetone, reagent grade (lab grade)

**Procedure:**

*Take the residue of NDF and transfer it into 500 ml conical flask.*

- Add 100 ml of acid detergent solution into the above said conical flask.
- Fox the air condenser on the above said conical flask.
- Provide heat to the flask (slow heating without foams) for 60 minutes.

Note: Heat to boiling point for 2-6 minutes then reduce the temperature and allow to reflux for 60 minutes.

*Then remove the air condenser with filter the contents using suction pump.*

- Wash the residue with distilled water (60-70°C) for 3-4 times.
- Then wash twice the residue with Acetone (5-10 ml)
- Transfer the residue into dried crucible and put it in a hot air oven at 105°C for 24 hours. Take the crucible out of the oven and put in a desiccator and allow it to cool.

Record the weight of the crucible along with dried residue.

**Calculation:**

\[
ADF \% = \left(\frac{\text{Wt.of crucible+ADF residue}}{\text{Wt.of sample}} - \text{Wt.of crucible} \right) \times 100
\]
Annexure 4
Grid-EMA used for determination of Eye muscle area
Annexure 5

Sensory evaluation performa for cooked meat score
For excellence

SENSORY EVALUATION PERFORMANCE FOR COOKED MEAT SCORE
FOR EXCELLENCE

KASHIF ISHAQ
PhD Scholar, Department of Livestock Management
UNIVERSITY OF AGRICULTURE, FAISALABAD

Name of Judge: -----------------------------------------------

Age: -------------------------------------------------------------

Signature: -------------------------------------------------------------

Date: -------------------------------------------------------------

9 points hedonic scale follow for rating the sample.
5. Neither dislike nor like  6. Like slightly  7. Like moderately  8. Like very much
9. Like extremely

<table>
<thead>
<tr>
<th>S. No</th>
<th>Sample Code</th>
<th>Color</th>
<th>Texture</th>
<th>Juiciness</th>
<th>Flavor</th>
<th>Chewiness</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td></td>
</tr>
</tbody>
</table>

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Annexure 6

General SOP of sensory evaluation of food Sensory Evaluation (Laboratory at NIFSAT, UAF)

If sensory testing is considered to be ‘Fair’, it is important that conditions are carefully controlled.

1. Sipping water between each samples to remove the taste of previous food.
2. Using separate booths so that testers are not influenced by each other.
3. Labeling food with numbers or letters so that the tester does not recognize a brand name.
4. Having a well-lit room with the minimum of noise and smells.
5. Using clean cutlery and utensils for each sample.
6. Sometimes using blindfold (blind testing) so that the tester of not influenced by the appearance of the food.
7. Each sample of food being the same size.
8. Having a minimum of 6 testers.
9. Testers must not be suffering from a condition which would affect their taste (for example, smoking, a heavy cold, or taking strong medication).
10. Allergic to foods or ingredients.
11. Place the food samples randomly.
### Annexure 7

**ANOVA Tables of Paper-1**

**i. ANOVA for fixed effect variable**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSS F-value P-value</td>
<td>MSS F-value P-value</td>
<td>MSS F-value P-value</td>
<td>MSS F-value P-value</td>
<td>MSS F-value P-value</td>
</tr>
<tr>
<td>Dietary Protein levels (PL)</td>
<td>47083 55.928 &lt;0.001</td>
<td>66270 27.063 0.001</td>
<td>0.115 10.324 &lt;0.001</td>
<td>45.34 25.363 &lt;0.001</td>
<td>0.075 4.27 0.012</td>
</tr>
<tr>
<td>Age of Weaning (AG)</td>
<td>10282 12.213 &lt;0.001</td>
<td>326623 133.38 &lt;0.001</td>
<td>0.002 0.214 0.808</td>
<td>52.88 29.5783 &lt;0.001</td>
<td>0.029 1.68 0.202</td>
</tr>
<tr>
<td>Initial Weight (Covariate)</td>
<td>495 0.587 0.449</td>
<td>NA NA NA</td>
<td>NA NA NA</td>
<td>NA NA NA</td>
<td>NA NA NA</td>
</tr>
<tr>
<td>Block (Sex)</td>
<td>22235 26.41 &lt;0.001</td>
<td>93814 38.31 &lt;0.001</td>
<td>0.083 7.461 0.01</td>
<td>0.019 0.0108 0.917</td>
<td>0.06 3.39 0.075</td>
</tr>
<tr>
<td>PL×AG</td>
<td>1760 2.091 0.086</td>
<td>21534 8.7943 &lt;0.001</td>
<td>0.013 1.2371 0.316</td>
<td>11.96 6.6897 &lt;0.001</td>
<td>0.016 0.943 0.479</td>
</tr>
</tbody>
</table>
# Annexure 8

