REVIEW OF LITERATURE

Introduction of cross breeding programme in the livestock in general and sheep in particular has been intensively applied in this country during the past two decades. Inadequate nutrition and the traditional practices of management are the major factors responsible for poor growth, low production and heavy losses of sheep in our nation. Literature ardently related with the enhanced productivity of mutton and wool has inspired a field for close study to adjudge the potentiality of indigenous as well as the exotic and the crossbred stock for the optimum expression of the genetic traits on a comparative basis. The literature cited in this work has, therefore, been divided in four sub-heads:

A) Energy and/or protein requirement for maintenance and growth

B) Growth rate and efficiency

C) Blood constituents as influenced by the dietary energy and protein levels

D) Production of wool as affected by energy and protein content of the diet.

A. Energy and/or protein requirement for maintenance and growth

Scientists of mid Thirties and early Forties have conducted experiments to improve the gain in weight and the
fattening of sheep by using grains in the diet. Rasmussen and Weir (1941) conducted the trials for fattening of sheep in Romneycross, Corriedale and Rambouillet breed lambs and found that the amount of grain required per kg of liveweight was less for Romneycross and Corriedale as compared to Rambouillet lambs.

Hinds et al. (1964) found highly significant increase in the live weight and a significant decrease in the feed requirement of the early weaned lambs by increasing the dietary protein from 15.4 to 18.5 per cent while Coetzee and Vermeulen (1967) observed that feeding of 9 per cent protein before and 15 per cent protein after weaning gave the best results in studies conducted on Merino lambs fed different creep feeds.

Preston et al. (1965) indicated that 21 g of digestible protein was required for each 1000 Kcal of digestible energy (DE) consumed by lambs for a better growth. According to Devuyst et al. (1966) the nitrogen requirement for maintenance in lambs was not constant but increased with the protein content of the diet. He postulated that the protein requirement should be expressed in relation to the metabolizable energy (ME) of the diet.

Robinson and Forbes (1966) in their work on protein requirement for maintenance of non-pregnant ewes reported that the apparent digestible nitrogen increased with the increasing nitrogen intake. Based on the regression
correlation in their experiment they postulated the apparent digested nitrogen requirement for maintenance as 0.15 to 0.18 g nitrogen per kg W^{75} per day corresponding to 0.93 to 1.16 g digestible crude protein per kg W^{75}.

Preston (1966) on the other hand suggested that the digestible protein requirement for the body weight gain in growing lambs could be calculated by the equation:

\[
DP = 2.79 \times W^{75} (1 + 6.02 \times G)
\]

Whereas DP = Digestible protein in g
W kg^{75} = Metabolic body size
G = Daily gain in Kg

In his continued work Preston (1967) recommended 22 g digestible protein per Mcal digestible energy (DE) for the maximum body weight gain and observed the DP : DE ratio of 1 : 23 and 1 : 33 to be non significantly different in affecting the increase in weight while the ratio of 1 : 14 caused significant less increase in the weight gain.

Shukla and Pal (1972) studied the influence of protein energy ratio of 1 : 8, 1 : 10 and 1 : 12 in the ration, on body composition of Malpura rams. Body fat was estimated from the total body water measured by antipyrine dilution technique. The rams fed ration with protein energy ratio 1 : 8 had the minimum total body fat and the rams fed the ratio of 1:12 had the maximum amount of fat.

Dror et al. (1969) found that adult rams retained 20 per cent more nitrogen and young rams 20 per cent less nitrogen on the high energy than on the
control diet. Addition of maize to the diets was followed by a decrease in the protein digestibility but no parallel trend was observed between the nitrogen retention and protein digestibility values.

Singh and Mahadevan (1970) reported the digestible crude protein (DCP) requirement for maintenance to be 0.875 g per kg metabolic body weight amounting to 12 g per day for a ram weighing 35 kg. They also observed that a higher efficiency of nitrogen utilization was achieved on a low protein and high carbohydrate diet, only in case of older animals.

Andrews and Orskov (1970) showed that the rate of growth in lambs increased linearly with the increased intake of digestible energy and curvilinearly with an increase in the protein content of the diet. They found that the diets containing 17, 15 and 11 per cent crude protein showed the best results when the caloric intake of 3.0, 2.6 and 2.1 Mcal was coupled with diets having the above, mentioned protein per cent respectively.

Jordan and Hanke (1970) found that the diets containing 9 to 15 per cent crude protein did not affect the weight gain in the suckling lambs. A daily intake of less than 100 g crude protein resulted in a reduced liveweight gain.
Jahn (1971) estimated the maintenance requirements of lambs to be 1 g and 4 g nitrogen per day at 4 and 35 kg liveweight respectively and 5 g nitrogen per day as the maintenance requirement for the adult sheep.

