DEVELOPMENT OF LOW-COST RATIONS BASED UREA-AMMONIA TREATED MAIZE STOVER AND THREE TYPES OF SUPPLEMENTS FOR GOATS AND SHEEP

By

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CERTIFICATE

Mr. MATAM CHANDRASEKHARAIAH has satisfactorily prosecuted the course of research and that the thesis entitled "DEVELOPMENT OF LOW-COST RATIONS BASED ON UREA-AMMONIA TREATED MAIZE STOVER AND THREE TYPES OF SUPPLEMENTS FOR GOATS AND SHEEP" is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

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Date: 26-02-1993.
Place: Hyderabad.

CERTIFICATE

This is to certify that the thesis entitled **"DEVELOPMENT OF LOW-COST RATIONS BASED ON UREA-AMMONIA TREATED MAIZE STOVER AND THREE TYPES OF SUPPLEMENTS FOR GOATS AND SHEEP"** submitted in partial fulfilment of the requirements for the degree of **"Doctor of Philosophy"** in Veterinary Science of the Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Mr. MATAM CHANDRASEKHARAIAH**, under my guidance and supervision. The subject of the thesis has been approved by the Students' Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigation have been duly acknowledged by the author of the thesis.

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ABSTRACT

Experiments were conducted in two phases to evaluate 1. Optimum moisture level and incubation period for urea treatment of chopped maize stover and 2. The effect of feeding urea treated maize stover on growth and nutrient utilization in sheep and goats.

In the first phase, chopped maize stover was treated with urea (4%) at varying levels of moisture (30, 40 and 50%) and incubation periods (1, 2 and 3 weeks) in polythene bags to study the optimum moisture level and incubation period. The samples were evaluated for physical and chemical characters, *in vitro* dry matter and organic matter digestibilities.

Among the three moisture levels tested 40 per cent was optimum for urea treatment of maize stover as evidenced by higher organic matter, crude protein, ammonia nitrogen, cell contents, *in vitro* dry matter and organic matter digestibilities. Among the three incubation periods 3 week period had no advantage over 2 weeks. Though, the 2 weeks treatment showed higher IVDMD over 1 week incubation, the latter was at par with the former with regards to the content of all the constituents except cellulose. Hence, maize stover treated at 40 per cent moisture and incubated for 1 week (ration 1) and 2 weeks (ration 2) was further evaluated

in digestion experiments in adult sheep and goats using Randomized Block Design.

The DM intake, digestibility coefficients of all nutrients except ether extract and nutritive value (DCP and TDN) were significantly ($P<0.01$) higher at 2 weeks incubated urea treated maize stover (UTM) showing its supremacy over that incubated for 1 week.

In the second phase, the UTM (4% urea, 40% moisture and 2 weeks incubation) supplemented with concentrate feed (ration 1)/sunhemp hay meal (ration 2)/ subabul leaf meal (ration 3) and these three rations were tested in a Randomized Block Design for growth and nutrient utilization in lambs and kids. The average daily gains (ADG) recorded were not significantly different among the three rations. However, ration 1 containing concentrate feed had better feed efficiency compared to other rations, though the cost of feed/kg gain was more on this ration. Further, subabul leaf meal was superior to sunhemp hay meal in supporting the growth in lambs and kids. Lambs recorded higher ($P<0.01$) ADG and were superior to kids in utilizing the nutrients from these rations.

The dry matter intake/100 kg body weight was less ($P<0.01$) on ration 1 compared to rations 2 and 3. The digestibility coefficients of all nutrients except ether extract, crude protein, neutral detergent solubles and lignin were significantly ($P<0.01$) higher on ration 2. However, the digestibility coefficients of the above nutrients were significantly ($P<0.01$) higher on ration 3 compared to ration 1. Though, the DM and water intakes were significantly ($P<0.01$) higher in lambs, the digestibility coefficients of all nutrients except hemicellulose, cellulose and lignin were significantly ($P<0.01$) higher in kids.

All the experimental animals showed positive nitrogen, calcium and phosphorus balances on all the experimental rations. All the experimental animals met DCP and TDN requirements on all the experimental rations except for TDN on ration 1.

These results suggest that 40 per cent moisture and 2 weeks incubation period were optimum for urea treatment of chopped maize stover. For optimum growth and nutrient utilization in lambs and kids, supplementation of leguminous fodders particularly subabul leaf meal to urea treated maize stover was beneficial for growth and nutrient utilization rather than concentrate feed containing 30 per cent poultry droppings.

INTRODUCTION

CHAPTER I

INTRODUCTION

Green fodder availability in India is 224.08 million tonnes as against the requirement of 611.99 million tonnes for the present livestock population, leaving a gap of 387.91 million tonnes (Anonymous, 1984). Population boom makes it impossible to divert more cultivable land for fodder production. Under these circumstances, cereal straws like wheat, paddy, oat, barley and stovers like sorghum, maize, bajra etc. assume special significance in livestock feeding as they constitute the largest proportion of roughage (about 80 per cent) available. An estimated quantity of 417 million tonnes of crop residues are produced annually in our country (Kossila, 1985) which are capable of supplying 5.69 kg dry matter, 0.343 kg crude protein and 2.81 kg TDN per adult livestock unit per day. However, these crop residues are inefficiently utilized by ruminants because of high lignin content, poor digestibility of fibrous fractions and low nitrogen content apart from low density. Better utilization of these crop residues has become a key theme in the recent years.

The nutritive value of low quality roughages can be raised to that of medium quality hay by the use of ammonia treatment (Sundstol _et al_., 1978). Due to high cost and non availability of anhydrous ammonia, urea, a cheap source of ammonia got greater acceptence all over the world. Treatment of crop residues (Paddy straw and wheat straw) with urea improves palatability and digestibility of nutrients apart from providing non-protein nitrogen to the ruminant diets (Jackson, 1977).

Maize stover is one of the important crop residues used as livestock feed in many parts of the world. About 58.79 lakh ha is under maize (Zea mays) cultivation in India, of which Andhra Pradesh state alone contributes 3.1 lakh ha (Agriculture situation in India, 1987). Thus the huge quantity of maize stover is made available in the country as a renewable resource. However, sufficient work has not been undertaken on the urea treatment of maize stover.

Supplementation of crop residues with protein rich leguminous fodders like sunhemp hay and subabul leaf meal in ruminant rations will improve their palatability apart from sparing conventional protein supplements like groundnut cake for non-ruminants. Subabul (Leucaena leucocephala) a drought resistant leguminous, protein rich fodder tree yields about 100 tonnes of green fodder (30 to 35 tonnes of dry matter) containing 6.5 to 7.5 tonnes of crude protein per hectare per year in 6 to 7 cuttings under excellent management. Sunhemp (Crotalaria juncea) is a rich protenaceous legume fodder which yields about 35 to 40 tonnes/ha when grown seperately. Moreover, it is a general practice to grow this fodder in rice fallows and to feed the livestock along with paddy straw.

The possibility of recycling animal wastes like poultry droppings as economic supplement in livestock feeding has engaged the attention of scientists worldover during the past three decades. This material is relatively high in nitrogen and easily collectable due to intensive production system. Approximately 1.94 million MT of cage layer droppings are available every year as renewable resource in the country (Indian Poultry Industry year book, 1990). As early as in 1970 the Virginia Department of Agriculture and Commerce (USA) approved the use of dried poultry waste in commercially manufactured cattle feeds (Garken, 1987).

Due to non-availability of sufficient grazing lands and also due to poor quality grasses from waste lands and other community lands, it has become very difficult to raise sheep and goats profitably on free-range convential system. Hence, intensive feeding system based on locally available crop residues, leguminous fodders and other agro-industrial byproducts is an alternate promising feeding system to rear sheep and goats economically (Reddy and Raghavan, 1990).

In this study, an attempt was made to establish optimum conditions for urea treatment of chopped maize stover. Further, efforts were made to study the effect of supplementation of urea treated maize stover with sunhemp (*Crotalaria juncea*) hay/subabul (*Leucaena leucocephala*) leaf meal/low cost processed concentrate supplement containing 30 per cent poultry droppings in the rations of growing lambs and kids on growth, nutrient utilization, feed efficiency and cost of feed per unit gain.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 UTILIZATION OF MAIZE STOVER BY RUMINANTS

Singh *et al.* (1972) reported the proximate composition (% DM basis) of maize stover as DM 91.6; CP 4.45, CF 38.09, EE 0.5, ash 7.5 and NFE 49.6 and the digestibility coefficients in buffaloe heifers for DM, CP, CF, EE and NFE as 52.96, 6.44, 63.28, 16.99 and 54.7 per cent, respectively.

Fernadez (1977) conducted a digestibility trial with castrated male Aragon lambs fed with chopped oat, maize or barley straws containing 44.9, 39.2 and 41.00 per cent crude fibre, respectively. Corresponding intake of roughage as organic matter, was 778, 944 and 1069 g/day.

Chopped corn stover was reconstituted, treated and stored at room temperature for at least 30 days (Oji *et al.*, 1977). Treatments were 1 control, 50 per cent H_2O; (2) 3 per cent NH_3, 30 per cent H_2O; (3) 5 per cent NH_3, 30 per cent H_2O. Intakes of DM and OM in wether lambs were 664 and 582, 949 and 846 and 984 and 876 g/day for 1, 2 and 3 treatments, respectively. They further reported the digestibility coefficients as DM 51.6, OM 57.2, GE 54.6, Nitrogen 60.8, ADF 47.7 and cellulose 65.6 for treatment 1; DM 60.1, OM 65.3; GE

61.1, Nitrogen 57.1, ADF 61.7 and cellulose 77.6 for treatment 2 and DM 60.3, OM 66.5, GE 62.0, Nitrogen 54.4, ADF 59.5 and cellulose 78.5 for treatment 3.

Oji and Mowat (1978) studied the nutritive value of steam treated corn stover with eight wether lambs in a single crossover design and reported that dry matter intake increased ($P < 0.05$) by 55 per cent with steam treatment and the treatment also increased the apparent digestibilities of organic matter, energy, non-cell wall content and cellulose, but decreased ($P < 0.05$) digestibilities of NDF and ADF. Further they stated that the chemical composition of the ration on per cent DM was GE (K.cal/g) 3.8, CP 11.1, NDF 63.9, ADF 43.9, cellulose 32.4 and ash 15.3.

The nutritive value of maize fodder hay was determined by Chauhan et al. (1979) in a digestion cum metabolic trial using male buffalo calves weighing 80-100 kg was DCP 2.4 and TDN 47.37 per cent. The chemical composition recorded by them (% DM basis) was DM 92.5, CP 6.49, EE 1.41, CF 33.89, NFE 50.26, Total ash 8.00, NDF 68.5, NDS 31.5, ADF 43.13, Hemicellulose 25.37, cellulose 31.37, lignin 8.98 and silica 3.8.

A metabolic trial was conducted with nine surthi buffalo heifers to study the influence of feeding ad lib Maize straw-untreated with one kg concentrate, ten (10) per cent molasses and one (1) per cent urea sprayed and five (5) per cent molasses and one (1) per cent urea sprayed to three animals in each of the 3 treatments (I, II and III) (Balasubramanya et al., 1980). CP, CF, EE, NFE, Total ash, calcium and phosphorus contents were (per cent DM basis) 5.14, 39.66, 0.80, 45.85, 8.55, 0.51 and 0.04 for untreated maize straw, 7.44, 38.99, 0.44, 43.61, 9.52, 0.45 and 0.04 for treatment II and 7.65, 34.55, 0.58, 44.84, 12.38, 0.40 and 0.04 for treatment III, respectively. Digestion coefficients of DM, CP, CF, NFE, Total carbohydrates and Ether extract were 52.17, 52.99, 58.27, 56.06, 58.38 and 75.99 for treatment I, 49.34, 15.56, 55.79, 47.99, 51.18 and 46.27 for treatment II and 56.34, 46.29, 70.38, 57.05, 63.00 and 39.99 for treatment III, respectively. Further they reported that in none of the feeding regimes the DCP requirement for growing heifers was met. TDN requirement, according to standard was met in treatment III.

Morris and Mowat (1980) studied the nutritive value of chaffed untreated and ammoniated (3 per cent DM basis) corn stover with eight Hereford-Angus yearling steers and reported the chemical composition (per cent DM basis) as GE (Kcal/g) 3.87 and 4.06, ADF 39.4 and 38.9, NDF 69.3 and 66.9, CP 12.6 and 12.2 and Ash 11.3 and 11.4 for control (untreated) and Ammoniated corn stover, respectively. Further, they reported that the digestibility coefficients of control and ammoniated corn stover for DM, OM, Energy, CP, ADF and NDF were 54.9 and 60.9, 59.1 and 64.9, 51.7 and 61.4, 54.4 and 46.3, 54.1 and 61.1 and 59.7 and 68.4, respectively.

Saenger et al. (1982) conducted three trials to evaluate the feeding value of corn stover treated with anhydrous ammonia (NH_3 2 per cent). The four diets evaluated in each of the trials were : (1) NH_3 treated stover plus corn supplement (C - NH_3); (2) Untreated stover plus soyabean meal supplement (CS) (3) untreated stover plus urea supplement (CU) and (4) untreated stover plus corn supplement (NC). Four yearling steers were fed corn stover ad libitum and one of the three supplements (0.91 kg/d) in a 4 x 4 Latin square design and the dry matter intake (kg/d) was 4.09, 3.31, 3.39 and 3.12; dry matter digestibility (%) was 62.05, 56.62, 57.39 and 55.46 and N-retention was 31.24, 18.18, 29.55 and 6.42g for C-NH_3, CS, CU and NC diets, respectively.

Samples of maize stover, untreated and treated with 35 g anhydrous NH_3/kg were studied by Alibes et al. (1983/84) during two sucessive years 1980 and 1981. The ammonia treatment increased the CP content by 144 and 76 per cent, respectively. The organic matter digestibility by wether sheep increased by 19 and 15 per cent and the voluntary intake of stover increased by 33 and 23 per cent, respectively over untreated stovers. They reported the chemical composition of the maize stover of 1980 as (% DM basis) DM 88.9 and 87.3, CP 3.6 and 8.8, NDF 76.9 and 73.0 and the voluntary intake (g/kg $W^{0.75}$ per day) of stover as 29.2 and 38.7 and DMD *in vitro* as 53.8 and 64.2 and OMD *in vivo* as 54.2 and 64.3 per cent for untreated and NH_3 treated maize stover, respectively. They also reported the chemical composition of the maize stover of 1981 as (% DM) DM 88.6 and 83.0, CP 5.4 and 9.5, NDF- and 73.2 and the voluntary intake of stover (g/kg $W^{0.75}$/day) as 33.2 and 40.9, DMD *in vitro* as 53.6 and 63.3 and OMD *in vivo* as 53.2 and 61.0 per cent for untreated and NH_3 treated maize stover, respectively. Chemical composition of maize stover was reported by Brzoska and Mucha (1985) as CP 9.53, EE 1.36, CF 30.88, crude ash 8.42, NFE 49.81, cellulose 36.02 per cent of DM and *in vitro* DM digestibility was 52.5 per cent.

The nutritive value of winter maize stover hay (WMS) in adult crossbred bulls was reported by Chauhan (1985). The chemical composition of WMS was (% DM basis) DM 95.0, CP 4.63, CF 35.06, EE 2.5, total ash 11.7, NFE 46.64, NDF 67.38, ADF 41.85, Hemicellulose 25.53, silica 2.05, DCP 1.46 and TDN 52.88. The digestibility coefficients recorded were DM 51.19, CP 31.52, CF 61.15, ADF 60.7, EE 66.82 and NFE 54.24. DM intake was 1.46 kg/100 kg body weight.

Johnson *et al.* (1985) studied the effect of stage of maturity and addition of Molasses on nutritive value of maize stover silage in cattle and sheep and reported that the digestibility coefficients of DM, OM, CP, NDF, ADF, cellulose and Hemicellulose were 51.0, 53.7, 47.4, 52.7, 51.1, 61.6 and 55.0, respectively. Mosi and Butterworth (1985) have reported the chemical composition of maize stover as DM 91.0, OM 88.2, CP 5.1, NDF 75.5, ADF 51.3, Lignin 4.8, Hemicellulose 24.2, cellulose 46.5, ADF-ash 5.2 and P 0.17 percent.

Butterworth and Mosi (1986) compared the intake and digestibility of oat straw and maize stover, offered with different levels of nougmeal (*Guizotia abyssinica*) among sheep and found that the intake of roughages when given alone was similar but the apparent digestibility of cell wall constituents was higher for maize stover than for the oat straw. They reported the chemical composition of maize stover as OM 89.8, N_2 0.4, NDF 72.1, ADF 47.0, cellulose 41.6, Hemicellulose 25.1 and lignin 5.4.

Manget Ram and Gupta (1989) reported the chemical composition of maize hay (% DM) as DM 92.00, CP 10.2, EE 3.2, CF 32.2, Total ash 13.3 and NFE 42.10. The DCP and TDN contents were 5.86 and 58.77; 8.85 and 60.15 and 8.51 and 58.6 for *ad lib* feeding of maize hay (A), *ad lib* feeding of maize and cowpea hays (mixed in equal parts) (B) and *ad lib* feeding of maize hay sprinkled with urea (C) to provide N equivalent to group B in Male crossbred animals weighing 161 kg.

Alhassan and Aliyu (1991) reported the chemical composition of untreated and 4 per cent urea treated maize straw as (% DM) DM 93.9 and 93.4, CP 4.8 and 8.4, ADF 53.7 and 59.6, lignin 8.5 and 10.6 and Ash 4.4 and 8.2. Chopped maize straw treated with urea (4%) and ensiled for 1 week was given in a 2 x 2 factorial feeding trial with native Zebu cattle. The factors were straw type (treated vs. untreated) and supplement type (groundnut haulms vs. no groundnut haulms). Organic matter digestibility was 65.3 per cent for treated straw and 51.0 per cent for untreated straw. Both urea treatment and supplementation with groundnut haulms significantly increased the straw intake, but did not prevent cattle weight loss.

Joy *et al*. (1992) reported the chemical composition (% DM) of untreated and urea treated (4% and 30% moisture) maize stover as DM 76.7 and 70, Ash 7.8 and 9.2, NDF 76.5 and 72.8, ADF 43.7 and 43.1, ADL 7.0 and 6.0 and N_2 0.68 and 1.45 and IVDMD was 49.9 and 55.50, respectively. Voluntary intake (g $kg^{-1}BW^{0.75}$) of untreated and urea treated maize stover among Angora breed wethers was 30.5 and 33.4 and DOM 14.2 and 16.4 and digestibility (%) of OM 50.5 and 54.3, respectively.

2.2 EFFECT OF UREA TREATMENT ON THE UTILIZATION OF CROP RESIDUES BY RUMINANTS

Sommer (1981) surveyed various methods of physical and chemical treatments of straws for feeding cattle and reported that the consumption of ammoniated straw was higher by 17.4 per cent than that of untreated straw.

Dolberg *et al*. (1981) found that urease enzyme is present in rice straw. Based on this observation they have developed a simple technique for mixing urea with straw, sealing the straw stack and allowing the ammonia gradually released from the urea by urease enzyme to react with the straw.

Jayasuriya and Perera (1982) carried a series of experiments to improve the nutritive value of rice straw and concluded that 4 per cent urea with ensiling period of 3 to 4 weeks appeared to be the best method of treating rice straw. Digestibility *in vitro* was found to increase significantly with increase in the level of urea for 3 to 4 weeks treatment. Sheep fed 4 per cent urea treated rice straw alongwith 100 g concentrate mixture as control and compared the performance of sheep fed 4 or 8 per cent urea treated rice straw ensiled for 4 weeks. It was found that doubling the quantity of urea had no effect on digestibility but DM intake increased by 25 per cent. In a further study, Jayasuriya and Pearce (1983) studied the effect of urease enzyme on treatment time and the nutritive value of urea treated straw. Addition of urease enzyme decreased the treatment time to 2 to 4 days and ground soybean has been chosen as a satisfactory source of urease for treating straws.

Perdok et al. (1984) revealed that ensiling of rice straw treated with 4 per cent urea at 1L per kg in bamboo baskets gave poor results as compared to ensiling in polythene bags with best quality silage coming from cement lined brickwork silos or in large heaps between black polythene sheet. Feeding of treated straw to sahiwal heifers over a 10 week period revealed higher intake for ensiled straw than untreated straw with maximum weight gain of 346 g per day as compared to 73 g per day for untreated straw. In a further trial involving grazing of buffaloes on Gliricidia Maculata in addition to feeding of urea treated straw, increased milk yield was observed which was attributed to increase in straw intake rather than improved energy utilization.

Williams et al. (1984) studied the effect of dry matter and urea concentrations and the rate of hydrolysis of urea. Two kg samples of barley straw were sprayed with solutions of urea to yield treated straws to contain 450 - 750 g DM and 35.3 - 105.9 g urea per kg straw DM and stored at 18°c for 6 weeks. Degree of hydrolysis was significantly affected by the concentration of dry matter in the straw. Raising the level of urea when the concentration of DM was 600 g kg^{-1} straw significantly increased the weight of urea hydrolysed.

Chaffed samples of paddy straw (100 g each) were treated with 0, 3, 4 and 5 per cent urea at 50 per cent moisture level and kept in sealed air-tight bags for 0, 1, 2, 3 and 4 weeks (Gupta et al., 1985). After four weeks of storage the CP concentration was 3.78, 12.61, 14.05 and 16.00 per cent, while the crude fibre content was 36.12, 30.00, 24.83 and 23.42 per cent, respectively for various urea concentrations. It was concluded that 5 per cent urea treatment with a storage period for 4 weeks is an effective way of improving the nutritive value of paddy straw.

Ammoniation through 4 per cent urea at 30 per cent moisture level for 4 weeks increased the CP content of wheat straw from 3.17 to 8.64 per cent and paddy straw from 5.22 to 12.17 per cent (Yadav and Yadav, 1986a). In their study, wheat and chaffed paddy straws were treated with 4 per cent urea at 30 per cent moisture level for 4 weeks in concrete bunkers. From 4 to 18 weeks the CP content of treated straw was almost constant indicating least N loss from fourth week onwards. They conducted a growth trial with crossbred male calves by feeding untreated or ammoniated wheat straw or paddy straw with varying levels of concentrate mixture. Digestibilities of OM, DM and hemicellulose ($P < 0.05$) or those of CF, total carbohydrates, NDF, ADF, lignin and cellulose increased ($P < 0.01$) in animals fed ammoniated straws. Further, with one-third quantity of concentrate mixture, the treated straws gave a similar growth rate at around 35 to 40 per cent lower cost per unit live weight gain than with the untreated straws.

