NUTRITIONAL EVALUATION OF BAKLA (*Vicia faba* L.) ON LONG TERM FEEDING IN LAMBS

By

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Dissertation submitted to the Chaudhary Charan Singh Haryana Agricultural University in partial fulfilment of the requirements for the degree of:

DOCTOR OF PHILOSOPHY

in

ANIMAL NUTRITION

College of Animal Sciences
Chaudhary Charan Singh
Haryana Agricultural University
HISAR

1993

D E D I C A T E D

TO MY

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CERTIFICATE - I

This is to certify that this dissertation entitled, "Nutritional Evaluation of Bakla (Vicia faba L.) on Long Term Feeding in Lambs" submitted for the degree of Ph.D. in the subject of Animal Nutrition of the Chaudhary Charan Singh Haryana Agricultural University, is a bonafide research work carried out by Shri Y.G. Fulpagare under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

(GOPAL KRISHNA)
MAJOR ADVISOR

CERTIFICATE - II

This is to certify that this dissertation entitled, "Nutritional evaluation of Bakla (Vicia faba L.) on long term feeding in lambs" submitted by Shri Y.G. Fulpagare to the Chaudhary Charan Singh Haryana Agricultural University in partial fulfilment of the requirements for the degree of Ph.D. in the subject of Animal Nutrition, has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.

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ACKNOWLEDGEMENTS

The candidate hereby places on record his sincere thanks and gratefulness to Dr. Gopal Krishna, M.V.Sc., Ph.D. (India), Ph.D. (Norway), AvH Fellow (Germany), as major advisory, for his constant inspiration, constructive criticism and valuable suggestions and guidance right from the selection of research project upto final shaping of this manuscript.

Dr. M.N. Razdan, M.Sc. (Hons), D. Phil (Calcutta), Senior Professor, Department of Animal Production Physiology, in the capacity of Dean, Postgraduate nominee who gave valuable suggestions from time to time in the execution of research work.

Dr. V.P. Sharma, Ph.D., Professor in the capacity of member from major subject, who gave valuable suggestions from time to time.

Dr. S.M. Chahal, Ph.D. Associate Professor in the capacity of member from minor subject, who contributed constructive criticism from time to time.

Dr. R.K. Tuli, Ph.D., Associate Professor in the capacity of member from supporting field, for cooperating and giving necessary help as and when needed during the period of present investigation.

Dr. M.U. Kharole, M.V.Sc., Ph.D., Senior Professor, Veterinary Pathology, who gave valuable help and technical guidance in the area of conducting histological studies.

Dr. J. Sahoo, M.V.Sc., Assistant Professor, Department of Animal Products Technology, who extended valuable help in conducting meat studies.

The Vice-Chancellor, Mahatma Phule Agricultural University, Rahuri (M.S.) for sanctioning study leave to continue Ph.D. programme at CCS Haryana Agricultural University, Hisar.

The Professor and Head, Department of Animal Nutrition, CCS Haryana Agricultural University, Hisar for providing necessary facilities during the course of this investigation.

The Incharge, Computer Centre, CCS Haryana Agricultural University, Hisar for processing raw research data.

Mrs. & Drs. V.M. Mandokhot, M.U. Kharole, P.D. Deshpande, D.S. Phokharkar, D.B. Yadav, A.M. Pande, V.P. Pathak, N.N. Zade, A.J. Wagh and and G.G. Khot, who had provided a gleeful and social environment and made the stay at Hisar as comfortable as at native.

Mrs. Subhadra, my wife and daughters Meenakshi and Manjushri for their patience and moral support throughout the period of this study.

Hisar
April , 1993

(V.G. FULPAGARE)

C O N T E N T S

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1. INTRODUCTION

The projection and the requirement of green fodder, drymatter and concentrate for the country's livestock population at their optimum dose of nutrition has been put at 747, 488 and 87 million tonnes for the year 1990 and 837, 529 and 52 million tonnes for 2000 A.D., respectively. However, with present feed and fodder resources, the country can meet only 46.6 per cent requirement and that too by feeding poor quality forages (Singh, 1990).

Therefore, in order to minimise the gap between availability and requirement of concentrate, a variety of improved protein-rich crop is the only answer. Plant scientist identified a high yielding protein-rich crop called 'Fababean' popularly known as Bakla (Hindi). The protein gap can be narrowed down by using this under-irrigated and under-utilized proteinous crop in the routine diets of farm animals.

Fababean (Vicia faba L.) is a leguminous crop and has the advantage of fixing atmospheric nitrogen in the soil and benefitting the following crop. Fababean is the fourth important pulse crop of the world specially grown in European countries (Germany) after dry beans, dry peas and chickpeas (Hawtin and Stewart, 1977). This crop is a high yielder than conventional rabi pulses. Fababean thrives well under irrigated

conditions and can withstand high water table and soil salinity. The relative high yielding potential of fababean and its adaptability to different climatic conditions and soils would suggest that it can not only be exploited as food for human beings but also as a feedstuff for livestock and poultry.

The major fababean growing countries are China, Egypt, United Kingdom and Syria. About 70 per cent of its global production is contributed by China alone. It is also an important crop in Northern Europe, the Mediterranean Basin and the Latin America (Hawtin and Hebblethwaite, 1983). The total area under cultivation in the world, Asia and China is 3201, 1760 and 1700 thousand hectare, respectively. The production of dry fababean in the world, Asia and China is 4312, 2704 and 2600 thousand metric tonnes (FAO, 1990). The data related to cultivation, area and production in India is not available. In India, its cultivation is confined as a minor pulse crop in Himalayan hills, Bihar and Eastern Uttar Pradesh.

In India, Fababean is variously known as Bakla, Anhuri, Kalamatar, Raj-rawan and Kadu huralikayee in different linguistic regions. It is also known by various local names in different parts of the country as Baklasem in Delhi and Katun in Kashmir, etc.

Fababean is a rich source of protein (Brisson et al., 1950, Hill et al., 1977, Evans, 1961, Eden, 1968 and Hove et al., 1978). Simultaneously, Fababean is also rich in vitamins and minerals except sodium and chloride (Eden, 1968, Clarke, 1970). The seed coat or hull accounts for about 14

per cent of its weight and contains 84.5 per cent of the fibre.

Review article published (Newton and Hill, 1983) has focused an important information related to the adverse effect of presence of antinutritional factors (present in Bakla) in non-ruminants specially poultry and pig, however, the information with regard to nutritive value and utility of fababeans in ruminants feeding is scarce. Literature is silent on the effects of its comprising as sole feed in lambs, specially with respect to utilization of nutrients, body weight gain, feed conversion rate, quality and quantity of meat produced and histological changes in liver, kidney and rumen wall. Bakla as a sole source of protein through concentrate mixture was also tried to investigate whether vicine, convicine and tannins contained in it have any adverse effect on rumen function and growth performance of the lambs.

In order to fill up the gaps in the information on long range Bakla feeding in growing lambs, the present study was undertaken with the following specific objectives:

1.1 Objectives

1.1.1 To study the Bakla (Vicia faba) and Bakla based rations in respect of following:

a. Proximate principles and tannic acid (Total phenol) content

b. Solubility of protein under in vitro system

c. Ruminal degradability of protein using in situ technique

d. Degradability of protein at abomasum and intestinal level

1.1.2 To study the effect of feeding Bakla and Bakla based rations on ruminal fermentation pattern and blood nitrogenous constituents in growing lambs during winter and summer seasons.

1.1.3 To study growth response, nutrient utilization and water balances as influenced by feeding Bakla and Bakla based rations in lambs during winter and summer seasons.

2. REVIEW OF LITERATURE

The crop is known as Bakla and Anhuri in Hindi, as broad beans, field beans, tick beans, horse beans, windsor beans in English. Many other English names for the crop are also used and includes Spanish Egyptian, Mazagan, Pigeon, Winter, spring garden, faba, Vicia and common beans. The fababeans are known botanically as Vicia faba L. Considerable confusion has resulted from multiplicity of names. In U.S.A. and many other countries as Phaseolus vulgaris not Vicia faba. The name fababean recently has been adopted to denote this bean and this being increasingly accepted internationally (Hawtin and Hebblethwaite, 1983). In this manuscript, the name fababean (Bakla) shall be used to refer botanically Vicia faba L.

The published work on this crop for livestock feeding is limited. However, sufficient literature is available on rat and poultry feeding involving fababean based diets. A critical review of literature indicates an increasing interest in the role of fababeans as a potential protein supplement in the diet of poultry but practically very little scientific information on feeding of Bakla is available in ruminants, in published literature. The inclusion of fababeans in compound diets for ruminants and non-ruminants, however, is restricted because of the presence of naturally occurring antinutritional factors

(ANF) in the beans (Van der Poel, 1989). In general terms, different problem requires special attention depending on the particular species of animal concerned and the situation involved. It is, therefore, necessary to plan the experiments related to the utilization of fababeans covering to various aspects of study.

2.1 Chemical Composition of Fababean

The protein density in fababeans ranged from 23 to 31 per cent and is highest in spring sown cultivars. Major proteinous moiety is found in the kernel and protein concentration of the testa is low (Evans, 1961). The crude fibre concentration of fababeans ranges from 6 to 11 per cent. However, higher value of fibre content (15.4%) has also been reported (Hove et al., 1978). On the other hand, Brisson et al. (1950) reported fibre content to be 9.2 per cent on dry matter basis. Eden (1968) reported that the fibre concentration was lower in spring sown fababeans. The ether extract content of fababean ranges from 0.9 to 4.2 per cent. The ash content ranges from 3.1 to 4.8 on dry matter basis.

Van der Peol et al. (1991)reported the chemical composition of fababean (cv. Alfred) specially with reference to protein and fibre levels which are considered typical for fababean. The dry fractionation shows that the protein is mainly located in the cotyledons while crude fibre is the major component of seed coat.

Garrido et al. (1991) determined the chemical compsoition of 24 strains of Vicia faba L. (8 white flowers, 8 normal

pigmentation and 8 diffuse pigmentation). They did not observed significant differences ($P<0.05$) with respect to crude protein content. The crude protein content ranged from 23.4 to 38.8 on dry matter per cent basis.

2.1.1 Carbohydrates

Carbohydrate concentration in fababeans ranges from 50 to 60 per cent. Inclusion of crude fibre within this fraction may raise levels to as high as 67.9 per cent (Pritchard et al., 1973).

2.2 Antinutritional Factors

2.2.1 Tannins

Most legumes are known to contain appreciable level of polyphenolic substances broadly referred to as tannins Among the antinutritional effects attributed to these tannins is decrease in digestibility of protein and carbohydrate as a result of the formation of insoluble enzyme resistant complexes with tannin. Other antinutritional effects which have been attributed to tannins include direct inhibition of the enzyme themselves, damage of the intestinal tract, toxicity of the tannin absorbed from the gut, an interference with the absorption of iron and a possible carcinogenic effect.

Major proportion of tannins in the fababeans is found in testa (Kadirvel and Clandinin, 1974). Digestibility has been reported to be reduced in the field beans with high tannin concentration (Bond, 1976 and Marquardt et al., 1978), however, the amount of protein precipitated by the tannin may be

relatively low. In the absence of testa, which contains much of the tannin in field beans, 98 per cent of protein present was soluble in pepsin but when the testa was present only 95 per cent of the protein was soluble (Griffiths and Jones, 1977) further they confirmed that white flowered seed lines contained less tannin in the testa.

Garrido et al. (1989) determined tannin content of 24 varieties of fababean with two methods and also acid detergent fibre, lignin and soluble nitrogen and in vitro digestibility of dry matter and crude protein were also determined. A high correlation between (r=0.93) tannin values obtained with both methods was found. The negative effect of tannin content on nutritive values was demonstrated by the correlation of -0.84 (Folin-c-method) and -0.94 (TI method) with in vitro dry matter digestibility.

Wang and Uberschar (1990) estimated condensed tannin of 22 varieties of fababeans were shown to contain 7.1-149.7 mg. On an average 87.1 $\pm$ 46.3 mg catechin equivalent g^{-1} shell. The difference between varieties was significant at <0.01. The tannin values analysed directly using whole beans were much lower than those calculated from the tannin values of the shells.

Nevertheless, tannins are not only the antinutritional factors present in the fababeans but substances such as haemaglutinins, saponins, glucosides and trypsin inhibitors which are main constraints in limiting the availability of energy and protein for maintaining the integrity of tissue.

2.2.2 Trypsin inhibitors

Trypsin a proteolytic enzyme found in pancreas may be inhibited by substances found in legumes. The inhibition of trypsin may be due to carbohydrate fraction, in field beans, the inhibitors were glycoproteins. The location of trypsin inhibitor within the field bean seed has not been clearly defined. Wilson et al. (1972) reported higher activity per unit weight in the cotyledon than in the testa but later Marquardt et al. (1975) determined that the trypsin inhibitor activity of the testa was upto twice that of the cotyledons. This suggest that dehulling of the bean is unlikely to reduce trypsin inhibitor activity in field beans. There is considerable variations in the amount of trypsin inhibitor activity among field bean cultivars (Bhatty, 1974, Hussain et al., 1974, Marquardt et al., 1975 and McNab and Wilson, 1977) so that selection for cultivars with low trypsin inhibitor activity is feasible.

Ward et al. (1977) observed that fababean hulls had a much higher concentration of growth inhibiting substances than the cotyledon portion of the bean. Fababeans contain both thermolabile (Marquardt and Ward, 1979) and thermostable antinutritional compounds (Olabaro et al., 1981a,b).

Griffiths (1981) compared enzyme inhibitory activity of testas from faba beans and pea varieties and observed that water extracts prepared from the testas significantly inhibit in vitro activities of trypsin α-amylase and fungal cellulase

and in all cases enzyme activity was restored on the addition polyvinyl pyrolidone. It indicates that observed inhibition was due to presence of tannin.

Vicine and Convicine

Bjerg et al. (1980) reported mean vicine and convicine contents 0.55 and 0.32 per cent in fababeans. Frohlich and Marquardt (1983) observed that vicine is excreted in the urine and bile and convicine in contrast to vicine was not absorbed by chicks. In vitro studies suggest that vicine and convicine are hydrolysed by microorganisms in the caeca of the chick but are not hydrolysed by the microorganisms in the GI tract by endogenous tissue enzymes or by enzymes present in fababeans and are only slightly hydrolysed by the low pH of the stomach.

Bjerg et al. (1985) isolated relatively large amount of vicine and convicine in crystaline stage from fababean seeds. These two compounds and dopa were added to casein based diet in different amounts and given to rats in nitrogen balance trials. Convicine 0.14 per cent reduced the biological value by 10.2 per cent.

Margaretha et al. (1989) reported that B-glucosidase from almonds are able to hydrolyse vicine and convicine in phosphate buffer (pH 6.8) but much more rapidly in HCl (pH 4.2).

Wang and Ueberschar (1990) estimated vicine, convicine and condensed tannis in 22 varieties of fababeans, 20 varieties of mature fababeans were shown to contain 6.68 $\pm$ 1.12 mg vicine, 2.33 $\pm$ 0.59 mg convicine and 9.02 $\pm$ 1.32 mg vicine + convicine per gram air dry bean.

2.3 Solubility/Degradability of Protein of Fababeans

With the increasing knowledge of true digestible process of protein in ruminants, it is now known that DCP values are not satisfactory indicators of the protein absorbed from the gastro-intestinal tract of ruminants. Agricultural Research Council (U.K.) in the year 1980, 1984 on nutrient requirement for ruminants has proposed that the dietary crude protein needs of the ruminants must be supplied in terms of rumen degradable protein (RDP) to meet requirement of rumen micro-organisms and undegradable dietary protein (UDP) which would be made available to the animal whenever the microbial protein synthesised in a rumen is insufficient to meet the nitrogen requirement of the host animal tissue (ARC, 1980, 1984).

Aufrere et al. (1991) studied ninety seven samples of concentrated feeds for the prediction of the in situ nitrogen degradation by a method using solubility in buffer (Phosphate buffer at pH 6.9) and an enzymatic technique. Both methods allowed same precision (residual standard deviation (RSD = 0.030) the prediction was very precise and much better with the enzymatic method (RSD = 0.025) than with the solubility method (RSD = 0.049). They have given the values of solubility and enzymatic degradation at 1 and 24 hrs and in situ degradability of fababeans were 0.66, 0.75, 0.84 and 0.90, respectively.

Aguilera et al. (1992) measured the rate and extent of degradation of dry matter and nitrogen in ground seeds of peas, lupin, field bean, vetch and bitter vetch previously autoclaved

or not autoclaved by using nylon bags incubated in rumen of wethers. The fractional outflow rate of the legume seed meal particles was determined with chromium as a marker. Autoclaving process decreased both the soluble fraction and the fractional rate of protein degradation of the slowly degraded fraction ($P<0.01$). Effective degradability of protein was strongly reduced by heat-treatment in pea and lupin seeds, moderately decreased in field beans and bitter vetch and almost unchanged in vetch seed meal. They have given the values of dry matter and nitrogen disappearance for not autoclaved and autoclaved fababean covering various incubation time from 0 to 72 hrs for dry matter and nitrogen disappearance which ranged from 20.1 to 93.3 and 15.6 to 89.0 for dry matter and 37.4 to 96.8 and 19.9 to 93.7 for nitrogen disappearance.

Cros et al. (1992) conducted experiment with four cannulated non-lactating Holstein cows to determine the effect of extrusion for 120°C of whole fababeans on nitrogen solubility in vitro and degradation of dry matter (DM) and crude protein (CP), in situ in the rumen and intestine. The experimental cows were fed on the diets of 30 per cent whole fababean (WFB) and 70 per cent Italian rye grass hay. The degradation of dry matter (DM) and crude protein (CP) was estimated using nylon bags suspended in rumen for 2, 4, 7, 16, 24 and 48 hrs, the effective ruminal degradability of DM and CP was evaluated assuming a ruminal outflow rate 0.06/h. Extrusion of whole fababean reduced nitrogen solubility in buffer solution (21.1 vs 74.9%). Processing diminished the effective rumen

degradability of DM (74.6 vs 80.4%) and CP (70.2 vs 89.2%). Amounts of DM and CP digested in the intestine increased 9.6 vs 1.4 and 25.2 vs 3.0 per cent, respectively. It indicates that extruded whole fababean increase the availability of dietary protein in the intestine compared with raw whole fababeans.

2.4 Utilization of Fababean in Ruminants Ration

The information on the sole feeding of fababean as such in ruminants (specially lambs) is not available in published literature. However, scanty and scattered literature on different levels of fababean feeding is available which is elaborated in following paragraphs.

At the Indian Veterinary Research Institute, Izatnagar (Bareilly) U.P., Pandey et al. (1966) conducted metabolic trials on bulls fed wheat straw and groundnut cake in control group and wheat straw and 'Akra' (A mixture of seed of Vicia hirsuta and Vicia sativa in the ratio of 64:36) to experimental group . The per cent digestibility values of proximate nutrient of 'Akra' calculated by difference were: DM 71.70, CP 81.05, EE 93.65, CP 86.48 and NEE 67.78, respectively. The per cent DCP and TDN values of 'Akra' were 27.14 and 72.64. They also reported that balances for retention of nitrogen was significantly better with 'Akra' feeding than with control feed. Balances for calcium and phosphorus were also positive. Although the differences were not significant between the two groups.

Further they recommended the use of Vicia species in the ration of livestock with much economic advantage. The digestible crude protein contents of fababean is higher than most of cereals and few of the most commonly used protein supplements. The inclusion of fababean seeds in the dairy ration reduced the cost of feed. This would be particularly useful during the lean period when the market rate of protein supplements and cereal grains are very high.

At the Indian Veterinary Research Institute, Izatnagar (Bareilly), U.P. in another study, 'Akra' was fed to the cattle alongwith the wheat straw. The combined digestibility coefficients ranged from 52.80 to 55.43 for DM, 63.17 to 64.52 for CP, 63.16 to 66.26 for EE (Pal and Pandey, 1970). The inclusion of 'Akra' also improved the digestibility coefficients of complete feed. They also reported that 'Akra' fed animals gained (346 g/day) but the differences were statistically non-significant. The Akra has been found to contain 22.1 per cent DCP and 73.6 per cent TDN in Haryana calves. The weight gain per day was more than that of control fed by conventional concentrate mixture.

Macleod et al. (1972) tested soyabean meal, fish meal and fababean as a protein supplements in the diets of young calves. The diets were isoproteinous (16% CP). The absolute nitrogen retention with beans was intermediate (22 g/d) to the values obtained with soyabean meal (27.9 g/d) and fish meal (19.9 g/d). The nitrogen from fababean meal was less digestible (68.4%) than that from either soyabean meal (71.5%) or fishmeal (71.2%)

but the differences were not significant. In another experiment, they have found a similar intake per kg metabolic body size for young calves on either a fish meal supplementation or high moisture fababean.

At the Danish Research Institute, Copenhagen, Denmark, Hansen and Anderson (1972) reported that dairy cows were fed rations containing fodder sugar beet silage and a concentrate containing upto 60 per cent beans, they observed that feed intake and milk yield were not affected. However, the inclusion of beans in the concentrate mixture led to higher fat and lower protein in milk.

Ingalls and McKirdy (1974) conducted an experiment with Holstein cows at University of Manitoba, Winnipeg (Canada). The diet containing fababeans (17 and 35%), soyabean or rape seed meal (19%) as the protein supplement. Adding 17 or 35 per cent fababeans to the dairy concentrate appeared to have little effect ($P<0.05$) on feed intake, milk production, milk protein content or milk solids non fat content (SNF). The diet with high level of fababeans appeared to result in higher butter fat test as compared with the diet containing rapeseed meal. It indicates that satisfactory production performance of dairy cows can be obtained while feeding concentrate containing 17 or 35 per cent fababeans and also reported that feeding 35 per cent fababean in dairy concentrate to Holstein cows did not affect the level of fat, protein and SNF in the milk.

Ingalls et al. (1974) indicated that ground fababean can replace soyabean meal in calf rations. Levels of 24 per cent

crude protein (CP) in a starter and 30 per cent in a grower ration were used to replace soyabean meal and barley. No significant differences were found in feed intake, growth rate and feed efficiency. Other trial conducted by the same authors in cows did not reveal any significant effect on milk production when soyabean was replaced with fababeans. However, in lambs study they found poor efficiency when fababeans were included upto 25 per cent in their ration.

Pisulewski and Rys (1975) reported the effect of formaldehyde treatment of fababeans at 0.4, 0.5 or 1.2 per cent levels on the biological value, true digestibility and available lysine of the product was investigated in vitro in experiments with rats. The effect of treated beans on N balance, weight gain, feed conversion and plasma urea in lambs was studied also and the effect of treatment on conversion of dietary protein to bacterial protein and ammonia in the rumen was studied in sheep fitted with fistulae. Formaldehyde treatment reduced solubility and susceptibility of the protein to deamination. The biological value was not affected and there was only small reduction in true digestibility with 0.8 or 1.2% formaldehyde, but available lysine decreased progressively. In sheep given the treated protein, in rumen and the proportion of bacterial to total nitrogen decreased upto 8 h after feeding. There was no effect on daily gain, feed conversion or N balance. In lambs, given treated protein, plasma urea was increased.

Sharma and Nicholson (1975) conducted experiment with 24 Holstein cows fed diet containing 8.4 per cent soyabean meal (SBM) or 18 per cent fababean treated with water (W-faba) or formaldehyde (FA-faba) to determine the influence on animal performance, of reducing the solubility of fababean protein. A 1:5 dilution of commercial fababean formalin (37% FA) was applied to the ground fababeans to supply 1.5 g FA/100 g protein. No differences were observed in dry matter intake (545.8, 590.5 and 537.6 kg, respectively), weight gain (81.7, 87.9 and 93.6 kg, respectively) among the calves fed the three diets for 84 days, but formaldehyde treatment of fabebeans tended to improve the daily weight gain and feed efficiency of calves as compared with the diets containing soyabean meal or water treated fababeans. Formaldehyde treatment depressed ($P<0.05$) blood urea nitrogen (19.2, 17.3 and 17 mg/100 ml, respectively) and rumen fluid ammonia nitrogen (19.3, 18.7 and 16.0 mg/100 ml, respectively) of the calves.

In another experiment, apparent digestibilities of dry matter, crude protein and energy as measured with mature sheep was statistically different ($P>0.05$) among the three diets. Three sheep fitted with cannulas in the abomasum and ileum were fed diets containing fababeans treated with water, formaldehyde or volatile fatty acids (57% acetic acid and 39% propionic acid). A slight depression ($P>0.05$) in apparent digestibility of crude protein (65.3, 60.8 and 61.7%, respectively) was observed when formaldehyde or VFA treated fababeans were fed as compared to water treated fababeans. The

volatile fatty acids (VFA's) treatment tended to increase the N retention (11.3, 10.5 and 14.4 as % N intake, respectively). A significant reduction (P>0.05) in blood urea (15.76, 13.34 and 14.81 mg/100 ml, respectively) and rumen fluid ammonia nitrogen (6.25, 6.52 and 5.82 mg/100 ml, respectively) at 1 h after feeding was observed in sheep fed formaldehyde treated diet compared with other diets. Formaldehyde and VFA treatments increased the flow of dry matter (528, 568 and 559 g/day, respectively), total nitrogen (17.6, 18.8 and 18.7 g/day, respectively) and protein nitrogen (11.6, 13.3 and 13.0 g/day, respectively) through the abomasum.

Giovanni et al. (1976) fed concentrates containing soyabean meal or fababeans to growing calves with 20 per cent crude protein upto three months of age and 15 per cent crude protein afterwards. Although the DM intake was similar but apparent digestibility of DM and CP was slightly less on the bean diets than soya but nitrogen retention was similar. Ruminal VFA's also did not differ but there was slight less concentration of butyric acid in that of bean fed calves. Changes in haematocrit values were similar on both diets. In trial one, intakes of hay were inversely related to the amount of concentrate mixture fed to the animals. Live weight gains of female calves were similar on each diet but the males tended to be heavier on soya diets.

Wittenberg (1977) reported that non ruminating calves fed on milk replacer containing fababean protein concentrate did not require methionine supplementation.

Ørskov (1978) suggested that microbial contribution of protein or amino acid nitrogen for 100 kg growing steers may not be sufficient to meet the growth requirement.

Ingalls et al. (1979) evaluated nutritive value of whole plant fababean (FB) silages, with dairy heifers and reported higher consumption of whole plant fababean silage than a grass legume silage with no difference ($P>0.05$) in average daily gain.

In second experiment, lactating Holstein cows were fed four diets, viz., grass legume silage plus high grain diet (control), direct cut fababean (33% DM) plus high grain, wilted fababean (37% DM) plus high grain and wilted fababean plus medium grain and reported that consumption of direct cut fababean silage was higher than that of grass silage and reducing the level of feeding from 56 to 43 per cent of the diet resulted in an increase ($P<0.05$) in whole plant fababean silage consumption.

In another experiment with beef calves fed four silages (early fababean, frosted fababean, corn or grass legume silage) or two type of dehydrated cubes (Fababean or alfalfa). Frosted fababean silage have higher ($P<0.01$) average daily gain as compared with the other treatments. Intakes of dry matter were similar for both fababean silages and alfalfa cubes but higher than in grass legume or corn silage treatments.

Finishing steers were fed three silages (fababean, grass legume or corn) free choice plus a barley supplement at one per cent of body weight. Total dry matter intake and average daily

gain were higher ($P<0.01$) for steers receiving fababean silage than for those fed the grass legume or corn silage. Energy digestibility of silage as measured by sheep digestion trials over 2 crop year and three silage samples was 69.4% $\pm$ 2.3 and digestible energy content of fababean silage was at par to that of corn silage.

Ingalls et al. (1980) in first experiment reported that complete calf starter formulated with 13 per cent soyabean meal or 30 per cent fababeans using barley as basal ration. Protein level of these diets were more than adequate for this type of diet. Starter intake, daily gain and feed efficiency were not different ($P<0.05$) among treatments. There was no indication of the fababean ration resulting in lower consumption. In another experiment with Holstein calves from birth to 7 week old, they observed the feed intake and rate of gains were similar between the group . From 8 to 20 weeks given diets with 10 per cent soyabean oil meal or 3.5 per cent soya plus 0.8 per cent urea or 24 per cent fababeans or 8.5 per cent fababean plus 0.8 per cent urea as supplementary source of nitrogen. There was no significant difference among groups in feed intake, weight gain or efficiency of feed conversion.

Allden and Geytenbeek (1980) reported that lambs showed rapid growth on bean (Vicia faba) stubble compared with barley stubble. In another experiment, they noted that lambs grazing barley stubbles but receiving 280 g bean supplemented per day made significantly greater gains than groups receiving barley supplement. The bean residue had a higher dry matter digestibility than barley residue.

Miller (1980) reported that proteins in fababean are extremely soluble in the liquid environment of the rumen and is very rapidly degraded by the rumen micro-organisms, its degree of degradation is such that it is comparable with the NPN source as urea. The starch content of fababean provides readily available source of energy for ruminants which can be enhanced by various processing techniques. The high availability of energy is important in the metabolism of rumen degradable protein and tends to minimise loss of ammonia from the rumen.

Mottelib et al. (1980) fed excessive amounts of residues of peas, sunflower, sugarcane, potatoes or fababeans. Non protein nitrogen decreased in blood in all the group, especially in those groups given pea. Blood urea also decreased significantly in those given potatoes, sunflower and peas. Total cholesterol in serum increased, especially in rams given sunflower or beans. Serum aspartate amino transferase and alanine amino transferase activity were also increased simultaneously.

Ingalls et al. (1980) conducted series of experiment. In experiment with lactating animal found that replacing soyabean meal (13%) with fababean (30%) had no apparent effect on milk yield (20.1 and 18.3 FCM) but did result in greater body weight loss (0.045 and -0.54 kg) even though dry matter intake was slightly higher as compared with the control group. Replacement of soyabean meal with fababeans and balancing with groundnut straw resulted in reduced milk fat (3.88 and 3.67) content and similar ($P<0.05$) milk protein (3.45 to 3.47%) content. Daily

production of milk fat and protein were similar for the two supplements, milk fat content (%) was not affected ($P<0.05$) when fababeans replaced by soyabean meal in the grain mixture of lactating cows. Ruminal fluid acetate : propionate ratios were not different for the cows receiving the two protein supplements. However, acetate : propionate ratio decreased with high level of grain feeding.