Singh and Mahadevan (1971) suggested 0.818 g of digestible crude protein per kg metabolic size (\( W^{73} \)) as the protein requirement for maintenance of adult sheep. Sharma and Negi (1973) on the other hand reported that the rams could be maintained in nitrogen equilibrium on a diet containing 3.4 per cent digestible crude protein having a nutritive ratio of less than 1 : 13.

Ely et al. (1976) studied the effect of feeding 9, 12 and 15 per cent crude protein to the Suffolk and Rambouillet lambs and reported that the increase in the dressing percentage of the carcass was in tune with the increase in the protein level of the diet. These results were in agreement with the work of Orskov et al. (1976).

The studies of Singh et al. (1966), however, revealed that a high level of dietary protein when associated with a low plane of energy neither increased the weight nor the productivity of lambs and thus indicated that the level of dietary energy could be a limiting factor in causing the beneficial effect in a higher dietary protein regime.

Allden and Jennings (1969) studied nitrogen excretion of Merino grazing sheep in relation to the
supplements of available energy and protein. Three groups of wethers, grazing on herbage were given a supplement with a constant amount of available energy supplying 4, 8 and 12 g nitrogen daily and other three similar groups had constant protein with 113, 227 or 340 g total digestible nutrients (TDN) daily. Extra energy had a nitrogen sparing effect and extra protein increased nitrogen excretion and the herbage intake fell as supplementary energy increased but did not change with the nitrogen intake.

Garrett et al. (1959) studied the energy requirement for sheep for maintenance and postulated that these can be obtained in terms of different measures of food energy by the following expressions:

\[ \text{TDN} = 0.036 W^{0.75} \]
\[ \text{DE} = 76 W^{0.75} \]
\[ \text{ME} = 62 W^{0.75} \]

Whereas
- \( \text{TDN} \) = Total digestible nutrients in lbs
- \( \text{DE} \) = Digestible energy in Kcal
- \( \text{ME} \) = Metabolizable energy in Kcal

They further stated that the partial utilization of food was independent of body size and therefore, recommended the relationship between energy intake and energy gain to be derived by the following expression:

\[ \text{DE} = 76 W^{0.75} (1.02)^{\text{ge}} / W^{0.75} \]

Whereas \( \text{ge} \) is gain in Kilocalories.
the group producing the highest growth. Bhargava and Ranjhan (1974) estimated the total dry matter intake ranging between 623 to 939 g, DCP from 43 to 64 g and TDN from 575 to 610 g per day per lamb with a daily gain ranging from 42.9 to 55.6 g.

Pilla et al. (1975) fed pelleted diets supplying 2900 or 2400 Kcal per kg metabolizable energy having 18, 15 or 12 per cent crude protein. The groups given the diet with more energy gained more, the feed intake was lower on the high energy diet and the protein content had little effect on growth or the feed conversion but the amount of protein used per unit of growth was higher in the groups on high protein diets.

Schulte et al. (1976) made a study on yearling lambs, maintained on low quality grass hay and 350 g concentrate, which provided ME 2.1 or 2.3 Kcal per kg each with 22 or 32 per cent crude protein. Average daily weight gain was highest with 2.3 Mcal and 32 per cent crude protein. Intakes of feed and of hay were not affected significantly with the level of energy or protein.

Wilke and Vender Merwe (1976) fed two diets viz. an all roughage diet and a high concentrate diet at two levels, one at a low level of estimated 1.5 times maintenance energy requirement and the other a high level of estimated two times maintenance energy requirements and found that there were significantly different rates of energy gain on different diets and feeding levels. The fat energy gained (per cent total energy gained) was similar in all four groups.
55.93 kg with average daily gain 80 and 82 g respectively.

Hasmat (1968) recorded body weights from birth to 12 months of age of 240 male and female Deccani, Merino X Deccani and Rambouillet X Deccani lambs. Males were heavier than females at all ages in all the three breeds. At all ages Rambouillet X Deccani crossbreds were heaviest and the growth rate was found to be 0.55 and 0.44 kg per week for male and female lambs respectively during the first month. Later the growth declined to 0.30 and 0.29 kg per week in the 12th month.

Crampton and Harris (1969) reported Sigmoid pattern of growth of two major segments, first, an increasing slope from birth to puberty and second, a decreasing slope from puberty to maturity. The requirements of total digestible nutrient and digestible crude protein in the ration for ram lambs, fattening lambs and yearlings, were in the range of 55 to 62 per cent and 5.5 to 6.6 per cent respectively. Ra-gab et al. (1968) on the other hand reported significantly increased body weight gains in crossbred lambs from 8 weeks of age up to marketing at 40 weeks.