Kundu and Mudgal (1986) attempted urea levels of 0.5 to 5 per cent alongwith 10 to 100 per cent water for enriching wheat straw. Maximal increase in *in sacco* digestible DM was observed at 3 per cent urea and 55 per cent water with reduction of water to 40 per cent did not showing any effect on the digestibility significantly.

Ammonia release was reported to be slower in long form of wheat straw resulting in a slower and smaller increase in IVDMD and slower and small decrease in CWC contents with increased treatment period when compared to ground wheat straw (Cloete and Kritzinger, 1986). The IVDMD of wheat straw increased substantially upto treatment period of 8 to 12 weeks, thereafter slower increase was reported upto 48 weeks with no wider signs of deterioration following prolonged treatment periods upto 48 weeks.

Rahman *et al*. (1987) sprinkled 4 per cent aqueous urea solution over 100 kg of wheat straw at moisturisation level of 55 per cent. After 4 weeks storage the CP content of treated straw was 9.53 per cent as against 2.39 per cent for untreated straw. Four male 1 year old Hariana calves were given treated straw for 3 weeks. Digestibilities of DM, CP, EE, CF, NFE and total carbohydrates were 48.15, 67.04, 64.65, 59.07, 44.95 and 51.87 per cent, respectively with DCP and TDN values of 6.56 and 47.98 per cent. Nitrogen, calcium and phosphorus balances were positive and averaged 14.10, 2.32 and 1.12 g, respectively for treated straw which was comparable to any maintenance type non-legume forage.

Jai Kishan *et al*. (1987) attempted ammoniating paddy straw with or without molasses using 1 to 5 per cent urea levels for periods varying from 1 to 5 weeks. Urea treatment at 5 per cent level raised the CP content three times and rendered about 60 per cent N of the ammonia treated straw in water soluble form. The moisture content of 38 per cent and incubation at 39°c favoured optimum ammoniation. Addition of 10 per cent molasses further enhanced the CP content of straw. The *in sacco* digestibility increased to 23 per cent in ammoniated straw with 5 per cent urea in contrast to 3 per cent urea treatment.

The CP content of rice straw treated with 5 per cent urea for 3 days was lower ($P < 0.001$) compared to that of 10 and 20 days storage which was attributed to untreated urea remaining intact. However, Saadullah et al. (1988) stated that the intact urea will be available with the straw in the rumen and made use of by the rumen microbes once the straw is eaten.

Yadav and Yadav (1988a) treated wheat straw and chaffed paddy straw with five concentration gradients of urea (0, 3, 4, 5, 6 g per 100 g straw), four moisture gradients (30, 40, 50 and 60% of straw), four treatment periods (1, 2, 3 and 4 weeks) and evaluated in vitro. The results of the findings revealed that a combination of 4 per cent urea at 30 per cent moisture level and four week period was optimum and suitable for ammoniation of wheat and paddy straws.

Chaffed paddy straw samples were treated with 0, 4, 5 and 6 per cent urea at 50 per cent moisture level and kept in polythene bags for a period of 1, 2, 3 and 4 weeks by Mattoo et al. (1986b). Significantly higher ($P < 0.01$) DM and CP degradabilities were recorded with increasing concentration of urea compared to untreated straw. With increase in weeks of storage and hours of incubation, a corresponding linear increase in both DM and protein degradabilities were recorded.

Saadullah et al. (1981) preserved fresh rice straw untreated or treated in earthen pits with 3 or 5 per cent urea for 20 days or 5 per cent urea for 40 days or a dry straw treated with 5 per cent urea in a bamboo basket for 20 days and observed CP values of 2.9, 5.9, 6.7, 6.5 and 7.1 per cent respectively. The DM and OM digestibilities were reported to be 40, 45; 51, 54; 54, 56; 55, 57; and 52, 56 per cent, respectively with nitrogen retention of -2.5, -1.3, -0.2, 0.2 and 4.8 g in sheep.

Thermo-ammoniation also caused greater increase in nitrogen content than ammoniation at ambient temperature (Mowat, 1981). In an earlier study Oji et al. (1979) reported an IVDMD, increase of five units for maize stover ammoniated at 90^{o}c for 6 hours as compared to treatment at 21^{o}c for 30 days. Yadav and Yadav (1986b) studied the effect of urea (ammonia) treatment on physical characteristics of straws. The DM loss increased in a linear manner as the moisture gradients and treatment periods increased. Chaffed wheat straw of 3.5 cm and 40 per cent moisture was treated with 5 per cent urea with and without urease by Singh and Makkar (1986). The treated samples were stored for 2, 4, 12, 16, 25, 40 and 60 days at 4, 21 and 36^{o}c. Only about 25 per cent of the added urea was hydrolysed at 4^{o}c compared to 98 per cent hydrolysed at 37^{o}c on day 10.

Results of Mikami *et al*. (1986) revealed that *in vitro* digestibility of straw increased proportionately upto 30 per cent moisture and gradually increased upto 40 per cent but the digestibility of hay did not increase above 20 per cent moisture. Digestibility of hay in sheep did not differ among moisture levels of 14, 25, 35 per cent, but was significantly increased by ammonia treatment. Further, they reported that the quantity of ammonia which is adhered firmly to wheat straw stored in venyl bags increased proportionately with moisture content upto 30 per cent in straw and 25 per cent in hay.

Mattoo *et al*. (1986a) treated chaffed paddy straw samples with 0, 4, 5 and 6 per cent urea at 50 per cent moisture level in polythene bags and stored for a period of 1, 2, 3 and 4 weeks to generate ammonia and to interact with paddy straw. Significantly higher ($P < 0.01$) CP content of 22.5 per cent was reported for samples treated with 6 per cent urea at fourth week of storage compared to 16.89 per cent with 5 per cent urea level and 3.61 per cent with untreated sample.

Rice straw was treated with 5 per cent urea at 50 per cent moisture level and stored in an open stack for 30 days by covering top alone with gunney bags by Toro and Majgaonkar (1987) and reported increase in CP content of straw from 2.8 to 8.35 per cent and decrease in CF level from 34.35 per cent to 31.33 per cent due to loss of lignin through solubulization of ammonia. The performance of crossbred heifers fed urea treated rice straw ad libitum with 1.5 kg concentrate mixture in comparision to those fed untreated rice straw ad libitum +2 kg concentrate mixture and a control group fed 10 kg green fodder with 1.5 kg concentrate mixture and dry grass ad libitum was compared and reported no differences in the performance of the crossbred heifers.

Tripathi et al. (1987) studied the effect of various methods of treatment on IVDMD and CP contents of rice straw using urea or ammonia as chemical agents. Straw treated with 5 per cent urea and incubated in earthen pit had higher ($P < 0.01$) CP content but the IVDMD was similar to other methods. They have further reported that the treatment time of straw will be reduced to 2 days on addition of 0.5 per cent jackbean meal, 5 per cent sheria cake or 7.5 per cent water milon seed extraction.

Unchaffed paddy straw treated with 4 per cent urea and moisturised to 50 per cent was stored as stack of one tonne in open air or ensiled for four weeks. Urea treatment increased the CP content by 100.9 and 159.2 per cent by stacking and ensiling, respectively (Reddy et al., 1989b). Crossbred bulls fed with untreated paddy straw, 4 per cent urea treated and stacked paddy straw or urea treated and ensiled paddy straw as sole feed and observed increased digestibilities for DM, OM, CP, CF and NFE by urea treated and stacked paddy straw with further improvement in digestibilities of nutrients in the ensiled straw. There was an improvement of 1.65 and2.65 per cent DCP and 5.45 and 8.85 per cent TDN in stacked and ensiled paddy straws, respectively as compared to untreated straw. Nitrogen retained by urea treatment was 29.9 per cent on stacking and 46.7 per cent on ensiling. The animals fed ensiled straw were reported to meet the nutrient requirements for maintenance.

Ammoniation not only improves nutritive value but also serves as an effective preservation method for wet roughages. Fermentation is seized in maize stover stored at 30 per cent moisture (Oji *et al.*, 1977) and probably at 60 per cent moisture also (Oji *et al.*, 1979). Straw containing upto 50 per cent moisture has been reported to possess fungicidal effect as well. Gupta *et al.* (1986b) studied the effect of moisture level on the natural fermentation of urea-straw mixtures. The results indicated that controlled and safe natural fermentation is possible when 1.6 per cent N from urea and 70 per cent moisture are provided during ninth day of natural fermentation.

Raman *et al.* (1990) incubated chopped pearl millet straw with 0, 3, 4, 5 or 6 per cent urea at 30 per cent moisture for 20 days and studied N degradability in the rumen of 5 fistulated steers, using the nylon bag technique and reported that 4 per cent urea was optimum treatment to improve the degradable protien content of pearl millet straw.

Almeida *et al.* (1989) studied the effect of urea as a ammonia source for conservation and upgrading of whole crop wheat, oat, barley and wild oat silages. Untreated silages were unstable, urea kept silages alkaline and reduced fermentation. Urea treatment increased total nitrogen, NH_3-N and insoluble - N content of silages, *in vitro* organic matter digestibility and gas production. Improvement in nutritive value was correlated with amount of phenolic compounds released by urea treatment.

In field conditions protein in 10 kg of barley straw treated with 0.7 L of 40 per cent urea was 5.87 per cent greater than for the untreated straw after six months storage with nitrogen losses of 25 per cent (Paliev, 1986). Singh (1986) studied the changes in fibre fractions, distribution of N in urea, urine and ammonium hydroxide treated wheat straw and observed little or no effect on crude fibre and ether extract values. The NDF tended to decrease, with little or no change in ADF and cellulose fractions with a decline in hemicellulose content. The lignin values were tended to decrease slightly with treatment of straw.

Mascarenhas et al. (1989) studied the effect of urea treatment on chemical composition of Meadow hays. Samples of 250 g of 2 meadow hays (H_1 and H_2) were sprayed with urea solution to increase the moisture content upto 400 g/kg. Urea was applied at 60 g/kg and the samples were stored at 25°c for 3, 6, 9, 45 and 60 days. The hydrolysis of urea was extensive and increased by treatment time. The pH of treated samples was alkaline at all treatment times and after 45 and 60 days of storage averaged 10.98 and 11.07, respectively. Urea treatment reduced the neutral detergent fibre, hemicellulose and lignin contents and increased cellulose content. These effects were increased by treatment time.

Ramana et al. (1989) treated Bajra (Pennisetum typhoideum) stalks with 3, 4, 5 or 6 per cent urea for 10, 20 or 30 days at 30, 40 or 50 per cent moisture and reported that level of urea did not influence proximate composition except CP and cell wall constituents. Increasing the moisture level from 40 to 50 per cent decreased the CP content at all levels of urea treatment. They concluded that 4 per cent urea was effective in improving the nutritional quality of bajra stalks when incubated for 20 days at 30 per cent moisture.

In a 2 x 3 x 6 factorial design trial, wheat straw with moisture contents of 25 or 40 per cent was treated with urea 55 g, sodium hydroxide 45 g, or urea 55 + sodium hydroxide 45 g for 0, 0.5, 1, 2, 4 or 8 weeks by Brand et al. (1990). They reported that increasing the treatment period increased the rate of urea hydrolysis and decreased total nitrogen content in the urea treated straw.

Tinnimit (1990) treated rice straw with 6 per cent urea solution at 20, 40, 60, 80 and 100 per cent moisture levels and stored for 3 weeks. He reported that NDF and ADF tended to increase with increasing amounts of moisture in the treated straw and lignin content was not greatly affected by varying amounts of the moisture added.

Wanapat et al. (1985a) fed buffalo steers with untreated rice straw, rice straw ensiled for 3 weeks in a 1 : 1 ratio with 5 per cent urea or urea ensiled straw + dried cassava leaves. Digestibility coefficients of all fractions of nutrients were increased by urea ensiling of rice straw. Addition of cassava leaves gave a further increase in the apparent digestibilities of OM, ADF and CP from 56.4, 43.4 and 2.9 per cent with untreated straw to 64.4, 58.5 and 22.2 per cent, respectively with treated straw.

Singh and Negi (1985) developed a method of ammoniating chaffed wheat straw to provide a urea level of 37.5 g and a moisture level of 500 g/kg straw allowing 25 days for reaction at room temperature. Rams fed untreated or treated straw ad libitum and supplemented with 300 g of concentrate mixture had a dry matter intake of 1.97 and 1.93 kg per 100 kg body weight. Further, there were no differences in the apparent digestibilities of DM, CP, CF, EE and NFE as well as NDF, ADF, hemicellulose while cellulose-lignin digestibility decreased after ammoniation.

Feeding of 4 per cent urea treated rice straw at 50 per cent moisture level reduced the cost of feeding of growing crossbred heifers from Rs. 3.76 to Rs.3.14 per day (Toro and Majgaonkar, 1986).

Verdonk et al. (1991) conducted experiment with 8 rumen-fistulated crossbred cattle fed ad libitum quantities of diet containing wheat straw impregnated with 2 per cent urea and 10 per cent molasses or treated and ensiled with 4 per cent urea at 40 per cent moisture for 4 weeks (groups 1 and 2, respectively). DM intake in groups 1 and 2 was 6.98 $\pm$ 0.71 and 6.07 $\pm$ 0.36 kg/day, respectively. Organic matter digestibility increased ($P < 0.05$) from 55.25 $\pm$ 1.19 per cent in group

1 to 60.10±1.17 per cent in group 2 with increased ($P < 0.01$) crude fibre digestibility from 42.69 ± 1.51 to 52.86 ± 0.64 per cent. Crude protein digestibility was similar in both groups, but digestible crude protein content was higher ($P < 0.05$) in urea-treated straw. Total digestible nutrients content was higher ($P < 0.05$) in urea-molasses supplemented straw.

Male Murrah buffaloes were fed untreated or urea treated wheat straw at 3 or 4 per cent level alongwith concentrate mixture by Singh and Gupta (1984) and reported cellulose digestibility of 49.61, 62.06 and 62.04 per cent, respectively.

Wanapat et al. (1983) observed increase in in vitro DM digestibility and CP, ADF and ADL contents of rice straw after 3 to 4 weeks ensilage with urea. In trials with crossbred steers, the daily DM intake was found to increase from 4.97 kg per head without urea treatment to 6.82 kg when urea was used in ensilage for about 8 weeks.

Singh and Barsaul (1985) reported significantly higher digestibility coefficients for DM, EE, CF and NFE of the ration containing urea treated wheat straw with reduced intake of concentrate mixture by 63 per cent as compared to feeding untreated straw without any effect on CP digestibility in heifers.

Wanapat *et al.* (1985b) fed steers with rice straw, rice straw ensiled with 5 per cent urea, urea treated rice straw and water hyacinth in a ratio of 3 : 1 or 1 : 1 and observed a DM intake of 3.03, 3.24, 3.33 and 3.49 kg/100 kg live weight per day with a live weight change of-34, 7, 133 and 23 g per day, respectively. The nutrient most effected by diet was CP content with digestibility values of 20.7, 23.8, 29.3 and 45.7 per cent, respectively.

Walli *et al.* (1986) studied the effect of feeding wheat straw treated with different levels of urea on the flow rate of digesta at abomasum. The level of urea treatment did not show difference in the dry matter intake of Murrah buffaloes without any effect on the flow rate or DM digestibility at abomasum.

2.3 UTILIZATION OF DRIED POULTRY DROPPINGS IN RUMINANT RATIONS

Flegal *et al.* (1972) reported crude protein as the most variable component which varied from 30.3 to 18.3 per cent depending on the duration of storage of the wet manure from 7 to 98 days.

Smith and Lindahl (1977) reported the following van-soest fractions : Cell wall constituents 35-45 per cent, cellulose 10-16 per cent, Hemicellulose 22-25 per cent and lignin 2-6 per cent.

The chemical composition of the poultry excreta as reported by various authors is presented in Table A.

Guedas (1966) reported the digestibilities of 69.9 per cent for crude protein, 29.9 per cent for crude fibre and 71.4 per cent for NFE on diet containing 80 per cent dehydrated layer waste in sheep. It was concluded that uric acid represented about 8 per cent of the absorbed nitrogen.

Rodriques (1967) reported that six months old lambs fed on a ration containing 36 per cent dried poultry waste as an equal weight replacement for carob bean in a concentrate mixture showed no difference in average daily gain in a 135 days growth experiment.

Oltjen et al. (1968) reported that uric acid was degraded to ammonia by rumen microbes more slowly than urea creating a more favourable ruminal ammonia pattern for efficient nitrogen utilization.

Slyter et al. (1968) observed higher concentrations of cellulolytic bacteria in steers receiving supplemental nitrogen from uric acid than in those supplemented with urea or urea phosphate.

Parigi-Bini (1969) reported that the metabolizable energy value of dehydrated layer waste for sheep was 2.22 Mcal/kg. The apparent digestibilities recorded for diets containing 0 or 32 per cent layer waste, were

Table A : Chemical composition of poultry excreta as reported by various authors (on % DM basis)

DM	CP	EE	CF	NFE	TA	AIA	Ca	P	Reference
--	26.60	1.40	8.20	39.30	16.70	--	2.50	0.80	Lowman and Knight (1970)
--	33.56	4.01	12.55	28.09	21.79	4.80	3.73	1.93	Jayal and Misra (1971)
--	15.30	1.20	16.50	29.50	13.50	--	2.90	1.20	Silva *et al.* (1976)
93.69	22.06	3.51	31.55	22.10	20.78	--	--	--	Gihad (1976a)
--	--	--	--	--	23.00 to 26.00	--	8.00 to 9.00	1.80 to 2.50	Smith and Lindahl (1977)
94.00	--	2.34	--	--	29.00	--	--	--	Swingle *et al.* (1977)
--	19.00	0.18	10.49	32.00	37.82	14.66	--	--	Reddy and Prasad (1982)
98.28	20.25	3.92	13.42	34.59	27.82	--	4.18	1.92	Thakur *et al.* (1982)
--	28.00	2.00	12.70	28.70	28.00	--	8.80	2.50	Fontenot *et al* (1983)
--	29.00 to 32.00	--	11.00 to 18.00	25.00 to 34.00	22.00 to 25.00	--	--	--	Guseva and Batazova (1983)
--	22.94	2.10	12.60	37.16	25.20	--	--	--	Krishna Srinivas (1987)

dry matter 87.5 and 80.5, crude protein 85.0 and 77.9, crude fibre 59.9 and 46.7, ether extract 85.7 and 78.7 and NFE 93.1 and 89.1 per cent, respectively. Neither rumen pH nor the molar proportions of volatile fatty acids were affected in rumen liquor of sheep receiving dehydrated layer waste.

El-Sabban et al. (1970) incorporated autoclaved, cooked and dried poultry waste alongwith semipurified diets in sheep rations and observed no significant difference in animal performance among the processed poultry wastes to that of control. They opined that dried poultry waste was an effective nitrogen supplement in ruminant diets containing moderate to high energy levels, but few studies examined the usefulness of poultry wastes on low energy diets, particularly those with high levels of poor quality roughages.

Diets containing 0, 25, 50, 75 and 100 per cent dehydrated layer waste were fed to sheep by Lowman and Knight (1970), ME value of the waste was estimated to be 1.74 Mcal/kg dry matter. Values calculated for the diets containing 100 per cent waste and 100 per cent barley were, dry matter 56.6 and 77.9, organic matter 66.5 and 80.7, energy 60.3 and 80.0, protein 77.2 and 68.4 per cent, respectively.

Smith and Calvert (1972) substituted dried poultry waste for 0, 50 and 100 per cent soybean meal in sheep rations. They reported no difference among the three diets in digestibility of dry matter and crude protein and concluded that the use of dried poultry waste as a protein source produced average daily gain at least 90 per cent as great as soybean meal. However, the digestibilty of soybean meal in their control ration was only 55 per cent.

Tinnimit *et al*. (1972) fed diets in restricted or *ad lib*. in which dehydrated layer waste or soybean meal supplied 40 - 65 per cent of the total protein to sheep averaging 31 kg. When the waste was increased from 20 to 80 per cent, though the feed was acceptable, dry matter digestibility fell from 74 to 58 per cent and organic matter digestibility fell from 77 to 68 per cent. They observed a significant ($P<0.05$) depression in protein digestibility of the DPW ration. However, nitrogen retention and per cent of absorbed nitrogen retained for the dried poultry waste ration were equal to and 20 per cent higher, respectively, than control in the restricted feeding study; each parameter was 10 per cent higher than the control for the DPW ration in the *ad lib* feeding study. When the same study was continued with DPW providing 88 per cent of the ration nitrogen under *ad lib* feeding conditions, both the total nitrogen retained and per cent absorbed nitrogen retained dropped significantly by 30 per cent.

Bohme (1973) reported that the digestibility of organic matter in dehydrated layer waste was 67 per cent with sheep. The digestible energy and TDN values of the waste were estimated to be 2,304 Mcal/kg and 51.4 per cent, respectively.

Digestibility of dehydrated layer waste for sheep was estimated by Salo et al. (1975) and the results were as follows: organic matter 62.8, crude protein 76.9, ether extract 33.1, crude fibre 31.7 and NFE 57.5 per cent, ME value was estimated to be 1.58 Mcal/kg.

The organic matter digestibility of the ration was lowered from 97.6 to 84.00 per cent as the level of waste, in the diet increased from 15 to 35 per cent in rations of sheep. Crude protein digestibility increased from 68.70 to 77.90 and nitrogen-free extract from 79.9 to 87.6 per cent as the level of waste increased from 15 to 35 per cent. Digestibility of crude fibre was 85.50 per cent when the diet contained 25 per cent layer waste (Zgajnar, 1975).

While comparing the nutritive value of soybean meal with that of dried poultry excreta, Smith and Calvert (1976), opined that both were equal in nutritive value. Digestibility of dry matter, organic matter and nitrogen for both the experimental rations were 65.4 and

65.2, 66.4 and 65.4 and 53.7 and 57.9 per cent, respectively.

Kazheka and Kozyr (1977) reared 2 months old 30 lambs over 142 days on hay, silage and concentrates in winter or green fodder and concentrates in summer; with additional 200 g poultry droppings or 100 g sunflower oil meal, diammonium phoshate, sodium chloride and cobalt chloride. Average daily gain during the experimental period was 168 and 175 g with and without poultry droppings. The diets with poultry droppings gave lower digestibility of dry matter, organic matter, crude protein and NFE. They were of the opinion that poultry droppings can be used to replace upto 20 per cent of dietary protein and it acts as an additional source of minerals in diets for lambs.