Giovanni (1984) fed 3 groups of 17 lambs with equal in nitrogen and energy based on maize grain containing fababeans with or without tannins 23 and 24.9 per cent or as reference, 10 per cent soyabean oil meal. The concentrate mixture was fed for 2 weeks, then supplied ad libitum to a maximum of 1000g daily. The grass hay was freely available. In balance trial, lambs were given the test concentrate in turn and 100 g hay daily with soya and beans with tannin and less with other beans. Weight gain of females was poor in all group . Feed conversion as total dry matter or concentrate dry matter needed per kg gain was less efficient with beans, especially the tannin free variety, than with soya. The carcass grading was impared with beans containing tannins. Digestibility of drymatter, organic matter and nitrogen and excretion and retention of nitrogen did not differ among treatments.

Rys et al. (1984) fed 4 groups of cows from calving to 105 days of lactation on meadow hay 5, maize silage 20, maize meal from whole plants 3 kg and concentrates 0.4 kg/kg milk produced in excess of 6 kg daily. The concentrates had untreated or formaldehyde protected ground fababeans 68 per

cent or 28 with 2.2 per cent urea and barley 28 or 65.8 per cent. Milk yield during the experiment was more with untreated or protected field beans, 1907 and 1913 kg with less untreated to protected field beans and urea 1998 and 2118 kg. Milk fat and protein were similar. Intakes/kg milk were of digestible crude protein 84.1, 79.6, 80.4 and 72.6 g and of oat feed units 0.78, 0.71, 0.76 and 0.70. Rumen ammonia nitrogen with protected field beans was less than with untreated about 9 mg against 14 mg/100 ml. Overall the total fatty acids and acetic and propionic acid, fatty acid composition of milk fat was not affected.

Valentine and Bartsch (1987) observed that ruminal pH was significantly lower from 3 to 6 hrs after grains were given ($P<0.05$) for the barley diet than for the legume grain (Lupin and fababean) diets. The rumen lactic acid concentration was higher when given the fababean and lupin grains. Rumen ammonia nitrogen concentration was significantly ($P<0.05$) higher at 0 to 18 hrs after giving the legume grains than after giving the barley grains. However, the differences in the volatile fatty acids concentration and in the proportions of acetic, propionic and butyric acids in the rumen were nonsignificant.

Klocek et al. (1987) fed young cattles on a feed mixture containing fababean, peas or lupin seeds, replaced 10, 10 and 5.0 per cent of soyabean meal. Average daily weight gain was 1033, 965, 1029 and 997, respectively. The calves consumed 3.7, 3.9, 3.7 and 3.8 kg, 3.4, 3.6, 3.4 and 3.5 feed units and 607, 694, 626 and 625 g digestible protein per kg gain.

Rubino et al. (1988) conducted a study with three groups of lactating goats kept on pasture without supplementation (control) or supplemented with 0.5 kg fababean per day or with mixture of oats and beans. There was no significant differences among groups in average total milk yield (109-129 kg). Milk protein and fat 3.19-3.28 and 4.18-4.38 per cent, respectively did not differ significantly among the diets, but tended to decrease by oat/bean supplement.

Pilla et al. (1988) fed goats in three groups kept on pasture without supplementation (control) or supplemented with fababeans at 0.5 kg per day or with a mixture of oats fababeans for the 3 groups, respectively. Overall daily consumption of net energy adjusted for variation of live weight, averaged 0.60, 1.05 and 1.03 UFL (milk feed unit) and digestible crude protein intake averaged 39, 147 and 144 g. The control group goats were in negative balance for energy and protein throughout the trial. Overall the supplemented goats were close to energy balance and had a surplus in protein. Net energy intake per kg 4 per cent fat corrected milk was 0.55, 0.42 and 0.39 UFL for 3 groups, respectively, after substracting estimated requirements for maintenance. Although the unsupplemented goats took about 35 per cent more UFL from pasture than the supplemented goats. Feed intake and body weight change met only 62.5 per cent of their estimated energy requirement, compared with 103.9 and 97.2 per cent for the two other groups.

At the CCS Haryana Agricultural University, Hisar, Akbar (1989) conducted an experiment with 16 buffalo calves maintained on four treatment groups fed with test diet 20, 40 and 60 per cent crude protein replacement of conventional concentrate mixture containing barley, groundnut cake and rice polish by crushed Bakla (Fababean), reported that dry matter intake kg per 100 kg body weight was 2.34, 2.34, 2.41 and 2.31 kg, respectively, average daily body weight gain was 511.6, 501.7, 573.3 and 583.3 g, respectively and the feed/gain ratio was 7.90, 7.95, 7.84 and 7.02, respectively. The differences among the treatment were non significant but the average daily body weight gains were appeared higher at 40 and 60 per cent protein replacement level.

Akbar and Gupta (1990a) determined the nutritive value of fababean through feeding trial on adult sheep. Ten adult sheep were divided into two groups of five each on body weight basis. One group was fed alone on gram straw while the other group was fed gram straw and crushed fababean seeds in 60:40 ratio on ME basis. Feeding trial was continued for 35 days including 5 days collection period. During feeding and collection period the lambs were given weighed quantity of feed daily. Records of residue left and faeces voided were maintained. Representative samples of feed, faeces and residue left were subjected to proximate chemical analysis. The digestibility of drymatter 67.41, organic matter 71.97, crude protein 77.22 and crude fibre 57.78 per cent. Digestible crude protein and total digestible nutrients were 17.63 and 69.41 per cent, respectively.

Akbar and Gupta (1990b) conducted experiment with 16 growing male buffalo calves in four treatment groups fed rations with 0, 20, 40 and 60 per cent crude protein replacement of conventional concentrate mixture by faba bean and reported pH of SRL varied from 6.47 to 6.62 in various fababean fed treatment groups. However, there were no significant differences in pH among treatments. The differences in total -N, TCA-insoluble protein and ammonia nitrogen in rumen liquor between treatments were not significant. Ammonia-N, TCA-N content in rumen liquor in fababean fed groups were similar as that of the control indicating equal ruminal protein content in all the groups. It shows that utilization of nitrogen in the rumen of the animals fed fababean is comparable to that of conventional feed ingredients. The differences in molar proportions of acetic, butyric and propionic acids were not significant. It indicates that the replacement of groundnut protein with fababean protein of low tannin variety did not alter the fermentation pattern.

Akbar and Gupta (1991) estimated blood metabolites from the earlier experiments. The blood glucose level was 50.00, 46.25, 46.25 and 40.00 mg per 100 ml, respectively, serum total protein was 7.80, 7.60, 7.35 and 7.90 g/100 ml, respectively and serum urea nitrogen concentration was 52.50, 49.50, 47.25 and 49.00 mg/100 ml in group T_1, T_2, T_3 and T_4, respectively. The values obtained were statistically similar in all the treatment groups. The serum creatinine level ranged from 3.15 to 3.60 mg per 100 ml, serum cholesterol was 187.5, 177.5, 185 and 180 mg/100 ml, serum SGPT level was 8.87, 8.79, 8.62 and

8.75 IU/litre, SGOT values were 12.50, 12.50, 12.00 and 13.50 IU per litre and haemoglobin levels were 12.30, 11.87, 11.50 and 13.12 g per 100 ml, respectively. Like other blood parameters, these parameters were also statistically similar and not affected by feeding of fababean.

Jutz and Leitgeb (1991) conducted experiment in lactating cows, fed soyabean, fababean and peas with wheat barley based diet supplemented with molasses. The daily milk yield was 20.4, 19.4 and 20.2 kg, milk fat content was 4,35, 4.20 and 4.35 per cent and protein content 3.51, 3.47 and 3.44 per cent. Cows consumed 67, 68 and 63 g protein and 3.13, 3.22 and 2.99 MJ metabolizable energy per kg milk produced. Protein source had no effect on milk fatty acid composition. the result indicate that fababean have the same nutritive value as soyabean in feeding dairy cattle.

Virk et al. (1991) at CCS Haryana Agricultural University, Hisar conducted a growth cum digestion trial in crossbred goats fed concentrate mixture where 0, 20, 40 and 60 per cent crude protein of GNC was replaced with crushed fababean seeds. No significant differences were observed amongst treatments with respect to DM intake 67.08, 58.81, 62.43 and 57.74 g per kg metabolic body size, respectively, body weight gain 47.66, 42.07, 50.60 and 50.00 g/day, respectively. They reported digestibility coefficient of dry matter (58.88, 55.38, 61.77 and 58.43, respectively), crude protein (57.30, 58.34, 63.18 and 56.74, respectively), ether extract (74.97, 75.81, 73.00 and 82.52, respectively) and

nitrogen free extract (81.56, 83.09, 83.10 and 83.68, respectively) but the digestibility of crude fibre differed significantly (33.06, 40.08, 50.43 and 41.54, respectively). Overall the concentration of blood glucose (39.7, 40.45, 39.96 andn 43.59 %, respectively), serum protein (6.12, 6.21, 6.41 and 6.37, respectively). Serum urea (30.18, 30.96, 34.07 and 32.95 mg/100 ml) and SGOT and SGPT were found at par with control group animals. Therefore, they concluded that fababean could repalce 40 per cent of CP of GNC in ration of growning kids.

At a Research Institute of France, Benchaar et al. (1992) studied the effect of extrusion at 195°C of fababeans on organic matter, nitrogen and starch degradation in the rumen and their flow to and absorption from the small intestine. The diets were composed of 23.1% fababeans, 56.2% maize silage, 10.1% maize grain and 0.7% Italyan ryegrass hay on dry matter basis. The markers Cr-EDTA, $Ybcl_3$ and purines were used in this study particulate and bacterial markers, respectively. They observed that extrusion process of the fababean did not influence intraruminal pH (6.6), ammonia nitrogen (99 mg/litre) and volatile fatty acids (97 mMol/lit). Apparent digestibility of energy, organic matter, nitrogen and starch were not affected with inclusion of extruded fababeans. Efficiency of bacterial protein synthesis (g N/kg organic matter truly digested in the stomach) was higher for extruded bean diets compared with raw bean diets (25 vs 22).

Fritz et al. (1992) fed sheep with diet containing ground peas, lupin or fababeans for 3 months. Rumen volume was estimated by polyethylene glycol (PEG). In rumen digesta taken 1 to 6 hrs after feeding pH, NH_3N, VFA and bacterial nitrogen were estimated. They observed that ground fababean gave lowest value for pH, NH_3N, VFA and highest value for bacterial nitrogen. Molar proportion of acetic, propionic and butyric were not affected by various experimental diets. The rumen volume ranged from 8.5 to 9.3 litres.

At Ciudad University, Madrid, Spain, Caballero et al. (1992) conducted two experiments for 2 years continuously in finishing diets of lambs in order to assess the suitability of fababean. In first year fababeans were compared with soyabean meal with the proportion of maize in the diet 0.15, 0.25 or 0.35, respectively. In the second experiment, the effect of replacing soyabean meal and sunflower meal by inclusion of fababean at proportions of 0, 0.1, 0.2, 0.3 and 0.4 of the diet was studied. They observed in both the experiments, the composition of diet had no significant effect on the average daily gain or the food conversion ratio in either experiment.

2.5 Meat Studies

The published literature is silent to show the effect of sole feeding of fababean on the quality and quantity of mutton.

Leitgeb (1988) in a feeding trials with growing bulls, used 0, 30, 60 and 90 per cent fababean as protein concentrate in experimental feeding. The energy, protein and dry matter

intake between the groups were similar. As slaughter traits were studied the dressing percentage were between 56.1 and 56.5 and the abdominal fat ranged between 11.3 and 12.8 kg. He concluded that fababeans are good alternative to common protein feed stuffs for grazing bulls.

Namiotkiewicz et al. (1991) fed young cattle on prestarter/starter concentrates from 24 to 120 days old on rations containing ground barley (31/51, 7/31, 12/34.50, 7/31 or 12/34.50%, respectively), soyabean meal (36/15, 20/0, 20/0 or 20/0%, respectively), ground yellow peas (0/34, 40/0, 0/0, 0/0 or 0/0%, respectively), ground fababeans (0/0,0/0,0/0,40/30 or 0/0%, respectively) and extruded fababeans (0/0, 0/0, 0/0, 0/0 or 35/30.5%, respectively). Average daily body weight gain was 720, 769, 728, 755 and 745 g and the calves consumed 2.34, 3.23, 3.27, 3.19 or 3.28 oat unit and 579, 470, 520, 474 and 525 g CP/kg gain. They observed that extruded peas and fababeans slightly reduced digestibility of crude protein and nitrogen retention and at 2 months age, slightly reduced fat digestibility but increased fibre digestibility was observed. There was no significant differences between groups in carcass dressing percentage or combination of both.

At the Research Institute, Austria, Pichler (1990) conducted investigations on the use of field beans (Vicia faba var. minor) in fattening young bulls. The experiment was initiated on 29 days old bull calves initially weighing 81 kg. The animals were free access to conventional maize soyabean diets with 0, 50, 75 or 100 per cent soyabean meal replaced by

fababeans 0, 25, 35 and 50 per cent and 0, 15, 25 and 35 per cent in starter and finisher diets for controls and groups 1-3, respectively. Average live weight was not different between groups at 125 or 245 days old, but at 365 days old average live weights were 486, 464, 451 and 457 kg for control and groups 1-3, respectively. Over the total period, digestible crude protein consumed was 542, 539, 605 and 678 g/kg gain. The carcass characteristics were similar for all groups except for net gain and high quality cuts, where control values were higher. There were no digestive problems and it was concluded that fababeans ~~are~~ is suitable for fattening young bulls. If young calves were given high proportion of fababeans, a decreased overall fattening performance must be accepted.

Swartz et al. (1991) studied the effect of diets of varying rumen undegradable protein on dry matter intake, growth, feed efficiency and carcass composition in HF calves from birth to 25 weeks old. Feed efficiency increased with increasing rumen undegradable protein, carcass composition was not affected by dietary treatments for 9-10-11 ribs section or half carcass. Prediction equations for carcass, protein and fat were calculated for 25 weeks. Urea space was not beneficial over live weight for predicting carcass protein and fat in intact male or female Holstein calves.

At a Research Institute of Austria, Ringdorfer (1991) studied the influence of fababean on fattening and slaughter performance in sheep. Male sheep 45 in numbers from about 19.6 to slaughter at 42 kg were given hay 100 g each daily plus

concentrate ad libtum with 0, 20 or 40 per cent fababean replacing soyabean oil meal. Average daily gain, feed conversion and slaughter performance were not different among groups. The experimental animals given 40 per cent fababean had 1 per cent higher carcass yield and about 60 g less perirenal fat. The calcium : phosphorus ratio was unfavourable in all 3 concentrates and it is suggested that 1 per cent calcium carbonate should be added in exchange for barley.

At the Ciudad University, Madrid (Spain), Caballero et al. (1992) conducted two experiments over 2 years to assess the suitability of fababeans in finishing diets of lambs. They reported that increasing amount of fababeans in the basal diet did not affect protein, fat and water content of a loin sample of meat or fatty acid composition of kidney fat.

3. MATERIAL AND METHODS

The research work was conducted in the Department of Animal Nutrition, College of Animal Sciences, Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 1990-92. In order to achieve the objectives (laid down at 1.1 earlier) two sets of experiments were conducted.

3.1 Materials

General considerations in the selection of Experimental Animals.

3.1.1 Experiment I

In the first experiment, eighteen heterogenous crossbred lambs upto 6 months of age, irrespective of sex, were procured from Animal Science College Farm. On an average, weight of lambs ranged from 8.5 to 15.9 kg and these were randomly divided into three groups of six each following CRD. A long term feeding trial of one year duration was conducted on these lambs fed Bakla based rations. Basic approach of feeding was to meet 60 per cent of total ME requirement through concentrate mixture. The control group (T_1-0) was fed conventional concentrate mixture (Table 3). In the experimental group (T_2-25), the protein content in the concentrate mixture given to T_1-0 was replaced to the extent of 25 per cent with Bakla. In the third group (T_3-100) entire protein content of the

concentrate provided solely from Bakla reducing the other protein source components in the concentrate mixture appropriately (Table 3).

3.1.2 Experiment II

The second experiment was conducted on six growing crossbred lambs ranging in age from 3 to 4 months. The weights of the lambs ranged from 6.8 to 13.6 kg. The feeding trial was conducted for 90 days duration. The ration was same as in the control group (T_1-0) of the Experiment I, with the difference that protein content of the concentrate mixture was provided to the extent of 50 per cent from Bakla alone by suitably altering other proteins ingredients (Table 3) and referred as T_4-50.

Table 1. Proximate nutrient composition of concentrate mixture and gram straw fed to experimental lambs during metabolism trial (On 100 per cent DM basis)

Concentrate mixture	Season	DM	CP	EE	CF	NFE	Ash
T_1-0*	Winter	93.785	22.578	2.693	6.390	59.426	8.913
	Summer	92.143	21.556	2.166	6.825	61.994	7.459
T_2-25*	Winter	93.071	22.187	2.599	8.066	58.016	9.132
	Summer	92.714	21.801	2.599	8.213	62.429	6.958
T_3-100*	Winter	90.928	28.965	2.382	12.511	47.172	8.970
Fababean	Summer	91.785	28.986	2.309	12.480	48.396	7.829
T_4-50**		91.427	22.481	2.484	10.967	54.171	9.897
Gram straw	Winter	89.428	7.401	1.536	37.982	39.940	13.141
	Summer	92.714	6.701	1.572	38.098	41.507	12.122

*First set Experiment

**Second set Experiment

In both the experiments, diets were supplemented with 10 g of Sharkofferol (Alembic) in order to supply the required amount of vitamins A, D and E as per NRC (1968) recommendations.

3.1.3 Experimental rations

Gram straw (Cicer arietinum) was fed as roughage, meeting 40 per cent of ME requirement. The ingredients of experimental concentrate mixture for the control group were maize, groundnut cake, wheat bran supplemented with mineral mixture. Various ingredients were procured in one lot. The fababean seed was also obtained in one lot. The proximate nutrient composition of concentrate mixtures and gram straw fed to experimental lambs is given in Table 1 while the proximate nutrient composition of complete feed offered (concentrate : Roughage 60:40 on ME basis) to the experimental lambs is depicted in Table 2. The proximate nutrient analysis is based on samples of feed offered during metabolism trials. Total phenol concentration was 0.333, 0.499, 0.832 and 0.666 in T_1-0, T_2-25, T_3-100 and T_4-50, respectively. The ingredients of various concentrate mixtures are given in Table 3.

The concentrate mixture for the control group was formulated by mixing maize, groundnut cake, wheat bran and mineral mixture with salt. In the concentrate mixture for groups (T_2-25, T_3-100, T_4-50 %) the crude protein content of the control concentrate mixture (T_1-0) was replaced suitably with crushed fababean.

Table 2. Proximate nutrient composition of complete feed (Conc.: Rough, 60:40 on ME basis) fed to experimental lambs during metabolism trial (On 100 per cent DM basis)

Complete feed	Season	DM	CP	EE	CF	NFE	Ash
T_1-0*	Winter	92.569 ±0.305	15.937 ±0.189	2.370 ±0.059	22.503 ±0.583	51.682 ±0.597	7.507 ±1.224
	Summer	93.304 ±0.461	13.985 ±0.166	1.885 ±0.014	22.270 ±0.233	52.780 ±0.201	9.079 ±0.275
T_2-25*	Winter	91.931 ±0.126	15.443 ±0.120	2.155 ±0.020	22.796 ±0.098	49.612 ±0.092	9.994 ±0.319
	Summer	92.958 ±0.627	13.968 ±0.079	2.133 ±0.007	24.224 ±0.542	51.499 ±0.065	8.175 ±0.536
T_3-100*	Winter	90.073 ±0.289	20.298 ±0.720	2.011 ±0.014	26.315 ±0.730	42.973 ±0.331	8.403 ±1.052
	Summer	93.617 ±0.458	19.729 ±0.499	2.133 ±0.191	29.485 ±1.599	41.488 ±1.193	7.165 ±0.915
T_4-50*		92.066 ±0.017	15.572 ±0.059	2.245 ±0.048	25.002 ±0.354	48.362 ±3.329	8.299 ±0.581

* Ist set Experiment
**IInd set Experiment

Table 3. Ingredients composition of concentrate mixture under various treatments (Raw matter basis)

Ingradient	Treatments			
	T_1-0	T_2-25	T_3-100	T_4-50
Maize	40	40	-	20
Groundnut cake	35	21	-	10
Wheat bran	22	17	-	29
Bakla	-	19	97	38
Mineral mixture with salt	3	3	3	3

N.B. 1. Sharkoferrol (Alembic) - Source of vitamin A, D and E was fed to the experimental lambs at the rate of 10 g/lamb/day.

2. Concentrate: Roughage, 60:40 on ME basis was maintained throughout feeding period of one year duration.

3.1.4 Computation of experimental ration

For example, the live weight of the animal was 27 kg, its metabolic body size comes to 11.85 kg so its digestible energy requirement was 3 Mcal/lamb per day (NRC, 1968). From digestible energy we calculate metabolizable energy i.e. ME is 82 per cent of DE as per NRC (1968). Average ME requirement was 3 x 0.82 = 2.46 ME (Mcal/lamb/day). Then it was converted in Kcal i.e. 2.46 x 1000 = 2460 Kcal ME per lamb per day.

Attempts were made to calculate ME requirement per kg of metabolic body size i.e. 2460 ÷ 11.85 = 207.59 say 210 Kcal per kg of metabolic body size. Then from these figures ME requirement/day/lamb comes to i.e. 210 x 11.85 = 2488.5 Kcal/day or 2.488 Mcal/day/lamb. Out of this 60 per cent was supplied from concentrate mixture and rest 40 per cent was met from the roughages (Gram straw).

Now we calculate the amount of different feed/fodder ingredients by using the following energy values:

	TDN (%)	ME (Mcal/kg)
1. Maize	84.90	3.056
2. GNC	71.00	2.556
3. Wheat bran	63.40	2.282
4. Gram straw	52.13	1.930
5. Bakla	69.41	2.690

After calculating the total energy (Metabolizable energy, ME) of ration overall 60 per cent of total energy requirement (ME requirement) was supplied through concentrate and remaining 40 per cent through gram straw. The total ME requirement in

above sample example is 2.488 Mcal/day/lamb, so the 60 per cent of it will be:

$2.488 \times \frac{60}{100} = 1.493$ Mcal was met through concentrate mixture and remaining 0.995 Mcal was supplied through gram straw.

3.1.5 Calculation of daily quantity of feed and fodder

By using the ME values of experimental ration, we can calculate the quantity of feed and fodder required to be given per lamb per day.

For example, we calculate the quantity of T_1 concentrate mixture and gram straw for the above animal.

The ME content of T_1-0 = 2.62 Mcal/kg. Means 2.62 Mcal is supplied through 1000 gms of experimental concentrate mixture, so how much gms of T_1 concentrate mixture will supply 1.493 Mcal ME.

$1000 \times \frac{1.493}{2.62} = 569.85$ gms conc. mixture likewise we calculate the quantity of gram straw also, i.e.

$1000 \times \frac{0.995}{1.93} = 515.54$ gms gram straw

All the four concentrate mixture, thus, formulated were nearly isocaloric and isonitrogenous except T_3-100 because in this group attempt has been made to fed only Bakla with gram straw which contained more nitrogen and energy (ME).

The experimental rations were computed as per NRC (1968) for every fortnight according to precedings lambs body weight. Daily weighed amount of experimental concentrate mixture was supplemented with Sharkofferol (10 g/day/lamb).

The amount of concentrate mixture was rescheduled as per ME requirement (NRC, 1968) every fortnightly.

3.1.6 Housing and management

The experimental lambs were reared at the Animal Nutrition Farm of CCS Haryana Agricultural University, Hisar. The lambs were housed in individual stalls already disinfected with melathione solution (10% w/v) to nullify previous infections, if any. The lambs were vaccinated as per regular schedule and dewormed with appropriate dose of broad spectrum anthelemetics (Helmoni - Alembic) before start of experiment and every fortnight deworming was practiced during the whole experimental period of one year. Every month lambs were sprayed with diluted melathione solution so as to get them prevented from skin infections. Ad libitum clean and whole some drinking water was offered to all the lambs twice a day in winter and thrice a day in summer.

3.1.7 Feeding trial

The long range feeding trial was started on November 7, 1990 after the adaptation period of two weeks on the experimental ration and continued for one year covering winter and summer season. Simultaneously second short term feeding trial of three months duration was started from April 14, 1992 after adaptation period of two weeks and continued for 90 days only. The feed ingredients used were procured in a single lot from the Central Feed and Fodder Store of CCS HAU, Hisar. The weighed quantity of concentrate mixtures was offered to each

lamb daily at about 9.00 a.m. in a clean washed plastic tub and after one hour of offering concentrate mixture the weighed amount of Gram straw was offered to avoid the wastage of concentrate mixture. Under Experiment-I, in first set of experiment, first digestion trial was conducted after the completion of early stage of growth (first six months - during winter season) and simultaneously second digestion trial was conducted at the end of later stage of growth (later six months- during summer season). After 24 hrs of offering the feed, left over was weighed on next day before feeding and watering in morning hours.. For computing the experimental ration for next fortnight, the experimental lambs were weighed on two continuous days and computation of experimental ration was done on average of two days body weights for every fortnight.

3.1.8 Digestion trial

Standard method usually followed under Asian conditions was adopted as described by Krishna and Ranjhan (1991) for conducting digestion trial.

Under Experiment-I, in first set of experiment one digestion trial was conducted at the end of first six months feeding period and simultaneously another digestion trial was conducted at the end of second half of year (at later stage of growth). In experiment-II, a digestion trial was conducted at the end of 90 days feeding period. Daily records of concentrate mixture and gram straw offered, weigh back, faeces and urine voided were maintained during the period of 7 days collection period.

3.1.9 Collection of samples of feed and fodder

The representative samples of feed and fodder offered and residue from each treatment were collected and preserved for proximate nutrient analysis. At the end of the trial all the samples of feed and fodder collected during 7 days were pooled separately and a representative samples of concentrate mixtures and Gram straw were ground and analysed for proximate nutrient composition as per AOAC (1984) standard methods followed in Asian laboratories compiled by Krishna and Ranjhan (1980).

3.1.10 Sampling of faeces voided

The fresh faeces voided daily during 24 hours by the individual lambs were collected from the cage. Suitable aliquot was taken for determination of dry matter and nitrogen daily. For dry matter determination one-tenth part of total faeces voided was weighed in an enamelled tray and dried in hot air oven at 100 $\pm$ 5°C for 24 hours and transfered to numbered paper bags. The weight of empty tray plus faecal sample was recorded and samples were preserved for further analysis. For nitrogen determination, every day an aliquot 1/20th part of total faeces was weighed daily and preserved with 40 per cent sulphuric acid (w/v) in wide mouth plastic bottles as mentioned by Krishna and Ranjhan (1991).

3.1.11 Sampling of urine

Urine of all experimental lambs was collected daily by using collection bags (which are fixed to the urine conduit in metabolic cages) measured and representative samples 1/10th of

volume of urine voided was taken for nitrogen estimation and 50 ml urine sample was measured separately in a plastic bottles for estimation of titrable alkalinity. The urine sample was preserved with 5 ml tolune (antifungal chemical). At the end of digestion trial pooled sample was used for nitrogen estimation. The titrable alkalinity of urine was estimated daily during metabolism trial following the method of Morris and Garcia Rivera (1955).

3.1.12 Sampling of rumen liquor

Rumen liquor samples were collected after every digestion trial for each test diet. It was collected 4 hours post feeding with the help of stomach tube using negative suction pressure. The rumen liquor samples collected were strained through four layers of muslin cloth and kept in plastic bottles. Immediately thereafter, pH of the rumen liquor sample was recorded by digital pH meter. The strained rumen liquor (SRL) samples were used for further analysis. Later about 100 ml of strained rumen liquor samples of each test diet were poured separately into clean plastic bottles containing few drops of 10 per cent (w/v) mercuric chloride. These samples were stored in deep freezer and used for further estimation of different nitrogenous fractions.

For the estimation of volatile fatty acids 9.5 ml of strained rumen liquor (SRL) was mixed with 0.5 ml of 50 per cent formic acid (v/v) and centrifuged at 3000 rpm for 10 minutes. The supernatant was then stored in small capped glass vials (culture tubes) at 4°C in a refrigerator for injecting in

Gas Liquid Chromatgraph (GLC) made by Hewlett and Packard Model-5890A column (Cottyn and Boucque, 1968 modified by Astrup and Associates 1973).

3.1.13 Collection of blood samples

Blood samples were collected from jugular vein using sterilized sharp 16 gauge stainless steel needles at the end of each digestion trials at two hours prior to feeding, samples of blood were collected in previously marked oven dried test tubes. After collection, the blood containing test tubes were kept in slanting position and then the clot was separated from wall of tubes by clean glass applicator stick. It was then centrifuged for 15 minutes at 3000 rpm and clean serum was withdrawn and stored at 4°C in a separate small capped glass vials (culture tubes) for estimation of total protein, urea nitrogen, ammonia nitrogen and non protein nitrogen.

3.1.14 Slaughter studies and carcass evaluation

Six crossbred lambs each of T_1-0 and T_3-100 batch ~~each~~ and four lambs of T_2-25 batch were slaughtered at about one and half year age after completion of one year experimental feeding in the slaughter house located at the Department of Animal product Technology, CCS Haryana Agricultural University, Hisar. The minced samples were packed in polyethyene bags and sealed. The prepackaged samples were kept in deep freeze. At the time of analysis samples were thawed by keeping at room temperature. Immediate after slaughter, Meat : bone ratio was studied for each cut (Foreleg , hind leg and Loin) by standard method of

Palsson (1939). Meat samples thus collected were freed from the visible fat and then minced thoroughly to make them homogenous.

3.2 Methods

The various analytical techniques employed for the analysis of samples of feed, faeces, urine, strained rumen liquor (SRL), blood serum, meat samples and water metabolism studies were as follows:

3.2.1 Proximate nutrient analysis

Samples of feed, faeces and weigh back (residue) were analysed for dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE) and ash by using AOAC (1984) methods. Nitrogen content of the pooled urine sample was determined by conventional microkjeldahl method of AOAC (1984).

3.2.2 Tannic acid (Total phenol) assay

Tannic acid content of experimental concentrate mixture was estimated by standard methods of AOAC (1970, 1984). Determination of tannic acid is accompanied by extraction of sample with ether to remove fats. Precipitation of salts is resorted by organic and inorganic reagents. Formation of coloured products and the oxidation with acid permanganate on a volumetric basis is the main basic principle of analytical method.