Torell and Weir (1970) measured the effect of protein on ewes on pasture and alfalfa supplementation and found the adjusted average daily gain ranging from 0 to 111 g respectively. The correlation coefficient of supplemental nitrogen intake and weight gain was 0.95.

Pandey and Pal (1971a) studied the growth rate and plane of nutrition of Malpura lambs of 3 to 5 months of age
using three different diets comprising of concentrate mixture alone, concentrate and Akra in equal parts and Akra (Vicia Sativa) alone. Wheat straw was fed ad lib. to all the groups. Growth studies over 30 weeks indicated an average body weight gain of 0.22, 0.34 and 0.47 kg per week respectively.

Bondarenko (1971) reported average daily gain in Border Leicester x Caucasian back crossed male and Caucasian males to be 117 and 101 g. The consumption of feed unit per kg gain was 8.5 and 9.5 respectively while consumption of DCP per kg gain was 940 and 1069 g respectively.

Gerasimenko (1971) observed food utilisation by different sheep breeds and stated average daily gain to be 103 to 108 g, the wool growth over a 100 cm² area to be 8.4 to 12.3 g, the consumption of Feed Unit (FU) per kg weight gain was 3.0 to 3.3 while the consumption of Feed Unit per kg wool growth was 54 to 76.

Balaine et al. (1971) investigated the performance of Nali and Lohi and their crosses with Nellore and Mandya sheep after weaning. The experimental lambs were fed fattening ration ad lib. The results indicated that the performance of purebreds was slightly better as compared to all the crossbreds regarding the body weight gains, feed consumption efficiency of feed utilization, dressed carcass weight and dressing percentage. Murthy et al. (1972) studied the trend of growth in Nellore and Mandya lambs and found that the lambs grew faster up to one year of age. The growth rate
retarded considerably after 34 weeks of age.

Glimp (1971) studied the effect of energy value on growth of lambs of 8 breeds by feeding diets having 60, 75 and 90% concentrate. A significant breed ration concentrate level interaction was observed. There was a significant improvement in efficiency of feed utilization as energy increased.

Steele and Hohenboken (1972) estimated bi-weekly gains, feed consumption and feed efficiency by regression on mid weights for corresponding two week periods in crossbred lambs. The results revealed that the body weight gain first increased with advancing mid weights, but after reaching approximately 43 kg body weight the gain in weight decreased at an increasing rate. Feed consumption increased as the liveweight increased but at a decreasing rate. Finally as weight increased, feed efficiency decreased.

Kellaway (1973) measured growth rates, chemical composition of the body and wool production from two genotypes of sheep grazing at two planes of nutrition. Post weaning growth rates on high and low planes of nutrition were 168 g and 78 g per day for Merinos and 183 and 116 g per day for the crossbreds. Despite the differences in growth rate there was virtually no effect on body composition.

Prasad et al. (1973) evaluated the growth rate of Corriedale and crossbred lambs kept on improved and native pastures. All the lambs were also given 100 g concentrate daily.
Corriedale lambs gained 76 g daily on improved pasture and 34 g on native pastures, while crossbred lambs gained 111 g on improved and 107 g on native pastures.

Calotoiu et al. (1973) observed the performance of fattening lambs on fibrous and succulent feeds with 0.3 kg concentrate. The lambs gained 132 to 196 g daily and consumed 4.89 to 7.69 FU and 698 to 1058 g DCP per kg gain.

Kasymov (1973) observed intakes of Feed Unit ranging from 2.6 to 4.00 per kg gain at 4 months, 4.2 to 5.0 per kg gain at 6 months and 6 to 6.8 per kg gain at 8 months of age for the lambs weaned at first, third and 110th day.

Odonovan and Ghadaki (1973) in a study on lamb performance, feed intake and digestibility of diets containing different levels of wheat straw found that the daily gain ranged from 127 g to 159 g. The feed intakes varied from 9.78 to 11.30 kg per kg gain and carcass yields from 53 to 54.5 per cent.

Patnayak et al. (1973) reported an average daily gain of 44 g of the crossbred lambs fed on hay alone and 121 g on hay plus concentrate mixture. The feed conversion ratio on hay ration was 7.13 and on high concentrate ration 5.65. It was concluded that feeding hay alone has limitations in providing adequate energy for maximum growth. Later Patnayak and Madan Mohan (1974) studied the performance
of crossbred lambs of about 6 months of age under liberal or limited supplementation. Control group fed 50 per cent concentrate and 50 per cent roughage ration consumed on an average 980 g of feed per lamb per day with a feed conversion ratio of 9. The feed consumption was found to be 4.7 per cent of the body weight and the average daily gain varied from 60 to 130 g.