Smith and Lindahl (1977) compared dehydrated cage layer excreta and alfalfa meal as nitrogen supplements for lambs at 8 and 12 per cent dietary crude protein. Lambs digested nitrogen from both the diets equally well. Lambs fed the diets containing poultry excreta tended to consume more feed and convert digestible organic matter available for growth 32 per cent more efficiently than lambs fed diets supplemented with alfalfa; but the differences were not significant. Cost of gain for lambs fed 12 per cent, CP diet was 17 per cent lower when supplemented with poultry excreta compared to those supplemented with alfalfa.

Swingle et al. (1977) found that the dry matter intake of sheep was not affected when dehydrated poultry waste, cotton seed meal or urea provided over 85 per cent of dietary nitrogen. About 35 per cent of the absorbed nitrogen was retained with the diet containing cotton seed meal where as 16 per cent was retained with the diet containing dehydrated poultry waste or urea.

El-Hag and El-Hag (1981) replaced cotton seed cake (29 per cent in concentrate mixture) completely by dried poultry manure in the sheep ration. Body weight gains were 75 and 40 g/day in the groups receiving cotton seed cake and poultry manure containing concentrate mixtrues. Feed units required per unit gain in both the above groups were 17.0 and 24.7, respectively. Concentrate intake per day for both the groups was 1.28 and 0.98 kg (DM basis), respectively.

Kalinin and Kirilov (1981) were of the opinion that dried poultry wastes were better utilized than urea, when they were supplemented to protein deficient diets offered to Romanov sheep.

Thakur et al. (1982) used autoclaved poultry excreta in the concentrate mixture (30 per cent level) of kids. The dry matter intakes from concentrate mixture (containing 0 and 30 per cent poultry excreta) was 490 and 410 gms and growth rate was 49 and 29 gms, respectively. Feed efficiency was 9.96 and 16.24 feed units/unit weight gain, respectively for both the feeds.

El-Boushy and Roodbeen (1984) reported that the protein and amino acid availabilities of dried poultry waste were 28.98 and 44.29 per cent, respectively. The dried poultry waste contained all limiting amino acids.

Abu-Izzeddin and Lakpini (1985) utilized dried poultry waste (31% CP) at 0, 10, 20, 30 and 40 per cent levels replacing 0, 25, 50, 75 and 100 per cent cotton seed cake. These concentrate mixtures were offered to 1 year old Yankasa ram lambs for a period of 102 days. 500 g of concentrate and hay formed the daily ration. Dry matter intake was 392, 380, 321 and 289 g/day, respectively for five rations. Nitrogen retention (g/day) and nitrogen digestibility (%) were 3.49 and 73.4; 3.62 and 67.8; 3.0 and 63.5; 2.77 and 59.9 and 2.55 and 55.7, respectively under the five treatments. Weight gains were 100, 83, 52, 41 and 33 g/day, respectively for the five treatments, growth being affected significantly ($P < 0.01$) due to inclusion of poultry waste above 20 per cent and feed efficiency being significantly ($P < 0.01$) reduced above 25 per cent level of replacement of cotton seed cake.

2.4 UTILIZATION OF SUNHEMP (*Crotalaria juncea*) HAY IN RUMINANT RATIONS

The chemical composition of sunhemp forage recorded by different workers is presented in Table B.

Digestibility coefficients of 56.9, 81.8, 30.1, 58.8 and 54.5 for DM, CP, EE, CF and NFE, respectively were reported by Katiyar and Ranjhan (1969) in Kherigarh bullocks fed with sunhemp hay as sole ration. The DM intake was 1.9 kg/100 kg body weight. The DCP, TDN and SE values of green fodder with 25 per cent DM were 3.92, 13.9 and 10.4 per cent, respectively. They further reported that sunhemp was palatable to bullocks and to Bikaneri rams and there was no ill effect on health or appetite.

Reddy and Murthy (1972) fed sunhemp hay to adult Hariana bullocks at 0.50 or 0.75 kg/100 kg live weight with rice straw to hay ratio of 3 : 1 and 2 : 1 and determined the OM and NFE digestibilties of hay by difference method as 66.9 and 79.1 per cent, respectively. The DM intake was 1.9 and 2.1 kg per 100 kg body weight, respectively for the above rations.

In the metabolic studies conducted by Balaraman and Venkata Krishnan (1974) with Mandya Rams fed sunhemp leaf meal, the digestibility coefficients of nutrients were 61.90, 65.07, 59.93, 75.88, 35.62 and 57.30 for DM,

Table 8 : Chemical composition of sunhemp hay (Crotalaria juncea) as reported by various authors (on % DM basis)

DM	CP	EE	CF	NFE	TA	Ca	P	Reference
--	19.15	1.79	30.22	38.41	10.43	1.29	0.27	Katiyar and Ranjhan (1969)
--	29.30	--	19.10	--	--	--	--	Reddy *et al.* (1970)
--	32.60	17.30	14.30	33.60	12.20	2.15	0.31	Sivaraman and Jayaraman ((1971)
88.00	18.10	1.20	38.10	34.80	7.80	--	--	Reddy and Murthy (1972)
--	24.95	2.81	31.62	27.62	13.00	1.47	0.36	Balaraman and Venkatakrishnan (1974)
91.30	18.70	3.12	30.60	29.13	18.45	1.54	0.61	Venkata Rao (1989)
33.40	13.30	0.90	37.00	30.70	18.10	--	--	Sharma *et al.* (1992)*

-- Not reported

* Freshly harvested *Crotalaria sericea*

OM, CF, CP, EE and NFE, respectively and the values of DCP and TDN were 18.93 and 55.83 per cent, respectively.

Average digestibility coefficients for DM, CP, EE, CF and total carbohydrates for sunhemp hay were 56.25, 69.78, 38.23, 53.59 and 62.67, respectively (Jayal and Johri, 1977) and the hay had the nutritive value of 10.3 per cent DCP and 55.6 per cent TDN when fed to goats.

In sacco studies on sunhemp hay (Krishna _et al_., 1985) cut at various stages between 30 to 58 days after sowing revealed that disappearance of DM, OM and N from samples of forage from nylon bags suspended in the rumen for 72 h ranged from 72.6 - 50.9, 73.2 - 49.6 and 91.9 - 81.0 per cent, respectively.

Bansal _et al_. (1987) mixed chaffed _crotalaria juncea_ tops and M.P. Chari (_Sorghum bicolor_ x _S. sudanense_) in 1 : 1 ratio. DM of the mixed fodder contained 15.92 per cent CP, 2.37 per cent EE, 17.60 per cent CF, 56.34 per cent NFE, and 7.77 per cent ash. In feeding trials with sheep intake recorded was 2.4 kg/100 kg body weight. Daily consumption/head was 96 g DCP and 555 g TDN. The fodder contained sufficient amounts of DCP, TDN and energy for animal maintenance.

Sunhemp hay contained 51.7 per cent NDF, 44.5 per cent ADF, 7.2 per cent Hemicellulose, 25.6 per cent cellulose and 9.25 per cent ADL. Complete feed containing NB21 waste/sunhemp hay in ratio of 40/20 fed to sheep recorded digestibilities of 46.13, 51.35, 65.12, 36.49, 75.32, 51.23, 35.29, 26.48, 52.67 and 45.44 per cent for DM, OM, CP, CF, EE, NFE, NDF, ADF, Hemicellulose and cellulose, respectively (Venkata Rao, 1989).

2.5 UTILIZATION OF SUBABUL (*Leucaena leucocephala*) LEAF MEAL IN RUMINANT RATIONS

The proximate composition of subabul as reported by different workers is summarized in the Table C.

Kharat *et al.* (1980) reported that *L. leucocephala* contained the neutral detergent fibre 29.80, hemicellulose 16.80, cellulose 16.50 and permanganate lignin 12.80 per cent, on dry matter basis. Gupta and Chopra (1985) reported 37.1 per cent NDF, 22.0 per cent ADF, and 15.1 per cent hemicellulose on DMB for *L. leucocephala*. Dogra *et al.* (1986) observed that NDF ranged from 22.80 to 26.00 (average 24.32) ADF from 14.60 to 18.20 (Average 15.88), hemicellulose from 5.60 to 8.00 (Average 7.84), cellulose from 7.20 to 10.10 (Average 8.48) per cent in *L. leucocephala*.

Rangnekar *et al.* (1983) reported 4.25 kcal/g of GE for *Leucaena leucocephala* fodder. Subabul foliage contained 45.6 per cent NDF, 29.08 per cent ADF, 16.70 per cent cellulose and 16.52 per cent hemicellulose

Table C : Chemical composition of <u>Leucaena leucocephala</u> as reported by various authors on % DM basis)

DM	CP	EE	CF	NFE	TA	Ca	P	Reference
29.40	5.30	0.60	9.70	12.20	1.80	--	--	CSIR (1962)*
24.98 to 36.39	18.90 to 25.57	2.59 to 5.88	10.15 to 17.23	46.70 to 52.60	7.49 to 10.90	--	--	Singh and Mudgal (1967)
34.26	21.45	6.54	14.25	49.48	8.28	2.70	0.17	Upadhyay *et al.* (1974)
29.00	20.70	4.20	17.90	43.90	13.43	4.05	0.21	Joshi and Upadhyay (1976)
30.03	26.38	8.00	26.70	33.30	--	--	--	Alvarez *et al.* (1977)
--	29.98	3.56	16.76	44.86	5.54	--	--	Sobale *et al.* (1978)
--	24.00	4.76	--	--	23.29	2.47	3.53	D'Mello and Thomas (1978)
--	20.15	6.76	11.12	50.34	11.63	2.50	0.24	Satya Sitaramam (1980)
--	22.40 to 29.40	3.40 to 4.80	7.30 to 12.40	--	6.80 to 10.40	--	--	D'Mello and Fraser (1981)
--	30.00	4.41	10.00	45.17	10.42	2.86	0.22	Dharma Raju (1983)
83.60	24.20	1.40	19.60	--	9.50	1.52	0.45	Prasad *et al.* (1983)
--	23.50	3.81	13.48	49.43	9.78	2.23	0.28	Vahidulla (1984)
92.50	21.87	4.74	9.73	--	--	--	--	Gupta *et al.* (1986a)

Contd.....

(Contd...Table C)

DM	CP	EE	CF	NFE	TA	Ca	P	N	Reference
91.20	30.41	4.90	12.80	41.10	10.80	1.80	0.30	--	Bhaskar *et al.* (1987)
--	23.19	4.25	8.60	52.54	11.42	--	--	--	Sudhakar and Rao (1987)
--	22.06	6.70	10.22	48.38	12.64	--	--	--	Kumar *et al.* (1987)
27.50	22.70	5.70	15.00	50.00	6.60	--	--	--	Hongo *et al.* (1987)
29.80	8.33	--	6.03	10.89	--	--	--	--	Ashry *et al.* (1989)
--	18.20	4.42	14.40	54.08	8.90	1.50	0.33	--	Chakraborty and Ghosh (1988)
--	25.50	6.38	14.60	--*	10.20	1.80	0.18	--	Gupta *et al.* (1988)
--	24.90	7.68	9.03	43.71	14.47	--	--	--	Sunaria and Vidyasagar (1989)
--	22.08	6.70	10.22	48.38	12.64	--	--	--	Gupta *et al.* (1989)
89.79	24.00	4.00	14.50	46.05	11.45	2.81	0.31	--	Srinivasulu (1990)
--	20.78	--	14.34	--	--	--	--	--	Thirumalai *et al* (1991)
--	--	--	--	--	--	1.87	0.184	3.36	Jones *et al* (1992)

-- Not reported
* On fresh basis.

(Chakraborty and Ghosh, 1988). Gupta *et al*., (1988) recorded 27.30, 14.4, 12.9, 7.1 and 7.3 per cent NDF, ADF, hemicellulose, cellulose and lignin, respectively in subabul meal on DMB.

The cell wall constituents of various parts of 12 cultivars of *L. leucocephala* were reported by Yadav and Yadav (1988b). The leaves contained (on DMB) 17.7 to 25.8 per cent NDF 11.9 to 14.8 per cent ADF, 5.8 to 13.1 per cent Hemicellulose, 5.8 to 9.4 cellulose, 4.1 to 5.8 per cent lignin and 0.1 to 0.9 per cent silica in different cultivars. Costa *et al*. (1991) reported the GE of *Leucaena leucocephala* as 4365 kcal/kg.

The digestible crude protein (DCP) and total digestible nutrients (TDN) and nutritive ratio of *L. leucocephala* leaves were 3.0, 17.5 and 3.5, respectively on fresh basis (Council of Scientific and Industrial Research, 1962).

Upadhyay *et al*. (1974) reported that the average DM intake of Barbari bucks was 2.16 kg per 100 kg body weight. The digestibility coefficients of DM, CP, EE, CP and NFE were 71.0, 78.0, 47.0, 57.0 and 81.0 per cent, respectively with a DCP of 16.73 and TDN of 70.22 per cent. Ferreiro *et al*. (1978) observed a DM intake of 3.66 kg/100 kg body weight with *L. leucocephala* in wethers. The digestibility of DM and CF were 65.4 and 27.6 per cent, respectively.

James (1978) fed Saanen x Malabar goats to appetite with subabul and reported that the digestibility of DM and CP as 67.6 and 70.7 per cent, respectively. Further, positive nitrogen and mineral balances were recorded with an average daily DM intake of 3.9 kg/100 kg live weight. The average daily gain was 26.2 g. In sheep fed with L. leucocephala as sole ration, Yerana et al. (1978) recorded 59.7 per cent OM digestibility. The DM intake of 3.66 kg/100 kg live weight and nitrogen intake of 25.8 g/day with a N retention of 12.1 g/day.

The average daily intake of L. leucocephala as reported by Devendra (1982) was 51.0 to 60.9 $g/W^{0.75}kg$ and 39.4 to 53.7 $g/W^{0.75}kg$ for goats and sheep, respectively. The digestibility of DM in goats and sheep varied from 53.9 to 56.4 and 50.0 to 50.5; OM 54.1 to 57.0 and 50.0 to 51.5; CP 44.8 to 45.0 and 40.5 to 46.3 and CF 38.5 to 64.8 and 31.2 to 60.2 per cent, respectively. The nutritive value in terms of DCP was 9.3 to 11.0 and 9.1 to 10.1, TDN 46.9 to 67.8 and 46.7 to 54.2 per cent, digestible energy (DE) 8.66 to 12.62 and 8.62 to 10.00 MJ/kg and metabolizable energy (ME) 7.10 to 10.35 and 7.07 to 8.20 MJ/kg for goats and sheep, respectively. The DCP and TDN contents were 16.0 and 55.4 per cent, respectively for goats fed L. leucocephala (Mahatab et al., 1984).

Jai Kishan *et al.* (1986) fed 3 groups of goats, one with control concentrate and in the other two groups, CP was replaced by 25 and 50 per cent with Leucaena leaves. Daily intakes of TDN were 364, 386 and 352 g; DCP 56, 54 and 37 g. The digestibilities of DM were 63.78, 60.28, 56.54; OM 66.96, 63.29, 59.50; CP 57.56, 52.90, 38.46; EE 66.82, 45.54, 33.99; CF 49.19, 49.96, 48.50; NFE 76.33, 72.21, 71.26 for group 1, 2 and 3, respectively. Retentions expressed as g/day were 5.61, 4.27, 3.73 for nitrogen; 1.21, 1.97, 2.13 for calcium; 0.41, 0.44, 0.75 for phosphorus for group 1, 2 and 3, respectively. Diet had no significant effect on weight gain, balances of calcium, phosphorus and nitrogen and DCP requirement per unit live weight gain.

The results of feeding subabul *ad libitum* to Black Bengal goats showed that the subabul foliage contained 15.77 per cent DCP and 69.57 per cent TDN on DMB. The average percentage digestibilities of various nutrients were DM 73.50, OM 71.49, CP 86.72, EE 75.06, CF 70.23, NFE 67.00, NDF 53.89, cellulose 26.74, ADF 38.80 and hemicellulose 78.68 (Chakraborty and Ghosh, 1988).

Eys *et al.* (1985) carried out experiment in which they added *Gliricidia maculata*, *leucaena leucocephala* and *Sesbania grandiflora* to chopped *Pennisetum purpureum* diets for growing goats and concluded that there were no differences between these legumes in their effect on intake, digestibility, live weight gain and total DM intakes and DE did not differ between control and supplemented diets. They further reported that the supplementation improved the mineral provision, average daily live weight gain and increased nitrogen uptake from 0.83 to 0.93 g/kg and the apparent digestibility of DM, cell-wall constituents and the nitrogen, phosphorus and calcium were not affected.

In studies conducted by Bamualim (1985), goats were offered diets of 1) *Heteropogon contortus* (HC), 2) HC supplemented with urea or 3) HC supplemented with leucaena and observed that daily organic matter intake and non-ammonia nitrogen flowing from abomasum were greater on the leucaena supplemented diet than on HC or HC with urea diets. In another experiment using sheep fed with 1) basal diets of HC or 2) HC with urea and minerals (HC + U/M) or 3) supplemented with leucaena (HC + U/M+L) or 4) casein infused into the abomasum (HC + U/M+C) and reported that daily organic matter intake from leucaena supplement (38 $g/w^{0.75}kg$) and casein infusion (30 $g/w^{0.75}kg$) were higher than from basal diet (29 $g/w^{0.75}kg$) and non-ammonia nitrogen flowing from abomasum were 11.1 g, 13.4 g and 5.1 g/day, respectively for the three diets. It was suggested that enhanced feed intake from supplementation in both experiments was associated with an improved flow of amino acids into the intestines.

In a 57 days experiment, lambs gained 5.3 and 7.4 kg when allowed grazing on panicum pasture alone or supplemented with 1 kg of leaves and fine branches of leucaena daily, respectively (Carvalhofilho and Languidey, 1986).

Cheva-Isarakul (1990) fed young rams, initial body weight 19.8±1.8 kg with one of the 5 dietary regimens; fresh paragrass; 4 per cent urea treated rice straw (UTS) to appetite; Urea-molasses mixed rice straw (UMS) to appetite; UTS to appetite plus fresh leucaena leaves 1000 g; UMS to appetite plus fresh leucaena leaves 1000 g. Average daily body weight gain was 86, 37, 40, 63 and 60 g,respectively. Digestibility of DM was 51.1, 45.7, 50.4, 59.5 and 49.2 per cent and of CP 70.3, 46.8, 58.4, 64.0 and 67.5 per cent, total intake of DM was 776, 688, 774, 730 and 802 g, respectively.

Adejumo and Ademosun (1991) conducted growth trial with sheep and goats and given 0, 20, 40, 60 or 80 per cent chopped fresh leucaena leaves and chopped fresh *Panicum maximum* for 16 weeks. Leucaena reduced feed intake in both species and goats ate less than sheep. DM intake was 39.6, 35.1, 33.9, 33.7 and 27.0 g/$W^{0.75}$ kg for goats given 0, 20, 40, 60 and 80 per cent leucaena, respectively. Corresponding values for sheep upto the

60 per cent diet were 69.3, 67.3, 64.8 and 58.4 g/$W^{0.75}$ kg. At 6 weeks health of sheep given 80 per cent leucaena greately deteriorated. Overall growth rate inproved upto 40 per cent for sheep (59.3 g/day) on addition of leucaena and 60 per cent for goats (33.1 g/day). Sheep grew faster than goats. DM digestibility of the diet increased with increasing leucaena and goats digested more DM than sheep. In a 18 week growth trial with 12 West African dwarf goats, Novwakpo *et al.* (1991) reported that the average daily weight gain was 8.0±0, 20.0±1.3, 12.4±0.5 and 24.4±1.5g for goats fed on natural pasture without or with supplements of *Leuceana leucocephala*, *Gliricdia sepium* or brewers gains, respectively.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Experiments were conducted in two phases to evaluate (1) optimum moisture level and incubation period for urea treatment of chopped maize stover and (2) the effect of feeding urea treated maize stover on growth and nutrient utilization in sheep and goats.

3.1 UREA TREATMENT OF MAIZE STOVER

Maize stover was procured from the experimental fields of National Academy of Agricultural Research Management, Rajendranagar, Hyderabad. Maize stover was chopped to 10 to 12 mm size and then subjected to urea treatment to study optimum moisture level and incubation period at a constant level of urea (4%). Three different moisture levels (30, 40 and 50%) and three different incubation periods (1, 2 and 3 weeks) were selected. The chopped maize stover contained 10 per cent moisture. Hence, 3.6 kg urea was dissolved in calculated quantity of water (28.5, 50 and 80 litres of water for 30, 40 and 50 per cent moisture level, respectively) to reconstitute the stover to respective moisture level. 100 kg chopped stover was spread on the cement concrete floor and the urea solution was sprayed on the stover using a garden sprayer. The stover was hand mixed thoroughly so that the urea solution mixed with the stover uniformly.

The treated material was stored in polythene bags of 112 x 76 cm size with 0.2 mm thickness. The material was tightly packed and sealed. Triplicate bags were maintained for each moisture level and were opened at the end of 1, 2 and 3 weeks of incubation.

3.1.1 *In vitro* Evaluation

The samples were evaluated for physical characters like colour, odour, texture and temperature and the samples were analysed for proximate analysis, cell wall constituents, pH and NH_3-N. The *In vitro* dry matter and organic matter digestibility of these samples were also assessed.

The *in vitro* evaluation showed superiority of 40 per cent moisture level over 30 and 50 per cent moisture levels. However, incubation periods of 1 and 2 weeks were comparable but superior to 3 weeks. Hence, maize stover treated at 40 per cent moisture and stored for 1 and 2 weeks was further evaluated in digestion experiments in adult sheep and goats.

3.1.2 *In vivo* Evaluation

3.1.2.1 Experimental rations : Experimental rations used in this study were :

1. 4 per cent urea treated maize stover (chopped) at 40 per cent moisture and incubated for one week.

2. 4 per cent urea treated maize stover (chopped) at 40 per cent moisture and incubated for 2 weeks.

3.1.2.2 Experimental design : Randomized Block Design was used to study the effect of incubation period of urea treated maize stover (UTM, 1 and 2 weeks) on the nutrient utilization in sheep and goats.

3.1.2.3 Experimental animals and their management : Eight adult Nellore sheep and eight adult local male goats weighing on an average 23 and 21 kg, respectively, obtained from livestock experimental station, Rajendranagar, Hyderabad (Table 1), were randomly divided into two groups in each species (four animals in each group) and kept under hygienic and well ventilated individual cages with feeding and watering arrangements throughout the experimental period. The animals were dewormed before commencement of the experiment. Each animal was offered respective UTM *ad libitum* as sole ration without any supplement. Clean and wholesome water was always made available to the animals throughout the experiment. A 30-day preliminary period and a 7 day collection period were followed.