2 g sample was extracted for 20 hours with anhydrous ether. Residue was boiled for 3 hours with distilled water, diluted and filtered and volume was made to 500 ml, 25 ml infusion was taken, 20 ml of indigo-solution and 750 ml water

was added to it and titrated against standard $KMnO_4$ solution. Simultaneously blank was also run i.e. without sample. Difference in readings of samples and blank was noted. Per cent tannic acid (Total phenol) was calculated by following formula:

$$\% \text{ Tannic acid} = \frac{\text{Reading x 0.001664 x Volume made x 100}}{\text{Aliquote taken x Weight of sample}}$$

3.2.3. Protein solubility

The solubility of experimental rations in each solvent was determined by the method of Crooker *et al*. (1978). The feed stuff to be analysed was ground through a 1 mm mesh seive and analysed for total protein (AOAC, 1984). The composition of various mineral solvents is given in Table 4.

Procedure

Exactly 2.0 g of sample was taken in 150 ml Erlenmeyer flask and 100 ml of mineral solvent (preheated in a water bath at 40°C) was added and incubated at 40°C for over night to extract nitrogen in water bath. After extraction the sample was filtered through Whatman No. 4 filter paper and washed 5-7 times by lukewarm distilled water. Then filter paper alongwith residue was digested for protein estimation and distilled, then back titrated with N/100 HCl to work out the insoluble protein content following standard (AOAC,1984) procedure. Later on soluble protein was estimated by difference. Per cent total soluble protein was determined by following formula:

$$\% \text{ Protein solubility} = \frac{\text{Total soluble protein}}{\text{Total protein incubated in the substrate}} \times 100$$

Table 4. Composition of mineral solvent mixtures used during present study

Sr. No.	Salts	Physiological saline (NaCl) (g/lit)	Artificial saliva (AS) (g/lit)	Bicarbonate phosphate buffer (PB) (g/lit)	Burrough's mineral mixture (BMM) (g/lit)
1.	$NaH_2PO_4.2H_2O$	-	-	23.401(A)	-
2.	Na_2HPO_4	-	-	26.7 (B)	10.41
3.	$NaHCO_3$	-	9.80	-	26.25
4.	$Na_2HPO_4.7H_2O$ (anhydrous)	-	7.00 (3.71)	-	-
5.	KCl	-	0.57	-	3.75
6.	NaCl	9.0	0.47	-	3.75
7.	$MgSO_4.7H_2O$	-	0.12	-	1.113
8.	$CaCl_2$	-	0.04	-	0.25
9.	$(NH_4)_2\ SO_4$	-	-	-	18.75
10.	$FeSO_4$	-	-	-	0.04
11.	$CoCl_2.6H_2O$	-	-	-	0.01
12.	$ZnSO_4.7H_2O$	-	-	-	0.04
13.	$MnSO_4,H_2O$	-	-	-	0.03
14.	$CuSO_4.5H_2O$	-	-	-	0.02

AS - After dissolving above salts in 1 lit. distilled water the CO_2 gas was passed for 10 minutes till the pH 7 is reached.

PB - A and B were prepared separately and taking 195 ml of A and 3-5 ml of B were mixed together, made the volume upto 1 litre with distilled water and pH was adjusted to 7 by bubbling pure CO_2 in the flask.

Autoclaved rumen fluid (ARF) alongwith incubated substrate was centrifuged at 1500 rpm for 10 minutes prior to filtering through Whatman filter paper No. 4 and blank without substrate was also run simultaneously so as to deduct the nitrogen contribution from the extraneous sources.

3.2.4 Protein degradability

Protein degradability of different concentrate mixture [T_1-(0), T_2-(25), T_3-(100) and T_4-(50)] were determined by nylon bag method of Mehrez andØrskov (1977) modified by Mehrez et al. (1980).

The sample was ground through 1 mm seive and predried at 60-70°C. The sample size of 5-7 mg/cm bag surface was used. The pore size of nylon was approximately 32-40 mμ so as to get maximum exposure to microbial digestion. This method was adopted by Krishna and Günther (1987) in their study where all the five existing in vitro methods were compared.

About 5 g substrate was taken in a preweighed nylon bag. The bags were tied separately with a nylon string. The other end of string was tied to a iron ring fitted inside the top of the cannula. The free length between the top of the cannula and the ring was about 50 cm. The bags were soaked in water for 1 minute and then suspended in rumen of fistulated cattle. The bags were withdrawn at different intervals 6, 12 and 24 hours of incubation. Then washed thoroughly under running tap water till the rinsing water was colourless and later on transferred in the deep freeze for over night and on next day the bags were transferred to shaking water bath for 4 hours at

39°C. They were then dried to a constant weight at 100°C. The proportion of dry matter which had disappeared was calculated and that left in the bag after incubation, was taken to determine nitrogen content (AOAC, 1984). By difference the degradability of nitrogen was calculated by using the formula of Mehrez and Ørskov (1977) later on modified by Mehrez et al. (1980).

$$p = a + \frac{bc}{c+k}$$

Where

p = Effective degradability

a = 100 - % degradability

b = % degradability

c = 0.087 (Degradation rate)

k = 0.04 (Ruminal passage rate)

3.2.5 Protein digestibility at abomasum and intestinal level

In vitro protein digestibility was estimated by standard methods of Gutcho (1973) using pure protein digesting enzyme. In first stage one gram sample of concentrate mixture was weighed in 100 ml Erlenmeyer flask to which 20 ml of gastric fluid (Dissolve 2.0 g NaCl in 950 ml distilled water, add 3.2 g pepsin in this solution and deliver 7 ml conc. HCl to this solution, adjust the pH to 2 with aqueous NaOH) was added and incubated for 4 hours with continuous shaking at 39°C in water bath. At the end of first incubation period, contents of flask were neutralized with 2.4 ml 0.12 M NaOH. In the second stage 20 ml intestinal fluid (Dissolved 2 g NaCl in 950 ml distilled water, added 3.2 g pepsin in this solution and deliver 7 ml

conc. HCl, adjust the pH of this solution to 7.0 with 0.1 N NaOH, add pancreatin enzyme 1.0 mg/ml of solution) was added and incubated for additional 48 hours at 39°C. At the completion of second stage, the content of the flask was filtered through Whatman paper No. 54 by washing with hot water, weighed and dried in oven at 105°C for overnight and transferred alongwith treated substrate to Kjeldahl flask for determination of crude protein by AOAC (1984) method accordingly digestibility of crude protein was estimated by deducting the amount of protein presented in the enzyme treated substrate from the original crude protein present in the raw material.

3.2.6 Digestible energy (DE)

Digestible energy (DE) of complete experimental rations (concentrate and roughage) was calculated by using Rostock equation, based on digestible coefficients of proximate nutrients obtained during present studies published by Schiemann et al. (1971) as given below:

$$DE\ (Mcal/kg.DM) = 5.72 \times CP + 9.05 \times EE + 4.38 \times CF + 4.06 \times NFE$$

3.2.7 Metabolizable energy(ME)

Metabolizable energy content of complete experimental rations (concentrate and roughage) was calculated by using Rostock equation, based on digestible coefficients of proximate nutrients obtained during present studies published by Schiemann et al. (1971) as given below:

$$ME\ (Mcal/kg\ DM) = 4.49 \times CP + 9.05 \times EE + 3.61 \times CF + 3.66 \times NFE$$

3.2.8 Metabolizability of gross energy (q)

Metabolizability of gross energy of experimental rations was calculated by using ARC (1980) based on equations by Van Es (1978).

$$q = \frac{ME}{DE} \times 100$$

3.2.9 Net energy for maintenance (NEm)

Net energy for maintenance was calculated by using the equations given by Lofgreen and Garrett (1968).

Log F = 2.2577 - 0.2213 x ME (Mcal/kg) then obtain Antilog F of this final figure

$$NEm \text{ (Mcal/kg DM)} = \frac{77}{\text{Anti log F}}$$

N.B. Convert Mcal/kg to MJ/kg by multiplying with 4.186.

For example,

Calculate NEm from ME = 2.486 Mcal/kg

Log F

= 2.2577 - 0.2213 x ME

= 2.2577 - 0.2213 x 2.486

= 2.2577 - 0.5501

= 1.7076 (See antilog)

Antilog F = 51.003

$$NEm = \frac{77}{\text{Antilog F}}$$

$$= \frac{77}{51.003}$$

= 1.5097 Mcal/kg DM

3.2.10 Net energy for gain (NEg)

Net energy for gain (NEg) was calculated by using the equations given by Lofgreen and Garrett (1968) as follows:

NEg (Mcal/kg DM) = 2.54 - 0.0314 x Antilog F

For example : Calculate NEg for above example

NEg (Mcal/kg DM) = 2.54 - 1.601

= 0.938 Mcal/kg DM

3.2.10.1 Gross efficiency of protein utilization: Brody's (1945) formula was used to calculate gross efficiency of protein utilization taking into consideration the amount of crude protein consumed per day versus amount of protein deposited in the gained biomass.

$$\text{Gross efficiency of protein utilization} = \frac{\text{Amount of protein deposited in gained biomass}}{\text{Amount of crude protein consumed}} \times 100$$

3.2.10.2 Gross efficiency of energy utilization: Brody's (1945) formula was used to calculate gross efficiency of energy utilization, taking into consideration the amount of ME consumed per day per lamb and calorific value of gained biomass (based on factor of Bath et al., 1965).

$$\text{Gross efficiency of energy utilization} = \frac{\text{Amount of energy deposited in gained biomass}}{\text{Amount of ME consumed including maintenance cost}} \times 100$$

3.2.11 Rumen metabolic profile study

3.2.11.1 pH: The pH of strained rumen liquor (SRL) was determined by using digital pH meter immediately after sampling using standard buffer of 7 pH (BDH) freshly prepared.

3.2.11.2 Ammonia nitrogen: Ammonia nitrogen of SRL was determined by using the standard method of Cooke and Sansum (1976) as given below:

Measure 10 ml of SRL, add 2 ml of 50 per cent trichloro acetic acid (TCA), mix and allow to stand. Centrifuge at 3000 rpm for 15 minutes. Use the supernatant for ammonia nitrogen assay. The supernatant was diluted 10 times in a prewashed and dried test tube. Take 0.2 ml of diluted rumen liquor, add to it 5 ml of Reagent A (Dissolve 10 g phenol and 0.05 g sodium nitroprusside in little ammonia free distilled water and make the volume to 1.0 litre with ammonia free distilled water). Add 5 ml of Reagent B (Dissolve 5.0 g sodium hydroxide and 8.4 ml of sodium hypochlorite solution (containing 4-6% available chlorine) in little amount of ammonia free distilled water and make the volume to one litre with ammonia free distilled water). Mix and incubate at 37°C for 15 minutes. Measure the O.D. at 650 nm using spectronic 20 (Bosch and Lomb). Simultaneously prepare the standard solution by dissolving 707.8 mg ammonium sulphate in 100 ml of ammonia free distilled water. This will give 0.3 mg N per 0.2 ml of solution. Prepare working solution by diluting standard solution to 100 times.

Calculation

3 mg N in 0.2 ml standard solution gives O.D. 0.446, so 1 mg N in 0.2 ml solution will give $\frac{0.446}{3} = 0.148$. Calculate reading of sample (R) : Observe O.D. of sample at 650 nm is divided by 0.148 (1 mg N in 0.2 ml gives 0.148 O.D.) 10 ml of solution is effectively 1 ml of SRL.

$$\text{Ammonia nitrogen (mg/100 ml of SRL)} = \frac{R \times 10 \times 100}{0.2 \times 1000}$$

3.2.11.3 Volatile fatty acids fractions: The volatile fatty acids (VFA) were estimated by using GLC following the original method of James and Martin (1952) later modified by Annison (1954), Cottyn and Boucque (1968) and finally modified at the Agricultural University of Norway, ÅS-NLH (Astrup and Associates, 1973). This method was followed by Krishna (1973) at the Agricultural University of Norway during his Ph.D. dissertation work and the same has been adapted during the current study. During current investigation, Gas-liquid chromatograph. Hewlett Packard, GLC-5890 A. Installed in the Department of Animal Nutrition, CCS Haryana Agricultural University, Hisar was used.

An aliquot of 9.5 of strained rumen liquor (SRL) was mixed with0.5 ml of 50 per cent formic acid and centrifuged for 10-15 minutes at 2000 rpm and supernatant was preserved in capped culture tubes in the freezer for quantitative estimation of vFA. An aliquot of one microlitre processed rumen liquor was injected in the GLC column. Glass column was filled with Supelco-101-catalogue NO. 02-0213 manufactured by Supelco S.A. Switzerland. Flow of N_2 and H_2 was 20 kg/cm^2 and 1 kg/cm^2, respectively.

Injection temperature	:	220-230°C
Oven temperature	:	190°C
Detector temperature	:	210-250°C
Sensitivity	:	100
Attenuator	:	128

A volatile fatty acid standard was prepared as given below:

VFA	Milli equivalent per litre	Per cent
Acetic acid	50	0.300
Propionic acid	20	0.148
Isobutyric	5	0.044
Butyric	20	0.176
Isovaleric	5	0.051
Valeric	5	0.051

N.B. After every six samples a standard was run simultaneously and then followed by blank.

The calculation of the contents of acid was carried out. For each acid the relative (R) was calculated as below:

$$\text{Concentration of acid mEq/lit} = \frac{\text{Peak height (counts) in unknown sample} \times \text{mEq/lit acid in standard}}{\text{Peak height (counts) of standard}}$$

3.2.11.4 Total protein in strained rumen liquor (SRL): 2 ml of SRL was taken in a micro Kjeldahl flask, digested and processed for nitrogen estimation as per standard methods of AOAC (1984) without any dilution.

3.2.11.5 Non protein nitrogen and true protein nitrogen: 10 ml SRL was taken in a centrifuge tube mixed with 1 ml 30% trichloroacetic acid (TCA) and centrifuged at 3000 rpm for 15 minutes, supernatant was discarded. Precipitate was transferred on filter paper (Whatman No. 54) with distilled water and washed with boiled water six times and washed precipitate alongwith filter paper was digested, distilled

directly without making volume. About 50 ml distillate was collected in 2% boric acid indicator mixed solution and back titrated with N/100 HCl using mixed indicator, thus, NPN was calculated as given below:

NPN = Crude Protein - True Protein

3.2.12 Blood serum analysis

Blood serum was analysed for total protein, non protein nitrogen, ammonia nitrogen and urea nitrogen.

3.2.12.1 Total protein (Biuret Reagent Method): Total protein content of serum was estimated by using Transesia Blood Analyser (Model - Erba Chems) following Biuret method. For estimation, the procedure was followed as laid down in operating manual as described below:

Principle

Peptide bonds of protein form blue violet coloured complex with cupric ions in an alkaline medium and the intensity of colour is proportional to the number of peptide bonds and the colour is read at 546 nm (530 to 570 nm). The final colour is stable for 8 hours.

Reagent

(i) **Biuret reagent:** It contains
0.02 M copper
0.16 M sodium potassium tartrate
0.2 M sodium hydroxide

(ii) **Folin-Ciocalteu reagent (Ames)** titrated and diluted to equal 1 mol/lit. HCl.

Composition of standard

Albumin 6 g/dl (bovine albumin solution standardised against human serum albumin).

Procedure

10 ml of serum was taken in cuvette by micro pipette then add 1 ml of biuret reagent in it mixed and kept for incubation upto 20 minutes. After 20 minutes take out the cuvettes from incubator and inverted once. Put the instrument switch in the 'ON' position, insert the capillary in cuvette containing the standard and calibrate to read 6 g/dl. Replaced this cuvette with test cuvette and read the results in g/dl at 546 nm.

3.2.12.2 Ammonia nitrogen: Ammonia nitrogen content was determined by using the standard method of Cooke and Sansum (1976).

The details of estimation procedure are same as already given under procedure of rumen metabolic profile for ammonia nitrogen.

3.2.12.3 Urea nitrogen: Urea nitrogen content was estimated by Conway (1957) diffusion technique.

Principle

The ammonia liberated in the outer chamber by addition of alkali is absorbed in boric acid plus indicator in central chamber. The pH of this mixture being approximately 5 before absorption. During ammonia absorption, the pH of mixture rises from 4 to 8. After required incubation period, the fluid in the central chamber is titrated to a faint permanent reddish tint with standard acid.

Reagents

(i) Boric acid: 10 g pure boric acid was weighed into a one litre flask, add 200 ml absolute alcohol and about 700 ml distilled water and then add 10 ml of mixed indicator on mixing, the whole solution is brought to the desired end point colour of faint reddish which usually requires the addition of a little dilute acid (N/100 HCl).

(ii) Mixed indicator: This contains bromocresol green, 0.033 per cent and methyl red 0.066 per cent in alcohol.

(iii) N/10 HCl: Dissolved 8.845 ml conc. HCl in 1 lit. distilled water.

(iv) Saturated potassium carbonate: 110 g K_2CO_3 was weighed in 250 ml beaker, add 100 ml of distilled water and heated until dissolved.

(v) Gum arabic fixative: 10 g of powdered gum acacia was taken in beaker, and to this 15 ml of distilled water, 5 ml of glycerol and 5 ml of saturated potassium carbonate was added. The mixture was allowed to settle over night.

(vi) Urease phosphate buffer enzyme using urease tablet

A. Dissolve 27.6 g sodium dihydrogen phosphate in 1 lit. ammonia free distilled water.

B. Dissolve 71.7 g disodium hydrogen phosphate in 1 lit. ammonia free distilled water.

Then mixed 39.0 ml of A and 61.0 ml of B in measuring cylinder and made the volume to 200 ml by adding ammonia free distilled water and then adjust the pH 7 . Then dissolved urease tablet at the rate of 10 mg/ml phosphate buffer was added to prepare urease enzyme.solution.

(vii) Urea standard solution: Dissolve 5 g reagent grade urea in water and diluted to 1 lit. Out of this pipette 20 ml of this solution into 250 ml volumetric flask and diluted to volume with phosphate buffer to the marked volume. The dilution contains 2 mg urea/5 ml.

Procedure

Smear the gum arabic fixative on the brim of lid of Conway petridish. Added 1 ml of boric acid indicator in the central chamber, then put 1 ml urease phosphate buffer in outer chamber and add 1 ml serum into it. Mixed urease enzyme with serum by tilting the Conway petridish. Incubated at 39°C for 105 minutes (1.75 hrs). After incubation added 1 ml saturated potassium carbonate in outer chamber and again incubate the contents at 39°C for 105 minutes (1.75 hrs). After completion of incubation, the contents of central chamber was titrated with N/10 HCl using calibrated syringe, simultaneously blank was run so as to deduct ammonia contribution from extraneous sources.

Urea nitrogen was calculated by following formula:

Urea nitrogen (mg/100 ml) = R x A x 100 X 0.04 x 14

Where,

R = Reading of calibrated syringe

A = Normality of acid used

0.04= Calibration constant of syringe developed against standard urea solution

3.2.12.4 Non protein nitrogen: 10 ml serum was taken in a centrifuge tube mixed with 1 ml 30% trichloroacetic acid (TCA) and centrifuged at 3000 rpm for 15 minutes, supernatant was discarded. Precipitate was transferred on filter paper (Whatman No. 54) with distilled water and washed with boiled water 6 times simultaneously precipitate alongwith filter paper was digested, distilled without making volume, about 50 ml distillate was collected in 2% boric acid and back titrated with N/100 HCl using mixed indicator, thus NPN was calculated as given below:

NPN = Crude protein - True protein

3.2.13 Crude protein in gained biomass

Crude protein in gained biomass was calculated as per chemical composition reported by Pearson (1973).

3.2.14 Calorfic value in terms of metabolizable energy (ME) in gained biomass

Energy equivalent of gained or lost biomass was calculated as 1 kilogram of body weight change was equivalent to 5 Mcal of energy deposited as published by Bath et al. (1965).

3.2.15 Water metabolism studies

Water intake was calculated from the quantity of voluntary water drunk and water of feed from moisture per cent present in natural form. Based on figures of digestible crude protein, digestible carbohydrate and digestible ether extract consumed was multiplied by 0.44, 0.60 and 1.07, respectively to calculate metabolic water produced (Brody, 1945). The water

outgo was estimated from urinary and faecal moisture. Difference between water intake and outgo was denoted as "Apparent water balance". It was assumed that the water balance in the adult animal is zero.

3.2.16 Slaughter studies

During present investigation, standard method published by Scotish worker Palsson (1939) was followed adapted during current investigation.

Six crossbred lambs of treatment T_{1-0} and T_{3-100} batch each and four lambs of T_{2-25} batch were slaughtered at about one and half year age in the slaughter house located at the Department of Animal Products Technology, College of Animal Sciences, CCSHAU, Hisar. The lambs were not fed experimental ration preceding 12 hrs of actual slaughtering. The lambs were brought to the abattoir. The lambs were weighed using hanging salter balance before slaughtering. The lambs to be slaughtered was placed on the bleeding table by hanging the head towards the floor of abattoir and keeping the neck on the edge of bleeding table. The sharp knife was used to split the neck till the jugular vein was exposed and started bleeding. The blood oozed out from the jugular vein was collected in a beaker placed below central hole of bleeding table. In about 15-20 minutes entire blood from the body came out and the entire carcass was hanged on the salter balance to weigh the lamb, so as to work out the weight of blood oozed out from the body.

The carcass was hanged on the clutch hook of the abattoir, scaling and then the skin was detached at abdominal viscera and through the legs (foreleg and hindleg) by putting the folded hands between skin and viscera. Then head and hooves of foreleg and hindleg were detached from the hanging carcass.

The incission was put in the middle of abdominal region so as to expose the internal contents of abdomen and pluck. The visceral fat was also detached from the viscera and then the different body organs, rumen alongwith content, the weight of intestine and evacuated rumen were weighed together to workout the weight of empty intestine, simultaneously the weight of heart, liver, kidney, lungs and trachea and spleen were recorded. The carcass weight referred to hereafter, except where otherwise stated indicates the weight of dressed carcass weight without head, feet and pluck.

The entire carcass was splitted into two halves by a cut vertically through the flank to the anterior edge of the last rib on each side then the curve of ribs was followed to the vertibral column where the latter severed at the junction of the last and second to last thoracic vertibrae. The last thoracic vertibrae was therefore left on the hind quarters.

3.2.17 Carcass measurements

Large number of different measurements of the carcass were recorded. Linear measurements were taken in carcass with a linen tape scale in centimeters (Appendix-I).

The following external measurements were taken on the carcass, hanging in the abattoir, suspended from a gamble of constant width.

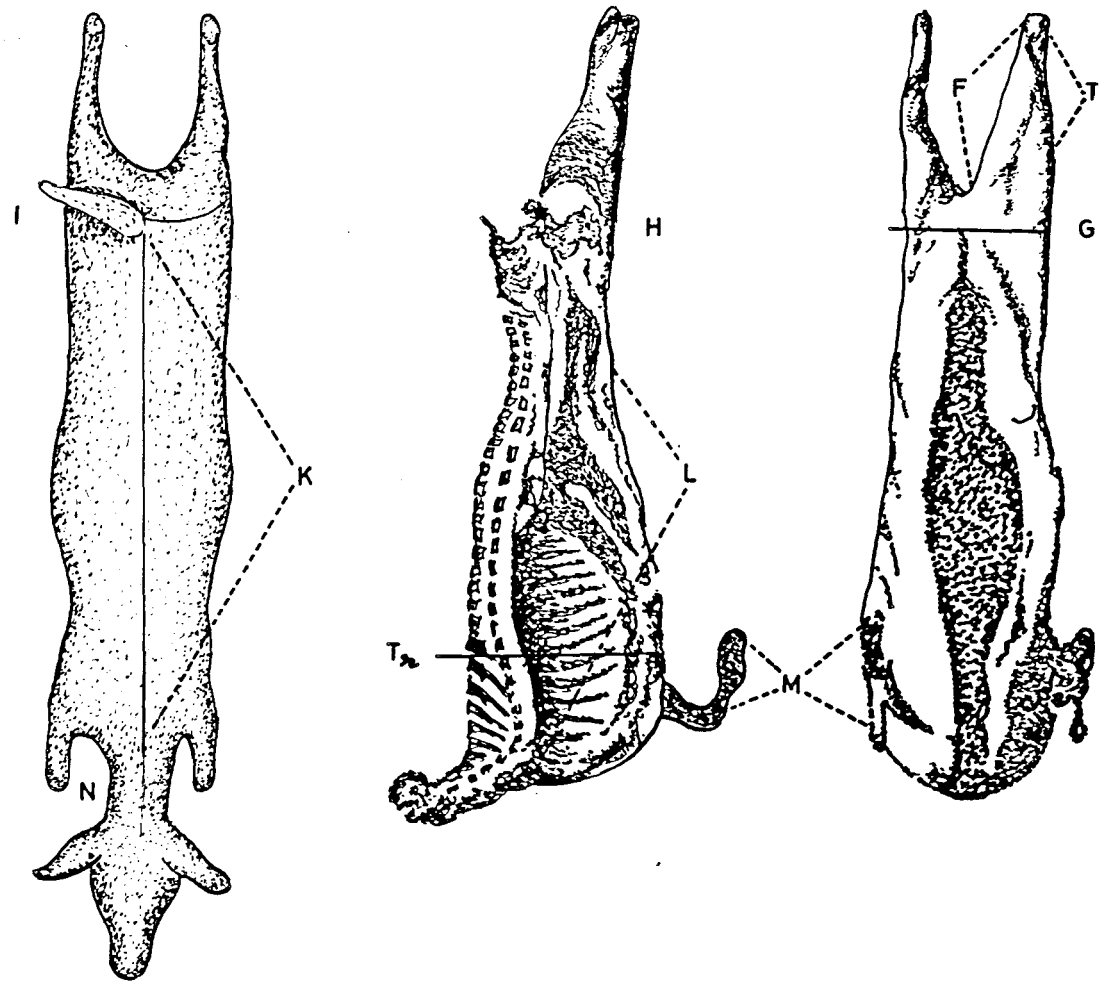


Fig. 1. Carcass measurements

1. F = Leg length
2. G = Width of gigots
3. H = Depth of gigots
4. I = Fullness of thighs

From a point just below the patella on one side, the tape was passed under the tail to a corresponding point on the other side.

5. K = Length of body from the tail head to the base of neck
6. L = Length of body from the symphysis pubis to the anterior edge of the middle the first rib
7. M = Length of fore cannon (metacarple)
8. N = Length of neck
9. R = Length of radium ulna from the olecranon process to the styloid process
10. T = Length of tibia plus tarsus from the tubercle on the proximal end of the tibia to the anterior edge of the distal end of the tarsal
11. Th= Depth of thorax. The maximum depth of chest behind the shoulders.

N.B. - The above points of measurement are depicted in Fig. 1 and the photograph of deressed experimental lambs under different treatments T_1-0, T_2-25 and T_3-100 are presented in photographs 1-9.

3.2.18 Measurement of eye muscle (Longissimus dorsi)

The length, width and depth of the eye muscle was noted. Loin eye area of longissimus dorsi muscle at 13th rib level was recorded by marking its outline on a tracing paper and surface area was measured by using Placom, Digital Planimeter, KP-90 N.

A. 'Length' of eye muscle: The maximum distance across the cross section surface of the longissimus dorsi from the end next the spinal process outwards along the rib.

B. 'Depth' of eye muscle: The distance at right angle to 'A' on the same surface. Judging of musculature round the femurs and between legs and judging compactness of hind quarters:

(i) F-T = This difference between leg length and the length of tibia gives very good idea of development of musculature.

(ii) $\frac{G \times 100}{F}$ - The width of gigot (G) expressed as % of the length of leg is a good index of the compactness of hind quarters, as a high positive correlation with the weight of muscle expressed as % of the bone weight in lambs.

(iii) Shape index of the eye muscle: It was calculated by using the following formula:

$$\frac{B \times 100}{A}$$

(iv) Dressing percentage: During current investigation dressing percentage was calculated by using following formula.

$$\text{Dressing percentage} = \frac{\text{Weight of hot carcass minus Wt. of head, hooves, pluck and gastro intestinal tract}}{\text{Preslaughter weight}} \times 100$$

3.2.19 Meat : bone Ratio

For working out the meat: bone ratio different primal cuts viz., foreleg, hindleg and loin were deboned by sharp knife and weight of the lean meat was taken to calculate this parameter. Net corrected daily gain for every fortnight were calculated by using dressing percentage (Saue, 1968).