## ANOVA Tables of Paper-II

### i. Main Effects Anova of Slaughter Traits

<table>
<thead>
<tr>
<th>Form of feed</th>
<th>Hot carcass wt.</th>
<th>Dressing wt. (%)</th>
<th>Proportion Head wt.</th>
<th>Proportion Skin wt.</th>
<th>Proportion Limbs wt.</th>
<th>Proportion Pluck wt.</th>
<th>Carcass length (cm)</th>
<th>Leg length (cm)</th>
<th>Buttock width (cm)</th>
<th>Buttock Perimeter (cm)</th>
<th>Thoracic width (cm)</th>
<th>Carcass compactness</th>
<th>Leg compactness</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSS</td>
<td>8.166</td>
<td>57.753</td>
<td>0.877</td>
<td>0.866</td>
<td>0.180</td>
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<td>5.041</td>
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<td>0.167</td>
<td>32.66</td>
<td>32.66</td>
<td>0.0027</td>
<td>0.000704</td>
</tr>
<tr>
<td>F-Value</td>
<td>1.593</td>
<td>5.467</td>
<td>0.960</td>
<td>0.655</td>
<td>1.27</td>
<td>2.948</td>
<td>0.244</td>
<td>0.592</td>
<td>0.300</td>
<td>0.588</td>
<td>1.291</td>
<td>2.689</td>
<td>0.2024</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.242</td>
<td>0.047</td>
<td>0.355</td>
<td>0.441</td>
<td>0.291</td>
<td>0.124</td>
<td>0.634</td>
<td>0.463</td>
<td>0.866</td>
<td>0.465</td>
<td>0.288</td>
<td>0.1397</td>
<td>0.6647</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Form of feed</th>
<th>Hot carcass wt.</th>
<th>Dressing wt. (%)</th>
<th>Proportion Head wt.</th>
<th>Proportion Skin wt.</th>
<th>Proportion Limbs wt.</th>
<th>Proportion Pluck wt.</th>
<th>Carcass length (cm)</th>
<th>Leg length (cm)</th>
<th>Buttock width (cm)</th>
<th>Buttock Perimeter (cm)</th>
<th>Thoracic width (cm)</th>
<th>Carcass compactness</th>
<th>Leg compactness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeast addition</td>
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<td>0.012</td>
<td>0.023</td>
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<td>0.055</td>
<td>3.086</td>
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<td>0.115</td>
<td>0.063</td>
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### ii. Main Effects Anova of Carcass Traits (Cuts)

<table>
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<tr>
<th>Form of feed</th>
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<th>Gain to Intake ratio</th>
<th>Cold carcass wt. (kg)</th>
<th>Right side weight kg</th>
<th>Left side weight kg</th>
<th>Neck weight kg</th>
<th>Leg weight kg</th>
<th>Loin + Rib weight kg</th>
<th>Shoulder weight kg</th>
<th>Breast weight kg</th>
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<tbody>
<tr>
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<table>
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<th>Cold carcass wt. (kg)</th>
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<th>Left side weight kg</th>
<th>Neck weight kg</th>
<th>Leg weight kg</th>
<th>Loin + Rib weight kg</th>
<th>Shoulder weight kg</th>
<th>Breast weight kg</th>
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<td>0.001</td>
<td>8.1</td>
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### iii. Main Effects Anova of Carcass Traits