Craddock et al. (1974) fed lucerne hay to concentrate pellets in the ratio of 50 : 50 or 20 : 80 having TDN 63 or 71 per cent and found the average daily gain to be 0.20 and 0.19 kg and intakes of feed 9.37 and 9.24 kg per kg gain. The two groups did not differ in dressing percentage carcass measurements or chemical composition.

Jordan and Tichich (1974) studied the effect of self feeding of early weaned lambs on all concentrate diet and reported daily liveweight gain from 0.28 to 0.35 kg with a total feed conversion of 3.5 kg per kg gain. Robinson and Shaabi (1974) reported the feed conversion in lambs of different breeds ranging between 6.27 to 8.98 kg per kg gain.

Accardi et al. (1974, 1975) in a study on the production of Sicilian Barbary and crossbred Berrichon fed dried lucerne or ground Sulla hay supplemented with maize and soyabean meal and found average daily gains of 203 to 207 g.
in Barbary and 188 to 208 g in crossbreds. Feed conversion was 4.91 to 4.60 FU per kg in Barbary and 5.43 to 5.16 FU per kg in the Berrichon crossbreds. These workers later on fed lambs three levels of crude protein and showed that the two breeds namely Sicilian Barbary and Berrichon required 5.85 and 5.35 FU per kg gain or 4.09 and 3.74 kg SB per kg gain. While Plesyannikov and Ilyaletdinov (1975) observed consumption of DCP from 896 to 1020 g per kg gain in crossbred lambs.

Joyce and Gordon (1975) reported weekly gains between 1.64 and 1.76 kg with an average feed conversion of 3.4 in crossbred lambs fed on a diet of barley and soyabean meal. Ram Ratan et al. (1975) showed gains between 34 to 54 g per day in Chokla and Nali lambs fed ad lib. Cenchrus hay and 350 g concentrate mixture.

Makarechian et al. (1975) studied the influence of breed and weaning age on feed lot performance of the three Iranian breeds and concluded that breeds differed significantly in daily gain and there was no significant difference in feed efficiency among breeds.

Malik and Acharya (1972) in a study on blood differences in pre and post-weaning weights of Indian sheep reported that crossbreds in general had higher body weights than pure-breds, whereas, Pant et al. (1974) observed the growth of different crossbreds and stated that up to 9 months of age crosses of Nali and Chokla with Rambouillet performed better than those with Merino. Crossbred lambs
out of Kali ewes had a higher growth rate than those out of Chokla ewes.

Aboul Naga et al. (1976) fed lambs on barseem alone or with concentrate supplement and reported that differences among breeds were not significant for the gains. Observations on breed differences were also reported by Farid et al. (1976) in an experiment on Mehraban and Karakul lambs with a diet of 40 per cent hay and 60 per cent concentrate. They found no significant difference in daily gain or feed conversion among treatments. However, Mehraban lambs showed significantly better gain in weight and feed conversion than Karakul lambs.

Elshobokshy et al. (1976) in a trial on lambs fattened on 70 per cent concentrate and 30 per cent roughage or 55 per cent concentrate and 45 per cent roughage found that the lambs when fed concentrate in more or less quantity, gained 9.90 and 6.25 kg and required 5.5 and 7.9 kg SE per kg gain. Younis et al. (1976) reported average daily gain in Ibbidie sheep from 87 to 116 g and efficiency from 5.33 to 5.78 kg SE per kg gain on an intake of dry matter from 31.1 to 64.4 per cent as concentrate.

C. Blood constituents as influenced by dietary energy and protein.

The value of certain haematological and biochemical data for the assessment of the nutritional
status of the animal has been discussed with regard to haemoglobin (Hb), packed cell volume (PCV), plasma protein, urea nitrogen and blood glucose.

Becker and Smith (1950) found no significant difference among breeds or between sex with regard to Hb, PCV and plasma protein in sheep, while Reda and Hathout (1957) reported Hb percentage to be higher in young animals.

Holz et al. (1961) did not find significant difference in Hb value at birth between twins or single born lambs or between sex. The values ranged from 8.4 to 12.0 g per 100 ml of blood.

Mehrotra and Mullick (1959) reported seasonal variation in Hb, serum protein and blood urea. The data indicated the maximum and minimum values of Hb to be 9.09 g in October and 6.55 g in April per 100 ml of blood, serum protein 6.69 g in July and 6.34 g in March. The values for non protein nitrogen (NPN) were found to be 42.65 mg in November and 37.96 mg in October per 100 ml of serum and concluded the monthly differences to be highly significant.