3.1.2.4 Sampling of feed and feed residues : Representative samples of each of the two rations were taken everyday before feeding to the animals and estimated

Table 1 : Scheme of distribution of experimental animals (Digestion trial)

Incubation period (Weeks)			
1		2	
Animal No.	Weight (kg)	Animal No.	Weight (kg)
SHEEP			
1	20.50	1	27.00
2	23.50	2	24.00
3	26.00	3	19.50
4	22.00	4	22.00
Mean + SE	23.00 1.17	Mean + SE	23.00 1.59
GOATS			
1	22.00	1	20.00
2	22.50	2	21.00
3	20.00	3	23.00
4	20.00	4	20.00
Mean ± SE	21.13 0.66	Mean ± SE	21.00 0.71

drymatter by drying in hot air oven at $100 \pm 5^{\circ}c$ over night. Thus samples pooled for 7 days were ground in a laboratory Wiley Mill and preserved in polythene bags for subsequent analysis. Representative samples of residues of each ration were collected everyday for drymatter estimation.

3.1.2.5 Collection of faeces : Faeces as and when voided were collected carefully into seperate containers which were closed with tight lids to prevent drying. The total quantity of faeces voided during 24 hours period was weighed daily at 9.00 A.M. The faeces thus collected was thoroughly mixed and a representative sample was taken from each animal in a bottle approximately 500 g and carefully carried to the laboratory for analysis.

3.1.2.6 Aliquoting and preservation of faeces : For nitrogen estimation, 1/100 th part of the faeces voided each day by individual animal was weighed, mixed with sufficient quantity of 25 per cent sulphuric acid and preserved in previously weighed airtight stoppered samples bottles. Daily samples were preserved in the same labled bottles. After a 7-day collection period, the weights of the samples were recorded.

For drymatter estimation an aliquot of 1/10 th part was taken into petridishes from the individual animal seperately and dried in a hot air oven overnight at 100±5°c. The dried samples were pooled, ground in a laboratory Wiley Mill and stored in polythene bags seperately for subsequent analysis.

3.2 UTILIZATION OF UREA TREATED MAIZE STOVER

Based on the results of the digestion trial 4 per cent urea treated maize stover at 40 per cent moisture level and incubated for 2 weeks was selected and the same was used in the second phase to evaluate it's effect on growth and nutrient utilization in lambs and kids.

3.2.1 Processing of Experimental Feeds

The experimental feeds used in this study were:

1. Urea treated maize stover + Concentrate pellets (containing 30% dried poultry droppings)

2. Urea treated maize stover + Sunhemp (*Crotalaria juncea*) hay meal in 70:30 ratio

3. Urea treated maize stover + Subabul (*Leucaena leucocephala*) leaf meal in 70:30 ratio.

Maize stover was chopped, treated with 4 per cent urea, 40 per cent moisture and incubated for 2 weeks as described in section 3.1. Sunhemp hay and subabul leaf meal were obtained from fodder plots of Forage Production Scheme, Rajendranagar. Sunhemp hay was chopped to 10 to 12 mm size whereas the subabul leaves were collected after drying the stems under shade. The concentrate mixture was proportioned in 100kg batches as per formula (Table 2) and the ingredients requiring grinding (Dried poultry droppings, cotton seed cake, groundnut cake, Sorghum grain) were ground in a hammer mill using 8 mm sieve. The ground material was conveyed from the hammer mill through screw conveyor to bucket elevator which inturn elevates the material and conveys into the hopper over the horizontal mixer. The mineral mixture, salt and vitamins were prepared into a premix and added into the mixer directly. Molasses was pumped from a storage tank to a pre-heater tank and the pre-heated molasses was added into the mixer through a dosage tank while mixing. The concentrate mixture was mixed for 5 mts and then dropped into the bucket elevator which lifted and conveyed the material into a hopper over the pellet mill. The mash was conveyed from the hopper into the conditioning chamber of the pellet mill through a screw-conveying system. The rate of flow of feed into the conditioning chamber was controlled by wheel valve.

The steam produced from a boiler (capacity 113 kg/hr) attached to the plant, was supplied into the conditioning chamber of the pellet mill. The required quantity of steam with 97 to 98^{o}c temperature was

Table 2 : Ingredient composition of concentrate pellet

Ingredients	Quantity (kg)
Dried poultry droppings	30.00
Cotton seed cake	30.00
Groundnut cake	7.00
Sorghum grain	20.00
Molasses	10.00
Salt	1.00
* Mineral mixture	2.00
** Rovimix	
Total	100.00

Mindif : Contained Ca, 20.8%; P, 6.2%; Salt, 35.8%; Iron, 0.4%, Iodine, 250 ppm, Manganese, 740 ppm; Cu, 280 ppm and Sulphur, 0.15%.

** Rovimix : Contained 40,000 IU Vit A, 20 mg Vit B_2 and 5,000 IU Vit D_3 per g was added at the rate of 20 g per 100 kg of concentrate pellet.

supplied into the conditioning chamber through control valve. The conditioned mash at 90 to 92°c temperature and 16 to 17 per cent moisture was conveyed into the pellet mill and extruded through a ring die with 8 mm holes. The pellets with 8 mm diameter having 83 to 85°c temperature and 14 to 15 per cent moisture were dropped from the pellet mill into the vertical cooler below the pellet mill. The cooled pellets were collected into gunny bags from the cooler, stored and used for experimental feeding.

3.2.2 Cost Economics

The average power consumption for various processing methods used in the preparation of experimental feeds (Table 3) was calculated as per the formulae given by Teraj (1965). Processing cost of concentrate feed (pellets) was calculated taking into consideration of all the fixed costs (depreciation on machinery and buildings, interest on block investment and maintenance) and direct charges (cost of power, labour, operators etc) for two shifts of eight hours each for 300 working days per year. The processing cost of maize stover and sunhemp hay were calculated taking direct charges only into consideration. The total cost of the experimental feeds per quintal was calculated on the basis of the processing cost and the prevailing market rate of feed

Table 3 : Average power consumption (KWH) for various processing methods (100 kg)

Method of processing	Experimental rations		
	Concentrate pellet	Sunhemp hay	Maize stover
Chopping	--	0.36	0.33
Grinding	3.15	--	--
Screw conveyor	0.46	--	--
Bucket elevator	0.46	--	--
Mixing	0.35	--	--
Pelleting	2.49	--	--
Total	6.91	0.36	0.33

ingredients and cost of cultivation of subabal leaf meal and sunhemp hay.

3.2.3 Experimental Studies

Experiments conducted are dealt with under the following headings.

1. Growth studies
2. Metabolic studies.

A brief outline of the experimental techniques and methods of analysis adopted during the course of the present study is given below.

3.2.4 Growth Studies

Eighteen weaned Nellore lambs weighing on an average about 11 kg and eighteen local weaned kids weighing on an average about 12.50 kg obtained locally from IDRC (International Development Research Centre) funds, Sheep and goat project, were used for the growth studies. A 150 day feeding experiment was conducted at the Department of Feed and Fodder Technology, College of Veterinary Science, Rajendranagar, Hyderabad.

3.2.4.1 Experimental Design

Randomized Block Design was used to study the effect of the three rations on growth and nutrient utilization in lambs and kids.

3.2.4.2 Selection and distribution of animals : 18 weaned Nellore male lambs and 18 local weaned male kids of 3 to 4 months of age were randomly alloted to 3 experimental rations, such that each ration had 6 weaned Nellore male lambs and 6 local weaned male kids. The particulars of the experimental animals and their distribution into different groups are given in Table 4.

3.2.4.3 Housing and Management : All the animals were housed in well ventilated pens paved with cement concrete (without bedding) with an open yard outside. The animals were dewormed at the beginning of the experiment and once again after two months of the commencement of the experiment. The animals were vaccinated against infectious diseases viz., Haemorrhagic Septicaemia, Enterotoxaemia and Rinderpest. Throughout the experimental period healthy surroundings and proper cleanliness were maintained in the experimental shed.

3.2.4.4 Feeding and watering of animals : Experimental rations 1 to 3 were randomly assigned to 3 groups of animals of each species. The animals on ration 1 were fed with 200 g concentrate pellets and urea treated maize stover ad libitum. The animals on rations 2 and 3 were fed with the respective rations ad libitum. The animals were offered the respective rations at 9 AM and 3 PM. The residues, if any, were weighed in the next day morning. The dry-matter content of feed offered and

Table 4 : Scheme of distribution of experimental animals (growth and metabolic studies)

Experimental rations					
1		2		3	
Animal No.	Weight (kg)	Animal No.	Weight (kg)	Animal No.	Weight (kg)
		LAMBS			
1	10.83	1	11.17	1	11.50
2	10.67	2	11.00	2	11.83
3	10.83	3	11.00	3	11.17
4	12.67	4	11.17	4	11.50
5	10.50	5	12.00	5	10.00
6	11.00	6	10.33	6	11.00
Mean + SE	11.08 0.32	Mean + SE	11.11 0.22	Mean + SE	11.17 0.26
		KIDS			
1	12.50	1	13.50	1	12.75
2	12.00	2	11.75	2	13.25
3	13.70	3	12.25	3	13.30
4	12.50	4	11.50	4	11.75
5	11.60	5	13.50	5	12.50
6	12.50	6	12.50	6	11.50
Mean ± SE	12.47 0.29	Mean ± SE	12.50 0.35	Mean ± SE	12.51 0.31

residues was estimated daily to arrive at the exact quantity of feed consumed daily by the experimental animals.

3.2.4.5 Live weight records : The animals were weighed weekly using Avery weigh bridge balance before feed or water was offered. Average daily gain was calculated by using the formula

$$\text{Average daily gain} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Number of days (150)}}$$

3.2.5 Metabolic Studies

3.2.5.1 Experimental animals and their management : A digestion and metabolism trial was conducted on all the 36 animals (18 weaned Nellore male lambs and 18 local weaned male kids) of growth experiment to assess the nutrient utilization of the three rations during the last week of growth experiment. The animals were kept in well ventilated hygienic individual cages with feeding and watering arrangements. Faeces and urine was collected during a 7-day collection period. Dry matter content of samples of feeds offered and residues were determined daily. Daily records of feed consumption as well as faeces and urine voided were maintained for 7 consecutive days.

3.2.5.2 Sampling of feed and feed residues : Representative samples of each of the 3 rations offered and the residues were taken every day before feeding to the animals, dried in hot air oven at 100 $\pm$ 5^{o}c to estimate the dry matter and pooled for 7 days. The samples of the 3 rations and leftouts were ground in a laboratory Wiley Mill and preserved in polythene bags for subsequent analysis.

3.2.5.3 Collection of faeces and urine : The same criteria described in section 3.1.2.5 was used for collection of faeces.

The total urine voided in 24 hours by individual animal was measured daily and representative samples were taken seperately in well stoppered bottles.

3.2.5.4 Aliquoting and preservation of faeces and urine:

a) <u>Faeces</u> : The same procedure described in Section 3.1.2.6 was used for aliquoting and preservation of faeces.

b) <u>Urine</u> : For nitrogen estimation 1/100th part of the total urine voided daily by individual animal after thorough mixing was pippetted out in duplicate into Kjeldahl flasks containing 30 ml of concentrate sulphuric acid. The aliquots thus pooled in the flask for 5 days were maintained seperately for each animal.

Similarly, 1/100th part of aliquot was taken in duplicate for mineral estimation in silica crucibles and dried at 100 ± 5^{o}c daily and 7-day collections were added to the same crucibles. They were ashed in muffle furnace and extracted with hydrochloric acid and preserved for subsequent analysis.

3.2.6 Analytical Methods

The pH of the urea treated maize stover samples was estimated by Wilson and Wilkins (1972) method. Ammonia nitrogen (NH_3-N) was estimated colorimetrically as per the method of Weatherburn (1967). *In vitro* dry matter and organic matter digestibilities were estimated as per the procedure suggested by Barnes *et al*. (1971). AOAC (1980) methods of analysis were followed for estimation of dry matter, organic matter, crude protein, ether extract, crude fibre, nitrogen-free extract and total ash. Calcium estimation was done according to Talapatra *et al*. (1940) method. Phosphorus was estimated colorimetrically as per AOAC (1980) procedure. The samples were analysed for cell wall constituents in 'Fibre tek' instrument using the analytical procedures of Van Soest and Moore (1965). The gross energy content of the feeds and faeces was found out using "Gallenhamp adiabatic, bomb carlorimeter". Metabolizable energy content of the rations was calculated using the factor recommended by NRC (1978, D.E x 0.82).

3.2.7 Statistical Analysis

The experimental data were analysed according to the methods of Snedecor and Cochran (1968).

RESULTS

CHAPTER IV

RESULTS

In the first phase, chopped maize stover was treated with 4 per cent urea at three different moisture levels (30, 40 and 50%) and incubated for three periods (1, 2 and 3 weeks) to assess the optimum conditions for urea treatment of maize stover. In the second phase the urea treated maize stover (UTM) was supplemented with (1) concentrate feed (pellet) (2) sunhemp hay meal and (3) subabul leaf meal in the rations of lambs and kids to assess the growth, feed efficiency and nutrient utilization.

4.1 CHEMICAL COMPOSITION OF MAIZE STOVER

Maize stover used in this experiment (Table 33) contained (% on DM basis) 90.14 organic matter, 7.04 crude protein, 38.78 crude fibre, 1.36 ether extract, 42.96 nitrogen-free extract, 9.86 total ash, 0.69 calcium, 0.16 phosphorus, 22.24 cell contents, 77.76 cell wall constituents, 48.95 acid detergent fibre, 28.81 hemi cellulose, 40.72 cellulose, 6.80 lignin and 1.43 silica.

4.2 EFFECT OF UREA TREATMENT OF MAIZE STOVER

4.2.1 Temperature

The mean temperature of urea treated maize stover (Table 5) was 26.50, 29.83 and 29.83^{o}c for 30, 40

Table 5 : Mean values* of temperature (^{o}c) of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%) 30	40	50	Overall mean	± SE
1	26.50	29.50	29.50	28.50	± 0.55
2	26.50	30.50	30.00	29.00	± 0.67
3	26.50	29.50	30.00	28.67	± 0.58
Overall mean	26.50^{a}	29.83^{b}	29.83^{b}		
± SE	0.20	0.28	0.24		

* Mean of three values

a,b - Values with different superscripts within the row differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	66.67	33.34	59.54**
Period	2	1.17	0.59	1.05
Moisture x period	4	1.33	0.33	0.59
Error	18	10.00	0.56	
Total	26	79.17		

** Significant ($P < 0.01$)

and 50 per cent moisture level and 28.50, 29.00 and 28.67°c for 1, 2 and 3 weeks of incubation, respectively. Temperature was significantly ($P < 0.01$) higher on 40 and 50 per cent moisture levels but not affected by period of incubation.

4.2.2 pH

The mean pH values of UTM recorded (Table 6) were 8.54, 8.56 and 8.59 for moisture levels of 30, 40 and 50 per cent and 8.54, 8.63 and 8.51 for incubations of 1, 2 and 3 weeks, respectively. The pH was comparable at all the moisture levels and incubation periods.

4.2.3 Organic Matter

The mean organic matter values of UTM (Table 7) recorded (% on DM basis) were 88.08, 88.85 and 88.46 for moisture levels of 30, 40 and 50 per cent and 88.48, 88.96 and 87.95 for incubations of 1, 2 and 3 weeks, respectively. Organic matter values were significantly different among the three moisture levels ($P < 0.05$) as well as the three incubation periods ($P < 0.01$).

4.2.4 Crude Protein

The mean crude protein values of UTM (Table 8) recorded (% on DM basis) were 14.72, 15.27 and 13.67 for moisture levels of 30, 40 and 50 per cent and 14.70, 14.80 and 14.16 for incubation periods of 1, 2 and 3

Table 6 : Mean values* of pH of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean ± SE
	30	40	50	
1	8.64	8.50	8.49	8.54 ± 0.09
2	8.58	8.67	8.65	8.63 ± 0.12
3	8.40	8.51	8.63	8.51 ± 0.07
Overall mean	8.54	8.56	8.59	
± SE	0.11	0.05	0.11	

Mean of three values

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	0.01	0.005	0.05
Period	2	0.07	0.04	0.40
Moisture x period	4	0.13	0.03	0.30
Error	18	1.71	0.10	
Total	26	1.92		

Table 7 : Mean values* (on % DM basis) of organic matter of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean	± SE
	30	40	50		
1	88.28	88.43	88.72	88.48[ab]	± 0.17
2	88.32	89.13	89.43	88.96[b]	± 0.25
3	87.64	89.00	87.22	87.95[a]	± 0.30
Overall mean ± SE	88.08[a] 0.17	88.85[b] 0.21	88.46[ab] 0.37		

* Mean of three values

a,b - Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	2.69	1.35	4.22*
Period	2	4.56	2.28	7.13**
Moisture x period	4	4.79	1.20	3.75*
Error	18	5.81	0.32	
Total	26	17.85		

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

Table 8 : Mean values* (on % DM basis) of crude protein of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean	± SE
	30	40	50		
1	14.71	15.19	14.20	14.70	± 0.19
2	14.92	15.62	13.85	14.80	± 0.36
3	14.52	15.00	12.97	14.19	± 0.36
Overall mean	14.72[b]	15.27[b]	13.67[a]		
+ SE	0.11	0.15	0.35		

* Mean of three values

a,b - Values with different superscripts within the row differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	11.83	5.92	12.87**
Period	2	2.10	1.05	2.28
Moisture x period	4	1.16	0.29	0.63
Error	18	8.20	0.46	
Total	26	23.29		

** Significant ($P < 0.01$)

weeks, respectively. Crude protein content was significantly ($P < 0.01$) higher on 30 and 40 per cent moisture levels but not affected by period of incubation.

4.2.5 Crude Fibre

The mean crude fibre content of UTM (Table 9) recorded (% on DM basis) was 36.66, 36.09 and 36.60 for moisture levels of 30, 40 and 50 per cent and 36.50, 36.26 and 36.59 for incubation periods of 1, 2 and 3 weeks, respectively. Crude fibre content was significantly ($P < 0.01$) lower at 40 per cent moisture level compared to 30 and 50 per cent moisture levels. Crude fibre content was not affected by period of incubation.

4.2.6 Ether Extract

The mean ether extract content of UTM (Table 10) recorded (% on DM basis) was 1.16, 1.17 and 1.24 for moisture levels of 30, 40 and 50 per cent and 1.20, 1.20 and 1.17 for incubation periods of 1, 2 and 3 weeks, respectively. Ether extract content was comparable at all the moisture levels and incubation periods.

4.2.7 Nitrogen-free Extract (NFE)

The mean NFE content of UTM (Table 11) recorded (% on DM basis) was 35.54, 36.32 and 36.95 for moisture levels of 30, 40 and 50 per cent and 36.08, 36.70 and 36.03 for incubation periods of 1, 2 and 3 weeks,

Table 9 : Mean values* (on % DM basis) of crude fibre of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean	± SE
	30	40	50		
1	36.91	36.02	36.56	36.50	± 0.15
2	36.26	35.93	36.59	36.26	± 0.14
3	36.80	36.32	36.64	36.59	± 0.15
Overall mean	36.66[b]	36.09[a]	36.60[b]		
± SE	0.12	0.07	0.16		

* Mean of three values

a,b - Values with different superscripts within the row differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	1.74	0.87	6.69**
Period	2	0.51	0.26	2.00
Moisture x period	4	0.48	0.12	0.92
Error	18	2.29	0.13	
Total	26	5.02		

** Significant ($P < 0.01$)

Table 10 : Mean values* (on % DM basis) of ether extract of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%) 30	40	50	Overall mean ± SE
1	1.12	1.29	1.18	1.20 ± 0.10
2	1.22	1.01	1.37	1.20 ± 0.07
3	1.15	1.21	1.16	1.17 ± 0.04
Overall mean ± SE	1.16 0.03	1.17 0.07	1.24 0.11	

* Mean of three values

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	0.03	0.020	0.33
Period	2	0.004	0.002	0.03
Moisture x period	4	0.22	0.06	1.00
Error	18	1.04	0.06	
Total	26	1.29		

Table 11 : Mean values[*] (on % DM basis) of nitrogen-free extract of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%) 30	40	50	Overall mean ± SE
1	35.54	35.93	36.78	36.08 ± 0.24
2	35.92	36.57	37.62	36.70 ± 0.37
3	35.17	36.47	36.45	36.03 ± 0.34
Overall mean	35.54[a]	36.32[a]	36.95[b]	
± SE	0.19	0.21	0.37	

* Mean of three values

a,b - Values with different superscripts within the row differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	9.20	4.60	7.19**
Period	2	0.73	0.37	0.58
Moisture x period	4	3.40	0.85	1.33
Error	18	11.45	0.64	
Total	26	24.78		

** Significant ($P < 0.01$)

respectively. NFE content was significantly (P < 0.01) higher on 50 per cent compared to 30 and 40 per cent moisture levels. However, NFE content was not affected by period of incubation.

4.2.8 Total Ash

The mean Total ash content of UTM (Table 12) recorded (% on DM basis) was 11.92, 11.15 and 11.54 for moisture levels of 30, 40 and 50 per cent and 11.52, 11.04 and 12.05 for incubation periods of 1, 2 and 3 weeks, respectively. Total ash content was significantly affected by moisture levels (P < 0.05) and incubation periods (P < 0.01).

4.2.9 Calcium

The mean calcium content of UTM (Table 13) recorded (% on DM basis) was 0.69, 0.68 and 0.68 for 30, 40 and 50 per cent moisture levels and 0.68, 0.68 and 0.68 for incubation periods of 1, 2 and 3 weeks, respectively. The calcium content was comparable at all the moisture levels and incubation periods.