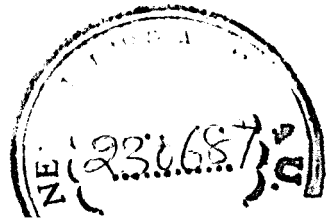


Photo 1. Experimental animal from treatment T_1-0

Photo 2. Experimental animal from treatment T_2-25

Photo 3. Experimental animal from treatment T_3-100


T1
C-2347


T2
C-582

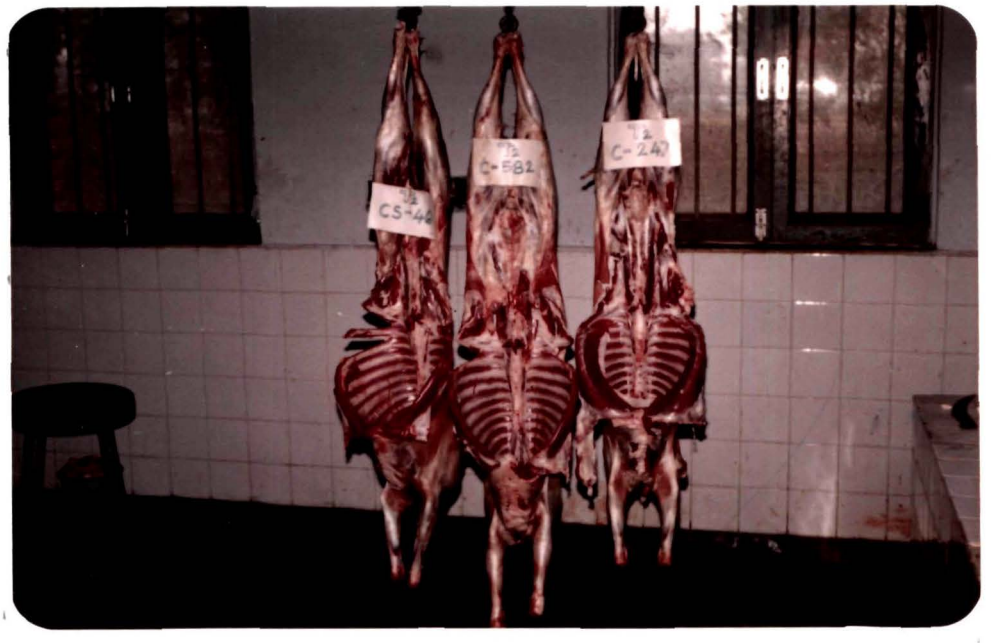

T3
C-658

Photo 4. Full carcass produce from treatment T_1-0

Photo 5. Full carcass produce from treatment T_2-25

Photo 6. Full carcass produce from treatment T_3-100


C-2317
C-625
C-652


C-582
C-247
CS-442

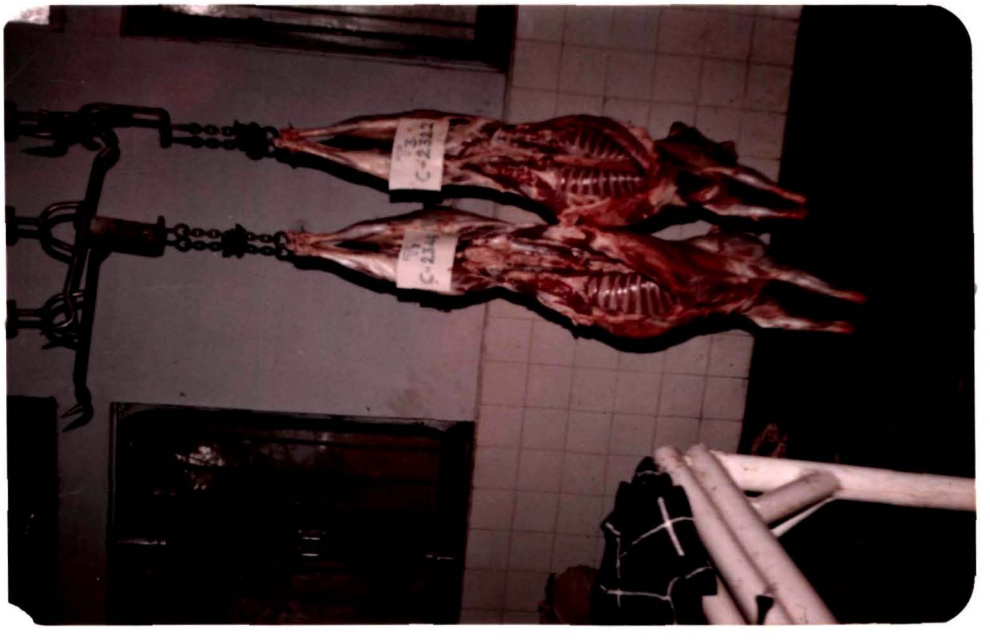
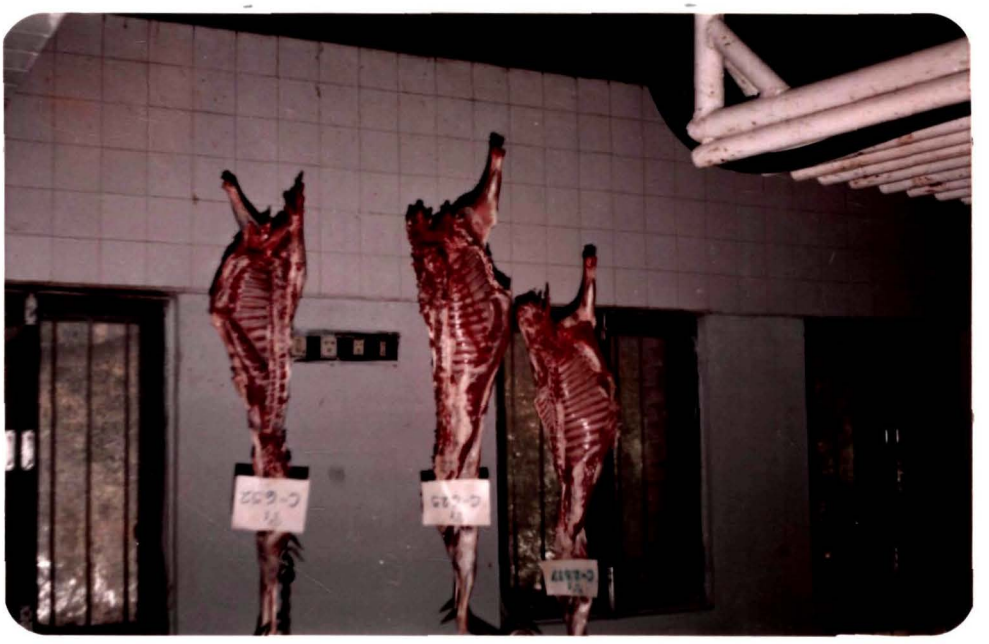
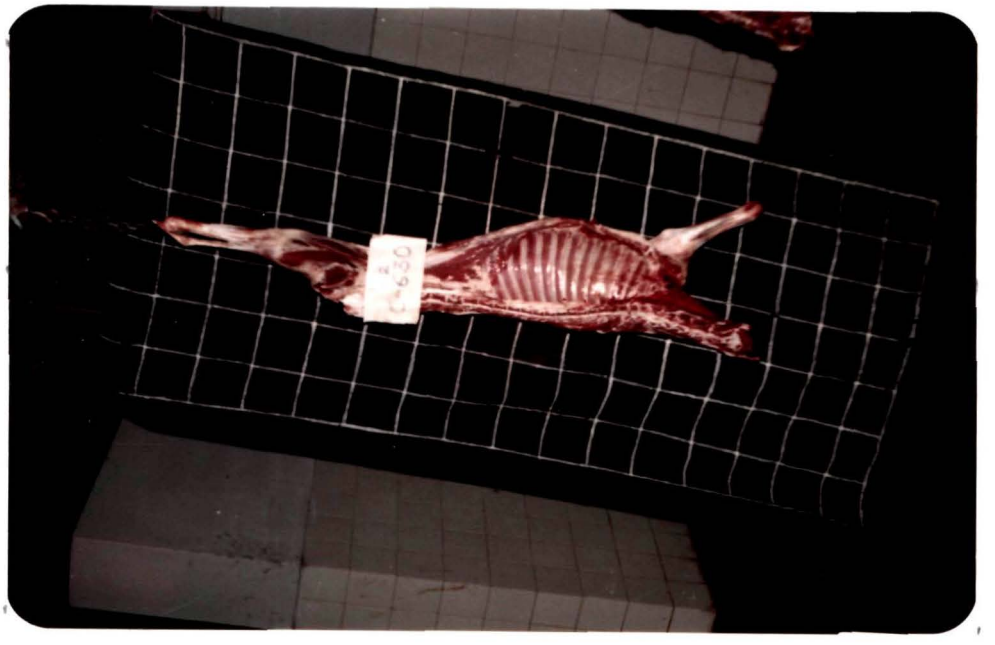


Photo 7. Half carcass produce from treatment T_1-0

Photo 8. Half carcass produce from treatment T_2-25

Photo 9. Half carcass produce from treatment T_3-100

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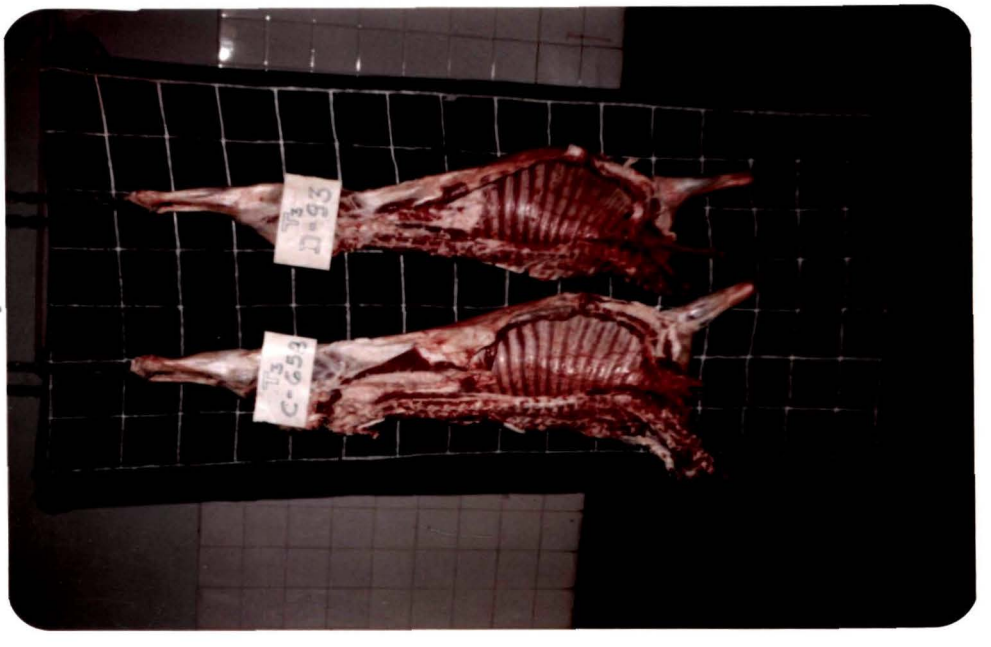
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3.2.20 Organoleptic evaluation

The standard Hedonic Scale (9 point) suggested by Peryam and Pilgrim (1957) was used for organo-leptic evaluation of composite meat sample (from the lambs under T_1-0, T_2-25 and T_3-100). The score card used during present investigation is presented under Appendix-II. The evaluation was done in the sensary evaluation laboratory of Department of Animal Products Technology. A panel of five semi trained persons were selected for the evaluation. Precautions were taken to avoid the biasness in judging for particular treatment group by not allowing them to know code numbers. The judges were requested to wash their mouth in between the use of two different samples. The time of testing was kept constant throughout the investigation.

The detailed carcass measurement chart is given in the Appendix I.

3.2.21 Proximate chemical composition

Proximate chemical composition of the meat samples was done as per the standard methods of AOAC (1984).

3.2.22 Histological examination

While performing slaughter studies, on opening the carcass the samples were collected from rumen wall, liver and kidney for microscopic examination. About 5 mm thick pieces of tissues from rumen wall, liver and kidney were collected in 10 per cent formalin solution for fixation of tissues. The pieces of preserved tissues were processed for paraffin embedding (Steedman, 1968) and paraffin sections of four micron thickness

were cut from paraffin embeded tissue block. The micro sections were stained with haemotoxylin and Eosin (H & E) and mounted with DPX (Luna, 1968). The stained sections were examined under the microscope and the changes, if any, were recorded.

3.2.23 Statistical methods and processing of data

The experimental observations obtained from the experiment were compiled, tabulated and statistically analysed following the factorial completely randomized design (2 FCRD) and simple completely randomised block (CRD) design for slaughter studies. The factors considered for the analysis were two seasons as factor one and three treatments (three type of experimental T_1, T_2 and T_3) as second factor with six replications, by using Electronic Computors ECIL, Micro-32 and LT-32 N installed in the Department of Mathematics and Statistics and Department of Animal Breeding of the University. Simple and multiple regression equations were fitted using Karl Pearson method considering the observations recorded on daily body weight gain, nitrogen retained, gross efficiency of energy and protein utilization. Statistical procedures described by Snedecor and Cochran (1980) were followed to analyse the raw data.

4. RESULTS AND DISCUSSION

The results of the current investigation are elaborated in tabulated form and described in brief alongwith discussion in this chapter.

Experiment I: Nutritional evaluation of Bakla based on long term (one year) feeding for growth in lambs

The results of Experiment-I conducted in order to evaluate the nutritive value of fababean (Vicia faba L.) are compiled and discussed below in this chapter. This experiment was conducted at two stages of growth viz., early stage during winter season and inlater stage during summer season and the data presented under each table should be read as above. The feeding of the lambs was started at the age of about 6 months and continued for one year. During early stage, coupled effect of winter season as well as age might have affected the nutritional wisdom system of animal and simultaneously during later stage of growth, coupled effect of summer season and age might have affected the research data presented under various tables of this dissertation.

4.1 Solubility and Degradability of Experimental Ration

4.1.1 Degradation of dry matter and protein in the rumen is entirely dependent upon their solubility due to presence of paunch microflora and other mineral solvents. The data with

respect to solubility are presented in Table 5. The perusal of results indicate that the solubility of fababeans protein (T_3-100) was observed highest (57.168%) in Burrough's mineral mixture (BMM) followed by artificial saliva (McDougall's buffer), ~~artificial saliva~~ (48.423) and autoclaved rumen fluid (ARF) (42.433%). Highest solubility was observed in T_1-0 and T_2-25 in Burrough's mineral mixture (52.107 and 43.769%, respectively) followed by artificial saliva (AS) (35.801 and 48.423%). While in T_4-50 the highest solubility was observed in artificial saliva (AS) (40.350) followed by Burrough's mineral mixture (BMM) (37.085%). It indicates that BMM is most efficient in extracting nitrogen from all experimental rations while solubility under artificial saliva (AS) treatment was more comparable to ARF than other solvents. However, no specific trend was observed, similar findings have been reported by Crooker et al. (1978) in their published work.

4.1.2 Degradability of dry matter and protein as tested by nylon bag method

The values for dry matter and protein degradability of experimental feeds fed to experimental lambs are presented in Table 6. The rumen degradation of dry matter and protein followed a linear relationship. The percentage degradability of protein and dry matter observed was highest at 24 hours incubation and lowest at 6 hours of incubation while the effective degradability of protein and dry matter was highest at 6 hours and lowest at 24 hours of incubation. It indicates that as time of incubation increases, the degradability

Table 5. Solubility of experimental rations in different mineral solvents

Treatment feed	Mineral solvent	Total crude protein (%)	Insoluble protein (%)	Soluble protein (%)	Per cent solubility
	DW		18.347	3.750	16.971
	AS		14.186	7.911	35.801
T_1-0	PB	20.097	19.104	2.993	13.545
	BMM		10.583	11.514	52.107
	NaCl		14.232	7.865	35.593
	ARF		15.600	6.497	29.402
	DW		18.548	3.899	17.370
	AS		13.817	8.630	38.446
T_2-25	PB	22.447	17.413	5.034	22.426
	BMM		12.622	9.825	43.769
	NaCl		16.006	6.441	28.694
	ARF		15.091	7.356	32.770
	DW		20.152	6.641	24.786
	AS		13.819	12.974	48.423
T_3-100	PB	26.793	15.930	10.863	40.544
	BMM		11.476	15.317	57.168
	NaCl		20.290	6.503	24.271
	ARF		15.424	11.369	42.433
	DW		18.554	3.927	17.468
	AS		13.410	9.071	40.350
T_4-50	PB	22.481	17.268	5.213	23.188
	BMM		14.144	8.337	37.085
	NaCl		15.797	6.684	29.732
	ARF		14.328	8.153	36.266

DW = Distilled water
AS = Artificial saliva (Mc Dougall, buffer)
PB = Bicarbonate phosphate buffer
BMM = Burrough's mineral mixture
NaCl = Sodium chloride
ARF = Autoclaved rumen fluid

Table 6. Degradability of protein and dry matter by nylon bag technique at different *in vivo* rumen incubation periods

Sr. No.	Time (hrs)	Treatment	Crude protein (%)	Undegradable protein (UDP) (%)	Rumen degradable protein (RDP) (%)	Protein degradability (%)	Protein effective degradability (p)	Dry matter degradability (%)	Dry matter effective degradability (p)
		T_1 -0	22.097	7.191	14.906	67.450	78.756	53.568	83.126
1.	6	T_2 -25	22.447	6.717	15.730	70.070	77.981	54.438	82.852
		T_3-100	26.793	7.049	19.744	73.690	76.790	33.805	89.351
		T_4 -50	22.481	6.607	15.874	70.608	77.761	44.787	85.892
		T_1-0	22.097	6.192	15.905	71.979	77.329	58.625	81.533
2.	12	T_2-25	22.447	5.423	17.024	75.840	76.113	43.981	86.146
		T_3-100	26.793	4.145	22.648	84.530	73.376	48.308	84.783
		T_4-50	22.481	4.171	18.310	81.445	74.348	57.077	82.021
		T_1-0	22.097	5.882	16.215	73.382	76.887	62.827	80.209
3.	24	T_2-25	22.447	5.258	17.189	76.576	75.831	66.974	78.903
		T_3-100	26.793	2.427	24.366	90.941	71.351	63.874	79.880
		T_4-50	22.481	3.663	18.818	83.708	73.635	70.828	77.689

increases and simultaneously effective degradability decreases with increase in incubation time. The degradability of dry matter was 53.568, 58.625 and 62.827 where as effective degradability was 83.126, 81.533 and 80.209 per cent at 6, 12 and 24 hours incubation, respectively, similar trend was observed for degradability of protein also. It means that there is a inverse relationship between per cent degradability and effective degradability.

The highest degradability of protein observed was 73.69, 84.53 and 90.94 per cent at 6, 12 and 24 hours of incubation, respectively in T_3-100 followed by T_2-25 and T_1-0 (70.07, 75.84 and 76.576 and 67.45, 71.979 and 73.382%), respectively. While the effective degradability of protein observed was more at three incubation periods in T_1-0 (78.756, 77.329 and 76.887%), respectively.

The findings of present study are in agreement with Aufrere et al. (1991) who had reported that in situ degradability of fababean was 90 per cent. Aguilera et al. (1992) who had reported that the effective degradability of protein was reduced with increase in incubation time and Cros et al. (1992) reported that effective degradability of dry matter diminished (74.6 vs 80.4) and in case of crude protein it was 70.2 vs 89.2 per cent, respectively.

4.2 In vitro Protein Digestibility at Abomasum and Intestinal level

The mean values of protein digestibility (in vitro) at abomasum and intestinal level based on protein digesting enzyme

viz., pepsin and pancreatine are presented in Table 7. The digestibility values at abomasum level were 48.705, 54.386, 37.774 and 41.846 per cent while at intestinal level these were 54.939, 56.125, 59.260 and 55.057 per cent in T_1-0, T_2-25, T_3-100 and T_4-50, respectively. It is clear from the perusal of results that the digestibility in T_3-100 was lowest (37.774%) at abomasum and highest (59.260%) at intestinal level. This may be due to the presence of higher concentration of tannins which binds the protein and made it available at the intestinal level.

4.3 Proximate Nutrient Composition and Intake of Experimental Ration Based on Digestion Trial

The formulated ration of different treatments and various ingredients of ration viz., maize, groundnut cake (GNC), wheat bran, Bakla (Fababean) and gram straw were processed for proximate composition analysis. The results related to per cent proximate nutrients i.e. crude protein (CP), ether extract (EE), crude fibre (CF), nitrogen free extract (NFE) and ash of various concentrate mixtures, Gram straw and complete feed are presented in Table 1 and 2.

The perusal of data presented in Table 1 and 2 envisage that concentrate mixtures (T_1-0, T_2-25, T_3-100 and T_4-50) as well as complete feed have enough availability of nutrients to meet maintenance and growth requirement as per NRC (1968) recommendations. The complete feed under treatment T_3-100 supplied maximum protein as fababean itself is having 6.4 per cent more protein as compared to conventional control group feed under treatment T_1-0.

Table 7. Protein digestibility at abomasum and intestinal level based on *in vitro* study using protein digesting enzyme (Pepsin and Pancreatin)

Sr. No.	Treatment	At abomasum level			At intestinal level		
		CP (%) on DM basis	Undigested CP (%)	Digestibility (%)	CP (%) on DM basis	Undigested CP (%)	Digestibility (%)
1.	T_1-0	22.097	11.334	48.705	22.097	9.957	54.939
2.	T_2-25	22.447	10.239	54.386	22.447	9.848	56.125
3.	T_3-100	26.793	16.671	37.774	26.793	10.915	59.260
4.	T_4-50	22.481	13.096	41.746	22.481	10.103	55.057

The results of proximate nutrient composition of fababean (Table 1) are in accordance with Brisson et al. (1950), Evans (1961), Eden (1968), Hill et al. (1977), Hove et al. (1978), Akbar (1989) and Van der Poel et al. (1991). However, the ash content is towards higher side.

Average daily proximate nutrient intake during the digestion trial under various treatments are presented in Table 8. The average dry matter consumption expressed as g per kg metabolic body size in both the seasons as well as during early and late stage of growth under various treatments was statistically non-significant ($P<0.05$), the interaction effect was also non-significant. However, it is worth noting that total dry matter intake per day was more in T_2-25 (910.6 g/day) followed by T_3-100 and T_1-0 (808.1 and 796.2 g/day). It is interesting to note that the palatability of ration based on sole feeding of fababean (T_3-100) was at par with control group (T_1-0).

The data related to actual crude protein intake during digestion trial are presented in Table 8. It appear to be significantly ($P<0.05$) higher in T_3-100 (159.06 g) as compared to T_1-0 and T_2-25 (133.56 and 118.25 g/day, respectively). This may be due to the fact that the T_3-100 ration was higher in crude protein content in comparison to T_1-0 and T_2-25 and it was sole feeding of fababean as complete replacement of concentrate. There was no effect of season on CP intake and interaction effect was also non-significant ($P<0.05$).

Net total daily ether extract intake on an average under various treatments (T_1-0, T_2-25 and T_3-100) was 16.629, 19.495

Table 8. Body weight, metabolic body size and proximate nutrient intake during digestion trial

Sr. No.	Attributes	Season*	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	Body weight (kg)	Winter	24.700 ±2.944	27.933 ±2.542	28.766 ±1.107	27.133 ±1.336
		Summer	28.400 ±2.327	33.633 ±2.432	36.933 ±2.611	32.989 ±1.583
		Mean	26.550^{a} ±1.874	30.783^{b} ±1.884	32.850^{b} ±1.828	
2.	Metabolic body size ($W^{0.75}_{kg}$)	Winter	11.011 ±0.967	12.104 ±0.824	12.412 ±0.363	11.842^{x} ±0.438
		Summer	12.298 ±0.742	12.932 ±0.757	14.945 ±0.807	13.725^{y} ±0.494
		Mean	11.655^{a} ±0.613	13.018^{ab} ±0.600	13.678^{b} ±0.569	
3.	Total dry matter intake (g/day)	Winter	716.270 ±99.505	863.364 ±67.153	787.508 ±69.086	789.048 ±45.749
		Summer	876.061 ±88.292	957.923 ±68.650	829.728 ±142.169	887.904 ±58.079
		Mean	796.160 ±67.840	910.644 ±47.950	808.618 ±75.624	
4.	Total dry matter intake ($g/W^{0.75}_{kg}$)	Winter	64.786 ±5.966	71.193 ±2.935	63.391 ±4.883	66.456 ±2.711
		Summer	70.608 ±3.818	68.584 ±2.142	54.154 ±7.267	64.448 ±3.196
		Mean	67.697 ±3.489	69.888 ±1.776	58.772 ±4.440	
5.	Total crude protein intake (g/day)	Winter	113.461 ±14.976	133.136 ±10.075	157.838 ±10.105	134.812 ±7.840
		Summer	123.116 ±13.748	134.000 ±10.168	160.284 ±24.020	139.134 ±9.942
		Mean	118.289^{a} ±9.715	133.568^{ab} ± 6.825	159.061^{b} ±12.440	
6.	Total EE intake (g/day)	Winter	16.791 ±0.078	18.574 ±1.396	15.795 ±1.307	17.053 ±0.927
		Summer	16.467 ±1.540	20.417 ±1.420	16.259 ±2.858	17.715 ±1.203
		Mean	16.629 ±1.234	19.496 ±0.989	16.027 ±1.500	

Table 8.. contd..

Sr. No.	Attributes	Season*	Treatments T_1-0	T_2-25	T_3-100	Season Mean
7.	Total NFE intake (g/day)	Winter	367.988 ±48.629	428.215 ±33.163	339.336 ±31.559	378.513 ±22.76
		Summer	461.702 ±45.334	493.194 ±34.963	352.364 ±68.649	435.753 ±31.585
		Mean	414.845^{a} ±34.701	460.705^{ab} ±24.974	345.850^{b} ±36.073	
8.	Total CF intake (g/day)	Winter	160.442 ±21.677	196.707 ±15.192	205.212 ±14.271	187.454 ±10.527
		Summer	194.139 ±17.703	232.588 ±18.935	234.374 ±29.464	220.367 ±13,086
		Mean	177.290 ±14.277	214.648 ±12.775	219.793 ±16.214	

*Each figure is an average of six values.
Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values							
		Body weight (kg)	Metabolic body size(kg)	Total DM intake (g/day)	Total DM intake ($g/w^{0.75}_{kg}$)	Total CP intake (g/day)	Total EE intake (g/day)	Total NFE intake (g/day)	Total CF intake (g/day)
Season	1	308.587	31.898	87953.962	36.284	168.117	3.934	29487.815	9749.686
Treatment	2	123.764	12.782	47338.671	416.016	5091.492	41.216	40109.797	6457.037
Season x Treatment	2	15.017	1.168	10408.575	170.899	65.884	3.610	5017.543	35.230
Error	30	34.495	3.522	51904.625	140.035	1291.157	20.538	12450.705	2444.371
	CD_1	3.837	1.126	NS	NS	23.476	NS	NS	NS
	CD_2	4.699	1.501	NS	NS	28.752	NS	89.284	NS
	CD_3	NS	NS	NS	NS	NS	NS	NS	NS

and 16.027 g/day, respectively. The intake of ether extract was statistically ($P<0.05$) at par in all the treatments and interaction effect was non-significant ($P<0.05$).

The data related to metabolizable energy (ME) and digestible crude protein (DCP) under the various treatments for both the seasons during digestion trial are presented in Table 9. It is observed that season has no effect on ME and DCP consumption per kg metabolic body size(g/ $W^{0.75}_{kg}$) and DCP intake g/100 Kcal ME intake, ME intake per kg of metabolic body size was higher in T_2-25 (177.230 Mcal/kg) followed by T_1-0 and T_3-100 (169.645 and 153.025 Mcal/kg, respectively). Overall digestible crude protein, per kg of metabolic body size was significantly ($P<0.05$) higher in T_3-100 (11.698) followed by T_2-25 and T_1-0 (9.512 and 8.388, respectively). Simultaneously digestible crude protein intake g/100 Kcal ME intake was significantly ($P<0.05$) higher in T_3-100 (7.669) followed by T_2-25 and T_1-0 (5.358 and 4.910, respectively).

The findings of the present study envisage that ME and DCP intake under various treatments could meet the requirements of protein and energy for maintenance and growth as per recommendations of National Research Council (1968), however, availability of digestible crude protein was more than NRC (1968) recommendations and such trend has been observed as the computation of ration was done on energy basis.

4.4 Proximate Nutrient Digestibility

The apparent digetibility of proximate nutrients under various treatments are presented in Table 10. The trend of data

Table 9. Metabolizable energy (ME) and digestible crude protein intake (DCP) under the various treatments during digestion trials

Sr. No.	Attributes	Season*	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	ME intake ($Kcal/W^{0.75}_{kg}$)	Winter	168.503 ±13.210	179.251 ±7.785	167·331 ±11.170	171.695 ±6.081
		Summer	170.780 ±8.229	175.209 ±6.706	138.718 ±16.144	161.571 ±7.222
		Mean	169.645 ±7.427	177.230 ±4.936	153.025 ±10.305	
2.	DCP intake ($g/W^{0.75}_{kg}$)	Winter	8.033 ±0.979	9.608 ±0.749	11.657 ±0.749	9.766 ±0.577
		Summer	8.742 ±1.040	9.416 ±0.724	11.739 ±1.731	9.966 ±0.740
		Mean	8.387 [a] ±0.689	9.512 [a] ±0.724	11.698 [b] ± 0.899	
3.	DCP intake (g/100 Kcal ME intake)	Winter	4.769 ±0.411	5.351 ±0 .370	7.005 ±0.262	5.708 ±0.299
		Summer	5.051 ±0.425	5.364 ±0.324	8.332 ±0.445	6.249 ±0.419
		Mean	4.910 [a] ±0.285	5.357 [a] ±0.234	7.668 [b] ±0.317	6.249

*Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values		
		ME intake (Kcal/$W^{0.75}$ kg)	DCP intake (g/$W^{0.75}$ kg)	DCP intake (g/100 Kcal ME intake)
Season	1	922.407	3.5884	26.3099
Treatment	2	1839.368	340.0154	263.0571
Season x Treatment	2	799.108	6.4027	14.4654
Error	30	733.197	66.8581	8.5949
	CD_1	NS	NS	NS
	CD_2	NS	2.0689	0.7418
	CD_3	NS	NS	NS

presented in Table 10 envisage that season has significant ($P<0.05$) effect on apparent digestibility of proximate nutrients except crude protein and ether extract.

4.4.1 The apparent digestibility of dry matter was significantly ($P<0.05$) higher in winter (63.533) in comparison to ~~season~~ summer (61.904). It was similar in T_1-0 and T_2-25 (61.733 and 62.966) but in T_3-100, it was significantly ($P<0.05$) higher (63.456) than T_1-0 (61.733). The figures of dry matter digestibility obtained during present study are towards higher side than the findings of Pal and Pandey (1970) who had reported that the dry matter digestibility coefficient of Akra (Vicia species) in cattle ranged from 52.80 to 57.43, however, the dry matter digestibility data of present experiment are in

Table 10. Apparent digestibility coefficients of proximate nutrients under various treatments based on *in vivo* digestion trials

Sr. No.	Attributes	Season*	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	Dry matter	Winter	62.487 ±0.382	63.196 ±0.811	64.915 ±0.569	63.533^{Y} ±0.414
		Summer	60.978 ±0.743	62.737 ±0.741	61.998 ±0.612	61.904^{X} ±0.419
		Mean	61.733^{a} ±0.459	62.966^{ab} ±0.528	63.456^{b} ±0.593	
2.	Crude protein	Winter	71.350 ±1.420	72.088 ±0.398	73.872 ±0.357	72.437 ±0.540
		Summer	70.664 ±1.247	70.246 ±0.266	73.387 ±0.428	71.433 ±0.540
		Mean	71.007^{a} ±0.907	71.167^{a} ±0.359	73.629^{b} ±0.276	
3.	Ether extract	Winter	60.751 ±0.551	61.114 ±0.486	62.000 ±0.373	61.289 ±0.288
		Summer	58.898 ±1.062	61.897 ±1.117	62.880 ±1.000	61.255 ±0.709
		Mean	59.825^{a} ±0.635	61.551^{b} ±0.595	62.440^{b} ±0.527	
4.	Crude fibre	Winter	48.635 ±0.564	56.330 ±0.390	59.754 ±0.712	54.906^{X} ±1.169
		Summer	47.930 ±0.432	58.585 ±0.461	62.798 ±1.013	56.437^{Y} ±1.563
		Mean	48.283^{a} ±0.355	57.457^{b} ±0.446	61.276^{c} ±0.748	
5.	Nitrogen free extract	Winter	75.299^{D} ±0.709	70.807^{BC} ±0.809	73.654^{CD} ±0.953	73.253^{Y} ±0.647
		Summer	70.803^{BC} ±1.039	69.973^{AB} ±1.216	67.390^{A} ±1.469	69.389^{X} ±0.766
		Mean	73.051^{a} ±0.905	70.390^{a} ±0.729	70.522^{b} ±1.260	

*Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values				
		Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
Season	1	23.858	9.077	0.010	21.097	134.421
Treatment	2	9.468	25.926	21.227	535.193	26.986
Season x Treatment	2	4.561	1.607	7.454	11.721	23.015
Error	30	2.603	4.111	4.062	2.402	6.919
	CD_1	1.098	NS	NS	1.012	1.790
	CD_2	1.345	1.690	1.680	1.240	2.193
	CD_3	NS	NS	NS	1.754	3.101

line with the findings of Akbar (1989) who had reported the digestibility coefficient of dry matter under various treatments as 64.54, 63.82, 64.10 and 66.12 at 0, 15, 30 and 45 per cent fababean fed to buffalo calves. Akbar and Gupta (1990) reported that dry matter digestibility of fababean by difference in sheep was 67.41 per cent. Virk *et al.* (1991) reported dry matter digestibility coefficient of fababean based diets was 58.88, 55.38, 61.77 and 58.43 at 0, 20, 40 and 60 per cent crude protein replacement levels in crossbred goats.