Lewis (1957) reported different levels of blood urea concentration which was correlated with rumen ammonia concentration due to changes in the diet and further clarified that fluctuations in blood urea level in sheep were not primarily due to change in the overall nitrogen intake.
Wright et al. (1962) observed a direct relation of increase or decrease of the total plasma protein with the protein content of the diet. The non protein nitrogen level was, however, found to be affected by both the level of feeding and the stage of reproduction. The results further indicated that probably blood glucose level might be affected both by the energy and the protein content of the diet.

Charton et al. (1966) reported blood sugar level to be 138 mg per 100 ml at birth which gradually declined to adult value of about 70 mg at 5 months of age and noted great difference between individuals.

Ghosh and Purohit (1964) found significant breed differences in Hb concentration in Rajasthani breeds of sheep. Soliman and ElAmrousi (1965) reported Hb values to be higher at birth and significantly low during pregnancy in Egyptian sheep. Schalma (1967) reported mean PCV and Hb values of sheep to range between 30 tp 40 per cent and 11 to 12 g per 100 ml of blood respectively with an appreciable decrease during and subsequent to lambing.

Shutt and McDonald (1966) in a study in sheep given diets providing 65 to 78 g or 145 g crude protein per day found no difference between the diet groups in the rate of Hb synthesis and concluded that the maximum rate of Hb synthesis reflected the capacity of bone marrow to produce red cells. Nelson and Watkins (1967) did not find
significant differences in Hb, serum protein or PCV percentage by feeding supplemental protein to sheep.

Preston et al. (1965) found a close relationship between the blood urea nitrogen and the protein intake (r = 0.986) in lambs. While Preston (1967) further attested the aforesaid observation but reported an increase in plasma urea nitrogen value.

Riegle and Nellor (1967) in a study on changes in blood cellular and protein components during aging of bulls, cows, goats, sheep and rats found an increase in average plasma protein concentration with increase in age, whereas, Stepanov (1967) reported a negative correlation between the amount of protein in the blood serum and the growth up to 4 months of age. But after this age a positive relation between the amount of blood serum globulins and weight gains was established in sheep.

Efrner (1968) found no significant difference in Hb value, haematocrit and red or white cell counts due to shortening of suckling period in lambs from weaning to 16 months of age. Ide et al. (1968) reported serum urea level and rumen ammonia concentration to be closely related to each other and to protein intake with a constant intake of energy. Whereas, Dror et al. (1969) reported higher values for rumen ammonia and blood urea in sheep given a control diet than in the group receiving the diet supplemented with maize.
In an experiment on urea and non protein nitrogen estimation in the blood of sheep, Kowalczyk and Buraczewski (1969) found the highest value of 14.9 mg per 100 ml for urea nitrogen after 70 minutes of feeding beet pulp with ammonium lactate, 15.9 mg after 130 minutes of feeding ground nut oil meal, 15.7 mg after 100 minutes of feeding ammoniated beet pulp and 15.5 mg after 230 minutes of feeding grass. A higher blood non protein nitrogen value of 43 mg per 100 ml was obtained on feeding grass or ammoniated beet pulp and a lower value of 37 mg per 100 ml on feeding ammonium lactate and ground nut oil meal.

Poe et al. (1969) observed lower urea levels at early age to slowly increase with the ingestion of feed and the development of the rumen. The blood glucose concentration, however, dropped sharply immediately after weaning and did not return to preweaning levels whereas total protein level remained relatively stable. They further reported the normal range for blood glucose to be 90 to 100 mg, urea 20 to 25 mg and total protein 5.7 to 6.8 g per 100 ml of blood in lambs. But Swenson (1970) reported the normal range for glucose to be 30 to 50 mg, urea nitrogen 8 to 20 mg, non protein nitrogen 20 to 38 mg and plasma protein as 5.74 g per 100 ml of blood.

McIntyre (1970) fed 5 roughage rations providing increasing amounts of nitrogen to sheep and found an increase in plasma urea nitrogen and rumen ammonia levels linearly to about 30 mg per 100 ml. These levels, however,
did not increase further on higher levels of nitrogen intake. Oscar and Anthony (1970) did not find any significant difference in blood protein levels of lambs fed Cobalt supplemented diets.

Prior et al. (1970) fed purified diets containing isolated soyabean protein or urea as the only source of nitrogen to lambs and found concentration of blood pyruvate and alpha ketogluterate to be higher in the urea fed lambs but blood ammonia and haematocrit were lower. Blood urea and glucose levels however, did not show significant difference between the treatments.