4.2.10 Phosphorus

The mean phosphorus content of UTM (Table 14) recorded (% on DM basis) was 0.16, 0.17 and 0.16 for moisture levels of 30, 40 and 50 per cent and 0.17, 0.17 and 0.17 for incubation periods of 1, 2 and 3 weeks,

Table 12 : Mean values* (on % DM basis) of total ash of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean	± SE
	30	40	50		
1	11.72	11.57	11.28	11.52[ab]	± 0.17
2	11.68	10.87	10.57	11.04[a]	± 0.25
3	12.36	11.00	12.78	12.05[b]	± 0.30
Overall mean ± SE	11.92[b] 0.17	11.15[a] 0.21	11.54[ab] 0.37		

* Mean of three values

a,b - Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	2.69	1.35	4.22*
Period	2	4.56	2.28	7.13**
Moisture x period	4	4.79	1.20	3.75*
Error	18	5.81	0.32	
Total	26	17.85		

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

Table 13 : Mean values* (on % DM basis) of calcium of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean ± SE
	30	40	50	
1	0.68	0.68	0.69	0.68 ± 0.003
2	0.69	0.68	0.68	0.68 ± 0.005
3	0.69	0.68	0.68	0.68 ± 0.005
Overall mean	0.69	0.68	0.68	
± SE	0.005	0.004	0.004	

Mean of three values

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	0.002	0.0001	0.50
Period	2	0.00	0.000	0.00
Moisture x period	4	0.004	0.0001	0.50
Error	18	0.0044	0.0002	
Total	26	0.005		

Table 14 : Mean values* (on % DM basis) of phosphorus of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%) 30	40	50	Overall mean ± SE
1	0.16	0.17	0.16	0.17 ± 0.006
2	0.17	0.17	0.16	0.17 ± 0.006
3	0.16	0.17	0.17	0.17 ± 0.007
Overall mean ± SE	0.16 0.007	0.17 0.007	0.16 0.005	

* Mean of three values

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	0.0003	0.0001	0.25
Period	2	0.00007	0.00003	0.08
Moisture x period	4	0.0003	0.00007	0.18
Error	18	0.007	0.0004	
Total	26	0.008		

respectively. The phosphorus content was comparable at all the moisture levels and incubation periods.

4.2.11 Ammonia Nitrogen (NH_3-N)

The mean NH_3-N values of UTM (Table 15) recorded (mg/100 g) were 120.90, 134.68 and 117.34 for moisture levels of 30, 40 and 50 per cent and 120.71, 126.76 and 125.44 for incubation periods of 1, 2 and 3 weeks, respectively. The NH_3-N values were significantly ($P < 0.01$) different among the three moisture levels as well as the three incubation periods.

4.2.12 Neutral Detergent Solubles (NDS)

The mean NDS values (Table 16) recorded (% on DM balues) were 26.07, 27.22 and 24.17 for moisture levels of 30, 40 and 50 per cent and 25.77, 25.79 and 25.91 for incubation periods of 1, 2 and 3 weeks, respectively. NDS values were significantly ($P < 0.01$) different among the three moisture levels but were comparable among the three incubation periods.

4.2.13 Neutral Detergent Fibre (NDF)

The mean NDF values (Table 17) recorded (% on DM basis) were 73.93, 72.78 and 75.83 for moisture levels of 30, 40 and 50 per cent and 74.23, 74.21 and 74.18 for incubation periods of 1, 2 and 3 weeks, respectively. NDF values were significantly ($P < 0.01$)

Table 15 : Mean values* of NH_3-N (mg/100 g) of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean	± SE
	30	40	50		
1	119.30	131.13	111.71	120.71[a]	± 2.91
2	122.78	136.21	121.29	126.76[b]	± 2.45
3	120.62	136.70	119.01	125.44[b]	± 2.85
Overall mean	120.90[b]	134.68[c]	117.34[a]		
+ SE	0.87	1.09	1.49		

* Mean of three values

a,b,c- Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	1510.13	755.07	184.16**
Period	2	182.01	91.00	22.20**
Moisture x period	4	43.85	10.96	2.67
Error	18	73.78	4.10	
Total	26	1809.77		

** Significant ($P < 0.01$)

Table 16 : Mean values* (on % DM basis) of Neutral detergent solubles of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean ± SE
	30	40	50	
1	25.35	27.00	25.95	25.77 ± 0.33
2	26.35	27.50	23.51	25.79 ± 0.64
3	26.50	27.16	24.06	25.91 ± 0.60
Overall mean ± SE	26.07[b] 0.23	27.22[c] 0.28	24.17[a] 0.40	

* Mean of three values

a,b,c - Values with different superscripts within the row differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	42.59	21.30	25.66**
Period	2	0.10	0.05	0.06
Moisture x period	4	5.81	1.45	1.75
Error	18	15.01	0.83	
Total	26	63.51		

** Significant ($P < 0.01$)

Table 17 : Mean values* (on % DM basis) of Neutral detergennt fibre of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean ± SE
	30	40	50	
1	74.65	73.00	75.05	74.23 ± 0.33
2	73.65	72.50	76.49	74.21 ± 0.64
3	73.50	72.84	75.94	74.18 ± 0.55
Overall mean + SE	73.93[b] 0.23	72.78[a] 0.28	75.83[c] 0.40	

* Mean of three values

a,b,c - Values with different superscripts within the row differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	42.59	21.30	25.66**
Period	2	0.10	0.05	0.06
Moisture x period	4	5.81	1.45	1.75
Error	18	15.01	0.83	
Total	26	63.51		

** Significant ($P < 0.01$)

different among the three moisture levels, but were comparable among the three incubation periods.

4.2.14 Acid Detergent Fibre (ADF)

The mean ADF values of UTM (Table 18) recorded (% on DM basis) were 47.25, 45.40 and 47.97 for moisture levels of 30, 40 and 50 per cent and 47.20, 46.97 and 46.44 for incubation periods of 1, 2 and 3 weeks, respectively. ADF content was significantly different among the three moisture levels ($P < 0.01$) and also among the three incubation periods ($P < 0.05$).

4.2.15 Hemicellulose

The mean hemicellulose values of UTM (Table 19) recorded (% on DM basis) were 26.69, 27.38, 27.86 for moisture levels of 30, 40 and 50 per cent and 27.03, 27.24 and 27.65 for incubation periods of 1, 2 and 3 weeks, respectively. The hemicellulose values were comparable at all the moisture levels and incubation periods.

4.2.16 Cellulose

The mean cellulose values of UTM (Table 20) recorded (% on DM basis) were 38.35, 35.99 and 39.07 for moisture levels of 30, 40 and 50 per cent and 38.42, 37.74 and 37.25 for incubation periods of 1, 2 and 3

Table 18 : Mean values* (on % DM basis) of Acid detergent fibre of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean	± SE
	30	40	50		
1	47.67	45.68	48.25	47.20^{b}	± 0.42
2	47.18	45.23	48.50	46.97^{ab}	± 0.50
3	46.90	45.28	47.15	46.44^{a}	± 0.33
Overall mean	47.25^{b}	45.40^{a}	47.97^{c}		
± SE	0.21	0.17	0.25		

* Mean of three values

a,b,c - Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	31.66	15.83	52.77**
Period	2	2.71	1.35	4.50*
Moisture x period	4	1.66	0.42	1.40
Error	18	5.32	0.30	
Total	26	41.35		

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

Table 19 : Mean values* (on % DM basis) of hemicellulose of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean ± SE
	30	40	50	
1	26.98	27.32	26.80	27.03 ± 0.20
2	26.47	27.27	27.99	27.24 ± 0.34
3	26.60	27.56	28.79	27.65 ± 0.49
Overall mean ± SE	26.69 0.28	27.38 0.29	27.86 0.41	

* Mean of three values

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	6.31	3.15	3.25
Period	2	1.77	0.88	0.91
Moisture x period	4	4.81	1.20	1.23
Error	18	17.42	0.97	
Total	26	30.31		

Table 20 : Mean values* (on % DM basis) of cellulose of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%) 30	40	50	Overall mean	± SE
1	38.76	37.21	39.30	38.42[c]	± 0.36
2	37.61	35.36	40.24	37.74[b]	± 0.71
3	38.67	35.41	37.66	37.25[a]	± 0.49
Overall mean ± SE	38.35[b] 0.20	35.99[a] 0.35	39.07[c] 0.39		

* Mean of three values

a,b,c - Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	46.51	23.25	122.37**
Period	2	6.29	3.14	16.53**
Moisture x period	4	13.05	3.26	17.16**
Error	18	3.33	0.19	
Total	26	69.18		

** Significant ($P < 0.01$)

weeks, respectively. Cellulose content was significantly ($P < 0.01$) different among the three moisture levels and the three incubation periods.

4.2.17 Lignin

The mean lignin values of UTM (Table 21) recorded (% on DM basis) were 5.71, 6.10 and 6.07 for moisture levels of 30, 40 and 50 per cent and 5.81, 5.87 and 6.19 for incubation periods of 1, 2 and 3 weeks, respectively. The lignin content was significantly ($P < 0.01$) different among the three moisture levels. However, the lignin content was significantly ($P < 0.01$) higher at 3 weeks of incubation period compared to 1 and 2 weeks.

4.2.18 Silica

The mean silica values of UTM (Table 22) recorded (% on DM basis) were 3.20, 3.31 and 2.83 for moisture levels of 30, 40 and 50 per cent and 2.96, 3.37 and 3.01 for incubation periods of 1, 2 and 3 weeks, respectively. The silica content was significantly ($P < 0.01$) affected by moisture levels and incubation periods.

4.2.19 *In vitro* Dry Matter Digestibility

The mean *in vitro* dry matter digestibility values of UTM (Table 23) recorded (% on DM basis) were 46.31, 50.66 and 50.48 for moisture levels of 30, 40 and

Table 21 : Mean values* (on % DM basis) of lignin of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Mositure level (%)			Overall mean ± SE
	30	40	50	
1	5.83	5.84	5.77	5.81[a] ± 0.03
2	5.94	5.93	5.73	5.78[a] ± 0.06
3	5.35	6.52	6.70	6.19[b] ± 0.23
Overall mean ± SE	5.71[a] 0.10	6.10[b] 0.14	6.07[ab] 0.16	

* Mean of three values

a,b - Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	0.96	0.48	12.00**
Period	2	0.87	0.44	11.00**
Moisture x period	4	2.35	0.59	14.75**
Error	18	0.69	0.04	
Total	26	4.87		

** Significant ($P < 0.01$)

Table 22 : Mean values* (on % DM basis) of Silica of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean ± SE
	30	40	50	
1	3.08	2.63	3.18	2.96^{a} ± 0.09
2	3.63	3.94	2.53	3.37^{b} ± 0.22
3	2.88	3.35	2.79	3.01^{a} ± 0.09
Overall mean ± SE	3.20^{b} 0.12	3.31^{b} 0.19	2.83^{a} 0.10	

* Mean of three values

a,b - Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	1.10	0.55	27.50**
Period	2	0.88	0.44	22.00**
Moisture x period	4	3.25	0.81	40.50**
Error	18	0.28	0.02	
Total	26	5.51		

** Significant ($P < 0.01$)

Table 23 : Mean values* of *in vitro* dry matter digestibility (%) of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean	± SE
	30	40	50		
1	45.91	50.25	50.04	48.73[a]	± 0.73
2	47.20	51.59	51.36	50.05[b]	± 0.72
3	45.81	49.98	50.04	48.66[a]	± 0.73
Overall mean	46.31[a]	50.66[b]	50.48[b]		
± SE	0.26	0.25	0.30		

* Mean of three values

a,b - Values with different superscripts column-wise as well as row-wise differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	16.61	8.31	30.78**
Period	2	11.01	5.51	20.41**
Moisture x period	4	92.52	23.13	85.67**
Error	18	4.89	0.27	
Total	26	125.03		

** Significant ($P < 0.01$)

50 per cent and 48.73, 50.05 and 48.66 for incubation periods of 1, 2 and 3 weeks, respectively. The *in vitro* dry matter digestibility was significantly ($P < 0.01$) higher on 40 and 50 per cent moisture levels compared to 30 per cent moisture. The digestibility values were significantly ($P < 0.01$) higher at 2 weeks incubation compared to 1 and 3 weeks.

4.2.20 *In vitro* Organic Matter Digestibility

The mean *in vitro* organic matter digestibility values (Table 24) recorded (% on DM basis) were 46.71, 55.64 and 55.46 for 30, 40 and 50 per cent moisture level and 52.30, 53.34 and 52.15 for 1, 2 and 3 weeks of incubation, respectively. The organic matter digestibility was significantly ($P < 0.01$) higher on 40 and 50 per cent moisture levels but not affected by period of incubation.

4.3 DIGESTION STUDIES IN SHEEP AND GOATS

In order to assess the optimum incubation period, digestion trials were conducted by feeding (1) UTM at 40 per cent moisture level incubated for 1 week and (2) UTM at 40 per cent moisture level incubated for 2 weeks *ad lib* without any supplement to 8 adult Nellore rams and 8 adult local male goats (4 in each group) to assess the nutrient digestibility and nutritive value of the treated UTM.

Table 24 : Mean values* of *in vitro* organic matter digestibility (%) of urea treated maize stover as affected by different moisture levels and incubation periods

Incubation period (weeks)	Moisture level (%)			Overall mean ± SE
	30	40	50	
1	46.85	55.22	54.83	52.30 ± 1.37
2	47.01	56.59	56.43	53.34 ± 1.59
3	46.27	55.13	55.06	52.15 ± 1.47
Overall mean ± SE	46.71[a] 0.18	55.64[b] 0.26	55.46[b] 0.28	

* Mean of three values

a,b - Values with different superscripts within the row differ significantly.

Analysis of variance

Source of variation	d.f.	S.S.	M.S.S.	F
Moisture	2	468.17	234.09	1170.45**
Period	2	7.53	3.77	18.85**
Moisture x period	4	1.83	0.46	2.30
Error	18	3.65	0.20	
Total	26	481.18		

** Significant ($P < 0.01$)

4.3.1 Voluntary Feed Intake

An average daily dry matter intake of 366.41 and 337.48 and 385.24 and 367.08 g was recorded by the sheep and goats fed rations 1 and 2, respectively. The average total dry matter consumption per 100 kg body weight recorded in this experiment (Table 25) was 1.55±0.03 and 1.60±0.05 and 1.66±0.06 and 1.75±0.05 kg among sheep and goats fed rations 1 and 2, respectivley. The dry matter intake was significantly affected by rations ($P < 0.01$) as well as periods ($P < 0.05$).

4.3.2 Voluntary Water Intake

An average daily water intake (Table 25) of 2.08 and 1.18 and 2.09 and 1.38 litres was recorded in sheep and goats fed rations 1 and 2, respectively. The average water intake per kg dry matter intake recorded was 5.86±0.31 and 3.49±0.10 and 5.40±0.51 and 3.71±0.36 litres among sheep and goats fed rations 1 and 2, respectively. The water intake per kg dry matter intake was highly significant ($P < 0.01$) between sheep and goats. However, threre was no significant difference in water intakes between rations 1 and 2 irrespective of the species.

4.3.3 Dry Matter Digestibility

The dry matter intake, out go and digestibility coefficients of experimental animals are presented in

Table 25 : **Voluntary dry matter and water intake by sheep and goats of urea treated maize stover of different incubation periods**

Incubation period (weeks)	Species	Animal No.	Body weight (kg)	Dry matter intake Per day (g)	Dry matter intake Per 100 kg body weight (kg)	Water intake Per day (lit)	Water intake Per kg DMI (lit)
1	Sheep	1	20.50	325.50	1.59	2.19	6.73
		2	23.50	378.07	1.61	2.19	5.79
		3	26.00	390.63	1.50	2.21	5.66
		4	22.00	331.42	1.51	1.74	5.25
		Mean	23.00	356.41	1.55	2.08	5.86
		± SE	1.17		0.03	0.11	0.31
	Goats	1	22.00	350.54	1.59	1.13	3.22
		2	22.50	388.70	1.73	1.38	3.55
		3	20.00	307.13	1.54	1.13	3.68
		4	20.00	303.54	1.52	1.06	3.49
		Mean	21.13	337.48	1.60	1.18	3.49
		± SE	0.66		0.05	0.07	0.10
2	Sheep	1	27.00	466.30	1.73	3.07	6.58
		2	24.00	422.23	1.76	1.74	4.12
		3	19.50	325.09	1.67	1.84	5.66
		4	22.00	327.33	1.49	1.71	5.22
		Mean	23.13	385.24	1.66	2.09	5.40
		± SE	1.59		0.06	0.33	0.51
	Goats	1	20.00	333.83	1.67	1.07	3.21
		2	21.00	390.18	1.86	1.81	4.64
		3	23.00	413.97	1.80	1.62	3.91
		4	20.00	330.32	1.65	1.02	3.09
		Mean	21.00	367.08	1.75	1.38	3.71
		± SE	0.71		0.05	0.20	0.36

Analysis of variance of dry matter intake per 100 kg body weight and water intake/kg DM intake in adult sheep and goats

Source	d.f	S.S	M.S.S.	F
Dry matter intake				
Weeks	1	0.0676	0.0676	19.59**
Species	1	0.0196	0.0196	5.68*
Weeks x species	1	0.0016	0.0016	0.46
Error	12	0.0414	0.00345	
Total	15	0.1302		
Water intake				
Weeks	1	0.0576	0.0576	0.1244
Species	1	16.48	16.48	35.58**
Weeks x species	1	0.466	0.466	1.006
Error	12	5.56	0.4632	
Total	15	22.56		

	DM intake		Water intake	
Weeks :	1	2	1	2
	1.58^{a}	1.71^{b}	4.68	4.56
Species :	**Sheep**	**Goats**	**Sheep**	**Goats**
	1.61^{a}	1.68^{b}	5.63^{b}	3.60^{a}

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ item wise significantly.

Table 26. The average dry matter digestibility coefficients recorded with the rations 1 and 2 among sheep and goats were 43.68±0.162 and 43.88±0.59 and 49.76±0.91 and 51.09±0.64, respectively. The dry matter digestibility was significantly ($P < 0.01$) higher on ration 2 than on ration 1. The dry matter digestibility was not significantly different between sheep and goats.

4.3.4 Organic Matter Digestibility

Average organic matter digestibility data of the experimental animals were given in Table 27. The average daily organic matter intakes recorded were 315.17 and 298.43 and 343.36 and 327.17 g with an average digestibility coefficients of 47.22±1.36 and 47.65±0.51 and 53.34±0.75 and 55.07±0.89, among sheep and goats, fed rations 1 and 2, respectively. Organic matter digestibility was significantly ($P < 0.01$) higher for ration 2 compared to ration 1 and was at par in both the species of animals.

4.3.5 Crude Protein Digestibility

The average crude protein intake, outgo and digestibility coefficients are shown in Table 28. Average daily protein intake of 54.14 and 51.26 and 60.18 and 57.34 g with an average digestibility coefficients of 49.34±2.31 and 44.43±3.06 and 55.85±3.9 and

Table 26 Dry matter digestibility of urea treated maize stover of different incubation periods in sheep and goats

Incubation period (Weeks)	Species	Animal No.	Intake	Voided in faeces (g)	Digested	Digestibility coefficient
1	Sheep	1	325.50	169.81	155.69	47.83
		2	378.07	211.01	167.06	44.19
		3	390.63	234.07	156.56	40.08
		4	331.42	190.14	141.28	42.63
		Mean ± SE	356.41		155.15	43.68 1.62
	Goats	1	350.54	199.77	150.77	43.01
		2	388.70	222.57	166.13	42.74
		3	307.13	168.80	138.33	45.04
		4	303.54	167.74	135.80	44.74
		Mean ± SE	337.48		147.76	43.88 0.59
2	Sheep	1	466.30	243.69	222.61	47.74
		2	422.23	215.17	207.06	49.04
		3	325.09	156.01	169.08	52.01
		4	327.33	162.88	164.45	50.24
		Mean ± SE	385.24		190.80	49.76 0.91
	Goats	1	333.83	160.57	173.26	51.90
		2	390.18	189.78	200.40	51.36
		3	413.97	210.26	203.71	49.21
		4	330.32	158.98	171.34	51.87
		Mean + SE	367.08		187.18	51.09 0.64

Analysis of variance of dry matter digestibility coefficients in sheep and goats

Source	d.f	S.S	M.S.S.	F
Weeks	1	176.62	176.62	43.08**
Species	1	2.34	2.34	0.57
Weeks x species	1	1.28	1.28	0.31
Error	12	49.16	4.10	
Total	15	229.40		

Weeks :	1	2
	43.78[a]	50.43[b]

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ significantly.

Table 27 : Organic matter digestibility of urea treated maize stover of different incubation periods in sheep and goats

Incubation period (Weeks)	Species	Animal No.	Intake	Voided in faeces (g)	Digested	Digestibility coefficient
1	Sheep	1	287.84	142.03	145.81	50.66
		2	334.33	174.67	159.66	47.75
		3	345.43	192.71	152.72	44.21
		4	293.07	157.51	135.56	46.25
		Mean ± SE	315.17		148.44	47.22 1.36
	Goats	1	309.98	161.58	148.40	47.88
		2	343.73	184.58	159.15	46.30
		3	271.60	142.25	129.35	47.63
		4	268.42	137.50	130.92	48.78
		Mean ± SE	298.43		141.96	47.65 0.51
2	Sheep	1	415.61	201.14	214.47	51.60
		2	376.33	177.30	199.03	52.89
		3	289.75	129.77	159.98	55.21
		4	291.75	135.24	156.51	53.65
		Mean ± SE	343.36		182.50	53.34 0.75
	Goats	1	297.54	129.56	167.98	56.45
		2	347.77	159.28	188.49	54.20
		3	368.97	173.46	195.51	52.99
		4	294.41	127.68	166.73	56.63
		Mean ± SE	327.17		179.68	55.07 0.89

Analysis of variance of organic matter digestibility coefficients in sheep and goats

Source	d.f	S.S	M.S.S.	F
Weeks	1	183.33	183.33	63.88**
Species	1	4.67	4.67	1.63
Weeks x species	1	1.69	1.69	0.59
Error	12	34.44	2.87	
Total	15	227.13		

Weeks : 1 2

47.44^{a} 54.21^{b}

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ significantly.

Table 28 : Crude protein digestibility of urea treated maize stover of different incubation periods in sheep and goats

Incubation period (Weeks)	Species	Animal No.	Intake	Voided in faeces (g)	Digested	Digestibility coefficient
1	Sheep	1	49.44	22.57	26.87	54.35
		2	57.43	27.56	29.87	52.01
		3	59.34	32.98	26.36	44.42
		4	50.34	26.89	23.45	46.59
		Mean ± SE	54.14		26.64	49.34 2.31
	Goats	1	53.25	28.77	24.48	45.98
		2	59.04	37.79	21.25	35.99
		3	46.65	25.61	21.04	45.11
		4	46.11	22.76	23.35	50.63
		Mean ± SE	51.26		22.53	44.43 3.06
2	Sheep	1	72.84	40.23	32.61	44.76
		2	65.95	25.11	40.84	61.93
		3	50.78	20.00	30.78	60.61
		4	51.13	22.44	28.69	56.10
		Mean ± SE	60.18		33.23	55.85 3.90
	Goats	1	52.14	20.33	31.81	61.01
		2	60.95	28.13	32.82	53.85
		3	64.66	28.72	35.94	55.58
		4	51.60	24.26	27.34	52.98
		Mean ± SE	57.34		31.98	55.86 1.80

Analysis of variance of crude protein digestibility coefficients in sheep and goats

Source	d.f	S.S	M.S.S.	F
Weeks	1	321.84	321.84	9.75**
Species	1	24.01	24.01	0.73
Weeks x species	1	24.21	24.21	0.73
Error	12	396.01	33.00	
Total	15	766.07		

Weeks :	1	2
	46.89^a	55.86^b

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ significantly.