4.4.2 Average digestibility of crude protein in three treatments was 71.007, 71.167 and 73.629 in T_1-0, T_2-25 and T_3-100, respectively, indicating a significant ($P<0.05$) differences within treatments. There was no significant

($P<0.05$) variation in T_1-0 and T_2-25 (71.007 and 71.167) but T_3-100 (73.62 g) was significantly higher in comparison to others. The effect of season and interaction was not significant ($P<0.05$). Pandey et al. (1966) reported that the digestibility coefficient of crude protein was 63.16 to 66.26 in cattle fed Akra and wheat straw and in another experiment with bulls, was 81.05 by difference method.

Sharma and Nicholson (1975) observed apparent digestibility of crude protein was not significant with mature sheep fed soyabean, water treated fababean, formaldehyde treated fababean, and the values were 73.0, 67.9 and 66.5, respectively. While Giovanni et al. (1976) concluded that apparent digestibility of crude protein was slightly less in fababean than soyabean meal fed group in rearing calves. At CCS Haryana Agricultural University, Hisar, Akbar (1989) reported that the apparent digestibility of crude protein was 73.69, 73.55, 73.96 and 70.60 in ration containing 0, 15, 30 and 45 per cent fababean levels in diet of buffalo calves. The differences were non-significant among the treatments. Another team at the CCS Haryana Agricultural University, Hisar, Virk et al. (1991) observed no significant ($P<0.05$) differences in the apparent digestibility of crude protein in crossbred goats. It was 57.30, 58.34, 63.08 and 56.74 at 0, 20, 40 and 60 per cent crude protein replacement from groundnut cake with fababeans.

4.4.3 The average crude fibre digestibility under various treatments (T_1-0, T_2-25 and T_3-100) was 48.283, 57.547 and 61.276, respectively. These observations indicate that the digestibility of crude fibre under the various treatment groups was significantly ($P<0.05$) different. The differences among the seasons were also statistically significant ($P<0.05$). The digestibility of crude fibre was more in summer than winter (56.437 vs 54.906, respectively) but the interaction effect was not significant. The crude fibre digestibility was significantly ($P<0.05$) higher in fababean fed groups than control. This may be due to the more microbial protein synthesis because of more digestible protein and digestible carbohydrate.

Akbar and Gupta (1990) observed that the apparent digestibility of crude fibre was 57.78 in adult sheep fed fababean with gram straw. The data of present study are in concordance with Virk et al. (1991), the values were 33.06, 40.08, 50.43 and 41.54 at 0, 20, 40 and 60 per cent CP of groundnut cake replacement by crushed fababeans. There was indication that the digestibility of crude fibre increases with increasing level of fababean.

4.4.4 The apparent digestibility of ether extract in T_1-0, T_2-25 and T_3-100 was 59.825, 61.551 and 62.440, respectively. The data indicates, significantly ($P<0.05$) higher digestibility of ether extract under T_2-25 and T_3-100 in comparison to T_1-0. This may be due to associative effect of utilization of

nutrients. The effect of season and interaction was not significant.

4.4.5 The digestibility of soluble carbohydrates (NFE) was 73.051, 70.390 and 70.522 in T_1-0, T_2-25 and T_3-100, respectively. Statistical analysis revealed that digestibility of soluble carbohydrates under T_1-0 (73.051) was significant ($P<0.05$) higher than T_2-25 and T_3-100 (70.390 and 70.522, respectively). The effect of season and interaction on nitrogen free extract was significant ($P<0.05$). It was higher ($P<0.05$) in winter (73.253) when compared to summer (69.389).

4.4.6 The results related to total digestible nutrient (TDN) and digestible crude protein(DCP) kg per 100 kg ration under the treatments, T_1-0, T_2-25 and T_3-100 were 62.465, 67.700 and 64.490 and 10.613, 10.472 and 14.744, respectively and these are presented in Table 11. The values of digestible crude protein under various treatments are marginally higher than the NRC (1968) recommendations because complete experimental rations contained crude protein per cent ranged from 14 to 20, while as per NRC (1968) recommendations, balanced complete feed should supply crude protein approximately 10 per cent. It is worth noting that the availability of total digestible nutrients (TDN) from complete experimental ration was at par with the recommendation of NRC (1968). The availability of energy among treatments were almost similar which indicated that the animals maintained on ration consisting fababean and gram straw in the ratio 60:40 on energy basis could meet energy requirement for maintenance and growth.

Table 11. Nutritive value of experimental ration based on *in vivo* digestion trial conducted at two stages of growth

Sr. No.	Attributes	Season	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	Digestible crude protein (DCP) (kg/100 kg ration)	Winter	11.381 ±0.361	11.132 ±0.081	15.003 ±0.593	12.505^{Y} ±0.482
		Summer	9.844 ±0.228	9.813 ±0.080	14.484 ±0.417	11.380^{X} ±0.553
		Mean	10.613^{a} ±0.308	10.472^{a} ±0.206	14.744^{b} ±0.354	
2.	Total digestible nutrients (TDN) (kg/100 kg ration)	Winter	64.494^{C} ±1.417	62.060^{AB} ±0.421	65.207^{C} ±1.132	63.920 ±0.668
		Summer	60.437^{A} ±0.771	63.340^{ABC} ±0.814	63.774^{BC} ±1.281	62.517 ±0.643
		Mean	62.465 ±0.983	62.700 ±0.477	64.490 ±0.843	
3.	Digestible* energy (DE) (Mcal/kg)	Winter	3.000^{BC} ±0.067	2.893^{AB} ±0.017	3.087^{C} ±0.058	2.995^{Y} ±0.034
		Summer	2.777^{A} ±0.034	2.929^{B} ±0.034	3.028^{BC} ±0.066	2.911^{X} ±0.036
		Mean	2.890^{a} ±0.050	2.911^{ab} ±0.019	3.057^{b} ±0.023	
4.	Metabolizable* energy (ME) (Mcal/kg)	Winter	2.624^{C} ±0.058	2.517^{AB} ±0.015	2.654^{BC} ±0.047	2.599^{Y} ±0.028
		Summer	2.423^{A} ±0.030	2.552^{BC} ±0.030	2.595^{BC} ±0.054	2.524^{X} ±0.028
		Mean	2.524^{a} ±0.044	2.535^{a} ±0.017	2.625^{b} ±0.035	

Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

*Based on prediction equations published by Schiemann *et al.* (1971).

ANOVA TABLE

Source of variation	D.F.	M.S.S. values			
		DCP (kg/100 kg ration)	TDN (kg/100 kg ration)	DE (Mcal/kg)	ME (Mcal/kg)
Season	1	11.397	17.721	0.062	0.051
Treatment	2	70.655	14.720	0.099	0.036
Season x Treatment	2	0.861	21.368	0.053	0.042
Error	30	0.720	0.364	0.015	0.010
	CD_1	0.577	NS	0.083	0.069
	CD_2	0.707	2.103	0.102	0.085
	CD_3	NS	NS	0.144	0.121

When energy utilization was measured in terms of TDN, the effect of season was non-significant ($P<0.05$) while the interaction effect was significant. Among the experimental groups, it was more in T_3-100 (64.49) followed by T_2-25 and T_1-0 (62.700 and 62.465%, respectively). In case of digestible crude protein (DCP) the effect of season and treatment were significant ($P<0.05$), the value was significantly ($P<0.05$) more in winter (12.505%) than summer (11.380%), however, T_1-0 and T_2-25 were statistically similar but T_3-100 differs significantly than the others. In nutshell, the nutritive value in terms of DCP and TDN, the experimental ration was adequate in order to supply energy and protein for maintenance and growth as per NRC (1968) recommendations during current investigation.

The data of present study are in line with the findings of Akbar (1989) who had reported the TDN per cent 60.81, 61.62, 61.90 and 63.98 and DCP per cent 10.16, 10.15, 10.14 and 10.08 at 0, 20, 40 and 60 per cent CP replacement from fababean in the ration of buffalo calves, respectively. On an average, the values among the treatment were non-significant.

Mean average values of digestible energy (Mcal/kg ration) based on in vivo digestion trial are 2.89, 2.911 and 3.057 in T_1-0, T_2-25 and T_3-100, respectively. The effect of season, treatment and interaction were statistically significant ($P<0.05$). It was more in winter (2.995) than summer (2.911) among the treatments T_1-0 and T_2-25 simultaneously T_2-25 and T_3-100 were statistically same but T_1-0 and T_3-100 differ significantly.

The metabolizable energy (Mcal/kg ration) was 2.524, 2.535 and 2.625 in T_1-0, T_2-25 and T_3-100, respectively. The effect of season, treatment and interaction were significant ($P<0.05$). It was marginally more in winter than summer. Among the treatments T_1-0 and T_2-25 were similar but T_3-100 was significantly higher to T_1-0 and T_2-25.

Akbar (1989) observed no significant differences in the energy values expressed as DE 2.66, 2.69, 2.73 and 2.38 (Mcal/kg) at 0, 20, 40 and 60 per cent crude protein replacement from fababean, respectively in buffalo calves.

If energy in terms of TDN compared with DE and ME, it can be revealed that DE and ME are better measures of energy

because it is observed that TDN system was unable to produce the effect of season and treatment in the present experiment while it has been significantly affected in case of DE and ME. It also proves that TDN under estimates the energy value of roughages and lignin which is indigestible, could easily be extracted with soluble carbohydrate portion (NFE) when treated with 1.25 per cent acid and alkali in Weende fibre method developed by Prof.Henneberg and Stohman at the University of Göttingen (Germany). In nutshell the trend of data suggest that expression of results in terms of DE and ME is better as they are not affected by the levels of feeding.

The data related to nitrogen intake, balance and utilization based on in vivo digestion trial are presented in Table 12, nitrogen intake (g/day) was significantly ($P<0.05$) higher under treatment T_3-100 as compared to control group treatment (T_1-0). While the nitrogen outgo through faeces was not significantly higher, however, more amount of nitrogen was channelled through urine under treatment T_3-100, such compensation resulted in nitrogen balance (as expressed as percentage of absorbed nitrogen) at par with control group animals when compared with treatment T_3-100 group animals.

The data related to nitrogen balance expressed as percentage of absorbed nitrogen reflects that the degradability of fababean protein (T_3-100) is very high at rumen level and it was at par with control group concentrate mixture (T_1-0) and such finding has been confirmed by conducting nylon bag

Table 12. Nitrogen intake, balance and utilization in growing lambs

Sr. No.	Attributes	Season	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	Nitrogen intake (g/day)	Winter	18.150 ±2.396	21.299 ±1.611	25.250 ±1.627	21.567 ±1.254
		Summer	19.692 ±2.157	21.439 ±1.627	25.639 ±3.846	22.256 ±1.591
		Mean	18.921[a] ±1.554	21.369[ab] ±1.092	25.445[b] ±1.992	
2.	Nitrogen outgo through faeces (g/day)	Winter	5.300 ±0.853	5.928 ±0.423	6.601 ±0.438	5.943 ±0.353
		Summer	5.771 ±0.585	6.330 ±0.442	6.851 ±1.083	6.317 ±0.423
		Mean	5.585 ±0.498	6.129 ±0.298	6.726 ±0.558	
3.	Nitrogen outgo through urine (g/day)	Winter	6.284 ±0.604	6.701 ±0.328	9.915 ±0.687	7.633 ±0.497
		Summer	7.532 ±1,298	8.312 ±1.190	12.162 ±2.439	9.336 ±1.062
		Mean	6.098[a] ±0.708	7.507[a] ±0.637	11.039[b] ±1.254	
4.	Nitrogen balance (g/day)	Winter	6.566 ±1.134	8.670 ±0.915	8.735 ±0.989	7.990 ±0.603
		Summer	6.388 ±0.961	6.796 ±0.870	6.625 ±1.647	6.603 ±0.657
		Mean	6.477 ±0.657	7.733 ±0.665	7.680 ±0.969	
5.	N balance (g) as % of intake (g)	Winter	35.764 ±2.624	40.158 ±1.533	34.374 ±2.707	36.765[Y] ±1.407
		Summer	32.402 ±3.473	31.900 ±3.897	25.876 ±5.076	30.059[X] ±2.391
		Mean	34.083 ±2.136	36.029 ±2.353	30.125 ±3.027	
6.	N balance (g) as % of absorbed nitrogen (g)	Winter	50.096 ±1.834	55.162 ±3.457	46.472 ±3.485	50.577 ±1.185
		Summer	46.294 ±4.512	50.370 ±5.393	35.160 ±6.759	43.941 ±3.429
		Mean	48.195[a] ±2.432	52.766[b] ±3.107	40.816[a] ±4.007	

ANOVA TABLE

Source of variation	D.F.	M.S.S. values					
		Nitrogen intake (g)	N outgo through faeces (g)	N outgo through urine (g)	Nitrogen balance (g)	N balance as % of intake	N balance % of absorbed
Season	1	4.283	1.261	26.085	17.311	404.687	396.302
Treatment	2	130.331	4.251	59.795	6.053	108.623	436.287
Season x Treatment	2	1.678	0.038	0.767	3.331	25.205	49.952
Error	50	33.076	2.808	9.993	7.495	69.580	122.597
	CD_1	NS	NS	NS	NS	5.678	NS
	CD_2	4.794	NS	2.635	NS	NS	9.230
	CD_3	NS	NS	NS	NS	NS	NS

protein degradability as well as effective degradability (Table 6). Such trend of data gives a future guideline of research based to bypass rumen degration of protein from bakla based ration. The data related to average bicarbonate excretion through urine are presented in Table 13. It is clear from the perusal of data presneted in Table 13 that the sole feeding of fababean did not affect significantly the buffer system as the amount of bicarbonate excreted through urine (g/day) under treatment T_3-100 and it was at par with control group animals T_1-0. Besides this there was no significant ($P<0.05$) effect of season on the amount of bicarbonate excreted through urine. Therefore, it may be concluded that presence of antinutrional factors in fababean are either hydrolysed completely by the paunch micro-organisms and fauna and converted to harmless end products thereby resulting in no change of buffer system.

Table 13. Average bicarbonate excretion data

Attribute	Season	Treatments			Season
		T_1-0	T_2-25	T_3-100	
Bicarbonate excreted through urine (g/day)	Winter	8.740 ±3.574	10.341 ±1.392	15.902 ±5.633	11.661 ±2.260
	Summer	8.354 ±1.185	9.653 ±0.983	11.186 ±1.777	9.731 ±0.788
	Mean	8.547 ±1.796	9.997 ±0.819	13.544 ±2.904	

4.5 Feed Conversion Efficiency and Growth Performance Based on Long term (One Year Period) Feeding Trial

Feed utilization for growth

The data based on one year growth trial studies involving observations on body weight gain, dry matter intake. Feed : gain ratio are presented in Table 14. Simultaneously the data related to gross efficiency of crude protein utilization and gross efficiency of ME utilization for growth are presented in Table 15.

The data related to body weight changes at fortnight interval during the early stage of growth (winter) and late stage of growth (summer) are depicted in Fig. 2 (season-wise) and simultaneously overall scenario related to change in body weight (kg) at fortnight interval are elaborated in Fig. 3 (overall).

During one year period highest daily body weight gain (67.8 g/day) was observed in the treatment T_3-100 where lambs were maintained solely on 100 per cent fababean and gram straw, fed in 60:40 ratio on ME basis. This proves the superiority of fababean feeding over the control group(conventional feeding). Had there been any detrimental effect of presence of antinutritional factors present in fababean, certainly growth performance should have been affected adversely. Since the daily body weight gain was 46 per cent higher in sole feeding of fababean fed group. T_3-100 as compared to control group T_1-0 such observations prove that the harmful substances present in fababean are completely hydrolysed at gastro-intestinal level.

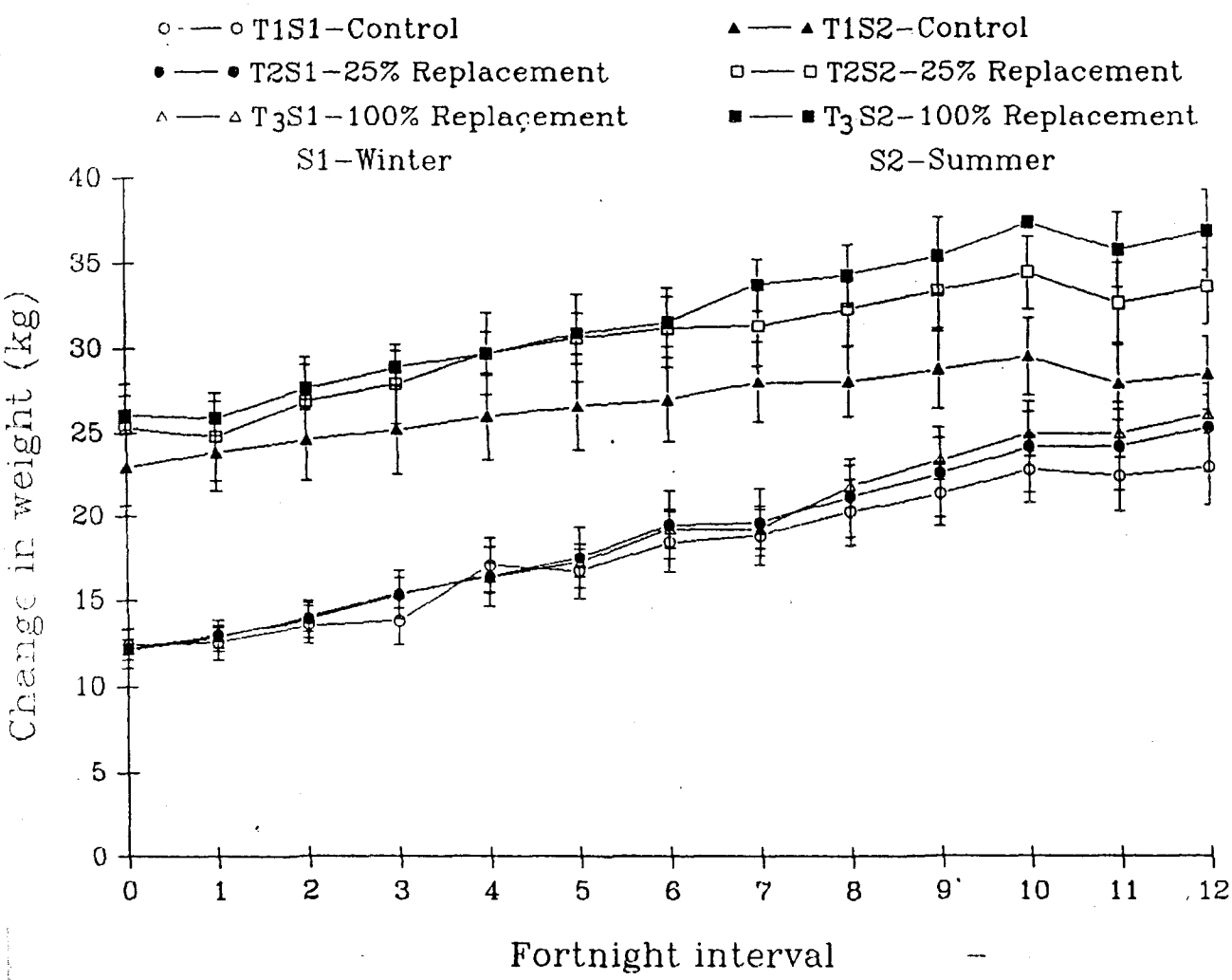


Fig. 2. Body weight changes in winter and summer season in lambs maintained at different levels of Bakla feeding

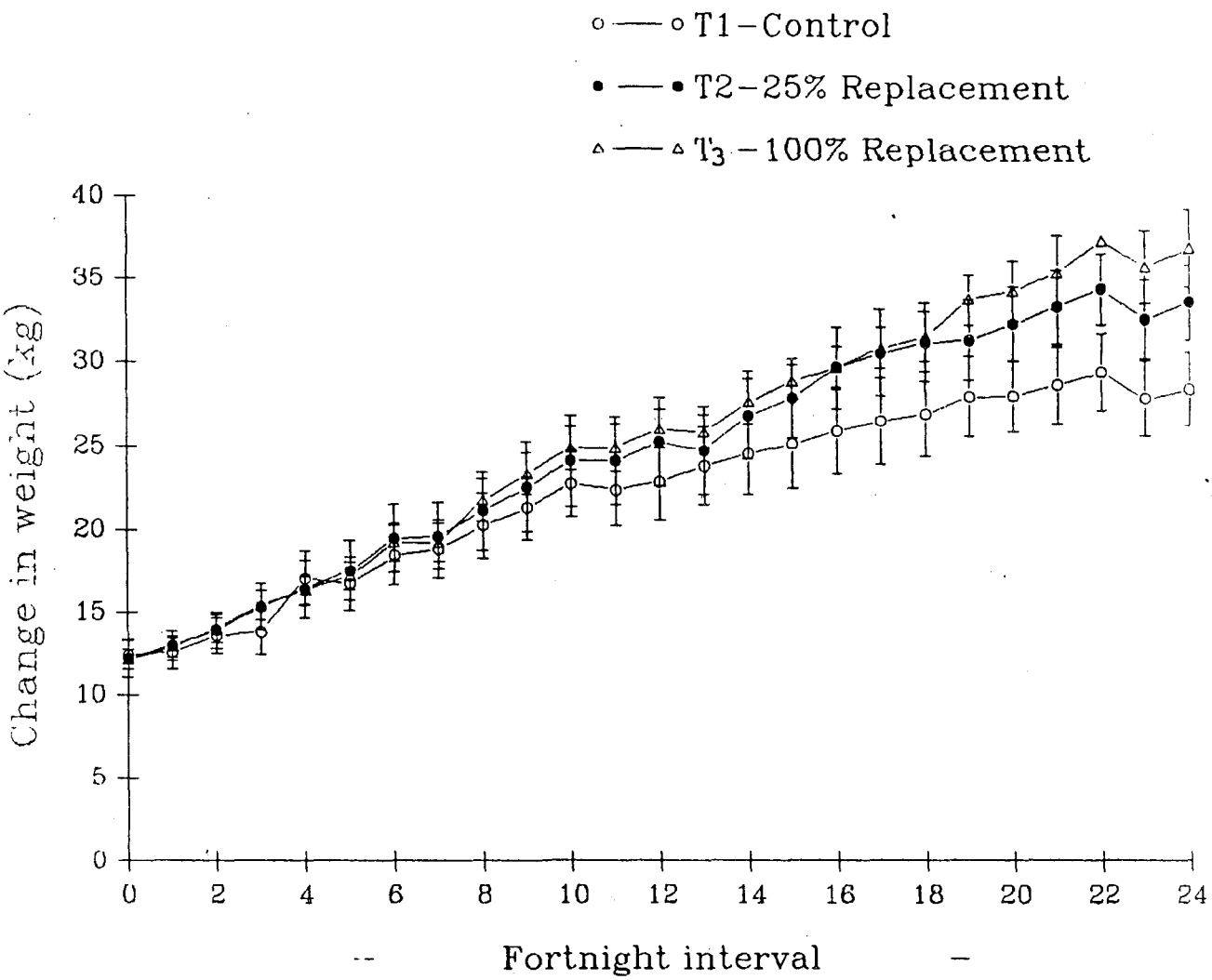


Fig. 3. Body weight changes in experimental lambs under long term feeding (1 year) maintained at different replacement levels of Bakla

Table 14. Body weight gain*, dry matter intake* and feed/gain ratio under the various treatments (overall)

Sr. No.	Attributes	Season	Treatments T_1-0	T_2-25	T_3-100	Season mean
1.	DM intake (g/day)	Winter	640.700 ±54.300	652.800 ±61.400	660.200 ±43.000	651.200^X ±29.000
		Summer	897.700 ±74.200	972.800 ±68.700	1015.700 ±47.300	962.100^Y ±36.900
		Mean	769.200 ±58.500	812.800 ±65.200	837.900 ±61.600	
2.	Dry matter intake (kg/100 kg B.wt.)	Winter	2.836 ±0.083	2.623 ±0.090	2.525 ±0.068	2.661^X ±0.054
		Summer	3.153 ±0.073	2.895 ±0.046	2.779 ±0.087	2.942^Y ±0.054
		Mean	2.994^c ±0.071	2.759^b ±0.063	2.652^a ±0.065	
3.	Dry matter intake ($g/W^{0.75}_{kg}$)	Winter	61.449 ±0.579	58.164 ±0.941	57.026 ±1.966	58.880^X ±0.840
		Summer	72.630 ±2.051	69.528 ±1.586	68.267 ±0.958	70.142^Y ±0.973
		Mean	67.039^b ±1.968	63.846^a ±1.926	62.647^a ±1.990	
4.	Body weight gain (g/day)	Winter	62.5 ±9.3	72.3 ±11.0	76.5 ±5.6	70.4^Y ±5.0
		Summer	30.3 ±5.7	45.5 ±4.6	59.2 ±10.0	45.0^X ± 4.8
		Mean	46.4^a ±7.1	58.9^{ab} ±7.0	67.8^b ±6.1	
5.	Corrected daily gain (g/day)	Winter	26.366 ±5.308	31.491 ±5.115	34.785 ±2.889	30.881^Y ±2.617
		Summer	14.924 ±2.141	21.161 ±2.126	28.480 ±4.796	21.522^X ± 2.225
		Mean	20.645^a ±3.228	26.326^a ±3.065	31.632^b ±2.833	
6.	Feed:gain ratio (F/G ratio)	Winter	10.251 ±0.950	9.029 ±1.350	8.630 ±0.454	9.250^X ±0.579
		Summer	29.627 ±9.588	21.380 ±4.627	17.157 ±3.222	21.380^Y ± 3.961
		Mean	16.577 ±6.126	13.800 ±3.096	12.358 ±2.262	

*Mean values of 182 and 183 days feeding trial for both seasons. Each figure is an average of six values.
Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values					
		DM intake (g/day)	DM intake ($g/W^{0.75}_{kg}$)	DM intake (kg/100 kg body wt.)	Body weight (g/day)	Corrected daily gain (g/day)	Feed:Gain ratio
Season	1	869.556	1411.527	0.711	0.006	788.182	2659.413
Treatment	2	14.525	61.863	0.369	0.001	362.288	334.729
Season x Treatment	2	7.466	0.026	0.003	0.000	21.911	217.712
Error	30	21.016	12.724	0.034	0.000	94.791	126.652
	CD_1	98.7	2.428	0.126	0.013	6.627	7.660
	CD_2	NS	2.974	0.155	0.016	8.116	NS
	CD_3	NS	NS	NS	NS	NS	NS

Table 15. Daily total crude protein, metabolizable energy intake crude protein deposited in gained biomass and their gross efficiency of utilization

Sr. No.	Attributes	Season	Treatments T_1 -0	T_2 -25	T_3 -100	Season Mean
1.	Total CP intake (g/day)	Winter	102.077 ±8.649	100.817 ±9.476	134.000 ±8.723	112.298^X ±6.121
		Summer	125.538 ±10.373	135.885 ±9.597	200.380 ± 9.326	153.935^Y ±9.623
		Mean	113.808^a ±7.346	118.351^a ±8.324	167.190^b ±11.713	
2.	Total ME intake (Mcal/day)	Winter	1.683 ±0.145	1.643 ±0.154	1.758 ±0.136	1.695^X ±0.079
		Summer	2.174 ±0.177	2.593 ±0.184	2.631 ±0.088	2.466^Y ±0.098
		Mean	1.929 ±0.132	2.118 ±0.188	2.195 ±0.152	
3.	Crude protein deposited in gained biomass	Winter	15.176 ±2.256	18.732 ±2.890	19.913 ±1.454	17.940^Y ±1.328
		Summer	7.389 ±1.398	11.850 ±1.191	15.458 ±2.603	11.566^X ±1.279
		Mean	11.282^a ±1.726	15.291^{ab} ±1.816	17.686^b ±1.572	
4.	Calorific value of gained biomass (Mcal)	Winter	0.312 ±0.046	0.362 ±0.055	0.382 ±0.028	0.352^Y ±0.025
		Summer	0.152 ±0.029	0.227 ±0.023	0.297 ±0.050	0.226^X ±0.024
		Mean	0.232^a ±0.035	0.294^{ab} ±0.035	0.340^b ±0.030	
5.	Gross efficiency of crude protein utilization	Winter	14.460 ±1.126	18.130 ±1.714	14.915 ±0.748	15.835^Y ±0.790
		Summer	6.107 ±1.410	9.164 ±1.439	7.548 ±1.070	7.606^X ±0.776
		Mean	10.283^a ±1.525	13.647^b ±1.722	11.232^{ab} ±2.273	
6.	Gross efficiency of ME utilization	Winter	18.111 ±1.474	21.360 ±1.997	22.013 ±1.362	20.495^Y ±0.978
		Summer	7.265 ±1.651	9.215 ±1.495	11.145 ±1.726	9.208^X ±0.962
		Mean	12.688 ±1.946	15.288 ±2.183	16.579 ±1.945	

Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values					
		Total CP intake (g/day)	Total ME intake (Mcal/day)	CP deposited in gained biomass (g)	Calorific value of gained biomass (Mcal)	Gross efficiency of CP utilization	Gross efficiency of ME utilization
Season	1	15602.425	5.358	365.733	0.144	609.423	1146.409
Treatment	2	10511.243	0.225	125.611	0.035	36.099	47.127
Season x Treatment	2	1478.593	0.181	8.899	0.004	1.950	1.658
Error	30	527.372	0.136	25.704	0.100	9.969	15.960
	CD_1	15.631	0.251	3.451	0.067	2.149	2.719
	CD_2	19.144	NS	4.226	0.083	2.632	NS
	CD_3	NS	NS	NS	NS	NS	NS

It is worth noting that the amount of feed required to obtain 100 g body weight gain under treatment T_3-100 was at par with control group animals. However, lambs required 2.4 times more feed at later stage of growth during summer season to reach a targeted growth of 100 g daily body weight gain. The trend of data suggest that Bakla (fababean) is more beneficial and give more economical gain during early stage of growth in winter season and such type of finding is proved on the basis of corrected daily gain (g/day) based on dressing percentage data, where corrected daily body weight gain was 43 per cent higher during early stage (winter season) of growth as compared to later stage (summer season) of growth.