Davison (1970) observed Hb and haematocrit values in sheep fed energy (carbohydrate or fat) and Dieldrin (insecticide or pesticide). Mean Hb value was 11.7 g per 100 ml and haematocrit was 34.5 per cent. Both Hb concentration and haematocrit increased in all the sheep during the experiment but these increases were reported to be not affected by the level of Dieldrin or energy fed. However, higher values for red blood cell, Hb and total proteins in the lambs were recorded by Pandey and Pal (1971b) on feeding Akra (Vicia Sativa) as fodder.

Mimrick et al. (1971) reported increased plasma urea nitrogen and concentration of most plasma free amino acids in lambs fed a corn soyabean meal diet from maintenance through increments to approximately 2.5 times maintenance level.

Pachalag et al. (1972) found no significant difference in Hb, PCV, red or white cell counts in sheep
maintained on Cenchrus hay and given additional amounts of different micronutrients, while Patel et al. (1972) indicated that blood Hb, protein, Ca, Cu, Fe and carotene were not affected in calves maintained on different planes of nutrition (energy and protein).

Patnayak et al. (1972) reported the mean Hb values in the range of 8.2 to 8.9 g, PCV 24.6 to 26.3 per cent and blood urea nitrogen 36 to 46 mg per 100 ml of blood in sheep fed different types of hay. However, Sharma (1973) in a study on changes in some of the blood constituents of Tharparkar calves fed on two levels of protein viz. 17.3 and 13.1 per cent and equal amount of total digestible nutrients did not find significant differences in the average values of any of the blood constituents.

Sharma et al. (1973) reported Hb values 9.82, 10.45 and 9.51 g per 100 ml of blood and PCV values 37.3, 36.3 and 34.4 per cent in adult, hoggets and lambs respectively. Arora and Arora (1975) reported the range of PCV in Chokla, Nali, Rambouillet x Nali, Merino x Nali, Rambouillet x Chokla and Merino x Chokla to be 20-49, 19-50, 23-49, 21-55, 17-50 and 15-52 per cent respectively. Sawhney and Bedi (1975) reported Hb values of sheep of hilly areas to be 7.0 to 7.5 g per 100 ml.

Lofgren and Warner (1971) fed sheep diets supplying 2.8, 3.0 or 3.2 Kcal DE per g dry matter for a 3 hr period twice daily and found increased blood glucose level ranging from 44.3 to 48.5 mg per 100 ml after 0.5 to 3 hr of feeding.
respectively. Lofgren and Warner (1972) further reported that the blood glucose and free fatty acids were not affected by the feeding pattern in lambs. Fennessy et al. (1972) found a highly significant negative correlation between plasma nonesterified fatty acids and energy intake in lambs and the weaning caused an immediate decrease in plasma glucose concentration irrespective of the age of the lambs. Kercher (1972) observed significant increase in blood urea level at 4 and 8 hr after feeding high levels of energy and at zero, 4 and 8 hr after feeding increased level of protein.

Cenni et al. (1968) observed the blood serum protein level to be in the range of 6.84 to 7.26 g per 100 ml. Whereas, Belonje (1975) reported the mean value of total plasma protein to be 6.91 ± 0.09 g per 100 ml in sheep.

Chomyszyn (1973) fed lambs on dehydrated maize meal. Urea level in blood was related to ammonia level in the rumen and the range was 7.40 to 24.5 mg and the glucose concentration ranged from 52 to 55 mg per 100 ml of blood. By intravenous energy infusion Eskeland et al. (1974) found that the glucose infusion did not lower plasma urea nitrogen (PUN) concentration in lambs receiving the high concentrate diet, but the three volatile fatty acids did lower it. They further stated that all energy sources significantly reduced the plasma urea nitrogen concentrations with the high roughage diet but differences between sources were not significant.
Torell et al. (1974) in an experiment on ewes fed with grass and varying amounts of concentrate found blood urea nitrogen (BUN) and weight gain increased during flushing period and reported that neither age nor sampling time had any significant effect on blood urea nitrogen level but found significant variation between animals with in age group.

Bhattacharya and Uwayjan (1975) stated that the environmental stress did not have any effect on total serum protein, red blood cell, haematocrit or Hb values in sheep fed different levels of roughage. Whereas, white blood cell, respiration rate and blood glucose concentration increased significantly. The values for glucose, serum protein and Hb were found to range between 31.1 to 42.7 mg, 5.5 to 5.7 g and 10.4 to 11.9 g per 100 ml of blood respectively. The PCV ranged from 29.0 to 34.8 per cent. Hussain et al. (1975) found plasma protein and haematocrit values to be affected significantly in Murrah buffaloe calves fed different levels of dietary protein and showed significant difference in all these haematological constituents with age.