55.86±1.80 were recorded in sheep and goats fed rations 1 and 2, respectively. Digestibility coefficients of crude protein recorded were significantly higher ($P < 0.01$) for ration 2 compared to ration 1 and were comparable between sheep and goats.

4.3.6 Crude Fibre Digestibility

The average crude fibre intake, outgo and digestibility coefficients are presented in Table 29. Average daily crude fibre intakes of 128.38 and 121.56 and 138.42 and 131.89 g with an average digestibility coefficeints of 58.47±2.30 and 59.92±0.93 and 62.99±0.98 and 64.97±1.54 were recorded in sheep and goats fed rations 1 and 2, respectively. Digestibility coefficients of crude fibre were significantly ($P < 0.01$) higher on ration 2 compared to ration 1 but these values were not significantly different between sheep and goats.

4.3.7 Ether Extract Digestibility

Ether extract digestibility data are presented in Table 30. The average daily ether extract intakes of 4.60 and 4.35 and 3.89 and 3.71 g with an average digestibility coefficients of 62.02±3.30 and 60.47±2.69 and 63.39±2.01 and 62.55±3.14 were recorded in sheep and goats fed rations 1 and 2, respectively. Digestibility

Table 29 : Crude fibre digestibility of urea treated maize stover of different incubation periods in sheep and goats

Incubation period (Weeks)	Species	Animal No.	Intake	Voided in faeces	Digested	Digestibility coefficient
			(g)			
1	Sheep	1	117.25	42.71	74.54	63.57
		2	136.18	56.04	80.14	58.85
		3	140.70	66.97	73.73	52.40
		4	119.38	48.89	70.49	59.05
		Mean ± SE	128.38		74.73	58.47 ± 2.30
	Goats	1	126.26	47.92	78.34	62.05
		2	140.01	58.41	81.60	58.28
		3	110.63	45.99	64.64	58.43
		4	109.34	42.72	66.62	60.93
		Mean ± SE	121.56		72.80	59.92 ± 0.93
2	Sheep	1	167.54	62.73	104.81	62.56
		2	151.71	52.58	99.13	65.34
		3	116.80	42.68	74.12	63.46
		4	117.61	46.34	71.27	60.60
		Mean ± SE	138.42		87.33	62.99 ± 0.98
	Goats	1	119.95	37.94	82.01	68.37
		2	140.19	51.53	88.66	63.24
		3	148.74	57.09	91.65	61.62
		4	118.68	39.57	79.11	66.66
		Mean ± SE	131.89		85.36	64.97 ± 1.54

Analysis of variance of crude fibre digestibility coefficients in sheep and goats

Source	d.f	S.S	M.S.S.	F
Weeks	1	91.58	91.58	9.52**
Species	1	11.76	11.76	1.22
Weeks x species	1	0.29	0.29	0.03
Error	12	115.40	9.62	
Total	15	219.03		

Weeks : **1** 2

59.20^{a} 63.98^{b}

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ significantly.

Table 30 : Ether extract digestibility of urea treated maize stover of different incubation periods in sheep and goats

Incubation period (Weeks)	Species	Animal No.	Intake	Voided in faeces (g)	Digested	Digestibility coefficient
1	Sheep	1	4.20	1.73	2.47	58.76
		2	4.88	2.11	2.77	56.76
		3	5.04	1.97	3.07	60.99
		4	4.28	1.22	3.06	71.57
		Mean ± SE	4.60		2.84	62.02 3.30
	Goats	1	4.52	1.86	2.66	58.90
		2	5.01	2.25	2.76	55.13
		3	3.96	1.59	2.37	59.93
		4	3.92	1.26	2.66	67.91
		Mean ± SE	4.35		2.61	60.47 2.69
2	Sheep	1	4.71	1.80	2.91	61.71
		2	4.26	1.38	2.88	67.67
		3	3.28	1.36	1.92	58.62
		4	3.31	1.14	2.17	65.55
		Mean ± SE	3.89		2.41	63.39 2.01
	Goats	1	3.37	1.46	1.91	56.64
		2	3.94	1.67	2.27	57.61
		3	4.18	1.32	2.86	68.31
		4	3.34	1.08	2.26	67.63
		Mean ± SE	3.71		2.33	62.55 3.14

Analysis of variance of ether extract digestibility coefficients in sheep and goats

Source	d.f	S.S	M.S.S.	F
Weeks	1	11.90	11.90	0.38
Species	1	5.71	5.71	0.18
Weeks x species	1	0.51	0.51	0.016
Error	12	380.33	31.69	
Total	15	398.45		

of ether extract was not affected either by rations or by species of animals.

4.3.8 Nitrogen-free Extract Digestibility

Digestibility data of nitrogen-free extract, of two experimental rations are presented in Table 31. An average daily intake of 128.06 and 121.26 and 140.88 and 134.24 g with an average digestibility coefficients of 34.51±0.76 and 36.27±0.96 and 42.50±2.08 and 44.80±1.23 were recorded in sheep and goats fed rations 1 and 2, respectively. Digestibility coefficients of nitrogen-free extract were significantly higher ($P < 0.01$) on ration 2 compared to ration 1 but were comparable in sheep and goats.

The digestibility coefficients of all nutrients in sheep and goats as affected by the two rations were summerized in Table 32.

4.3.9 Nutritive Value

The data of nutritive value of the experimental rations in sheep and goats are presented in Table 32. The experimental rations 1 and 2 contained 7.15 and 6.75 and 8.72 and 8.73 per cent digestible crude protein in sheep and goats, respectively. DCP content was significantly ($P < 0.01$) higher on ration 2 compared to ration 1 but was at par in sheep and goats. The average digestible crude protein consumed daily by sheep and goats

Table 31 : Nitrogen-free extract digestibility of urea treated maize stover of different incubation periods in sheep and goats

Incubation period (Weeks)	Species	Animal No.	Intake	Voided in faeces (g)	Digested	Digestibility coefficient
1	Sheep	1	116.95	75.02	41.93	35.85
		2	135.84	88.96	46.88	34.51
		3	140.35	90.80	49.55	35.30
		4	119.08	80.52	38.56	32.38
		Mean ± SE	128.06		44.23	34.51 0.76
	Goats	1	125.95	82.86	43.09	34.21
		2	139.66	86.13	53.53	38.33
		3	110.35	69.06	41.29	37.42
		4	109.06	70.75	38.31	35.13
		Mean ± SE	121.26		44.06	36.27 0.96
2	Sheep	1	170.53	96.38	74.15	43.48
		2	154.41	98.23	56.18	36.38
		3	118.89	65.73	53.16	44.71
		4	119.70	65.31	54.39	45.44
		Mean ± SE	140.88		59.47	42.50 2.08
	Goats	1	122.08	69.83	52.25	42.80
		2	142.69	77.96	64.73	45.36
		3	151.39	86.33	65.06	42.98
		4	120.80	62.77	58.03	48.04
		Mean ± SE	134.24		60.02	44.80 1.23

Analysis of variance of nitrogen-free extract digestibility coefficients in sheep and goats

Source	d.f	S.S	M.S.S.	F
Weeks	1	272.91	272.91	37.23**
Species	1	16.48	16.48	2.25
Weeks x species	1	0.30	0.30	0.04
Error	12	87.91	7.33	
Total	15	377.60		

Weeks

35.39[a] 43.65[b]

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ significantly.

Table 32 : Average digestibility coefficients of various nutrients and nutritive value as affected by urea treated maize stover of different incubation periods in sheep and goats

Item	Incubation period (weeks)			
	1		2	
	Sheep	Goats	Sheep	Goats
Digestibility Coefficients				
DM	43.68 ± 1.62	43.88 ± 0.59	49.76 ± 0.91	51.09 ± 0.64
OM	47.22 ± 1.36	47.65 ± 0.51	53.34 ± 0.75	55.07 ± 0.89
CP	49.34 ± 2.31	44.43 ± 3.06	55.85 ± 3.90	55.86 ± 1.80
CF	58.47 ± 2.30	59.92 ± 0.93	62.99 ± 0.98	64.97 ± 1.54
EE	62.02 ± 3.30	60.47 ± 2.69	63.39 ± 2.01	62.55 ± 3.14
NFE	34.51 ± 0.76	36.27 ± 0.96	42.50 ± 2.08	44.80 ± 1.23
Nutritive value (%)				
DCP	7.15 ± 0.35	6.75 ± 0.46	8.72 ± 0.61	8.73 ± 0.28
DCP intake (g/d)	26.64	22.53	33.23	31.98
TDN	42.76 ± 1.18	43.12 ± 0.50	48.34 ± 0.66	49.87 ± 0.78
TDN intake (g/d)	151.99	145.27	185.59	182.59

fed rations 1 and 2 was 26.64 and 22.53 and 33.23 and 31.98 g, respectively.

The experimental rations 1 and 2 contained 42.76 and 43.12 and 48.34 and 49.87 per cent total digestible nutrients (TDN) in sheep and goats, respectively. The TDN content was significantly ($P < 0.01$) higher on ration 2 compared to ration 1 however, it was comparable in both the species of animals. The average daily consumption of total digestible nutrients by sheep and goats fed rations 1 and 2 was 151.99 and 145.27 and 185.59 and 182.59 g, respectively.

4.4 EXPERIMENTS WITH GROWING ANIMALS

Based on the results of the digestion trial 4 per cent urea treated maize stover at 40 per cent moisture level and incubated for 2 weeks was selected and the same was used in the second phase to evaluate its effect on growth and nutrient utilization in lambs and kids by supplementing with (1) concentrate mixture (pellet) (2) sunhemp hay meal and (3) subabul leaf meal.

Experiments conducted are dealt with under the following headings:

1. Growth studies
2. Metabolic studies.

4.4.1 Chemical Composition of the Experimental Rations

Chemical composition of urea treated maize stover at 40 per cent moisture and incubated for 2 weeks, concentrate pellets, sunhemp hay meal and subabul leaf meal are presented in Table 33. The organic matter, crude protein, crude fibre, ether extract, nitrogen-free extract, total ash, calcium, phosphorus, cell contents (NDS), cell wall constituents (NDF), acid detergent fibre (ADF), hemicellulose, cellulose, lignin, silica and gross energy (Kcal/g) were 89.13, 15.62, 35.93, 1.01, 36.57, 10.87, 0.68, 0.17, 27.50, 72.50, 45.23, 27.27, 35.36, 5.93, 3.94 and 3.60 for urea treated maize stover, 83.11, 21.13, 11.68, 3.32, 46.98, 16.89, 1.28, 1.08, 79.02, 20.98, 12.78, 8.20, 4.02, 1.48, 7.28 and 3.51 for concentrate feed (pellets), 90.15, 18.87, 30.61, 2.80, 37.87, 9.85, 1.64, 0.29, 52.96, 47.04, 39.06, 7.98, 32.58, 6.03, 0.45 and 4.01 for sunhemp hay meal and 89.91, 30.18, 12.12, 4.56, 43.05, 10.09, 1.93, 0.30, 76.22, 23.78, 13.81, 9.97, 9.38, 4.40, 0.03 and 4.15 for subabul leaf meal, respectively.

4.4.2 Cost Economics

The data on the cost of processing of the experimental feeds are given in Table 34. The total power consumed per two shifts of 8 hours each was 26.40, 27.00 and 947.36 KWH for processing of maize stover

Table 33 : Chemical composition of the experimental feeds (% on DM basis)

Item	Experimental feeds					
	Dried poultry droppings	Concentrate feed (pellets)	Sunhemp hay meal	Subabul leaf meal	Untreated maize stover	Urea treated maize stover
Organic matter	62.37	83.11	90.15	89.91	90.14	89.13
Crude protein	25.12	21.13	18.87	30.18	7.04	15.62
Crude fibre	7.40	11.68	30.61	12.12	38.78	35.93
Ether extract	1.88	3.32	2.80	4.56	1.36	1.01
Nitrogen-free extract	27.97	46.98	37.87	43.05	42.96	36.57
Total ash	37.63	16.89	9.85	10.09	9.86	10.87
Calcium	5.62	1.28	1.64	1.93	0.69	0.68
Phòsphorus	2.89	1.08	0.29	0.30	0.16	0.17
GE (Kcal/g)	3.32	3.51	4.01	4.15	3.51	3.60
Cell contents (NDS)	49.38	79.02	52.96	76.22	22.24	27.50
Cell wall constituents (NDF)	50.62	20.98	47.04	23.78	77.76	72.50
Acid detergent fibre (ADF)	32.12	12.78	39.06	13.81	48.95	45.23
Hemicellulose	18.50	8.20	7.98	9.97	28.81	27.27
Cellulose	8.21	4.02	32.58	9.38	40.72	35.36
Lignin	3.27	1.48	6.03	4.40	6.80	5.93
Silica	20.64	7.28	0.45	0.03	1.43	3.94

Table 34 : Processing cost of experimental rations

Item	Experimental rations		
	Concentrate pellet	Sunhemp hay	Maize stover
I Direct charges			
1. Power cost @ Rs. 1.00/- KWH (Power consumption/day KWH)	947.36 (947.36)	27.00 (27.00)	26.40 (26.40)
2. Operators @ RS. 42.30/- day	84.60	42.30	42.30
3. Labour @ Rs. 23.40/- day	93.60	23.40	23.40
4. Cost of diesel @ Rs. 5.83/- day	378.95	--	--
II Fixed charges* (Rs.)	332.33	--	--
III Total expenditure/day (RS.)	1836.84	92.70	92.10
Production/day (tonnes) 2 shifts of 8 hours each	13.71	7.500	8.000
Processing cost/quintal (Rs.)	13.40	1.24	1.15

* Fixed charges

	RS.
1. Depreciation	
i) Depreciation - civil works @ 5% per year (on Rs. 1.00 lakh)	5,000.00
ii) Depreciation - Machinary @ 10% per year (on Rs. 3.50 lakh plant machinery)	35,000.00
2. Interest on block investment (Rs. 4.5 lakh) @ 10% per year.	45,000.00
3. Insurance cover @ 0.6% per year	2,700.00
4. Maintenance @ Rs. 1,000.00 per month	12,000.00
Total per year (300 working days)	99,700.00
Fixed charges per day Rs.	332.33

(chopping), sunhemp hay (chopping) and concentrate feed (pellets), respectively. The total cost of energy utilized per day was Rs.26.40, 27.00 and 947.36 for maize stover, sunhemp hay and concentrate feed (pellets), respectively.

Average processing cost for concentrate feed (pellet) was calculated based on two shifts of eight hours each for 300 working days per year. The processing cost for maize stover and sunhemp hay was calculated taking cost of power and labour charges into consideration. Total processing cost was Rs. 1.15, 1.24 and 13.40 per quintal for maize stover, sunhemp hay meal and concentrate feed (pellet), respectively.

The data on total cost of the experimental rations is presented in Table 35. The cost of cultivation of subabul leaf meal and sunhemp hay meal and the existing market prices for other ingredients were used for calculating the cost of feeds. The cost per quintal of urea treated maize stover, concentrate (pellet) feed, sunhemp hay meal and subabul leaf meal was Rs.149.79, 279.35, 76.24 and 120.00, respectively.

4.4.3 Growth Studies

The initial and final body weights of the experimental animals are presented in Table 36 a, b. The average daily gains (Fig. 1) were 85.22 and 53.44, 68.48

Table 35 : Cost of experimental rations per quintal

Ingredient	Cost per quintal Rs.	Experimental rations			
		Concentrate pellet	Sunhemp hay	Subabul leaf meal	Maize stover
Maize stover	140.00	--	--	--	140.00
Urea	240.00	--	--	--	8.64
Sunhemp hay	75.00	--	75.00	--	--
Subabul leaf meal	120.00	--	--	120.00	--
Dried poultry droppings	20.00	6.00	--	--	--
Cotton seed cake	410.00	123.00	--	--	--
Sorghum grain	400.00	80.00	--	--	--
Groundnut cake	435.00	30.45	--	--	--
Molasses	41.00	4.10	--	--	--
Mineral mixture	650.00	13.00	--	--	--
Common salt	110.00	1.10	--	--	--
Rovimix/kg	415.00	8.30	--	--	--
Processing cost/quintal (Rs.)		13.40	1.24	--	1.15
Total cost/quintal (Rs.)		279.35	76.24	120.00	149.79

Table 36a : Average daily gains of lambs as affected by different experimental rations (150 days)

Experimental ration	Animal No.	Initial weight (kg)	Final weight (kg)	Total gain (kg)	Average daily gain (g)
1	1	10.83	24.20	13.37	89.13
	2	10.67	25.50	14.83	98.87
	3	10.83	19.50	8.67	57.80
	4	12.67	28.00	15.33	102.20
	5	10.50	23.00	12.50	83.33
	6	11.00	23.00	12.00	80.00
	Mean	11.08	23.87	12.78	85.22
	± SE				6.51
2	1	11.17	25.00	13.83	92.20
	2	11.00	20.50	9.50	63.33
	3	11.00	19.00	8.00	53.33
	4	11.17	21.80	10.63	70.87
	5	12.00	21.50	9.50	63.33
	6	10.33	20.50	10.17	67.80
	Mean	11.11	21.38	10.27	68.48
	± SE				5.33
3	1	11.50	22.00	10.50	70.00
	2	11.83	23.00	11.17	74.47
	3	11.17	26.50	15.33	102.20
	4	11.50	24.00	12.50	83.33
	5	10.00	22.00	12.00	80.00
	6	11.00	23.20	12.20	81.33
	Mean	11.17	23.45	12.28	81.89
	± SE				4.53

Table 36b : Average daily gains of kids as affected by different experimental rations (150 days)

Experimental ration	Animal No.	Initial weight (kg)	Final weight (kg)	Total gain (kg)	Average daily gain (g)
1	1	12.50	25.00	12.50	83.33
	2	12.00	17.00	5.00	33.33
	3	13.70	23.70	10.00	66.67
	4	12.50	20.00	7.50	50.00
	5	11.60	16.60	5.00	33.33
	6	12.50	20.60	8.10	54.00
	Mean	12.47	20.48	8.02	53.44
	± SE				7.93
2	1	13.50	23.50	10.00	66.67
	2	11.75	16.75	5.00	33.33
	3	12.25	17.50	5.25	35.00
	4	11.50	18.00	6.50	43.33
	5	13.50	20.50	7.00	46.67
	6	12.50	19.00	6.50	43.33
	Mean	12.50	19.21	6.71	44.72
	± SE				4.80
3	1	12.75	22.75	10.00	66.67
	2	13.25	20.75	7.50	50.00
	3	13.30	18.30	5.00	33.33
	4	11.75	19.25	7.50	50.00
	5	12.50	20.50	8.00	53.33
	6	11.50	18.50	7.00	46.67
	Mean	12.51	20.01	7.50	50.00
	± SE				4.39

Analysis of variance of average daily gains in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	1043.36	521.68	2.64
Species	1	7644.00	7644.00	38.74**
Rations x species	2	130.43	65.22	0.33
Error	30	5920.29	197.34	
Total	35	14738.08	421.09	

Species : **Lambs** **Kids**

78.53^{b} 49.39^{a}

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ significantly.

Fig.1 : Average Daily gains (g)

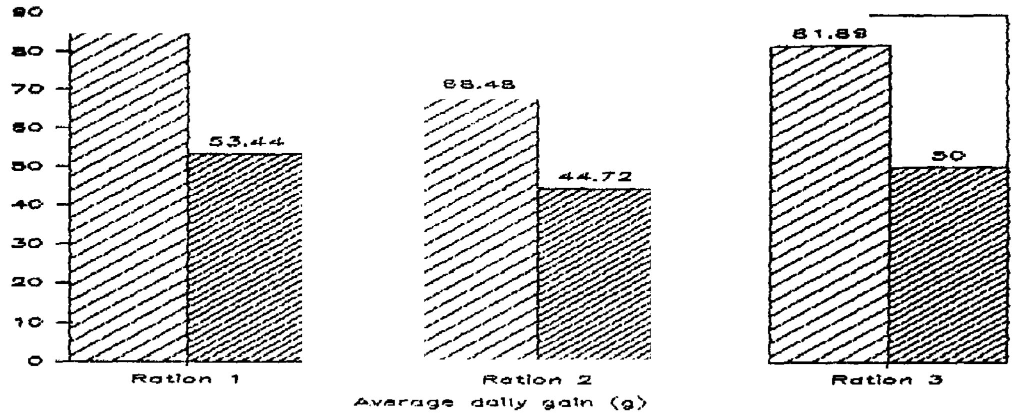


Fig.2 : Feed Efficiency (kg)

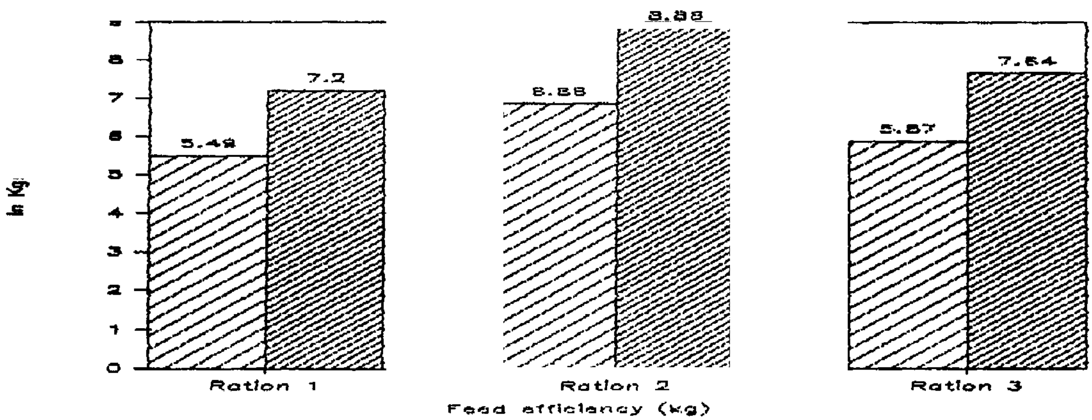
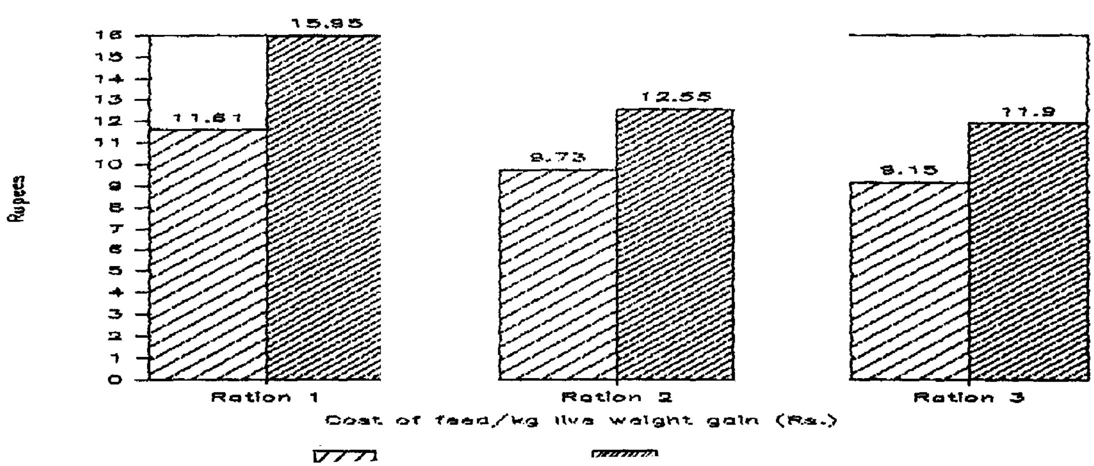


Fig.3 : Cost of Feed per kg live weight gain (Rs.)



and 44.72 and 81.89 and 50 g in lambs and kids fed rations 1, 2 and 3, respectively. The average daily gains on rations 1 and 3 were comparable both in lambs and kids. Statistical analysis of the data revealed that the average daily gains were not significantly different among the three rations, but differed significantly (P < 0.01) between lambs and kids (Table 36 a, b).