Attempts were made to nullify the effect of age on dry matter consumption by expressing results of dry matter intake per unit metabolic body size and it was observed that there was significant difference in dry matter consumption at later stage of growth during summer season when compared with early stage of growth during winter season. At National Dairy Research Institute, Karnal, Haryana, Krishna et al. (1977) observed that dry matter intake per unit metabolic body size was significantly ($P<0.05$) higher during summer season and the trend of data of present investigation are also on the same line. However, the dry matter consumption depend on comfort zone where the experimental animals were reared. During present investigation, the lambs were tethered in a protected place where scorchy sun rays could not reach, therefore, animals were not kept under

stress conditions during summer season and the higher intake of dry matter during summer season is feasible.

While MacLeod et al. (1972) observed similar intake per kg metabolic body size for young calves on either a fish meal supplementation or high moisture fababean. Virk et al. (1991) had reported that no significant differences exist in respect of dry matter intake in crossbred goats fed 0, 20, 40 and 60 per cent crude protein of groundnut cake replaced by crushed fababeans. Sharma and Nicholson (1975) reported that there was no significant differences in dry matter consumption in fistulated sheep fed with water treated, formaldehyde treated and VFA treated fababeans. The dry matter intake was 1.143, 1.134 and 1.136kg/day, respectively. Ingalls and Mckirdy (1974) also reported insignificant effect on dry matter intake when fababean was included upto 35 per cent in dairy concentrates. In another experiment (1974) with Holstein cows, they observed marginal effect ($P<0.05$) on feed intake, where as Cabbalero et al. (1992) fed the diet containing 0, 100, 200, 300 and 400 g fababean to finishing lambs. They observed that feed intake was 844, 860, 899, 894 and 878 g/day, respectively.

The trend of data related to N intake and body weight gain as well as gross efficiency of CP utilization indicate that the highest daily body weight gain under T_3-100 was due to the better crude protein utilization as value of gross efficiency of CP utilization under T_3-100 was at par with control group (T_1-0) and thereby more tissues were deposited in the biomass of growing lambs. This reveals that the presence of

antinutritional factors viz., tannins, vicine and convicine in bakla never interfered with nitrogen absorption at gastro-intestinal tract level nor the transaminase activity of the tissue was affected and whatsoever nitrogen was absorbed through the walls of GI tract was mobilized efficiently through metabolic pathway and converted into end products like urea and other non-protein nitrogen constituents of body.

It has been observed that daily body weight gain vary if we weigh the animals consecutively for 2 days because the water consumption vary daily accordingly to the body need, sometime the experimental lambs ate more dry matter from experimental ration and occasionally they take less dry matter, thereby the weight of GI tract affect the live body weight usually and this figures may not be reliable to test the growth performance of particular feed, therefore, to avoid such gross error of fact, attempt has been made to correct the daily gain by using the actual dressing percentage figures obtained during current investigation. The data related to live body weight gain at the start of feeding and at end of one year feeding trial was corrected by using the dressing percentage figures and the data obtained are presented in Table 22. The perusal of data related to corrected body weight gain reveal that after removing the head, all the four feet (lower portion of legs) GI tract and pluck, the net corrected daily gain in body was highest in sole bakla fed lambs (T_3-100). Therefore, corrected daily body weight gain are more reliable data and this is the basal data on the basis of which, it can be concluded that sole

bakla feeding is beneficial to exploit the genetic potential for growth in heterogenous group of crossbred growing lambs as confirmed from the current investigation.

Gross efficiency of energy and protein conversion for growth

The data related to this aspect of study are presented in Table 15. At early stage of growth, during winter season, gross efficiency of crude protein utilization, gross efficiency of metabolizable energy utilization and metabolizability of gross energy was significantly ($P<0.05$) higher in comparison to later stage of growth during summer season. And such interlinked gearing up action of enhance rate of energy utilization during early stage of growth in winter season reflected significantly ($P<0.05$) higher body weight and corrected daily weight gain and it may be concluded(based on such trend of data) that feeding of fababean is more beneficial for getting economic gain during early stage of growth preferably during winter season. These results reveal that lambs under T_3-100 required significantly ($P<0.05$) less amount of dry matter to obtain a gain of 1 kg biomass as a result of better utilization of protein and energy for depositing in gained biomass. This proves that sole Bakla feeding resulted in better efficiency of energy and protein utilization as observed from the amount of tissues deposited in the lambs of treatment T_3-100.

Average daily ME intake under the three treatments were 1.929, 2.118 and 2.195 (Mcal/day), similarly, the calorific value of gained biomass were 0.232, 0.294 and 0.340 (Mcal)/ under T_1-0,

T_2-25 and T_3-100, respectively. The gross efficiency of ME utilization for gain under the various treatments were 12.688, 15.288 and 16.579, respectively.

In general, it was observed that dry matter intake (kg/100 kg body weight and $g/W^{0.75}kg$), ME intake (Mcal/day) was significantly ($P<0.05$) more in summer, however, gross efficiency of ME utilization for gain was less in summer than winter. It is well known fact that level of intake and energetic efficiency of ME utilization has inverse relationship (Blaxter, 1962; Reid, 1956) and this fact has been confirmed during present study. By virtue of nutritional wisdom, satiety mechanism plays an important role in monitoring nutrients need of body and this fact is proved from the intake and gross efficiency of ME utilization data (see Table 15). Gross efficiency of ME utilization and crude protein utilization for gain was more in winter as compared to summer because energy and protein requirement is more in winter than summer, same trend was observed by NDRI, Karnal workers (Krishna et al., 1977a and 1977b) in lactating Zebu cows of Tharparkar and Sahiwal breed.

4.5.3 The amount of crude protein deposited in gained biomass varied significantly ($P<0.05$) with treatment. On an average, it was 11.282, 15.291 and 17.686 g under the treatments T_1-0, T_2-25 and T_3-100, respectively. The effect of season on this parameter was significant. It was higher in winter (17.940) than summer (11.566). It indicates that crude protein deposited in gained biomass was more in winter (17.940) than summer

(11.566). The interaction effect was non-significant.

The gross efficiency of crude protein utilization for gain in the respective treatments were 10.283, 13.647 and 11.232, respectively in treatments T_1-0, T_2-25 and T_3-100 where as the crude protein intake under the three different treatments differed significantly ($P<0.05$). It was 113.808, 118.351 and 167.190 (g/day) in treatments T_1-0, T_2-25 and T_3-100, respectively.

4.5.4 The crude protein intake was significantly ($P<0.05$) higher in T_3-100 (167.190) followed by T_2-25 and T_1-0 (118.351 and 113.808 g/day), respectively. The effect of season was significant ($P<0.05$). It was higher in summer (153.935) than winter (112.298). It indicates that gross efficiency of crude protein utilization for gain was less in summer (7.606) than winter (15.835). The effect of interaction was non-significant. The gross efficiency of crude protein utilization for gain was significantly ($P<0.05$) higher in T_2-25 (13.647) followed by T_3-100 and T_1-0 (11.232 and 10.283), respectively. It means that, the amount of crude protein consumed could not be utilized efficiently for depositing in gained biomass. Most of the protein consumed might have been wasted as heat of fermentation (HF) and the heat of nutrient metabolism (HNM). This might have coupled with significant higher amount of endogenous losses through urine and faeces, from these data, the Reid's theory of input and output relationship is also proved (Reid, 1956).

Ingalls and Mckirdy (1974) reported, adding 17 or 35 per cent fababeans in the diet of dairy cows appeared to have little effect ($P<0.05$) on feed intake. They have reported that the daily weight change was 0.43, 0.30, 0.59 and 0.14 kg at 17, 35 per cent fababean, soyabean and 19 per cent rapeseed, respectively. Another scientists, Sharma and Nicholson (1975) observed no differences in weight gain and feed efficiency among the calves fed soyabean, water treated fababean and formaldehyde treated fababean. The average weight gain was 81.7, 87.9 and 93.6 kg, respectively. While the feed efficiency was 6.6, 6.9 and 6.2, respectively. Ingalls et al. (1980) observed no significant ($P<0.05$) differences for weight gain and feed efficiency in dairy calves. Akbar (1989) reported average daily body weight gains in buffalo calves 511.70, 501.70, 573.30 and 583.30 g/day while feed gain ratio was 7.90, 7.95, 7.84 and 7.02 under 0, 15, 30 and 45 per cent of fababean, respectively. The differences were statistically non-significant.

4.6 Various Aspects of Energy Utilization

The observations related to various aspects of utilization of energy for gain are presented in Table 16. The metabolizability of gross energy was 56.240, 56.325 and 54.331 per cent, respectively. The effect of season, treatment and interaction was significant ($P<0.05$). Metabolizability of gross energy was significantly less in T_3-100 (54.331). It was more in winter (56.799) than summer (54.465 Mcal/kg). In case of data related to net energy for gain (NEg) the effect of season

Table 16. Efficiency of utilization of energy for maintenance and gain

Sr. No.	Attributes	Season	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	Gross energy (Mcal/kg)	Winter	4.232 ±0.095	4.234 ±0.016	4.437 ±0.071	4.301 ±0.044
		Summer	4.314 ±0.065	4.295 ±0.027	4.472 ±0.060	4.360 ±0.035
		Mean	4.273^{a} ±0.056	4.264^{a} ±0.018	4.454^{b} ±0.044	
2.	Metabolizable energy* (Mcal/kg)	Winter	2.491^{B} ±0.054	2.375^{A} ±0.015	2.457^{A} ±0.038	2.441^{Y} ±0.024
		Summer	2.309^{A} ±0.030	2.430^{A} ±0.032	2.382^{A} ±0.043	2.374^{X} ±0.023
		Mean	2.400 ±0.040	2.403 ±0.019	2.419 ±0.030	
3.	Metabolizability of gross energy (q)*	Winter	58.940^{D} ±1.353	56.054^{C} ±0.475	55.403^{BC} ±0.617	56.799^{Y} ±0.615
		Summer	53.540^{AB} ±0.550	56.595^{C} ±0.536	53.258^{A} ±0.366	54.465^{X} ±0.453
		Mean	56.240^{b} ±1.071	56.325^{b} ±0.351	54.331^{a} ±0.470	
4.	Net energy for gain(NEg) (Mcal/kg on DM basis)**	Winter	0.940^{AB} ±0.043	0.843^{AB} ±0.013	0.912^{AB} ±0.031	0.898 ±0.020
		Summer	0.791^{A} ±0.030	0.902^{AB} ±0.043	0.868^{AB} ±0.049	0.854 ±0.025
		Mean	0.865 ±0.038	0.872 ±0.023	0.890 ±0.028	
5.	Efficiency of ME utilization for maintenance (km)	Winter	21.131^{D} ±0.473	20.122^{C} ±0.166	19.894^{BC} ±0.216	20.382^{Y} ±0.215
		Summer	19.241^{AB} ±9.192	20.311^{C} ±0.188	19.143^{A} ±0.128	19.565^{X} ±0.159
		Mean	20.186 ±0.375	20.216 ±0.123	19.518 ±0.165	

Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

*Based on equations published by Van Es (1978).

**Based on prediction equations published by Lofgreen and Garrett (1968).

ANOVA TABLE

Source of variation	D.F.	M.S.S. values				
		Gross energy (Mcal/kg)	Metabolizable energy (Mcal/kg)	Metabolizability of GE (q)	NE for gain (Mcal/kg)	Efficiency of ME utilization for main. (km)
Season	1	0.032	0.041	49.028	0.314	6.014
Treatment	2	0.138	0.001	15.260	0.034	1.868
Season x Treatment	2	0.02	0.042	26.546	0.566	3.253
Error	30	0.023	0.008	3.160	0.141	0.387
	CD_1	NS	0.062	1.210	NS	0.423
	CD_2	0.126	NS	1.482	NS	0.518
	CD_3	NS	0.108	2.096	0.443	0.733

and treatment were not statistically significant but the interaction was significant. However, it was marginally more in winter (0.898 Mcal/day) than summer (0.854 Mcal/day). It was 0.865, 0.872 and 0.890 Mcal/day in T_1-0, T_2-25 and T_3-100, respectively. It indicates that the maximum energy was diverted for gain purpose in T_3-100 (0.890 Mcal/day) followed by T_2-25 and T_1-0 (0.872 and 0.862 Mcal/day). It is worth noting that even though the metabolizability of gross energy (q) was significantly less in T_3-100 but maximum energy was diverted for gain purpose in sole Bakla (Vicia faba L.) fed lambs, therefore, satiety mechanism in animal system was utilized to the fullest extent in order to extract the maximum energy from Bakla (Vicia faba L.).

The data of present study are in agreement with Scotish recommendation(Anonymous, 1975) accordingly the net energy allowances for gain at 30 kg live weight in sheep was 1.051 Mcal/day. This proves that our experimental animals were getting sufficient net energy as per prescribed recommendations. However, marginal differences were observed in the present study.

It is quite clear from perusal of data that the efficiency of ME utilization for maintenance (Km) was marginally higher in treatments T_2-25 and T_1-0 (20.216 and 20.186) than T_3-100 (19.518), respectively, but the difference was non-significant. On an average the effect of season and interaction was significant. it was significantly more in winter (20.382) than summer (19,.565), thereby reflected in more gain during winter season.

4.7 Rumen Metabolic Profile Study

The data related to this aspect of study are presented in Table 17.

4.7.1 The pH of SRL under the three different treatments on an average was 6.324, 6.282 and 6.241 in T_1-0, T_2-25 and T_3-100, respectively. The effect of season and interaction was significant ($P<0.05$) but the effect of treatment was non-significant. The pH was marginally more at early stage of growth in summer (6.333) than winter (6.232). There was no significant differences among the treatments. This indicates that there is no possibility of causing alteration in buffer system at rumen level due to the presence of antinutritional factors.

4.7.2 The total nitrogen content under the three different treatments were 135.567, 139.533 and 253.933 mg/100 ml, respectively. The effect of season, treatment and interaction was significant ($P<0.05$). The concentration of total nitrogen was significantly more in summer (176.733) than winter (156.45) probably this may be due to more consumption of dry matter in summer season. From the perusal of results, it is quite clear that the total nitrogen content in T_3-100 was very high (253.933 mg/100 ml) followed by T_2-25 and T_1-0 (139.533 and 135.467 mg/100 ml), however, in case of T_1-0 and T_2-25 it was not statistically different from each other.

4.7.3 The ammonia nitrogen under three different treatments was 13.579, 14.688 and 23.917 mg/100 ml of SRL in T_1-0, T_2-25 and T_3-100, respectively. The effect of treatment was

Table 17. Rumen metabolic profile under various treatment groups

Sr. No.	Attributes	Season*	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	pH	Winter	6.182^{A} ±0.056	6.190^{AB} ±0.039	6.325^{BC} ±0.075	6.232^{X} ±0.035
		Summer	6.467^{D} ±0.037	6.375^{CD} ±0.027	6.157^{A} ±0.038	6.333^{Y} ±0.037
		Mean	6.324 ±0.053	6.282 ±0.036	6.241 ±0.047	
2.	Total nitrogen (mg/100 ml of SRL)	Winter	134.400^{A} ±7.218	122.267^{A} ±7.469	212.683^{B} ±11.894	156.45^{X} ±10.904
		Summer	136.733^{A} ±10.311	139.533^{A} ±7.767	253.933^{B} ±11.538	176.733^{Y} ±14.309
		Mean	135.567^{a} ±6.011	130.900^{a} ±5.759	233.308^{b} ±10.054	
3.	Ammonia nitrogen (mg/100 ml of SRL)	Winter	14.006 ±0.621	14.613 ±0.732	24.969 ±0.836	17.862 ±1.284
		Summer	13.152 ±0.682	14.763 ±0.463	22.866 ±0.872	16.927 ±1.097
		Mean	13.579^{a} ±0.458	14.688^{a} ±0.414	23.917^{b} ±0.658	
4.	Non-protein nitrogen (mg/100 ml of SRL)	Winter	24.967 ±0.801	25.317 ±2.000	83.000 ±4.256	44.428 ±6.782
		Summer	26.133 ±1.181	33.600 ±1.446	77.467 ±4.132	45.733 ±5.673
		Mean	25.550^{a} ±0.703	29.458^{a} ±1.716	80.233^{b} ±2.948	
5.	Ammonia nitrogen as (%) of total nitrogen	Winter	10.560 ±0.705	12.127 ±0.755	11.922 ±0.753	11.536^{Y} ±0.434
		Summer	9.927 ±0.010	10.700 ±0.513	9.080 ±0.502	9.902^{X} ±0.420
		Mean	10.243 ±0.595	11.413 ±0.485	10.501 ±0.608	

*Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values				
		pH	Total nitrogen (mg/100 ml)	Ammonia nitrogen (mg/100 ml)	NPN (mg/100 ml)	NH_3-N as % of total nitrogen (mg/100 ml)
Season	1	0.091	3702.722	7.878	15.340	24.026
Treatment	2	0.021	40125.356	386.574	11167.285	4.535
Season x Treatment	2	0.170	1156.356	3.824	143.218	3.754
Error	30	0.014	549.126	3.062	43.312	3.168
	CD_1	0.080	32.572	NS	NS	1.211
	CD_2	NS	39.893	1.459	5.486	NS
	CD_3	0.138	56.417	NS	NS	NS

significant ($P<0.05$) while effect of season and interaction was non-significant. The trend of data prove that it was significantly higher in T_3-100 (23.917) followed by T_2-25 and T_1-0 (14.688 and 13.579 mg/100 ml of SRL, respectively), similar trend was observed in case of non-protein nitrogen also. It was 25.550, 29.458 and 80.223 mg/100 ml of SRL in T_1-0, T_2-25 and T_3-100, respectively.

4.7.4 Ammonia nitrogen as percentage of total nitrogen under three treatments was 10.243, 11.413 and 10.501, respectively. The treatment and interaction effect were non-significant while the effect of season was significant ($P<0.05$). It was higher in winter (11.536) than summer (9.902).

From the perusal of data presented in Table 17, it is noticed that the total nitrogen, ammonia nitrogen and non-protein nitrogen content is towards higher side. This may be because of the reason that the solubility of protein in rumen autoclaved fluid was high in T_3-100 and the degradability of protein was also higher in T_3-100.

It is quite clear from the findings of present investigation that the sole feeding of fababean has not caused any detrimental effect in experimental lambs, even it proves to be superior source of protein. This is evident from the fact that the daily body weight gain was significantly better in T_3-100 (67.8 g/day) than T_1-0 (46.4 g/day), similar results were reported by Rys et al. (1984) in lactating cows. They have observed that the rumen ammonia nitrogen with formaldehyde

protected fababean was less than untreated fababean (9 against 14 mg/100 ml). Benchaar et al. (1992) fed 23.1 per cent fababeans to lactating cows, they had reported that extrusion of fababean has no influence on intraruminal pH (6.6) and ammonia nitrogen (99 mg/litre).

4.8 Molar Proportion of Volatile Fatty Acids (VFA)

The average values of lower volatile fatty acid (VFA) concentration under the various treatments are presented in Table 18. The perusal of results presented in Table 18, enunciate that the inclusion of fababean in the experimental ration of lambs resulted in higher concentration of acetic acid and butyric acid expressed on molar basis, since both the volatile fatty acids are lipogenic in nature this may result in more deposition of subcutaneous fat. During current investigation it has been observed that it is not possible to obtain lean mutton from the lambs maintained 100 per cent fababean feeding.

During summer, ratio of C_2:C_3 acids was 3.07:1 while during winter ~~the figure~~ this was 2.68:1, however, this ratio difference may be due to agro-climatic variation as dry matter intake (g) per kg metabolic body size was significantly ($P<0.05$) more during summer season.

4.9 Effect of Feeding Experimental Rations on Blood Nitrogenous Constituents

The data related to the blood nitrogenous constituents viz., total protein, non-protein nitrogen, ammonia nitrogen and urea nitrogen are depicted in Table 19.

Table 18. Lower volatile fatty acid concentration in strained rumen liquor on molar basis

Sr. No.	Attributes	Season*	Treatments T_1 -0	T_2 -25	T_3 -100	Season Mean
1.	Acetic acid (mMol/lit.) C_2 acid	Winter	48.988 ±5.225	65.527 ±3.835	51.393 ±1.691	55.303 ±2.744
		Summer	49.223 ±4.581	66.072 ±2.892	56.459 ±3.593	57.251 ±2.635
		Mean	49.105[a] ±3.313	65.799[b] ±2.291	53.926[a] ±2.041	
2.	Propionic acid (mMol/lit.) C_3 acid	Winter	17.811 ±1.506	21.329 ±2.323	23.180 ±2.250	20.774 ±1.241
		Summer	17.058 ±0.829	19.968 ±1.069	18.745 ±0.649	18.590 ±0.552
		Mean	17.435 ±0.828	20.649 ±1.236	20.963 ±1.302	
3.	Butyric acid (mMol/lit.) C_4 acid	Winter	8.256 ±0.870	19.362 ±1.485	20.762 ±1.078	16.127 ±1.498
		Summer	8.545 ±0.930	19.234 ±0.786	18.918 ±0.518	15.565 ±1.274
		Mean	8.401[a] ±0.608	19.298[b] ±0.801	19.840[b] ±0.634	

*Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values		
		Acetic acid (mMol./lit.)	Propionic acid (mMol./lit.)	Butyric acid (mMol./lit.)
Season	1	34.168	42.893	2.835
Treatment	2	885.845	45.753	499.805
Season x Treatment	2	21.926	11.685	3.832
Error	30	87.123	14.984	5.876
	CD_1	NS	NS	NS
	CD_2	7.781	NS	2.020
	CD_3	NS	NS	NS

4.9.1 The average total protein level in the current study under various treatments (T_1-0, T_2-25 and T_3-100) was 6.866, 7.133 and 7.505 g/100 ml, respectively). In general, the effect of season, treatment and interaction ~~was~~ were non-significant.

4.9.2 The average values of ammonia nitrogen were 0.866, 0.910 and 0.847 mg/100 ml in T_1-0, T_2-25 and T_3-100, respectively. The treatment differences were non-significant but the effect of season and interaction was significant ($P<0.05$). Inspite of high concentration of total protein consumption in T_3-100, the concentration of total protein and ammonia nitrogen were statistically similar under all treatments. It indicates that animal could adjust normal blood protein concentration by homeostasis mechanism according to the requirement of body system which may be due to the nutritional wisdom adjustment.

Table 19. Blood total protein, non protein nitrogen, ammonia nitrogen and urea nitrogen under various treatments

Sr. No.	Attributes	Season*	Treatments T_1-0	T_2 -25	T_3-100	Season Mean
1.	Total protein (g/100 ml)	Winter	6.711 ±0.376	7.000 ±0.389	7.261 ±0.404	6.990 ±0.218
		Summer	7.021 ±0.408	7.266 ±0.498	7.750 ±0.330	7.346 ±0.238
		Mean	6.866 ±0.269	7.133 ±0.304	7.505 ±0.259	
2.	Non-protein nitrogen (mg/100 ml)	Winter	21.887 ±0.901	27.673 ±1.316	31.313 ±0.392	26.958^{Y} ±1.073
		Summer	17.453 ±0.359	21.513 ±1.805	26.180 ±1.631	21.916^{X} ±1.158
		Mean	19.670^{a} ±0.813	24.593^{b} ±1.413	28.747^{c} ±1.113	
3.	Ammonia nitrogen (mg/100 ml)	Winter	0.599^{A} ±0.026	0.782^{B} ±0.027	0.652^{AB} ±0.021	0.678^{X} ±0.023
		Summer	1.132^{C} ±0.098	1.038^{C} ±0.059	1.043^{C} ±0.022	1.071^{Y} ±0.038
		Mean	0.866 ±0.094	0.910 ±0.049	0.847 ±0.061	
4.	Urea nitrogen (mg/100 ml)	Winter	26.600 ±1.528	25.760 ±1.577	31.827 ±1.526	28.062 ±1.061
		Summer	31.173 ±1.727	27.440 ±1.571	30.880 ±1.573	29.831 ±0.972
		Mean	28.887^{a} ±1.298	26.600^{ab} ±1.091	31.353^{b} ±1.054	

*Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values			
		Total protein (g/100 ml)	NPN (mg/100 ml)	NH_3-N (mg/100 ml)	Urea nitrogen (mg/100 ml)
Season	1	1.137	247.328	1.393	28.161
Treatment	2	1.236	247.750	0.012	67.815
Season x Treatment	2	0.041	2.263	0.058	22.870
Error	30	0.980	8.745	0.015	15.077
	CD_1	NS	2.013	0.084	NS
	CD_2	NS	2.465	NS	3.237
	CD_3	NS	NS	0.146	NS

4.9.3 The values in term of non-protein nitrogen (NPN) level in serum on an average under various treatments T_1-0, T_2-25, T_3-100 were 19.670, 24.593 and 28.747 mg/100 ml. The effect of season and treatment were significant ($P<0.05$) but the interaction effect was not significant. It was higher in winter (26.958 mg/100 ml) than summer (21.716 mg/100 ml).

4.9.4 The perusal of the data presented in Table 19 give inference that sole feeding of fababean resulted in significantly higher concentration of blood urea nitrogen (mg/100 ml) and this may probably be due to higher concentration of non-protein nitrogen in the rumen (Table 17). Further urea recycling as well as synthesis rate may be higher due to presence of higher concentration of microbial urease enzyme at rumen level thereby resulting in greater urea pool size in lambs maintained on sole feeding of fababean. Further studies are immensely needed to study urea pool size and synthesis rate by using solid isotope as ^{15}N-urea with different levels of fababean feeding.

4.10 Water Balance Studies

4.10.1 The results related to voluntary water intake, feed water, metabolic water and water intake per 100 gm of dry matter are presented in Table 20. The voluntary water intake was 1969.759, 2265.687 and 2374.168 ml/day/lamb in T_1-0, T_2-25 and T_3-100, respectively. The treatment differences were not significant. The voluntary water intake was more in summer (2589.364 mg/day) than winter (1817.364 ml/day). In case of

Table 20. Water intake data during winter and summer season

Sr. No.	Attributes	Season	Treatments T_1-0	T_2-25	T_3-100	Season Mean
1.	Dry matter intake (g/day)	Winter	876.061 ±88.293	957.923 ±68.651	829.729 ±142.170	887.904 ±58.079
		Summer	716.271 ±99.505	863.364 ±67.153	787.508 ±69.087	789.048 ±45.749
		Mean	796.166 ±67.840	910.644 ±47.950	808.618 ±75.624	
2.	Voluntary water intake (ml/day)	Winter	1663.092 ±146.588	1947.088 ±93.557	1840.948 ±279.676	1817.043^X ±106.962
		Summer	2276.427 ±466.213	2584.286 ±203.415	2907.380 ±384.574	2589.364^Y ±209.211
		Mean	1969.759 ±250.663	2265.687 ±143.600	2374.164 ±277.916	
3.	Feed water (g/day)	Winter	61.801 ±5.608	74.843 ±12.860	60.248 ±14.000	65.631 ±6.406
		Summer	58.610 ±9.677	76.041 ±6.422	81.420 ±9.047	72.024 ±5.179
		Mean	60.206 ±5.354	75.442 ±6.843	70.834 ±8.563	
4.	Metabolic water (g/day)	Winter	3.099 ±0.288	3.596 ±0.262	3.005 ±0.465	3.233 ±0.200
		Summer	2.700 ±0.350	3.154 ±0.252	2.939 ±0.233	2.931 ±0.160
		Mean	2.899 ±0.224	3.355 ±0.186	2.972 ±0.248	
5.	Total water intake (ml/day)	Winter	1679.855 ±143.810	2017.031 ±100.245	1882.055 ±280.346	1859.647^X ±108.846
		Summer	2337.737 ±475.499	2663.482 ±206.778	2991.749 ±391.169	2664.323^Y ±213.432
		Mean	2008.796 ±256.755	2340.256 ±146.626	2436.902 ±283.945	
6.	Water intake Per 100g DM intake(ml)	Winter	181.497 ±19.995	214.803 ±15.793	244.794 ±39.926	213.698^X ±16.101
		Summer	317.281 ±21.508	313.268 ±21.081	378.979 ±29.289	336.509^Y ±15.041
		Mean	249.389 ±24.800	264.036 ±19.443	311.887 ±31.088	

Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values					
		DM intake (g/day)	Voluntary water intake (ml/day)	Feed water (g/day)	Metabolic water (g/day)	Total water intake (ml/day)	Water intake per 100 gm DM (ml)
Season	1	87953.962	5368326.811	367.859	0.824	5827524.747	135743.244
Treatment	2	47338.671	525768.339	732.710	0.788	604691.644	12820.314
Season x Treatment	2	10408.575	195053.651	505.917	0.127	209430.018	1335.642
Error	30	51904.625	515088.837	609.546	0.609	531194.423	4008.169
	CD_1	NS	997.598	NS	NS	1013.075	88.001
	CD_2	NS	NS	NS	NS	NS	NS
	CD_3	NS	NS	NS	NS	NS	NS

Table 21. Water outgo data during winter and summer season

Sr. No.	Attributes	Season	Treatments T_1 -0	T_2 -25	T_3 -100	Season Mean
1.	Losses through urine (ml)	Winter	327.262 ±69.579	508.405 ±99.992	615.238 ±127.444	483.635 ±62.276
		Summer	382.500 ±116.160	399.760 ±89.362	634.595 ±102.850	472.285 ±62.614
		Mean	354.881 ±65.086	454.082 ±65.997	624.916 ±78.128	
2.	Losses through faeces (ml)	Winter	382.514 ±73.397	431.704 ±52.059	293.856 ±45.270	369.358 ±34.440
		Summer	283.760 ±51.485	384.786 ±44.973	293.855 ±23.925	311.175 ±26.214
		Mean	333.137 ±45.259	408.245 ±33.550	279.417 ±24.795	
3.	Total water losses (ml)	Winter	709.776 ±141.604	940.109 ±124.354	909.093 ±249.953	852.993 ±101.093
		Summer	666.260 ±188.675	784.633 ±126.314	906.406 ±204.714	785.766 ±98.632
		Mean	688.018 ±112.653	862.371 ±87.693	907.750 ±154.025	
4.	Apparent water balance (ml)	Winter	969.746 ±52.516	1076.922 ±146.046	972.361 ±113.295	1006.543^X ±61.365
		Summer	1671.476 ±296.061	1887.182 ±153.110	2085.343 ±205.966	1881.334^Y ±129.348
		Mean	1320.611 ±178.155	1482.052 ±158.418	1529.152 ±201.696	

Each figure is an average of six values.