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<th>MSS</th>
<th>p-value</th>
<th>MSS</th>
<th>p-value</th>
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<th>p-value</th>
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<tbody>
<tr>
<td>F-Value</td>
<td>0.05042</td>
<td>0.375</td>
<td>0.009783</td>
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<th>p-value</th>
<th>MSS</th>
<th>p-value</th>
<th>MSS</th>
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<th>MSS</th>
<th>p-value</th>
<th>MSS</th>
<th>p-value</th>
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### iv. Main Effects Anova of Meat Composition

<table>
<thead>
<tr>
<th>Form of feed</th>
<th>MSS</th>
<th>Meat ether extract</th>
<th>MSS</th>
<th>Meat Protein</th>
<th>MSS</th>
<th>Meat Ash</th>
</tr>
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<tbody>
<tr>
<td>F-Value</td>
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<table>
<thead>
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<th>MSS</th>
<th>Meat Protein</th>
<th>MSS</th>
<th>Meat Ash</th>
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### v. Main Effects Anova of Sensory Evaluation

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<th>Color</th>
<th>MSS</th>
<th>Texture</th>
<th>MSS</th>
<th>Flavor</th>
<th>MSS</th>
<th>Juiciness</th>
<th>MSS</th>
<th>Chewability</th>
<th>MSS</th>
<th>Overall acceptability</th>
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<tbody>
<tr>
<td>F-Value</td>
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<td>0.024704</td>
<td>0.803</td>
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<td>P-Value</td>
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<table>
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<th>Color</th>
<th>MSS</th>
<th>Texture</th>
<th>MSS</th>
<th>Flavor</th>
<th>MSS</th>
<th>Juiciness</th>
<th>MSS</th>
<th>Chewability</th>
<th>MSS</th>
<th>Overall acceptability</th>
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vi. **Main Effects Anova of Blood serum metabolites**

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<th>Form of feed</th>
<th>MSS</th>
<th>Blood urea nitrogen</th>
<th>F-Value</th>
<th>P-Value</th>
<th>Serum creatinine</th>
<th>F-Value</th>
<th>P-Value</th>
<th>Serum cholesterol</th>
<th>F-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
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vii. **ANOVA for Interaction effects**

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<tr>
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<th>ADFI</th>
<th>KR</th>
<th>Cooking loss</th>
<th>Hue Angle</th>
<th>Moisture</th>
<th>Serum glucose</th>
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<tr>
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</table>
Annexure 9

ANOVA Tables of Paper-III

i. Growth Performance

<table>
<thead>
<tr>
<th></th>
<th>Average daily gain</th>
<th>Average daily feed intake</th>
<th>Klieber ratio</th>
<th>Gain to feed ratio</th>
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<tbody>
<tr>
<td>MSS</td>
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ii. Slaughter Traits

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<th>DP</th>
<th>HPW</th>
<th>SPW</th>
<th>LPW</th>
<th>PPW</th>
<th>CL</th>
<th>LGL</th>
<th>BTW</th>
<th>BTP</th>
<th>TW</th>
<th>CCP</th>
<th>LCP</th>
</tr>
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<tbody>
<tr>
<td>MSS</td>
<td>19.6875</td>
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<td>4.3312</td>
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<td>0.01</td>
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<td>0.101</td>
<td>0.097</td>
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<td>0.752</td>
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</table>

Where the abbreviations are:

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<tr>
<th>Hot carcass wt.</th>
<th>Dressing (%)</th>
<th>Proportion Head wt.</th>
<th>Proportion Skin wt.</th>
<th>Proportion limbs wt.</th>
<th>Proportion pluck wt.</th>
<th>Carcass length</th>
<th>Leg length</th>
<th>Buttock width</th>
<th>Buttock Perimeter</th>
<th>Thoracic width</th>
<th>Carcass compactness</th>
<th>Leg compactness</th>
<th>MCC</th>
<th>LCP</th>
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</thead>
<tbody>
<tr>
<td>HCW</td>
<td>DP</td>
<td>HPW</td>
<td>SPW</td>
<td>LPW</td>
<td>PPW</td>
<td>CL</td>
<td>LGL</td>
<td>BTW</td>
<td>BTP</td>
<td>TW</td>
<td>CCP</td>
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197
### iii. Carcass Traits (Cuts)

<table>
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<tr>
<th>Cold carcass wt. (kg)</th>
<th>Right side weight (kg)</th>
<th>Left side weight (kg)</th>
<th>Neck weight (kg)</th>
<th>Leg weight (kg)</th>
<th>Loin + Rib weight (kg)</th>
<th>Shoulder weight (kg)</th>
<th>Breast weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>&lt;0.001</td>
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<td>&lt;0.001</td>
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<td>0.002</td>
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### iv. Carcass Traits

<table>
<thead>
<tr>
<th>Eye muscle area</th>
<th>pH of meat</th>
<th>Tenderness/Shear force</th>
<th>Water holding capacity</th>
<th>Cooking loss</th>
<th>Drip loss</th>
<th>Hue angle</th>
<th>Lightness</th>
<th>Chromaticity</th>
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<tbody>
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### v. Meat Chemical Composition

<table>
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<th>Dry matter</th>
<th>Meat ether extract</th>
<th>Meat Protein</th>
<th>Meat Ash</th>
</tr>
</thead>
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<tr>
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**vi. Sensory Evaluation Score**

<table>
<thead>
<tr>
<th></th>
<th>Color</th>
<th>Texture</th>
<th>Flavor</th>
<th>Juiciness</th>
<th>Chewability</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
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**vii. Blood Serum Analyses**

<table>
<thead>
<tr>
<th></th>
<th>Serum glucose</th>
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<th>Serum creatinine</th>
<th>Serum cholesterol</th>
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<tr>
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<td>&lt;0.001</td>
</tr>
</tbody>
</table>
CV

Mr Kashif Ishaq s/o Mr Muhammad Ishaq was born in District Bahawalnagar in 1980. He started his early education from Sami-Ullah Foundation School, Bahawalnagar. He passed his primary exam from Jinnah Public School, Bahawalnagar. He passed his Secondary School Certificate from Govt. Model High School Colony, Bahawalnagar and his Higher Secondary School Certificate from Government Degree College, Bahawalnagar. He got admission in B.Sc. (Hons.) Animal Husbandry in 1999 in Faculty of Animal Husbandry at University of Agriculture, Faisalabad (UAF) and qualified his graduation in 2002. Later he completed his M.Sc.(Hons.) from Dept of Livestock Management in 2004. He won a merit scholarship in his M.Sc.(Hons.) degree. He qualified a condensed Doctor of Veterinary Medicine exam in 2006 to get a DVM degree.

He started his professional career as faculty member at Dept of Livestock Management, Faculty of Animal Husbandry, UAF in 2004. In 2007, he joined the Dept of Livestock Production and Management at PMAS, Arid Agriculture University, Rawalpindi as Lecturer. He has experience of teaching farmers, under- and post-graduate courses. He has completed two research projects. He got icing on cake from one of world finest lab for managing lab work for Somatic Cell Nuclear Transfer Techniques and In-Vitro Fertilization Protocols for Bovines from SNU, SEOUL, South Korea. He qualified GRE in 2012 with good score and won a HEC Scholarship for indigenous PhD program. He got relived from his Employer University for pursuing his PhD degree at Dept of Livestock Management, UAF.

He has collected data for PhD dissertation under PSF funded project. His work was accepted at national and international level in many conferences. He worked hard in getting his tangible goals for which he is a candidate now.