The data pertaining to feed efficiency and cost of feed per kg live weight gain are presented in Table 37 and Figs. 2 and 3. The average dry matter consumption and the corresponding weight gains during the experimental period (150 days) were (kg) 70.20 and 12.79, 70.50 and 10.27 and 72.15 and 12.28 in lambs and 57.75 and 8.01, 59.40 and 6.71 and 57.30 and 7.50 in kids on rations 1, 2 and 3, respectively. The average dry matter consumption (kg) per kg live weight gain and average cost of feed (Rs) per kg live weight gain on rations 1, 2 and 3 were 5.49 and 11.61, 6.86 and 9.73 and 5.87 and 9.15 in lambs and 7.20 and 15.95, 8.86 and 12.55 and 7.64 and 11.90 in kids, respectively.

4.4.4 Metabolic Studies in Lambs and Kids

4.4.4.1 Voluntary feed intake : An average daily dry matter intake of 817.27 and 642.92, 835.40 and 653.42 and 936.40 and 640.38 g were recorded by the lambs and kids fed rations 1,2 and 3, respectively. The average total dry matter consumption per 100 kg body weight

Table 37 : Average feed efficiency and cost of feed per unit gain in lambs and kids as affected by different experimental rations

	Lambs			Kids		
	Experimental rations			Experimental rations		
	1	2	3	1	2	3
1. Number of animals	6	6	6	6	6	6
2. Experimental period (days)	150	150	150	150	150	150
3. Average initial weight (kg)	11.08	11.11	11.17	12.47	12.50	12.51
4. Average final weight (kg)	23.87	21.38	23.45	20.48	19.21	20.01
5. Average weight gain in 150 days (kg)	12.79	10.27	12.28	8.02	6.71	7.50
6. Average daily gain (g)	85.22	68.48	81.89	53.44	44.72	50.00
7. Total feed (kg) consumed in 150 days (6 animals)	421.20	423.00	432.90	346.50	356.40	343.80
8. Average DM intake per aninal per day (kg)	0.468	0.470	0.481	0.385	0.396	0.382
9. Average DM intake in 150 days per animal (kg)	70.20	70.50	72.15	57.75	59.40	57.30
10. Dry matter intake per kg live weight gain (kg)	5.49	6.86	5.87	7.20	8.86	7.64
11. Dry matter intake per 100 kg live weight (kg)	3.42	3.91	3.99	3.18	3.44	3.21
12. Cost of feed per kg live weight gain/animal (Rs.)	11.61	9.73	9.15	15.95	12.55	11.90

recorded in this experiment (Table 38 a, b) was 3.42±0.13, and 3.18±0.14, 3.91±0.19 and 3.44±0.16 and 3.99±0.23 and 3.21±0.13 kg among lambs and kids fed rations 1, 2 and 3, respectively. The dry matter intake was significantly ($P < 0.01$) affected by different rations as well as species of animals.

4.4.4.2 Voluntary water intake : An average daily water intake (Table 38 a, b) of 2.35 and 1.68, 2.13 and 1.12 and 2.31 and 1.17 litres was recorded in lambs and kids fed rations 1, 2 and 3, respectively. The average water intake per kg DM intake recorded in this experiment, was 2.91±0.17 and 2.61±0.55, 2.56±0.21 and 1.72±0.10 and 2.51±0.20 and 1.83±0.09 litres among lambs and kids fed rations 1, 2 and 3, respectively. The water intake per kg dry matter intake was significantly ($P < 0.01$) higher on ration 1 than on rations 2 and 3. The water intake was significantly ($P < 0.01$) higher in lambs compared to kids.

4.4.4.3 Dry matter digestibility : The dry matter intake, outgo and digestibility coefficients of experimental animals are presented in Table 39 a,b. The average dry matter digestibility coefficients recorded with rations 1, 2 and 3 among lambs and kids were 60.27±0.58 and 63.00±0.58, 63.32±0.38 and 73.66±0.49 and 62.91±1.11 and 70.02±0.19 per cent, respectively. The dry matter digestibility differed significantly

Table 38a : Voluntary dry matter and water intake by lambs as affected by different experimental rations

Experimental ration	Animal No.	Body weight (kg)	DM intake		Water intake	
			Per day (g)	Per 100 kg body weight (kg)	Per day (lit)	Per kg DMI (lit)
1	1	24.20	690.28	2.85	2.09	3.03
	2	25.50	872.31	3.42	3.04	3.48
	3	19.50	680.80	3.49	2.04	3.00
	4	28.00	1025.69	3.66	2.24	2.18
	5	23.00	869.98	3.78	2.41	2.77
	6	23.00	764.56	3.32	2.29	3.00
	Mean	23.87	817.27	3.42	2.35	2.91
	± SE	1.16		0.13	0.15	0.17
2	1	25.00	880.35	3.52	2.80	3.18
	2	20.50	707.10	3.45	1.79	2.53
	3	19.00	791.91	4.17	1.47	1.86
	4	21.80	962.22	4.41	2.47	2.57
	5	21.50	944.60	4.39	2.01	2.13
	6	20.50	726.20	3.54	2.25	3.10
	Mean	21.38	835.40	3.91	2.13	2.56
	± SE	0.83		0.19	0.20	0.21
3	1	22.00	686.17	3.12	2.15	3.13
	2	23.00	1096.55	4.77	3.15	2.87
	3	26.50	1050.38	3.96	1.90	1.81
	4	24.00	912.51	3.80	2.04	2.24
	5	22.00	842.57	3.83	2.30	2.73
	6	23.20	1030.23	4.44	2.32	2.25
	Mean	23.45	936.40	3.99	2.31	2.51
	± SE	0.68		0.23	0.18	0.20

Analysis of variance of dry matter intake per 100 kg body weight and water intake/kg DMI in lambs and kids

Source	d.f	S.S	M.S.S.	F
		DM intake		
Rations	2	0.87	0.44	6.29**
Species	1	2.15	2.15	30.71**
Rations x species	2	3.61	1.80	25.71**
Error	30	1.99	0.07	
Total	35	8.62		
		Water intake		
Rations	2	3.26	1.63	8.15**
Species	1	3.64	3.64	18.20**
Rations x species	2	6.71	3.36	16.80**
Error	30	6.10	0.20	
Total	35	19.71		

	DM intake			**Water intake**		
Rations						
	3.30^{a}	3.68^{b}	3.60^{b}	2.76'	2.14'	2.17'
Species	**Lambs**	**Kids**		**Lambs**	**Kids**	
	3.77^{b}	3.28'		2.66^{b}	2.05'	

** Significant ($P < 0.01$)

a, b - Values with different superscripts differ item wise significantly.

Table 39a : Dry matter digestibility in lambs as affected by different experimental rations

Experi-mental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Dige-sted	Digesti-bility Coeffi-cient
		(g)						
1	1	180.54	626.63	116.89	690.28	285.02	405.26	58.71
	2	180.54	809.31	117.54	872.31	342.21	530.10	60.77
	3	180.54	726.53	226.27	680.80	277.56	403.24	59.23
	4	180.54	1009.36	164.21	1025.69	385.97	639.72	62.37
	5	180.54	800.12	110.68	869.98	337.20	532.78	61.24
	6	180.54	750.21	166.19	764.56	311.18	453.38	59.30
	Mean ± SE				817.27		494.08	60.27 0.58
2	1	288.86	674.00	82.51	880.35	323.79	556.56	63.22
	2	246.06	574.13	113.09	707.10	254.13	452.97	64.06
	3	287.52	670.87	166.48	791.91	287.94	503.97	63.64
	4	331.22	772.84	141.84	962.22	362.28	599.94	62.35
	5	324.08	756.18	135.66	944.60	357.72	586.88	62.13
	6	255.05	595.13	123.98	726.20	257.73	468.47	64.51
	Mean ± SE				835.40		528.13	63.32 0.38
3	1	240.49	561.15	115.47	686.17	256.49	429.68	62.62
	2	387.47	904.10	195.02	1096.55	392.89	703.66	64.17
	3	339.42	791.99	81.03	1050.38	405.87	644.51	61.36
	4	322.36	752.16	162.01	912.51	333.07	579.44	63.50
	5	270.08	630.18	57.69	842.57	304.59	537.98	63.85
	6	384.06	896.14	249.97	1030.23	391.80	638.43	61.97
	Mean ± SE				936.40		588.95	62.91 1.11

Table 39b : Dry matter digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder (g)	Offered: UTM (g)	Left over (g)	Total intake (g)	Voided in faeces (g)	Digested (g)	Digestibility Coefficient
1	1	180.54	865.95	222.88	823.61	306.71	516.90	62.76
	2	180.54	591.41	278.34	493.61	178.39	315.22	63.86
	3	180.54	691.14	239.68	632.00	236.06	395.95	62.65
	4	180.54	781.58	275.34	686.78	245.46	441.32	64.26
	5	180.54	662.99	274.95	568.58	224.87	343.71	60.45
	6	180.54	700.22	227.83	652.93	235.05	417.88	64.00
	Mean				642.92		405.16	63.00
	± SE							0.58
2	1	279.33	651.78	265.95	665.16	171.68	493.48	74.19
	2	261.99	611.32	208.49	664.82	175.25	489.57	73.64
	3	257.71	601.32	228.74	630.29	169.17	461.12	73.16
	4	252.06	588.15	205.92	634.29	163.52	470.77	74.22
	5	262.67	612.91	209.19	666.39	179.39	487.00	73.08
	6	258.08	602.18	200.68	659.58	173.60	485.98	73.68
	Mean				653.42		481.32	73.66
	± SE							0.49
3	1	272.37	635.52	213.59	694.30	208.98	485.32	69.90
	2	252.24	588.57	229.39	611.42	187.22	424.20	69.38
	3	225.98	527.30	217.96	535.32	156.26	379.06	70.81
	4	273.84	638.97	200.34	712.47	213.74	498.73	70.00
	5	250.88	585.38	186.42	649.84	194.56	455.28	70.06
	6	249.06	581.15	191.30	638.91	191.80	447.11	69.98
	Mean				640.38		448.28	70.02
	± SE							0.19

Analysis of variance of dry matter digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	297.68	148.84	134.09**
Species	1	407.23	407.23	366.87**
Rations x species	2	87.54	43.77	39.43**
Error	30	33.26	1.11	
Total	35	825.71		

Rations :	1	2	3
	61.64^{a}	68.49^{c}	66.47^{b}
Species :	**Lambs**	**Kids**	
	62.17^{a}	68.89^{b}	

** Significant ($P < 0.01$)

a, b, c - Values with different superscripts item wise differ significantly.

(P < 0.01) among the three rations as well as between the species of animals.

4.4.4.4 Organic matter digestibility : Average organic matter digestibility data of the experimental animals are given in Table 40 a, b. The average daily organic matter intakes were 711.82 and 557.12, 750.1 and 586.95 and 844.79 and 575.98 g with rations 1, 2 and 3 among lambs and kids, respectively. Average organic matter digestibility coefficients were 62.59±0.64 and 67.59±0.53, 64.94±0.32 and 75.87±0.14 and 64.40±0.42 and 72.16±0.15 among lambs and kids fed rations 1, 2 and 3, respectively. The organic matter digestibility was significantly (P < 0.01) affected by the rations and species of animals.

4.4.4.5 Crude protein digestibility : The average crude protein intake, outgo and digestibility coefficients are shown in Table 41 a, b. Average daily crude protein intake was 143.88 and 124.74, 142.98 and 121.08 and 186.87 and 139.83 g with an average digestibility coefficients of 65.09±0.77 and 70.32±0.84, 63.95±1.34 and 76.96±0.19 and 66.51±0.31 and 74.92±0.30 per cent were recorded in lambs and kids fed rations 1, 2 and 3, respectively. Digestibility coefficients of crude protein were significantly (P<0.01) lower for ration 1 compared to other rations. Crude protein digestibility was significantly (P<0.01) higher in kids than in lambs.

Table 40a : Organic matter digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	150.05	558.52	107.90	600.67	233.37	367.30	61.15
	2	150.05	721.34	108.73	762.66	280.24	482.42	63.25
	3	150.05	647.56	215.12	582.49	227.77	354.72	90.90
	4	150.05	899.64	151.39	898.30	315.99	582.31	64.82
	5	150.05	713.15	101.94	761.26	276.17	485.09	63.72
	6	150.05	668.66	153.19	665.52	254.98	410.54	61.69
	Mean				711.82		447.06	62.59
	± SE							0.64
2	1	260.41	600.74	68.64	792.51	276.84	515.67	65.07
	2	221.82	511.72	102.30	631.24	218.68	412.56	65.36
	3	259.20	597.95	150.63	706.52	247.83	458.69	64.92
	4	298.59	688.81	118.08	869.32	309.89	559.43	64.35
	5	292.16	673.98	117.89	848.25	306.60	541.65	63.85
	6	229.93	530.44	107.61	652.76	221.31	431.45	66.10
	Mean				750.10		486.58	64.94
	± SE							0.32
3	1	216.22	500.15	95.59	620.78	222.84	397.94	64.10
	2	348.37	805.82	161.52	992.67	341.46	651.21	65.60
	3	305.17	705.90	71.57	939.50	348.03	591.47	62.96
	4	289.83	670.40	134.06	826.17	289.30	536.87	64.98
	5	242.83	561.68	48.46	756.05	263.17	492.88	65.19
	6	345.31	798.73	210.47	933.57	340.08	593.49	63.57
	Mean				844.79		543.98	64.40
	± SE							0.42

Table 40b : Organic matter digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	150.05	771.82	205.07	716.80	232.06	484.74	67.63
	2	150.05	527.12	254.68	422.49	135.43	287.06	67.94
	3	150.05	616.01	216.93	549.13	179.50	369.63	67.31
	4	150.05	696.62	250.86	595.81	185.81	410.00	68.81
	5	150.05	590.92	250.97	490.00	170.54	319.46	65.20
	6	150.05	624.11	205.66	568.50	178.14	390.36	68.66
	Mean				557.12		376.88	67.59
	± SE							0.53
2	1	251.82	580.93	239.33	593.42	142.20	451.22	76.04
	2	236.18	544.87	183.80	597.25	144.21	453.04	75.85
	3	232.33	535.96	197.56	570.73	138.43	432.30	75.75
	4	227.23	524.22	182.75	568.70	134.71	433.99	76.31
	5	236.80	546.29	184.17	598.92	147.89	451.03	75.31
	6	232.66	536.72	176.70	592.68	142.68	450.00	75.93
	Mean				586.95		445.26	75.87
	± SE							0.14
3	1	244.89	566.44	188.47	622.86	176.13	446.73	71.72
	2	226.79	524.59	199.32	552.06	155.06	397.00	71.91
	3	203.18	469.98	191.80	481.36	131.10	350.26	72.76
	4	246.21	569.51	174.60	641.12	177.75	463.37	72.28
	5	225.57	521.75	163.01	584.31	162.40	421.91	72.21
	6	223.93	517.98	167.77	574.14	160.42	413.72	72.06
	Mean				575.98		415.50	72.16
	± SE							0.15

Analysis of variance of organic matter digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	171.76	85.88	104.73**
Species	1	561.22	561.22	684.41**
Rations x species	2	52.83	26.42	32.22**
Error	30	24.46	0.82	
Total	35	810.27		

Rations :	1	2	3
	65.09^{a}	70.41^{c}	68.28^{b}
Species :	**Lambs**	**Kids**	
	63.98^{a}	71.87^{b}	

** Significant ($P < 0.01$)

a, b, c - Values with different superscripts item wise differ significantly.

Table 41a : Crude protein digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder (g)	Offered: UTM (g)	Left over (g)	Total intake (g)	Voided in faeces (g)	Digested (g)	Digestibility Coefficient
1	1	38.15	97.88	12.61	123.42	43.21	80.21	64.99
	2	38.15	126.41	11.78	152.78	51.57	101.21	66.25
	3	38.15	113.48	29.57	122.06	46.55	75.51	61.86
	4	38.15	157.66	17.98	177.83	57.86	119.97	67.46
	5	38.15	124.98	12.42	150.71	52.20	98.51	65.36
	6	38.15	117.18	18.86	136.47	48.30	88.17	64.61
	Mean ± SE				143.88		93.93	65.09 0.77
2	1	54.51	105.28	10.97	148.82	55.43	87.39	58.72
	2	46.43	89.68	14.71	121.40	40.23	81.17	66.86
	3	54.26	104.79	21.58	137.47	45.29	92.18	67.05
	4	62.50	120.72	19.16	164.06	62.49	101.57	61.91
	5	61.15	118.12	17.93	161.34	59.35	101.99	63.21
	6	48.13	92.96	16.32	124.77	42.47	82.30	65.96
	Mean ± SE				142.98		91.10	63.95 1.34
3	1	72.58	87.65	25.89	134.34	46.78	87.56	65.18
	2	116.94	141.22	43.08	215.08	71.00	144.08	66.99
	3	102.44	123.71	9.24	216.91	71.11	145.80	67.22
	4	97.29	117.49	36.40	178.38	60.52	117.86	66.07
	5	81.51	98.43	11.60	168.34	55.71	112.63	66.91
	6	115.91	139.98	47.74	208.15	69.39	138.76	66.66
	Mean + SE				186.87		124.45	66.51 0.31

Table 41b : Crude protein digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered (g) Pellet/ Legume fodder	UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
1	1	38.15	135.26	22.64	150.77	44.26	106.51	70.64
	2	38.15	92.38	27.95	102.58	26.72	75.86	73.95
	3	38.15	107.96	23.15	122.96	39.59	83.37	67.80
	4	38.15	122.08	27.31	132.92	40.35	92.57	69.64
	5	38.15	103.56	27.33	114.38	35.06	79.32	69.35
	6	38.15	109.37	22.71	124.81	36.79	88.02	70.52
	Mean ± SE				124.74		87.59	70.32 0.84
2	1	52.71	101.81	29.68	124.84	28.07	96.77	77.52
	2	49.44	95.49	22.68	122.25	28.48	93.77	76.70
	3	48.63	93.93	23.95	118.61	27.08	91.53	77.17
	4	47.56	91.87	21.97	117.46	26.59	90.87	77.36
	5	49.57	95.74	22.97	122.34	29.03	93.31	76.27
	6	48.70	94.06	21.79	120.97	28.16	92.81	76.72
	Mean ± SE				121.08		93.18	76.96 0.19
3	1	82.20	99.27	31.23	150.24	39.06	111.18	74.00
	2	76.13	91.93	33.22	134.84	34.32	100.52	74.83
	3	68.20	82.36	30.58	119.98	28.44	91.54	76.30
	4	82.64	99.81	27.83	154.62	38.99	115.63	74.78
	5	75.72	91.44	27.61	139.55	35.84	103.71	74.32
	6	75.17	90.78	26.23	139.72	35.14	104.58	74.85
	Mean + SE				139.83		104.53	74.92 0.30

Analysis of variance of crude protein digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	68.62	74.31	11.87**
Species	1	714.49	714.49	247.23**
Rations x species	2	90.06	45.03	15.58**
Error	30	86.72	2.89	
Total	35	959.89		

Rations :	**1**	**2**	**3**
	67.67[a]	70.46[b]	70.72[b]
Species :	**Lambs**	**Kids**	
	65.16[a]	[illegible][b]	

** Significant ($P < 0.01$)

a, b, - Values with different superscripts item wise differ significantly.

4.4.4.6 Crude fibre digestibility : Daily average crude fibre intake, outgo and digestibility coefficients are presented in Table 42 a, b. Average daily crude fibre intakes were 263.29 and 191.00, 294.22 and 222.78 and 284.17 180.88 g with an average digestibility coefficients of 65.46±1.17 and 68.85±0.75, 68.45±1.11 and 79.36±0.17 and 67.96±0.66 and 75.18±0.67 on rations 1, 2 and 3 in lambs and kids, respectively. The differences in crude fibre digestibility were highly significant ($P < 0.01$) among the three rations as well as between lambs and kids.

4.4.4.7 Ether extract digestibility : Ether extract digestibility data are presented in Table 43 a,b. An average daily EE intake of 11.76 and 10.08, 13.27 and 10.79 and 20.66 and 14.99 g with an average digestibility coefficients of 72.13±0.55 and 74.54±1.00; 69.56±1.07 and 71.37±0.69 and 67.26±0.98 and 75.67±0.41 were observed with rations 1, 2 and 3 in lambs and kids, respectively. Digestibility coefficients of ether extract were significantly ($P < 0.01$) higher for ration 1 compared to other rations. Ether extract digestibility was significantly ($P < 0.01$) higher in kids than in lambs.

4.4.4.8 Nitrogen-free extract digestibility : Digestibility data of nitrogen-free extract of the three experimental rations are presented in Table 44 a, b.