Pfander et al. (1975) indicated superior performance in lambs fed a protein level designed to maintain plasma urea nitrogen at about 15 mg per 100 ml. Whereas, Yousri et al. (1976) found that the rumen ammonia and blood urea were more on higher protein intake and less with more energy intake.
D. Production of wool as affected by energy and protein content of the diet.

The quantity and quality of wool are most important production traits in sheep. Besides, the genetic factors associated with wool production, the plane of nutrition also plays an important role, particularly in early life of the lamb. Many workers have studied the effect of energy and protein in the diet of sheep on the quantitative and the qualitative characteristics of wool.

Fraser and Roberts (1933) reported little or no effect on the quantity of wool, its fineness, length and fibre weight with variations in protein intake. Belic (1955) found no appreciable sex difference in any of the fibre attributes. Belic and Petrovic (1956) reported the wool quality to become fixed at 2 and 8 months of age in the crossbred or Merinos and Tsigais respectively.

Ragab et al. (1957) on the other hand observed significant difference for staple length, fibre length, and fibre diameter at 23 months of age between Ossimi and Ossimi x Rahmani crossbreds with only slight improvement in the crimp in crossbreds.

Briggs et al. (1957) observed significantly more wool in ewes fed 1.8 kg starch equivalent than those
given 1.3 kg starch equivalent, while Ferguson (1959) found increased wool growth with the increase in the level of feed intake. However, the growth was not found to be affected by the changes in the dietary crude protein content.

Dunlop et al. (1966) found significant difference between the fine wool strain and others in efficiency of wool production (lb oven dry wool/100 therms of NE consumed) on feeding two levels of energy, one at maintenance and the other at 1.4 times maintenance level. No significant interaction between strain and ration was established.

Dubinin (1967) reported improvement in the quality of wool by feeding medium amount of silage and protein supplement. Feeding of silage in greater quantity, however, had an adverse effect. Hogen and Weston (1967) hypothesized the wool growth to be limited by the quantity of amino acid nitrogen absorbed from the alimentary tract and not the crude protein content of the ration.

Amble et al. (1967) reported that the crossbreds were superior in respect of birth weight, greasy fleece weight, fibre diameter, medullation percentage and fleece density except the staple length which was significantly less. The values recorded for staple length 5.81 and 5.96 cm in Merino and Rambouillet crossbreds were less as compared to 6.95 cm for Deccanis.
Vakil (1967, 1968) reported the mean value of staple length adjusted to 12 months growth to be 17.69 ± 1.01 cm and fibre diameter from 22.18 to 34.38 μm in wool samples representing 91 to 150 days growth. The results further indicated that there were two strains in Chokla sheep, a carpet and an apparel wool type.

Giles (1968) fed, a high or low plane of nutrition to ewe lambs from five selection flocks. Interactions between selection flocks and plane of nutrition were significant for greasy fleece weight and staple length.

Efner (1968) found no significant difference in yield, length, thickness and strength of wool of lambs weaned at 80 or 100 days and stated increased yearly yield of greasy wool from the dams of early weaned lambs.

Kaushik and Singh (1968) reported largest amount of wool with better wool qualities from crossbred sheep. Pelle and Csinkas (1968) recorded the fibre diameter at 4, 8, 12 and 16 months of age to be 20.13, 20.48, 21.49 and 21.82 μm respectively in lambs, whereas Ghanem (1969) stated high variability in the fibre diameter and presence of excessive colour in the wool of the crossbreds.

Allden and Jennings (1969) in an experiment on Merino wethers grazed on summer herbage and fed a supplement of energy and protein found significant increase in wool yield. Later the results obtained by Lazarov (1970) further confirmed the increased yields of clean wool, fibre length,
tensile strength, and fineness on high plane of nutrition.

Larsen and Kinnison (1970) studied the nutritional effect on certain wool fibre characters of ewe lambs and mature ewes for their life time. All combinations of protein and energy intake were designed. Midside samples of the first, second and third year fleeces, at 12 months interval were obtained. The comparative study revealed no significant difference in any of the characters between feeding regimes within years, but significant differences were found in all characters except fibre extension between the control fleeces and the fleeces grown on nearly all protein energy combinations.

Miraskar and Patil (1970) in an extensive study of wool characters of the important Indian breeds of sheep concluded that all the characters were significantly affected by breed and interaction of breed with fleece but not by fleece within breed.