Mean values with same superscript do not differ significantly ($P<0.05$) from each other.

ANOVA TABLE

Source of variation	D.F.	M.S.S. values			
		Losses through urine (ml)	Losses through faeces (ml)	Total water losses (ml)	Apparent water balance (ml)
Season	1	1159.368	30467.586	40674.419	6887330.143
Treatment	2	223888.629	50247.561	161479.916	143541.939
Season x Treatment	2	22264.715	3947.467	18773.202	135845.440
Error	30	63138.573	15392.257	191453.547	190439.652
	CD_1	NS	NS	NS	606.587
	CD_2	427.767	NS	NS	NS
	CD_3	NS	NS	NS	NS

feed water and metabolic water, the effect of season, treatment and interaction were observed non-significant.

4.10.2 The results related to water losses through urine, faeces and total water loss and apparent water balance are presented in Table 21. The average losses through urine were 354.881, 454.082 and 624.916 ml/day and losses through faeces were 333.137, 408.245 and 279.417 ml/day in treatments T_1-0, T_2-25 and T_3-100. No significant differences were observed in water losses through urine and faeces. However, the higher total water losses were observed in T_3-100 (907.75 ml/day) followed by T_2-25 and T_1-0 (862.371 and 688.018 ml/day). The apparent water balance was significantly ($P<0.05$) more in summer (1881.324 ml/day) than winter (1006.543 ml/day). It indicates that animal requires more amount of water in summer to maintain water metabolism of body and adequate water consumption is necessary for maintaining various physiological reactions in body. Water absorbing capacity of fababean as proved from the data of amount of water consumed for 100 g dry matter intake was found at par with control group.

4.11 Meat Studies

The data related to carcass quality and quantity as well as organoleptic studies were subjected to statistical analysis by simple CRD and the results obtained are presented in Table 22 to Table 26.

4.11.1 Dressing percentage

The mean preslaughter weight (kg) and dressed carcass weight (kg) in T_1-0, T_2-25 and T_3-100 were 30.33 ± 2.409, 33.30 ± 4.131 and 35.966 ± 2.643 and 14.09 ± 1.275, 15.35 ± 2.042 and 17.266 ± 1.379, respectively (Table 22). The dressing percentage was estimated on preslaughter weight by taking dressed carcass weight excluding weight of pluck or race head and hooves. It was 46.29 ± 1.319, 45.896 ± 0.468 and 47.961 ± 1.038 kg in T_1-0, T_2-25 and T_3-100, respectively. The perusal of data reveal that there was no significant ($P<0.05$) difference in dressing percentage observations among the treatments, though it was highest in T_3-100. The dressing percentage of sheep carcasses maintained on 25 and 100 per cent replacement of concentrate mixture protein by fababean showed no significant difference as compared to control group, similar findings were observed by Pichler (1990) in case of young bulls. He reported that even upto 50 per cent replacement of protein by fababean had no significant difference in respect of dressing percentage. Ringdorfer (1991) reported that sheep given 40 per cent fababeans had 1 per cent higher carcass yield. In the present study, the per cent yield of eviscerated carcass at sole protein replacement by fababean was 1.671 per cent higher than control and such finding favour feeding of sole fababean to growing lambs.

Table 22. Average values of live weight and carcass traits under different treatment groups

Sr.No.	Attributes	T_1-0	T_2 -25	T_3-100
1.	Pre-slaughter unshorn live weight (kg)	30.33 ± 2.409	33.30 ± 4.131	35.966 ± 2.643
2.	Dressed carcass weight (kg)	14.09 ± 1.275	15.35 ± 2.042	17.266 ± 1.379
3.	Dressing percentage on unshorn live Wt.basis	46.29 ± 1.319	45.90 ± 0.468	47.961 ± 1.038
4.	Meat : bone Ratio			
	a. Hind leg	2.396 ± 0.159	2.722 ± 0.291	2.671 ± 0.202
	b. Fore leg	2.915 ± 0.188	2.563 ± 0.127	3.253 ± 0.164
	c. Loin	3.442 ± 0.444	2.818 ± 0.364	2.872 ± 0.286
5.	Weight of uncleaned wool (kg)	2.605 ± 0.216	2.809 ± 0.256	3.040 ± 0.212

4.11.2 Yield of edible and inedible offals

The data related to yield as per cent yield of live weight basis of different edible and inedible offals viz., blood, head, skin, feet, digestive tract with content and pluck or race are presented in Table 23. It was found that the volume of blood as per cent of live weight was 4.189, 3.120 and 3.460 in T_1-0, T_2-25 and T_3-100, respectively. The per cent yield of head varied from 6.927 to 6.943 where as in case of feet it was 1.894 to 2.045. It was observed that treatment T_1-0 has higher weight of feet followed by T_2-25 and T_3-100. The weight of skin increased as the live weight increased. The skin per cent yield varied from 7.974 to 8.388 and it was more in T_3-100 animals. The per cent yield of digestive tract with content was 13.233 $\pm$ 1.644, 9.639 $\pm$ 0.302 and 8.852 $\pm$ 0.570 in T_1-0, T_2-25 and T_3-100, respectively. The perusal of data presented in Table 23, envisage that the weight of rumen content on fresh basis was 3.505, 3.080 and 3.483 kg in treatment T_1-0, T_2-25 and T_3-100, respectively. Krishna and Ekern (1976) reported 2.191 litre rumen water volume in adult sheep weighing about 70 kg by using marker ^{51}Cr-EDTA and this is well known fact that during current investigation the weight of rumen contents may give only the approximate idea of rumen water volume. Under Indian conditions weight of rumen content ranging from 3.08 kg to 3.505 kg gives an indication of approximate rumen water volume as observed during current investigation. The per cent yield of empty digestive tract was 3.891, 3.391 and 3.388 in T_1-0, T_2-25 and T_3-100, respectively. The per cent yield of

Table 23. Average values of carcass traits under different treatment groups

Sr.No.	Attributes	T_1-0	T_2-25	T_3-100
During slaughtering (as % of live weight)				
a.	Weight of blood (kg)	4.189 ± 0.431	3.120 ± 0.169	3.460 ± 0.242
b.	Weight of skin (kg)	7.974 ± 0.563	8.382 ± 0.156	8.388 ± 0.339
c.	Weight of head (kg)	6.937 ± 0.755	6.943 ± 0.517	6.927 ± 0.479
d.	Weight of feet (kg)	2.045 ± 0.107	2.008 ± 0.113	1.894 ± 0.102
e.	Weight of digestive tract with content (kg)	13.223 ± 1.644	9.639 ± 0.302	8.852 ± 0.570
f.	Weight of empty digestive tract (kg)	3.891 ± 0.431	3.391 ± 0.423	3.388 ± 0.201
g.	Weight of rumen content (kg)	11.748 ± 1.342 (3.505 ± 0.404)	9.129 ± 0.325 (3.080 ± 0.542)	9.558 ± 0.324 (3.483 ± 0.336)
h.	Weight of pluck (include heart, liver, lungs, trachea and spleen) (kg)	3.310 ± 0.096	3.458 ± 0.255	2.796 ± 0.141

N.B.: The values in the parentheses represent the weight of total rumen content on fresh basis, these figures were obtained after evacuating the entire rumen fill.

weight of rumen content was more in T_1-0 (11.748) followed by T_3-100 and T_2-25 (9.558 and 9.129), respectively. The higher weight of rumen may be due to more absorption of water by the ruminal contents. The per cent yield of pluck was varied from 2.796 to 3.458. It was more in T_2-25 (3.458) followed by T_1-0 and T_3-100 (3.310 and 2.796), respectively. Heavier weight animals yielded comparatively less pluck or race than the lighter ones, similar conclusions were drawn by Sahoo and Panda (1987) in crossbred goats.

4.11.3 Carcass characteristics

The carcass traits studied include carcass length, width and length of gigot and fullness of thighs (Table 24). The mean length (cm) was 58.00, 62.50 and 57.75 in T_1-0, T_2-25 and T_3-100, respectively. It was found that the carcass length did not increases in direct proportion to the increase in live weight. The eye muscle length, width, depth and loin eye area at 13th rib level in different treatments ranged from 24.625 to 26.666, 4.125 to 4.516, 2.825 to 3.866 (cm). Eye muscle area was 12.375,10.787 and 13.800 sq.cm under treatments T_1-0, T_2-25 and T_3-100, respectively and statistically the difference was non-significant. No significant trend was observed in the characteristics of eye muscle and other measurements. Sahoo and Panda (1987) reported the width and depth of eye muscle was 3.07 to 4.40 and 1.77 to 2.72 cm, the loin eye area was 3.47 to 10.20 sq.cm in goats. The findings of present study almost agreed with above workers.

Table 24. Average values of carcass measurements

Sr.No.	Attributes	T_1-0	T_2-25	T_3-100
1.	Leg length (F)	37.50 ± 1.523	40.75 ± 1.352	40.833 ± 0.761
2.	Width of gigots (G)	16.08 ± 0.721	15.00 ± 0.530	16.500 ± 0.411
3.	Depth of gigots (H)	6.000	11.87 ± 0.907	16.333 ± 0.962
4.	Fullness of thighs (I)	28.66 ± 1.407	27.90 ± 1.560	30.050 ± 1.218
5.	Length of carcass	58.00 ± 2.081	62.50 ± 4.323	57.750 ± 1.234
6.	Eye muscle			
	a. Length (A)	24.83 ± 1.141	24.625 ± 0.836	26.666 ± 1.228
	b. Width	4.516 ± 0.283	4.125 ± 0.108	4.316 ± 0.169
	c. Depth (B)	3.866 ± 0.324	2.825 ± 0.253	3.166 ± 0.268
7.	Loin eye area at 12 & 13 rib (cm^2)	12.375 ± 1.178	10.787 ± 0.834	13.800 ± 2.393
8.	$\frac{G \times 100}{F}$ (width of gigot as % of leg length)	268 -	126.31 -	101.02
9.	$\frac{B \times 100}{A}$ (shape index of eye muscle)	15.70 -	11.472 -	11.873

Each figure of T_1 and T_3 is an average of six values.

Each figure of T_2 is an average of four values.

4.11.4 Carcass evaluation

a. Proximate composition of meat

The data related to proximate nutrient composition are presented in Table 25. No significant differences were found for proximate nutrient composition in all the three cuts viz., hindleg, foreleg and loin except ether extract in the loin cut. It is observed that dry matter percentage was higher in T_1-0 in all the three cuts followed by T_2-25 and T_3-100. The data of present study are in concordance with Giovanni (1984) in growing lambs, who has reported that the carcass grading was impaired with levels of fababean feeding. Simultaneously Caballero et al. (1992) reported in finishing lambs that the increased amount of fababean in the basal diet did not alter protein, fat and water content. The higher dry matter content in T_1-0 may be due to the less availability of nutrients in comparison to T_2-25 and T_3-100.

b. Organoleptic evaluation

The data pertaining to the organoleptic evaluation of mutton are presented in Table 26. The perusal of data indicate that the T_2 scored highest in flavour (7.50), tenderness (7.63), juiciness (7.37) and acceptability (7.67) except colour and appearance (7.70) which was found highest in T_3-100 group. Considering most of the sensory attributes, it is concluded that under treatment T_2-25 group i.e. mutton from animals fed with 25 per cent conventional protein replacement by fababean was superior as compared to control group as well as the group with sole protein replacement by fababean T_3-100.

Table 25. Proximate composition of various cuts under different treatments

Sr.No.	Attribute	Loin			Foreleg			Hindleg		
		T_1-0	T_2-25	T_3-100	T_1-0	T_2-25	T_3-100	T_1-0	T_2-25	T_3-100
1.	Moisture	70.476 ±1.590	69.385 ±0.327	69.975 ±1.346	70.860 ±1.273	70.739 ±0.785	70.011 ±0.942	70.016 ±1.677	69.034 ±0.899	69.254 ±1.250
2.	Crude protein	23.982 ±1.237	25.994 ±0.825	25.843 ±0.578	23.591 ±1.106	24.589 ±0.599	25.648 ±0.698	24.784 ±0.770	27.421 ±0.820	26.602 ±0.513
3.	Ether extract	2.952[bd] ±0.108	2.618[a] ±0.497	2.456[ac] ±0.411	2.815 ±0.117	2.697 ±0.629	2.530 ±0.785	2.470 ±0.714	2.383 ±0.566	2.540 ±0.113
4.	Total ash	2.590 ±0.129	2.003 ±0.068	1.726 ±0.125	2.734 ±0.169	1.975 ±0.251	1.811 ±0.148	2.730 ±0.134	1.162 ±0.104	1.604 ±0.135

Each figure in T_1 and T_3 is an average of six values.

Each figure in T_2 is an average of four values.

Table 26. Organoleptic evaluation of mutton (Mean ± SE)
(Based on Hedonic scale)

Sr.No.	Attributes	T_1-0	T_2 -25	T_3-100
1.	Colour and appearance	6.87 ±0.196	7.37 ±0.190	7.70 ±0.118
2.	Flavour	6.83 ±0.190	7.50 ±0.094	6.77 ±0.165
3.	Tenderness	6.53 ±0.474	7.63 ±0.378	6.43 ±0.136
4.	Juiciness	6.73 ±0.237	7.37 ±0.321	6.70 ±0.170
5.	Acceptability	6.83 ±0.307	7.67 ±0.212	6.47 ±0.196

Each figure is based on three alternative days judging by five judges.

4.12 Developing prediction equations

To predict the growth performance and utilization of energy and protein, attempts were made to fit the simple regression equations and correlation coefficients were worked out using observations on gain in weight, nitrogen intake, efficiency of crude protein utilization, net energy gain (NEg) and dry matter intake as independent variable (Y) while dependent variables (X) were ME intake, DCP intake, gain in weight, nitrogen outgo and total water intake (lit.).

The prediction equations obtained having independent variable (Y) and dependent variable (X) are presented in Table 27 and Table 28.

It is worth noting that ME intake and DCP intake jointly showed a very highly significant multiple correlation of coefficient (R) over gain in weight, under all the three treatments (T_1-0, T_2-25 and T_3-100).

During early stage of growth in winter, nitrogen intake played an important role and showed a highly significant correlation coefficient with daily body weight gain. Simultaneously ME intake also showed a very highly significant correlation coefficient over gain in body weight during early stage of growth. It is worth noting that efficiency of crude protein utilization showed a highly significant correlation coefficient with gain in weight under all the three treatment.

The perusal of regression equations presented in Table 28 envisage that nitrogen intake showed a very highly significant

Table 27. Regression equation and correlation coefficient of various parameters related to energy, protein utilization and growth data

[n = Six observations for six months (182 days) continuously under each treatment]

Sr.No.	Independent variable (Y)	Dependent variable (X)	Equation for T_{1-0}	Equation for T_{2-25}	Equation for T_{3-100}
1.	Gain in weight in winter	X_1=ME intake in winter	$Y=-4.642+0.065X_1 -0.285X_2$	$Y=-11.295+0.061 X_1-0.242X_2$	$Y=-2.862+0.043 X_1-0.260X_2$
		X_2=DCP intake in winter	$R=0.945^{**}$	$R=0.900^{**}$	$R=0.801^{**}$
2.	Gain in weight in summer	X_1=ME intake in summer	$Y=-31.924-0.022 X_1+4.723X_2$	$Y=5.843-0.016 X_1+0.995X_2$	$Y=36.117+0.031 X_1-2.772X_2$
		X_2=DCP intake in summer	$R=0.781^{**}$	$R=0.868^{**}$	$R=0.851^{**}$
3.	N intake in winter	Gain in weight in winter	$Y=6.392+1.032X$ $r=0.729^{**}$	$Y=11.365+0.758X$ $r=0.945^{**}$	$Y=8.531+1.209X$ $r=0.815^{**}$
4.	Gain in weight in winter	ME intake in winter	$Y=-7.778+0.0649X$ $r=0.970^{**}$	$Y=128.471+ 13.243X$ $r=0.949^{**}$	$Y=126.784+ 13.564X$ $r=0.745^{*}$
5.	Efficiency of CP utilization in summer	Gain in weight in summer	$Y=-0.891+1.257X$ $r=0.938^{**}$	$Y=-3.624+1.535X$ $r=0.892^{**}$	$Y=1.281+0.577X$ $r=0.986^{**}$

Table 28 . Regression equation and correlation coefficient

Sr.No.	Independent variable (Y)	Dependent variable (X)	Equation
1.	N intake in winter	N outgo in winter	Y=1.36+1.49 X r=0.928**
2.	N intake in summer	N outgo in summer	Y=6.123+1.03 X r=0.909**
3.	N intake in winter	ME intake in winter	Y=4.421+0.056 X r=0.608**
4.	N intake in summer	ME intake in summer	Y=-7.877+0.0678 X r=0.743**
5.	Gain in weight in winter	ME intake in winter	Y=-6.121+0.062 X r=0.908**
6.	Gain in weight in year	ME intake in year	Y=-4.574+0.034 X r=0.763**
7.	Gain in weight in year	X_1=ME intake in yr X_2=DCP intake in yr	Y=-8.302+0.032X_1 +0.22X_2 r=0.606
8.	N intake in winter	Gain in weight in winter	Y=8.141+1.051 X r=0.775**
9.	N intake in summer	Gain in weight in summer	Y=11.794+1.267 X r=0.704**
10.	Efficiency of CP utilization in winter	Gain in weight in winter	Y=7.654+0.64 X r=0.750**
11.	Efficiency of CP utilization in summer	Gain in weight in summer	Y=2.22+0.652 X r=0.743**
12.	Net energy gain (NEg) for gained biomass in summer	Gain in weight in summer	Y=3.046+0.072 X r=0.567*
13.	Dry matter intake (kg)	Total water intake (lit.)	Y=-0.248+3.692 X r=0.792**

correlation coefficient with nitrogen outgo. This proves that nitrogen metabolism was not adversely affected by the presence of antinutritional factors in fababean. Net energy gain (NEg) also showed a significant correlation with gain in weight. This indicate that the lambs tried to extract required amount of net energy from fababean when it was a sole replacement of conventional concentrate mixture in treatment T_3-100. Had there been any interference by the antinutritional factors present in fababean, there was no chance of having significant correlation coefficient of net energy drawn from fababean over the dependent variable (X) viz., gain in weight during the late stage of growth. It is well known fact that dry matter intake (kg) and total water drunk (lit.) have a linear highly significant correlation coefficient and the same findings have been confirmed during current investigation.

4.13 Histological studies of rumen wall, kidney and liver

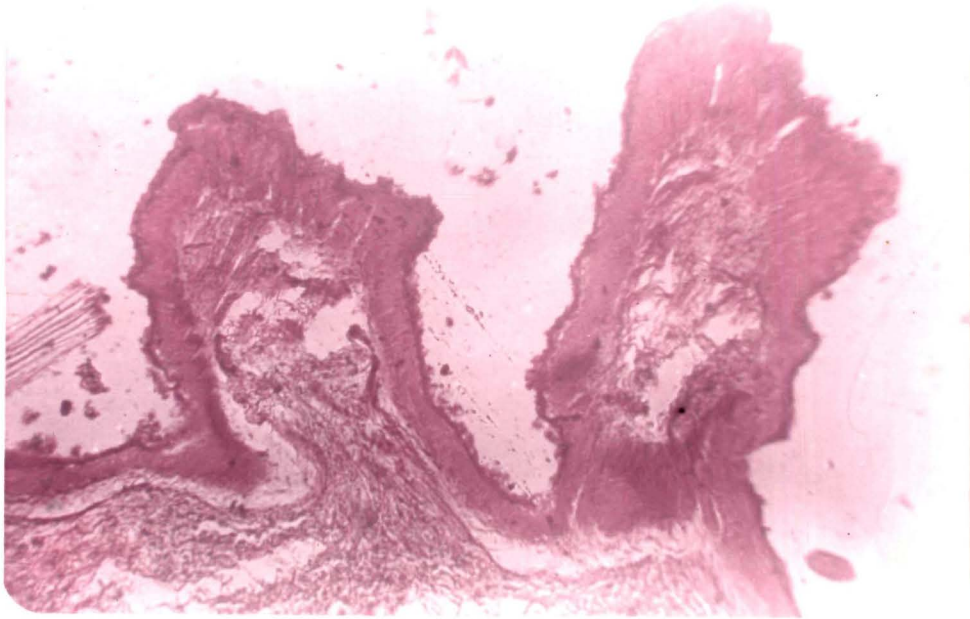
The histological photographs of tissues of rumen wall, kidney and liver are presented in (Photo 10-18).

From the microscopic examination of rumen wall (Photo 10-13), it is observed that there was slight elongation of ruminal papillae in T_2-25 group while significant elongation and slender growth of rumen papillae was observed in T_3-100 group in comparison to ruminal wall tissue picture of control T_1-0 group, however, sub-acute inflammation in the lamina propria was also observed in T_3-100 group. From perusal of results it seems that the fababean might be responsible for the elongation of ruminal papillae. Rumen is a seat of microbial

Photo 10. Rumen papillae of control group (T_1-0)
Note wide and short papillae (H & E, 3.2 X)

Photo 11. Rumen papillae of sheep fed diet containing 25% faba beans (T_2-25)

Note slightly elongated ruminal papillae (H &E, 13.2 X)



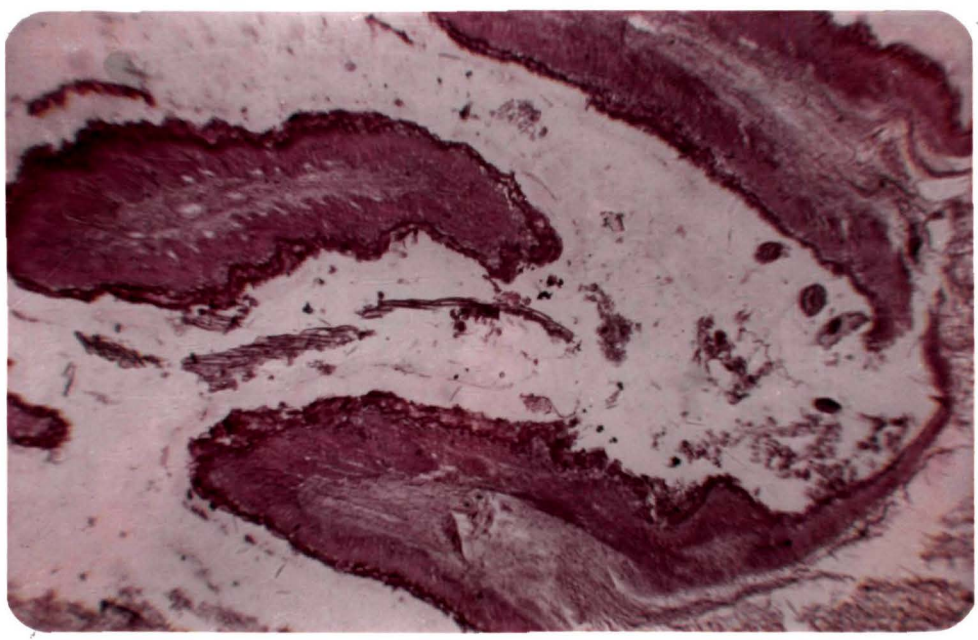
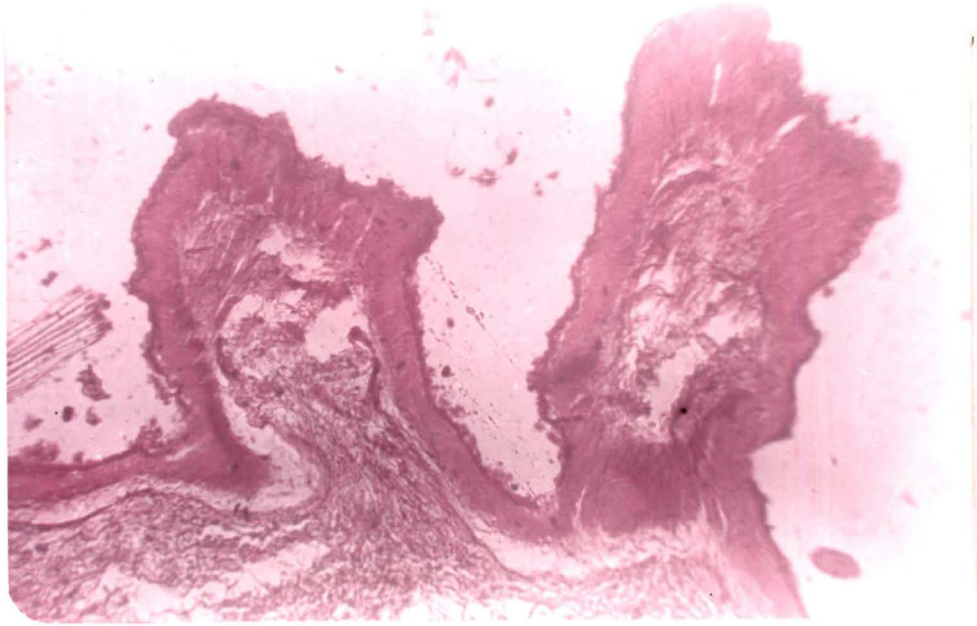


Photo 10. Rumen papillae of control group (T_1-0)

Note wide and short papillae (H & E, 3.2 X)

Photo 12. Rumen papillae of fed sheep diet containing 100% faba beans (T_3-100)

Note significantly elongated and slendor rumen papillae (H & E, 13.2 X)



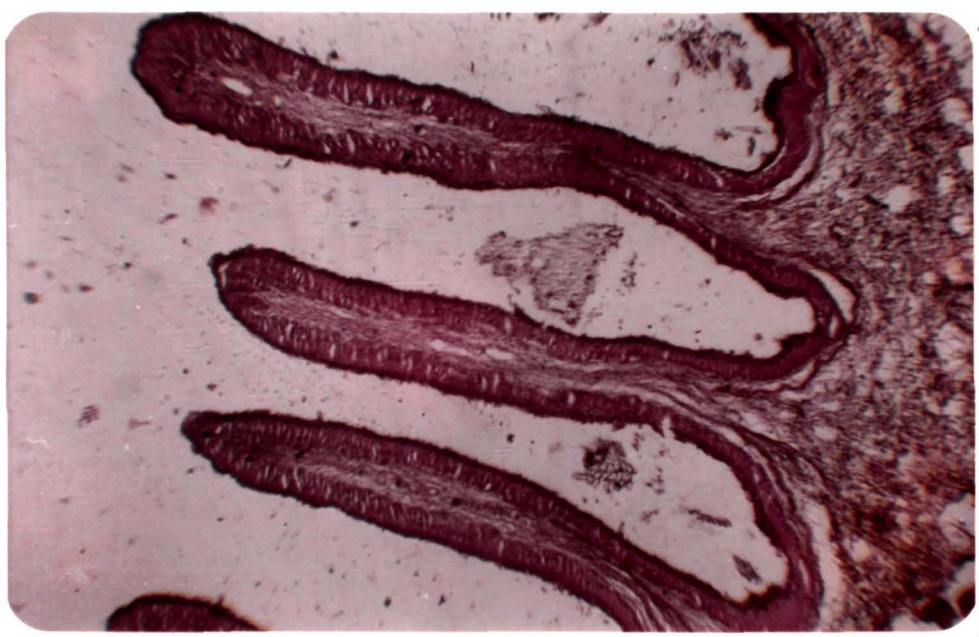


Photo 13. Rumen papillae of sheep fed diet containing 100% faba beans (T_3-100)

Note inflammatory (sub-acute inflammation) cells in the lamina propria (H & E, 66 X)

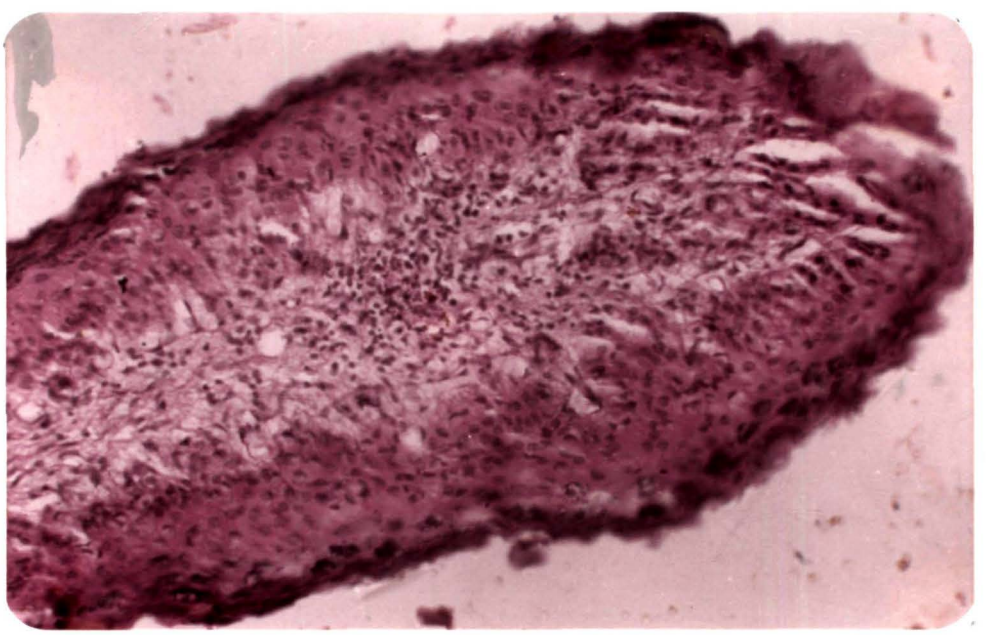
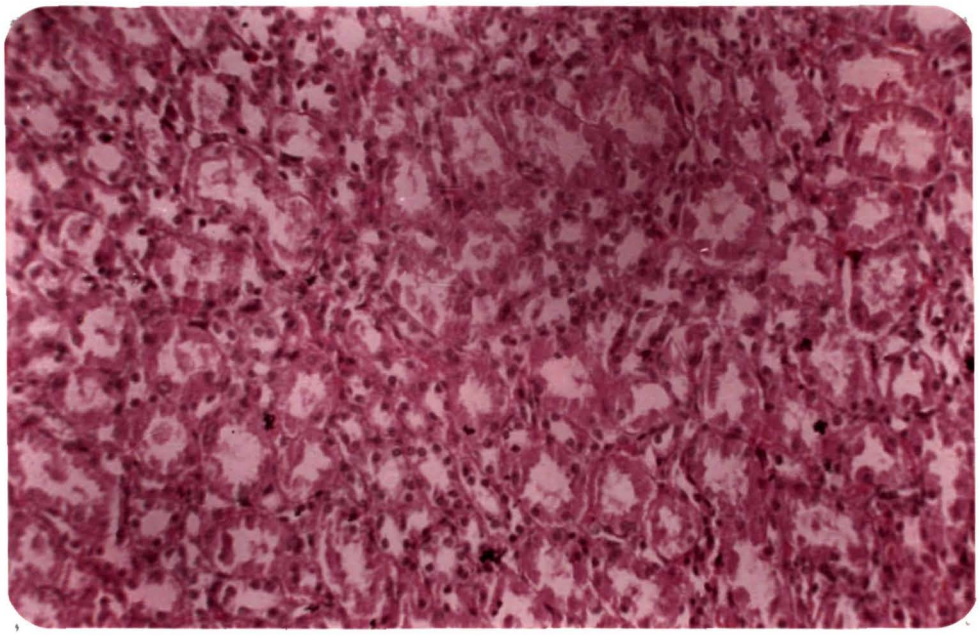


Photo 14. Medullary tubules of kidney from control group (T_1-0) (H & E, 66 X)

Photo 15. Medullary tubules of kidney from sheep fed diet containing 100% faba bean (T_3-100)

Note calcification of the tubules (H & E, 66 X)



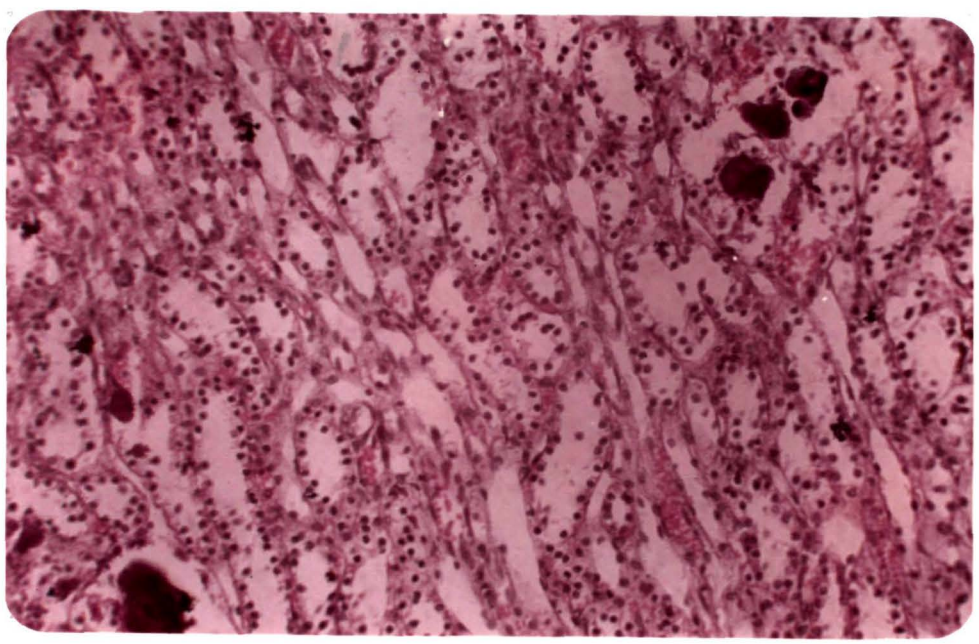
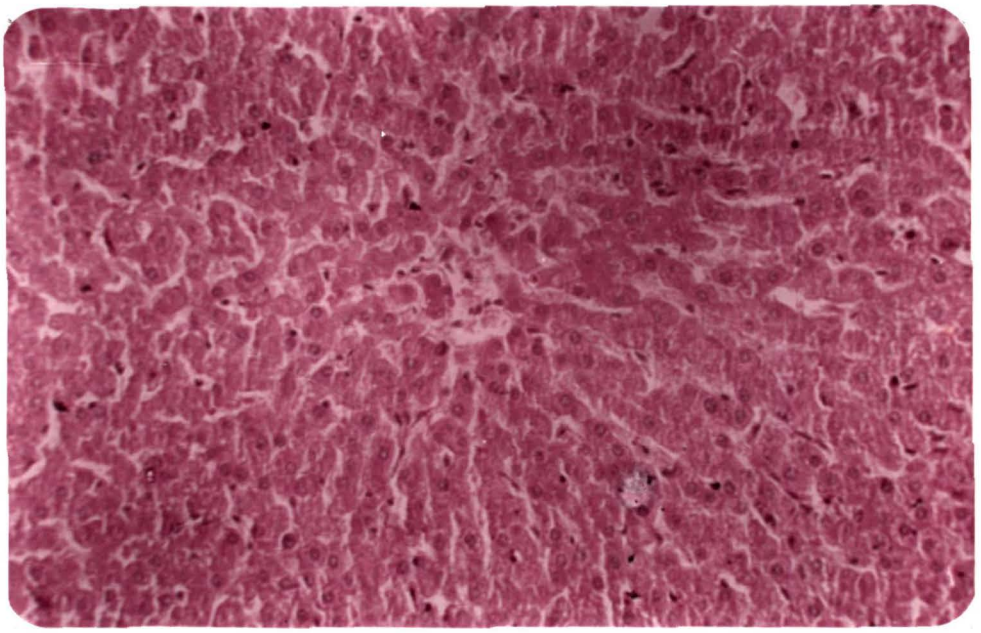


Photo 16. Liver from control group (H & E, 66 X)

Photo 17. Liver of sheep fed diet containing 25% faba beans (T_2-25)

Note mild proliferation of fibrous tissue in portal tract (H & E, 66 X)



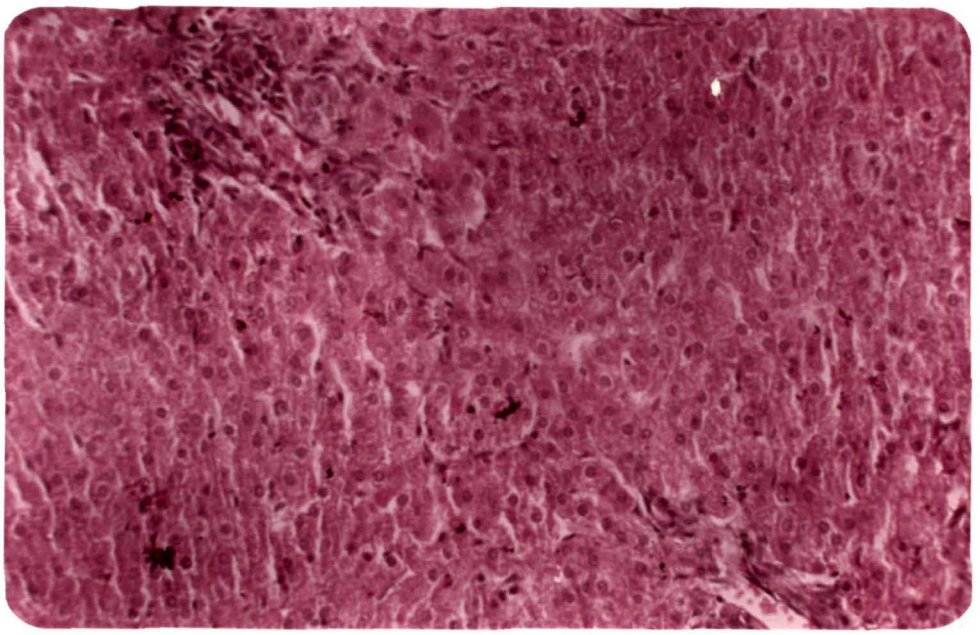
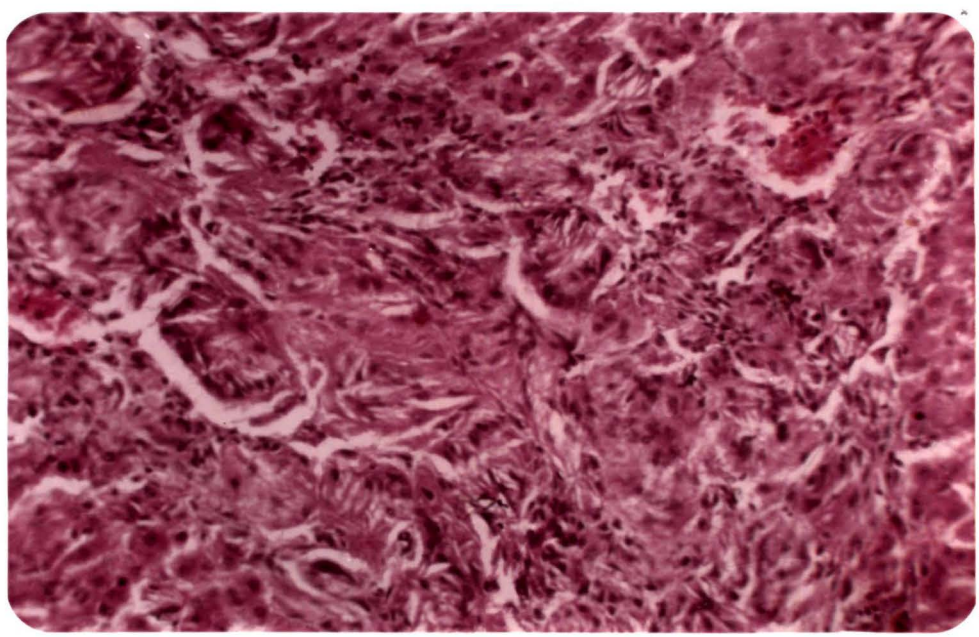


Photo 18. Liver from sheep fed diet containing 25% faba bean (T_2-25)

Note empty spaces previously occupies by needle shaped cholesterol crystals (H & E, 123 X)



digestion of crude fibre, ether extract, crude protein and NFE and there is continuous churning of dry matter content present in rumen which result in end product of digestion. During current investigation, a very important significant finding confirming the elongation of rumen papillae has been observed in the lambs maintained on fababean feed and this elongation of rumen papillae was proportionately more in comparison to control group lambs (Photo 12). The elongation of rumen papillae resulted in more propulsive movements of rumen contents and increased absorption of rumen digestion end products. The published literature is silent about the effect of fababean feeding on the physical form of rumen papillae, however, there is a need for further study related to this aspect involving the detailed study at cellular level particularly changes in DNA and RNA configuration.

In case of kidney tissues studied in all the three treatments (Photo 14) no specific changes were observed. However, calcification of medullary renal tubules was observed in one case in T_3-100% (Photo 15). Whether it is because of higher bicarbonate excretion through urine in T_3-100 group than control, results are to be confirmed. In case of liver tissue also no specific changes were observed except there was mild proliferation of fibrous tissue in portal tract (Photo 17).

Experiment II: Utilization of proximate nutrients and nitrogen balance (Treatment T_4-50)

The above experiment was conducted from 14th April to 15th July, 1992 for the period of three months only with six crossbred lambs at the age of about three months old. The average body weight was 11.200 kg. The experiment was conducted without the control group. The experimental ration was formulated to replace 50 per cent crude protein of conventional mixture by fababean. The ration was designated as T_4-50. The ingredient composition of experimental ration is given in Table 3 and proximate nutrient composition is incorporated in Table 2.

The period of experiment was under the summer season, therefore, the results of first experiment of control group of summer season (T_1-0) were used as control for comparing the findings of experimental group (T_4-50).

4.14 Proximate Nutrient Intake

The total proximate nutrient intake *viz*., dry matter, crude protein, ether extract, nitrogen free extract and crude fibre were 514.353 $\pm$ 44.102, 80.199 $\pm$ 7.015, 11.461 $\pm$ 0.820, 254.433 $\pm$ 32.103 and 127.492 $\pm$ 9.835 g/day where as in control it was 876.061, 123.116, 16.467, 461.702 and 194.139 g/day, respectively. The intake of total proximate nutrient in control was more but it may be due to differences in weight hence dry matter intake kg/100 kg body weight was compared, then it was observed that, it was more in T_4-50 (3.567 $\pm$ 0.181) than T_1-0 (3.153 $\pm$ 0.073 g/day).

4.15 Apparent Digestibility of Proximate Nutrients

The data related to apparent digestibility of proximate nutrients are depicted in Table 29.

Table 29. Digestibility coefficient of proximate nutrients

Attribute	Treatment	
	T_1-0	T_4-50
Dry matter	60.978 ± 0.743	59.250 ± 1.05
Crude protein	70.664 ± 1.247	66.590 ± 1.150
Ether extract	58.898 ± 1.062	59.161 ± 1.182
Crude fibre	47.930 ± 0.432	53.938 ± 0.936
Nitrogen free extract	70.803 ± 1.039	67.017 ± 1.347

It is clear from the perusal of results presented in above Table 29 that the apparent digestibility of proximate nutrient is almost similar except in crude fibre. It was more in T_4-50 (52.938%) than T_1-0 (47.930%), similar trend was observed in first experiment also and this may be because of more microbial protein synthesis due to more solubility and degradability of fababean protein.

4.16 Nutritive Value

The nutritive value of experimental rations based on *in vivo* digestion trial was worked out which is given below in Table 30.

Table 30. Nutritive value of experimental ration

Attribute	Treatment	
	T_1-0	T_4-50
DCP (kg/100 kg) ration	9.844 ± 0.228	10.371 ± 0.203
TDN (kg/100 kg) ration	60.437 ± 0.771	59.865 ± 2.317
DE (Mcal/kg)	2.777 ± 0.050	2.796 ± 0.900
ME (Mcal/kg)	2.423 ± 0.044	2.284 ± 0.086

The data presented in Table 30 envisage that there seems to be no differences in respect of nutritive value in control and experimental group, similar trend was observed in first experiment.

4.17 Growth Performance

The data related to growth performance of lambs under trial period are presented in Table 31.

Table 31. Growth performance and feed conversion data in lambs

Attribute	Treatment	
	T_1-0	T_4-50
Dry matter intake (g/day)	897.7 ± 74.2	590.022 ± 24.115
Dry matter intake (kg/100 kg body wt.)	3.153 ± 0.073	3.567 ± 0.181
Body weight gain (g/day)	62.5 ± 9.3	67.216 ± 2.698
Feed:gain ratio (F:G ratio)	10.251± 0.950	8.188 ± 0.169

The growth performance was better in T_4-50 than T_1-0. This may be due to the better feed conversion in lambs.

4.18 Efficiency of Utilization of Energy and Protein

The data in relation to efficiency of utilization are incorporated in Table 32.

Table 32. Efficiency of utilization of energy and protein

Attribute	Treatment	
	T_1-0	T_4-50
Crude protein		
1. Total CP intake (g/day)	125.538 ± 10.373	84.188 ± 3.69
2. Gross efficiency of CP utilization	14.460 ± 1.126	20.338 ± 0.45
3. Crude protein deposited in gained biomass (g)	15.176 ± 2.256	17.105 ± 0.687
Metabolizable energy		
1. ME intake (Mcal/day)	2.174 ± 0.177	1.261 ± 0.083
2. Gross efficiency of ME utilization	18.111 ± 1.474	27.008 ± 1.211
3. Calorific value of gained biomass (Mcal)	0.312 ± 0.046	0.336 ± 0.013

4.19 Gross Efficiency of Utilization of Energy for Gain

The data related to efficiency of utilization of energy are presented in Table 33.

Table 33. Energy utilization data

Attribute	Treatment	
	T_1-0	T_4-~~100~~ 50
1. GE (Mcal/kg)	4.314 ± 0.065	4.232 ± 0.095
2. ME (Mcal/kg)	2.309 ± 0.030	2.284 ± 0.086
3. Metabolizability of gross energy (q)	53.54 ± 0.550	52.943 ± 0.705
4. Net energy for gain (NEg) (Mcal/kg)	0.791 ± 0.030	0.756 ± 0.084
5. Efficiency of ME utilization for maintenance (km)	19.241 ± 0.192	19.11 ± 0.263

It is clear from the results that there was no differences in efficiency of energy utilization in T_1-0 and T_4-50 similar trend was observed in first experiment.

4.20 Nitrogen Balance

The nitrogen balance data are calculated with reference to nitrogen balance as percentage of intake and as percentage of absorbed nitrogen and data are presented in Table 34.

Table 34. Nitrogen balance

Attribute	Treatment	
	T_1-0	T_4-50
Total N intake (g)	18.150 ± 2.396	13.981 ± 1.224
Total N outgo (g)	11.584 ± 1.395	11.719 ± 1.016
Total N outgo through faeces (g)	5.771 ± 0.585	8.495 ± 0.756
Total N outgo through urine (g)	7.532 ± 1.298	3.141 ± 0.250
Balance (g)	6.566 ± 1.134	2.253 ± 0.457
Balance as % of intake	36.176 ± 2.623	16.115 ± 2.738
Balance as % of absorbed	46.294 ± 4.512	39.470 ± 5.909

5. SUMMARY AND CONCLUSION

The present series of experiments were conducted to achieve the objectives in two sets of experiment. The first experiment consisting of the nutritional evaluation of Bakla (Vicia faba L.) based on (one year duration) long term feeding for growth in lambs was undertaken in order to study the utilization of nutrients, feed:gain ratio, in vivo rumen fermentation pattern, important blood nitrogenous constituents, meat quality and quantity and wool quantity study. In experiment I, eighteen lambs of about six months of age were divided in three treatment groups of six each. The experiment was conducted in completely randomised design. These lambs were fed concentrates and Gram straw in the ration which provided 60 per cent ME from the former and 40 per cent from the later. The control group (T_1-0) was fed conventional concentrate mixture with groundnut cake as the main protein source. The experimental group T_2-25 was fed similar ration except that 25 per cent protein of the concentrate mixture was replaced with Bakla and in the third group (T_3-100), Bakla formed 100 per cent protein source. The ingredients of the concentrate mixtures of T_2-25 and T_3-100 were altered suitably to achieve the desired levels of protein from Bakla.

The salient findings of the investigation are briefly given below:

1. The average dry matter intake (kg/100 kg body wt. and g per kg metabolic body size) was significantly ($P<0.05$) higher during summer season as compared to winter season.

2. The lambs maintained on sole crushed Bakla feed could meet the nutrient requirement as per National Research Council (1968) recommendations.

3. Highest daily body weight gain and corrected daily body weight gain was observed throughout the year in case of lambs maintained on sole Bakla and Gram straw in the ratio 60:40 on ME basis. Feeding of fababean was found more beneficial for getting economic gains during early stage of growth (winter season). Overall significantly ($P<0.05$) higher gross efficiency of metabolizable energy and protein as well as metabolizability of gross energy was observed during winter (early stage of growth) in comparison with that of summer (later stage of growth).

4. The bicarbonate excretion through urine indicated no significant alteration in buffer system of lambs maintained on sole Bakla feeding.

5. The quality and quantity of meat produced and quantity of wool were not adversely affected by feeding sole Bakla.

6. The digestibility of proximate nutrients and nutritive value of experimental Bakla based rations (T_2-25) were found comparable with the control group (T_1-0). However, the values of these parameters were higher ($P<0.05$) in T_3-100 than T_1-0.

7. The data related to nitrogen balance expressed as percentage of absorbed nitrogen reflects that the degradability of fababean protein is very high at rumen level and it was at par with that of the concentrate mixture protein fed to the control group (T_1-0). This has been confirmed by conducting nylon bag protein degradability as well as effective degradability.

8. Overall net energy gain (NEg) and gross efficiency of ME utilization and crude protein utilization was significantly ($P<0.05$) higher in lambs maintained on Bakla based rations (T_2-25 and T_3-100).

9. All blood biochemical constituents viz., total protein, non-protein nitrogen, ammonia nitrogen and urea nitrogen and rumen metabolic profile picture in sole Bakla fed lambs was not different from the control group.

10. Water intake was significantly ($P<0.05$) related with dry matter consumption.

11. The organoleptic studies showed that mutton produced from the lambs maintained on Bakla based rations was equally acceptable as compared to lambs maintained on conventional ration.

12. From the histological studies of rumen wall, liver and kidney, it was observed that there was no distinct change in liver and kidney except slight elongation of rumen papillae in T_2-25 group and significant elongation of rumen papillae in T_3-100 group as compared to the control group (T_1-0).

Significantly elongated rumen papillae could have provided better churning process and subsequent nutrients absorption leading to higher daily body weight gain in the lambs maintained on Bakla as sole source of concentrate mixture protein (T_2-25 and T_3-100).

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*Original not seen.

Appendix-I

DEPARTMET OF ANIMAL NUTRITION

College of Animal Sciences

CCS Haryana Agricultural University

HISAR-125 004 (Haryana)

CARCASS EVALUATION DATA

Animal No. _____ Date of Slaughter _____

Treatment _____

A. Live Animal Measurements

1. Preslaughter weight
2. Body length
3. Heart girth
4. Height at withers
5. Paunch girth

B. During slaughtering

1. Weight after bleeding ___
   a. Weight of blood (Wt. before slaughter - Wt. after bleeding) Wt. of blood =
2. Weight of skin ___
3. Weight of head ___
4. Weight of feet ___ (Fore feet and hind feet)
5. Weight of digestive tract with contents ___
6. Weight of digestive tract empty ___
7. Weight of rumen contents ____

c. Carcass Measurements (cm)

1. Leg length (Hind) ___
2. Width of gigots (g) ___
3. Depth of gigots (H) __
4. Fullness of thighs (I)
5. Carcass length
6. Length of fore cannon (metacarpal) __
7. Length of hind cannon (metatarsal) __
8. Length of neck (N)
9. Depth of Thorax (Th)

10. Eye muscle
    a. Length
    b. Width
    c. Depth
11. Loin eye area (12 & 13 rib)
12. Thickness of back fat
13. Hot carcass weight ___
14. Cold carcass weight ___
15. Weight of pluck or race
    (Include weight of heart, liver, lung trachea and spleen)
16. Dressing percentage

D. Meat : bone ratio

1. Hind leg (Meat : bone ratio)
   Weight of meat ___
   Weight of bone ___
2. Fore leg (Meat : bone ratio)
   Weight of meat ___
   Weight of bone ___
3. Loin (Meat : bone ratio)
   Weight of meat ___
   Weight of bone ___

E. Proximate analysis of minced meat sample
   (On 100% DM basis)

1. Moisture ____
2. Protein _____
3. Total ash ___
4. Crude fat ___

Appendix-II

DEPARTMENT OF ANIMAL NUTRITION

College of Animal Sciences

Score Sheet for Semi-Trained Panel

Name

Date/Time

Address

Very desirable	_____	9
Desirable	_____	8
Moderately desirable	_____	7
Slightly desirable	_____	6
Neither desirable	_____	5
Nor desirable	_____	
Slightly undesirable	_____	4
Moderately undesirable	_____	3
Undesirable	_____	2
Very undesirable	_____	1

Code Number	Appearance	Flavour	Tender-ness	Juici-ness	Accept-ability	Remarks
1.						
2.						
3.						
4.						
5.						
6.						
7.						

Signature

Appendix-III

Body weight, metabolic body size and dry matter intake during early stage of growth (winter)

Sr. No.	Fort-night	T_1-0				T_2-25				T_3-100			
		Body wt. (kg)	Metabo-lic body size (kg)	DMI (g/day)	DMI ($g/W^{0.75}_{kg}$)	Body wt. (kg)	Metabo-lic body size (kg)	DMI (g/day)	DMI ($g/W^{0.75}_{kg}$)	Body wt. (kg)	Metabo-lic body size (kg)	DMI (g/day)	DMI ($g/W^{0.75}_{kg}$)
1.	1	12.567	6.674	461.501	69.149	12.967	6.833	457.667	66.978	12.866	6.793	426.112	62.728
2.	2	13.550	7.062	495.556	70.172	13.900	7.199	497.727	69.138	14.017	7.244	531.277	73.340
3.	3	13.833	7.173	525.001	73.191	15.317	7.742	553.668	71.515	15.417	7.780	555.333	71.379
4.	4	17.067	8.397	595.556	70.925	16.400	8.149	648.555	79.587	16.333	8.124	606.557	74.662
5.	5	16.733	8.273	685.334	82.840	17.533	8.568	693.944	80.992	17.233	8.458	685.778	81.080
6.	6	18.467	8.908	705.333	79.179	19.500	9.279	733.056	79.002	19.267	9.196	719.278	78.216
7.	7	18.867	9.053	718.278	79.341	19.633	9.327	738.889	79.220	19.267	9.196	732.443	79.648
8.	8	20.267	9.552	776.666	81.309	21.167	9.868	797.222	80.788	21.800	10.089	796.500	78.947
9.	9	21.333	9.926	680.001	68.507	22.600	10.365	851.999	82.199	23.400	10.639	885.000	83.184
10.	10	22.800	10.434	881.888	84.521	24.167	10.900	865.999	79.449	24.933	11.158	925.167	82.915
11.	11	22.467	10.319	905.167	87.718	24.167	10.900	900.000	82.844	24.967	11.169	989.499	88.593
12.	12	22.933	10.480	919.500	87.738	25.300	11.281	948.223	84.055	26.066	11.536	993.056	86.083

Each figure is an average of six values.

Appendix - IV

Body weight, metabolic body size and dry matter intake during late stage of growth (Summer)

Sr. NO.	Fort-night	T_1-0				T_2-25				T_3-100			
		Body wt. (kg)	Metabo-lic body size(kg)	DMI (g/day)	DMI ($g/W^{0.75}$ kg)	Body wt. (kg)	Metabo-lic body size(kg)	DMI (g/day)	DMI ($g/W^{0.75}$ kg)	Body wt. (kg)	Metabo-lic body size(kg)	DMI (g/day)	DMI ($g/W^{0.75}$ kg)
1.	1	23.800	10.775	917.667	85.166	24.800	11.113	944.837	85.021	25.900	11.481	1028.055	89.544
2.	2	24.600	11.046	884.678	80.090	26.900	11.812	911.612	77.177	27.677	12.063	947.056	78.509
3.	3	25.200	11.247	883.166	78.524	27.900	12.139	1006.001	82.873	28.867	12.454	1006.277	80.799
4.	4	25.967	11.503	934.222	81.215	29.733	12.733	1040.893	81.748	29.733	12,733	1041.833	81.841
5.	5	26.567	11.702	1005.889	85.958	30.600	13.010	1078.556	82.902	30.900	13.106	1058.390	80.756
6.	6	27.000	11.845	914.611	77.215	31.233	13.212	1018.667	77.102	31.567	13.317	997.110	74.875
7.	7.	28.033	12.183	992.445	81.461	31.367	13.254	1119.947	84.499	33.767	14.008	1116.277	83.258
8.	8	28.067	12.194	1018.444	83.520	32.333	13.559	1058.445	78.062	34.300	14.173	1168.944	82.477
9.	9	28.733	12.410	1064.333	85.764	33.367	13.883	1107.555	79.778	35.400	14.513	1209.056	83.308
10.	10	29.500	12.658	1080.889	85.392	34.433	14.274	1171.278	82.403	37.367	15.113	1271.055	84.103
11.	11	27.933	12.150	1074.111	88.404	32.633	13.653	1162.722	85.162	37.767	15.235	1297.555	85.169
12.	12	28.500	12.335	1061.056	86.020	33.633	13.966	1167.520	83.597	36.933	14.982	1244.278	83.051

Each figure is an average of six values.

Nutritional evaluation of Bakla (Vicia – faba L.) on long term feeding in Lambs.

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The present series of experiments were conducted to achieve the objectives in two sets of experiment. The first experiment consisting of the nutritional evaluation of Bakla (Vicia faba L.) based on (one year duration) long term feeding for growth in lambs was undertaken in order to study the utilization of nutrients, feed : gain ratio, in vivo rumen fermentation pattern, important blood nitrogenous constituents, meat quality and quantity and wool quantity study. In experiment I, eighteen lambs of about six months of age were divided in three treatment groups of six each. The experiment was conducted in completely randomized design. These lambs were fed concentrates and Gram straw in the ration which provided 60 per cent ME from the former and 40 per cent from the later. The control group (T1 –0) was fed conventional concentrate mixture with groundnut cake as the main protein source. The experimental group T2-25 was fed similar ration except that 25 per cent protein of the concentrate mixture was replaced with Bakla and in the third group (T3-100), Bakla formed 100 per cent protein source. The ingredients of the concentrate mixtures of T2-25 and T3-100 were altered suitably to achieve the desired levels of protein from Bakla.

The salient findings of the investigation are briefly given below:

1- The average dry matter intake (kg/100 kg body wt. And g per kg metabolic body size) was significantly ($P<0.05$) higher during summer season as compared to winter season.
2- The lambs maintained on sole crushed Bakla feed could meet the nutrient requirement as per National Research Council (1968) recommendations.
3- Highest daily body weight gain and corrected daily body weight gain was observed throughout the year in case of lambs maintained on sole Bakla and Gram straw in the ratio 60:40 on ME basis. Feeding of fababean was found more beneficial for getting economic gains during early stage of growth (winter season). Overall significantly ($P<0.05$) higher gross efficiency of metabolizable energy and protein as well as metabolizability of gross energy was observed during winter (early stage of growth) in comparison with that of summer (later stage of growth).
4- The bicarbonate excretion through urine indicated no significant alteration in buffer system of lambs maintained on sole Bakla feeding.
5- The quality and quantity of meat produced and quantity of wool were not adversely affected by feeding sole Bakla.

6- The digestibility of proximate nutrients and nutritive value of experimental Bakla based rations (T2-25) were found comparable with the control group (T1-0). However, the values of these parameters were higher ($P<0.05$) in T3-100 than T1-0.
7- The data related to nitrogen balance expressed as percentage of absorbed nitrogen reflects that the degradability of fababean protein is very high at rumen level and it was at par with that of the concentrate mixture protein fed to the control group (T1-0). This has been confirmed by conducting nylon bag protein degradability as well as effective degradability.
8- Overall net energy gain (NEg) and gross efficiency of ME utilization and crude protein utilization was significantly ($P<0.05$) higher in lambs maintained on Bakla based rations (T2-25 and T3-100).
9- All blood biochemical constituents viz. total protein, non-protein nitrogen, ammonia, nitrogen and urea nitrogen and rumen metabolic profile picture in solve Bakla fed lambs was not different from the control group.
10- Water intake was significantly ($P< 0.05$) related with dry matter consumption.
11- The organoleptic studies showed that mutton produced from the lambs maintained on Bakla based rations was equally acceptable as compared to lambs maintained on conventional ration.
12- From the histological studies of rumen wall, liver and kidney, it was observed that there was no distinct change in liver and kidney except slight elongation of rumen papillae of T2-25 group and significant elongation of rumen papillae in T3-100 group as compared to the control group (T1-0).

Significantly elongated rumen papillae could have provided better churning process and subsequent nutrients absorption leading to higher daily body weight gain in the lambs maintained on Bakla as sole source of concentrate mixture protein (T2-25 and T3-100).