Balaine et al. (1970) reported the average value of staple length to be 9.07 cm, fibre diameter 34.15 μ and medullation percentage 32.24 in Nali ewes. Chopra and Chopra (1972) reported the mean values of wool traits in Nali for greasy fleece weight to be 0.72 kg, staple length 7.76 cm, fibre diameter 34.54 μ and medullation 11.70 per cent.

Chatterjee and Kapoor (1971) found the average values in Chokla and Rambouillet x Chokla sheep to be for staple length 10.05 cm and 6.52 cm, crimps per cm 2.00 and 3.68, fibre diameter 31.25 and 23.44 μ and medullation 19.78
and 6.46 per cent respectively, whereas Dhan Rajan et al. (1972) showed an overall improvement in the quality of wool produced by crossbred sheep.

Kalla et al. (1971) observed the average fibre diameter in Chokla breed to be 27.55 to 30.63 \( \mu \) and mean crimps per cm 1.15 to 1.40. Chaudhari and Malik (1972) reported the greasy fleece weight to be 0.60 kg, staple length 4.87 cm, number of crimps per cm 1.21, fibre diameter 27.22 \( \mu \) and percentage of true wool fibre 86 in Chokla sheep.

Saville and Robards (1972) found the differences in wool growth between the Peppins and Collinsville and between Peppins and Bungarees fed to appetite due to their different feed efficiency, food conversion and body weights. Black et al. (1973) studied the effects of protein and energy intakes on the wool growth of Merino wethers and suggested that there was an optimum ratio of protein to energy absorption for maximum wool growth. It was further indicated that an increase in protein absorption stimulated wool growth but an increase in energy absorption reduced it and conversely, if protein was in excess, an increase in protein absorption reduced wool growth but it was stimulated by an increase in energy absorption.

Ferguson (1973) in an experiment on different diets observed the wool growth to be proportional to the intake of digestible organic matter. The effect of non-protein nitrogen was found to be relatively constant and
of protein fraction variable, consistent with its degree of breakdown in the rumen and amino acid composition.

Whereas, Kellaway (1973) found the rate of wool production to be 22 per cent higher on high plane of nutrition than on low plane.

Gouws et al. (1973) fed ewes during pregnancy high energy high protein, high energy low protein, low energy high protein and low energy low protein diets. The new born lambs revealed highly significant differences in curl type, hair length, pelt weight and pelt thickness. The pelt area was found to be significantly affected by the energy level whereas curl type, hair length and pelt thickness by protein level. No significant difference was observed in pelt quality between lambs from ewes on a high energy high protein and those on a low energy low protein diets.

Bhatnagar et al. (1973) found highly significant differences in fibre diameter and medullation percentage in wool obtained from different regions of the body in Magra sheep of different ages. The number of crimps at different ages were also significantly different.

Sharma and Mittal (1973) observed significant increase in the raw wool and the fibre diameter in Polwarth x Rampur Bushair crossbreds on higher doses of crude protein and further reported that the higher level of feeding too increased the fibre length and reduced
medullation percentage although the variations were not significant. Ghanekar and Bhatawadekar (1973) observed improved wool quality in crossbreds.

Mathur (1973) found significantly higher production of wool at the market age of 10 months in sheep fed ration containing 13 per cent crude protein. He further indicated that beyond the market age of 10 months the crude protein level of 10 per cent could be taken as optimum for the increased production of raw wool. It was also observed that the number of crimps declined with the increase in the length of the staple associated with the increase in the percentage content of crude protein in the ration.

Joshi and Ludri (1974) did not find significant difference in respect of mean fibre length, fibre diameter and medullation percentage under different feeds and observed leguminous fodder, in addition to grazing, to be most effective in increasing the wool yield.

Pant et al. (1974, 1975) observed more greasy wool yields from Chokla crossbreds than from Nali crossbreds. They concluded that halfbreds involving Chokla had lesser fibre diameter, medullation percentage and finer fleeces than those involving Nali and the halfbreds having Merino inheritance had lesser medullation percentage and slightly more staple length than Ram/Aulilet inheritance. No definite trend in the crossbreds with respect to number of crimps per inch was observed.
In an experiment on the influence of protein and energy levels on wool production and wool properties, Venter et al. (1975) found that all groups except that on the high energy high protein diet showed a highly significant increase in crimp per inch. The effect of feeding low protein diet in wethers was found to be associated with greater felting properties of wool. Robards et al. (1976) reported wool growth response to supplementation of low quality roughage to be more closely related to the total digestible organic matter intake than to the total nitrogen intake. The feed efficiency for wool production, however, depended upon the direction of liveweight changes of the sheep.