Table 42a : Crude fibre digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	21.09	225.15	32.53	213.71	83.82	129.89	60.78
	2	21.09	290.79	32.38	279.50	96.74	182.76	65.39
	3	21.09	261.04	58.85	223.28	67.81	155.47	69.63
	4	21.09	362.66	44.58	339.17	114.09	225.08	66.36
	5	21.09	287.48	29.99	278.58	94.79	183.79	65.97
	6	21.09	269.55	45.12	245.52	86.88	158.64	64.61
	Mean ± SE				263.29		172.61	65.46 1.17
2	1	88.42	242.17	21.26	309.33	104.91	204.42	66.08
	2	75.32	206.28	35.09	246.51	71.08	175.43	71.17
	3	88.01	241.04	50.94	278.11	79.24	198.87	71.51
	4	101.39	277.68	36.89	342.18	119.95	222.23	64.95
	5	99.20	271.70	38.50	332.40	108.60	223.80	67.33
	6	8.07	213.83	35.11	256.79	77.96	178.83	69.64
	Mean ± SE				294.22		200.60	68.45 1.11
3	1	29.15	201.62	19.71	211.06	67.61	143.45	67.97
	2	46.96	324.84	33.21	338.59	102.66	235.93	69.68
	3	41.14	284.56	20.34	305.36	106.62	198.74	65.08
	4	39.07	270.25	27.70	281.62	86.56	195.06	69.26
	5	32.73	226.42	11.11	248.04	79.86	168.18	67.80
	6	46.55	321.98	48.19	320.34	102.61	217.73	67.97
	Mean ± SE				284.17		193.18	67.96 0.66

Table 42b : Crude fibre digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	21.09	311.14	76.49	225.74	78.00	177.74	69.50
	2	21.09	212.49	96.06	137.52	46.08	91.44	66.49
	3	21.09	248.33	84.32	185.10	58.21	126.89	68.55
	4	21.09	280.82	93.64	208.27	59.43	148.84	71.46
	5	21.09	238.21	94.09	165.21	54.19	111.02	67.20
	6	21.09	251.59	78.53	194.15	58.48	135.67	69.88
	Mean ± SE				191.00		131.93	68.85 0.75
2	1	85.50	234.18	91.78	227.90	45.72	182.18	79.94
	2	80.20	219.65	74.14	225.71	47.32	178.39	79.04
	3	78.89	216.05	80.91	214.03	44.83	169.20	79.05
	4	77.16	211.32	72.50	215.98	43.86	172.12	79.69
	5	80.40	220.22	73.45	227.17	47.81	179.36	78.95
	6	80.00	216.36	70.50	225.86	46.32	179.54	79.49
	Mean ± SE				222.78		176.80	79.36 0.17
3	1	33.01	228.34	64.03	197.32	47.42	149.90	75.97
	2	30.57	211.47	75.58	166.46	46.43	120.03	72.11
	3	27.39	189.46	62.36	154.49	35.55	118.94	76.99
	4	33.19	229.58	60.54	202.23	49.57	152.66	75.49
	5	30.41	210.33	56.90	183.84	46.01	137.83	74.97
	6	30.19	208.81	58.08	180.92	44.25	136.67	75.54
	Mean ± SE				180.88		136.01	75.18 0.67

Analysis of variance of crude fibre digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	280.47	140.23	27.77**
Species	1	464.62	464.62	92.00**
Rations x species	2	84.04	42.02	8.32**
Error	30	151.50	5.05	
Total	35	980.63		

Rations :	1	2	3
	67.17[a]	73.91[c]	71.57[b]
Species :	1	2	
	67.29[a]	74.48[b]	

** Significant ($P < 0.01$)

a, b, c – Values with different superscripts item wise differ significantly.

Table 43a : Ether extract digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	5.99	6.33	1.89	10.43	2.91	7.52	72.10
	2	5.99	8.17	1.88	12.28	3.46	8.82	71.82
	3	5.99	7.34	2.31	11.02	2.78	8.24	74.77
	4	5.99	10.19	2.56	13.62	3.94	9.68	71.07
	5	5.99	8.08	1.73	12.34	3.47	8.87	71.88
	6	5.99	7.58	2.69	10.88	3.14	7.74	71.14
	Mean ± SE				11.76		8.48	72.13 0.55
2	1	8.09	6.81	0.86	14.04	3.85	10.19	72.58
	2	6.89	5.80	1.71	10.98	3.56	7.42	67.58
	3	8.05	6.78	2.38	12.45	3.97	8.48	68.11
	4	9.27	7.81	1.52	15.56	4.38	11.18	71.85
	5	9.07	7.64	1.70	15.01	5.08	9.93	66.16
	6	7.14	6.01	1.57	11.58	3.35	8.23	71.07
	Mean ± SE				13.27		9.24	69.56 1.07
3	1	10.97	5.67	1.22	15.42	4.98	10.44	67.70
	2	17.67	9.13	2.05	24.75	7.43	17.32	69.98
	3	15.48	8.00	1.59	21.89	8.08	13.81	63.09
	4	14.70	7.60	1.73	20.57	6.39	14.18	68.94
	5	12.32	6.36	0.76	17.92	6.03	11.89	66.35
	6	17.51	9.05	3.17	23.39	7.60	15.79	67.51
	Mean ± SE				20.66		13.91	67.26 0.98

Table 43b : Ether extract digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	5.99	8.75	2.79	11.95	3.25	8.70	72.80
	2	5.99	5.97	3.45	8.51	1.84	6.67	78.38
	3	5.99	6.98	3.02	9.95	2.86	7.09	71.26
	4	5.99	7.89	3.30	10.58	2.72	7.86	74.29
	5	5.99	6.70	3.35	9.34	2.27	7.07	75.70
	6	5.99	7.07	2.89	10.17	2.56	7.61	74.83
	Mean ± SE				10.08		7.50	74.54 1.00
2	1	7.82	6.58	3.43	10.97	3.02	7.95	72.47
	2	7.34	6.17	2.65	10.86	3.22	7.64	70.35
	3	7.22	6.07	2.68	10.61	3.32	7.29	68.71
	4	7.06	5.94	2.55	10.45	3.04	7.41	70.91
	5	7.35	6.19	2.55	10.99	2.96	8.03	73.07
	6	7.23	6.08	2.43	10.88	2.97	7.91	72.70
	Mean ± SE				10.79		7.71	71.37 0.69
3	1	12.42	6.42	3.18	15.66	4.18	11.48	73.31
	2	11.50	5.94	2.52	14.92	3.71	11.21	75.13
	3	10.30	5.33	2.83	12.80	2.77	10.03	78.36
	4	12.49	6.45	2.24	16.70	3.95	12.75	76.35
	5	11.44	5.91	2.37	14.98	3.85	11.13	74.30
	6	11.36	5.87	2.35	14.88	3.49	11.39	76.55
	Mean ± SE				14.99		11.33	75.67 0.41

Analysis of variance of ether extract digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	50.94	25.47	5.83**
Species	1	159.52	159.52	36.50**
Rations x species	2	79.91	39.96	9.14**
Error	30	131.07	4.37	
Total	35	421.44		

Rations :	1	2	3
	73.34^{b}	70.47^{a}	71.47^{a}
Species :	Lambs	Kids	
	69.65^{a}	73.86^{b}	

** Significant ($P < 0.01$)

a, b - Values with different superscripts item wise differ significantly.

Table 44a : Nitrogen-free extract digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	84.82	229.16	60.86	253.12	103.43	149.69	59.14
	2	84.82	295.96	62.68	318.10	128.47	189.63	59.61
	3	84.82	265.69	124.38	226.13	110.64	115.49	51.07
	4	84.82	369.12	86.26	367.68	140.11	227.57	61.89
	5	84.82	292.60	57.80	319.62	125.71	193.91	60.67
	6	84.82	274.35	86.52	272.65	116.66	155.99	57.21
	Mean ± SE				292.88		172.05	58.27 1.57
2	1	109.39	246.48	35.56	320.31	112.65	207.66	64.83
	2	93.18	209.96	50.79	252.35	103.81	148.54	58.86
	3	108.88	245.34	75.73	278.49	119.32	159.17	57.15
	4	125.43	282.63	60.51	347.55	123.07	224.48	64.59
	5	122.73	276.54	59.76	339.51	133.57	205.94	60.66
	6	96.59	217.64	54.61	259.62	97.53	162.09	62.43
	Mean ± SE				299.64		184.65	61.42 1.27
3	1	103.53	205.21	48.76	259.98	103.47	156.51	60.20
	2	166.81	330.63	83.18	414.26	160.38	253.88	61.29
	3	146.12	289.63	40.41	395.34	162.22	233.12	59.97
	4	138.78	275.06	68.22	345.62	135.83	209.79	60.70
	5	116.27	230.46	25.08	321.65	121.56	200.09	62.21
	6	165.34	327.72	111.36	381.70	160.48	221.22	57.96
	Mean + SE				353.09		212.44	60.39 0.59

Analysis of variance of nitrogen-free extract digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	147.60	73.80	12.16**
Species	1	582.74	582.74	96.00**
Rations x species	2	20.04	10.02	1.65**
Error	30	182.20	6.07	
Total	35	932.58		

Rations : 1 2 3

61.49[a] 66.44[c] 64.23[b]

Species : **Lambs** **Kids**

60.03[a] 68.07[b]

** Significant ($P < 0.01$)

a, b, c - Values with different superscripts item wise differ significantly.

Average daily intakes of 292.88 and 231.31; 299.64 and 227.47 and 353.09 and 240.29 g with an average digestibility coefficients of 58.27±1.57 and 64.70±0.86; 61.42±1.27 and 71.45±0.86 and 60.39±0.59 and 68.07±0.49 were recorded in lambs and kids fed rations 1, 2 and 3, respectively. The differences in nitrogen-free extract digestibility were highly significant ($P < 0.01$) among the three rations as well as between lambs and kids.

4.4.4.9 Energy digestibility : The average energy intake, outgo and digestibility of the experimental animals are presented in Table 45 a, b. An average energy intake of 2939.68 and 2323.38; 3091.02 and 2387.16 and 3496.87 and 2366.49 Kcal with an average digestibility coefficients of 72.93±0.29 and 75.79±0.52; 75.79±0.88 and 82.70±0.16 and 75.66±1.02 and 82.99±0.21 were recorded in lambs and kids fed rations 1, 2 and 3, respectively. The energy digestibility coefficients were significantly ($P < 0.01$) lower on ration 1 compared to rations 2 and 3. The energy digestibility was significantly ($P < 0.01$) higher in kids than in lambs.

4.4.4.10 Digestibility of neutral detergent solubles (NDS) : The intake, outgo and digestibility coefficients of nuetral detergent solubles among lambs and kids are presented in Table 46 a, b. The average daily NDS intakes were 317.08 and 291.96; 304.26 and 258.47 and 395.60 and 295.02 g with an average digestibility

Table 45a : Energy digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(Kcal)						
1	1	633.70	2255.87	411.45	2478.12	690.65	1787.47	72.13
	2	633.70	2913.52	412.57	3134.65	819.71	2314.94	73.85
	3	633.70	2615.51	803.26	2445.95	681.20	1764.75	72.15
	4	633.70	3633.70	573.09	3694.31	974.93	2719.38	73.61
	5	633.70	2880.43	378.53	3135.60	850.69	2284.91	72.87
	6	633.70	2700.76	584.99	2749.47	743.46	2006.01	72.96
	Mean ± SE				2939.68		2146.24	72.93 ± 0.29
2	1	1158.33	2426.40	328.39	3256.34	817.67	2438.67	74.89
	2	986.70	2066.87	416.17	2637.40	600.01	2037.39	77.25
	3	1152.96	2415.13	630.96	2937.13	688.17	2248.96	76.57
	4	1328.19	2782.22	565.94	3544.47	949.21	2595.26	73.22
	5	1299.56	2722.25	542.64	3479.17	908.41	2570.76	73.89
	6	1022.75	2142.47	473.60	2691.62	567.66	2123.96	78.91
	Mean ± SE				3091.02		2335.83	75.79 ± 0.88
3	1	998.03	2020.14	452.64	2565.53	550.31	2015.22	78.55
	2	1608.00	3254.76	744.98	4117.78	1136.10	2981.68	72.41
	3	1408.59	2851.16	316.83	3942.92	1053.55	2889.37	73.28
	4	1337.79	2707.78	667.48	3378.09	832.02	2546.07	75.37
	5	1120.83	2268.65	230.18	3159.30	691.25	2468.05	78.12
	6	1593.85	3226.10	1002.38	3817.57	907.05	2910.52	76.24
	Mean ± SE				3496.87		2635.15	75.66 ± 1.02

Table 45b : Energy digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(Kcal)						
1	1	633.70	3117.42	791.22	2959.90	716.00	2243.90	75.81
	2	633.70	2129.08	979.76	1783.02	415.80	1367.22	76.68
	3	633.70	2488.10	841.28	2280.52	552.80	1727.72	75.76
	4	633.70	2813.69	958.18	2489.21	569.53	1919.68	77.12
	5	633.70	2386.76	943.08	2077.38	552.17	1525.21	73.42
	6	633.70	2520.79	804.24	2350.25	564.77	1785.48	75.97
	Mean				2323.38		1761.54	75.79
	± SE							0.52
2	1	1120.11	2346.41	1005.29	2461.23	415.46	2045.77	83.12
	2	1050.60	2200.75	829.79	2421.56	422.56	1999.00	82.55
	3	1033.42	2164.75	908.10	2290.07	396.87	1893.20	82.67
	4	1010.76	2117.34	798.97	2329.13	391.76	1937.37	83.18
	5	1053.31	2206.48	838.85	2420.94	433.11	1987.83	82.11
	6	1034.90	2167.85	802.72	2400.03	418.33	1981.70	82.57
	Mean				2387.16		1974.15	82.70
	± SE							0.16
3	1	1130.34	2287.87	857.30	2560.91	438.68	2122.23	82.87
	2	1046.80	2118.85	903.80	2261.85	396.28	1865.57	82.48
	3	937.82	1898.28	839.15	1996.95	321.11	1675.84	83.92
	4	1136.44	2300.29	796.54	2640.19	448.57	2191.62	83.01
	5	1041.15	2107.37	766.19	2382.33	402.85	1979.48	83.09
	6	1033.60	2092.14	769.03	2356.71	410.77	1945.94	82.57
	Mean				2366.49		1963.45	82.99
	± SE							0.21

Analysis of variance of energy digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	194.08	97.04	42.19**
Species	1	292.41	292.41	127.13**
Rations x species	2	36.56	18.28	7.94**
Error	30	69.02	2.30	
Total	35	592.07		

Rations :	1	2	3
	74.36^{a}	79.25^{b}	79.33^{b}

Species :	Lambs	Kids
	74.79^{a}	80.49^{b}

** Significant ($P < 0.01$)

a, b - Values with different superscripts item wise differ significantly.

Table 46a : Neutral Detergent Solubles (NDS) digestibility in lambs as affected by different experimental rations

Experi-mental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Dige-sted	Digesti-bility Coeffi-cient
		(g)						
1	1	142.66	172.32	32.26	282.72	94.23	188.49	66.67
	2	142.66	222.56	32.77	332.45	99.89	232.56	69.95
	3	142.66	199.80	63.83	278.63	100.42	178.21	63.96
	4	142.66	277.57	46.01	374.22	112.90	261.32	69.83
	5	142.66	220.03	30.76	331.93	103.72	228.21	68.75
	6	142.66	206.31	46.42	302.55	108.66	193.89	64.09
	Mean				317.08		213.78	67.21
	± SE							1.12
2	1	152.98	185.35	22.77	315.56	94.29	221.27	70.12
	2	130.31	157.89	31.53	256.67	99.59	157.08	61.20
	3	152.27	184.49	46.96	305.23	116.18	189.05	61.94
	4	175.41	212.53	39.74	348.20	104.34	243.86	70.03
	5	171.63	207.95	40.94	338.64	122.66	215.98	63.78
	6	135.07	163.66	37.47	261.26	88.56	172.70	66.10
	Mean				304.26		199.99	65.53
	± SE							1.59
3	1	185.30	154.32	50.26	287.36	89.82	197.54	68.74
	2	295.33	248.63	85.07	458.89	138.61	320.28	69.79
	3	258.71	217.80	25.03	451.48	146.60	304.88	67.53
	4	245.70	206.84	70.93	381.61	120.67	260.94	68.38
	5	205.85	173.30	22.95	356.20	107.92	248.28	69.70
	6	292.73	246.44	101.11	438.06	139.72	298.34	68.10
	Mean				395.60		271.71	68.71
	+ SE							0.37

Table 46b : Neutral Detergent Solubles (NDS) digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	142.66	238.14	35.91	344.89	79.84	265.05	76.85
	2	142.66	162.64	44.67	260.63	63.04	197.59	75.81
	3	142.66	190.06	60.11	272.61	65.79	206.82	75.87
	4	142.66	214.93	46.48	311.11	68.07	243.04	78.12
	5	142.66	182.32	54.63	270.35	75.98	194.37	71.90
	6	142.66	192.56	43.04	292.18	65.23	226.95	77.68
	Mean				291.96		222.30	76.04
	± SE							0.91
2	1	147.93	179.24	51.43	275.74	52.00	223.74	81.14
	2	138.75	168.11	41.86	265.00	48.40	216.60	81.73
	3	136.48	165.36	61.12	240.72	48.31	192.41	79.93
	4	133.49	161.74	45.34	249.89	46.96	202.93	81.21
	5	139.11	168.55	46.12	261.54	51.92	209.62	80.15
	6	136.68	165.60	44.33	257.95	50.12	207.83	80.57
	Mean				258.47		208.86	80.79
	± SE							0.28
3	1	207.60	174.77	55.38	326.99	58.41	268.58	82.14
	2	192.26	161.86	71.91	282.21	57.53	224.68	79.61
	3	172.24	145.01	60.61	256.64	46.58	210.06	81.85
	4	208.72	175.72	69.08	315.36	66.02	249.34	79.06
	5	191.22	160.98	55.44	296.76	57.94	238.82	80.48
	6	189.83	159.82	57.49	292.16	57.35	234.81	80.37
	Mean				295.02		237.72	80.59
	+ SE							0.49

Analysis of variance of neutral detergent solubles digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	54.91	27.45	5.93**
Species	1	1293.84	1293.84	279.45**
Rations x species	2	62.07	31.04	6.70**
Error	30	138.95	4.63	
Total	35	1549.77		

Rations :	1	2	3
	71.63^{a}	73.16^{ab}	74.65^{b}
Species :	Lambs	Kids	
	67.15^{a}	79.14^{b}	

** Significant ($P < 0.01$)

a, b - Values with different superscripts item wise differ significantly.

coefficients of 67.21±1.12 and 76.04±0.91; 65.53±1.59 and 80.79±0.28 and 68.71±0.37 and 80.59±0.49 with rations 1, 2 and 3 in lambs and kids, respectively. The differences in digestibility coefficients of NDS recorded were highly significant (P < 0.01) among the three rations and between lambs and kids.

4.4.4.11 Digestibility of neutral detergent fibre (NDF) : Digestibility data of neutral detergent fibre among lambs and kids are presented in Table 47 a, b. Average daily intakes of 486.85 and 350.95; 535.40 and 394.95 and 540.80 and 345.36g with an average digestibility coefficients of 54.32±1.61 and 51.92±0.52; 62.39±1.28 and 68.99±0.21 and 58.67±0.58 and 60.93±0.50 were recorded in lambs and kids fed rations 1, 2 and 3, respectively. The differences in digestibility coefficients of NDF were highly significant (P < 0.01) among three rations and between lambs and kids.

4.4.4.12 Digestibility of acid detergent fibre (ADF) : Digestibility data of acid detergent fibre among lambs and kids are presented in Table 48 a, b. Average daily intakes of 313.70 and 197.71; 355.51 and 253.50 and 332.83 and 184.78 g with an average digestibility coefficients of 55.45±1.16 and 51.11±0.69; 60.62±0.57 and 68.29±0.30 and 57.45±0.99 and 58.84±0.95 were recorded in lambs and kids fed rations 1, 2 and 3, respectively. The digestibility coefficients of ADF were

Table 47a : Neutral Detergent Fibre (NDF) digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	37.88	454.31	84.63	407.56	190.79	216.77	53.19
	2	37.88	586.75	84.77	539.86	242.32	297.54	55.11
	3	37.88	526.73	162.44	402.17	177.14	225.03	55.95
	4	37.88	731.79	118.20	651.47	273.07	378.40	58.08
	5	37.88	580.09	79.92	538.05	233.48	304.57	56.61
	6	37.88	543.90	199.77	382.01	202.52	179.49	46.99
	Mean				486.85		266.97	54.32
	± SE							1.61
2	1	135.88	488.65	55.74	568.79	229.50	339.29	59.65
	2	115.75	416.24	81.54	450.54	154.54	296.00	65.70
	3	135.25	486.38	119.42	502.21	171.76	330.45	65.80
	4	155.81	560.31	96.18	619.94	257.94	362.00	58.39
	5	152.45	548.23	94.72	605.96	235.06	370.90	61.21
	6	119.98	431.47	86.51	464.94	169.17	295.77	63.61
	Mean				535.40		332.40	62.39
	± SE							1.28
3	1	57.19	406.83	65.21	398.81	166.67	232.14	58.21
	2	92.14	655.47	109.95	637.66	254.28	383.38	60.12
	3	80.71	574.19	56.00	598.90	259.27	339.63	56.71
	4	76.66	545.32	91.08	530.90	212.40	318.50	59.99
	5	64.23	456.88	34.74	486.37	196.67	289.70	59.56
	6	91.33	649.70	148.86	592.17	252.08	340.09	57.43
	Mean				540.80		317.24	58.67
	± SE							0.58

Analysis of variance of neutral detergent fibre digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	249.29	474.64	89.22**
Species	1	41.73	41.73	7.84**
Rations x species	2	121.54	60.77	11.42**
Error	30	159.63	5.32	
Total	35	1272.19		

Rations :	**1**	**2**	**3**
	53.12^{a}	65.69^{c}	59.80^{b}
Species :	**Lambs**	**Kids**	
	58.46^{a}	60.61^{b}	

** Significant (P < 0.01)

a, b, c - Values with different superscripts item wise differ significantly.

Table 48a : Acid Detergent Fibre (ADF) digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	23.07	283.42	51.17	255.32	126.21	129.11	50.57
	2	23.07	366.05	50.77	338.35	150.44	187.91	55.54
	3	23.07	328.61	98.65	253.03	109.55	143.48	56.70
	4	23.07	456.53	71.02	408.58	168.63	239.95	58.73
	5	23.07	361.89	48.22	336.74	144.86	191.88	56.98
	6	23.07	339.32	72.23	290.16	133.00	157.16	54.16
	Mean				313.70		174.92	55.45
	± SE							1.16
2	1	112.83	304.85	38.26	379.42	150.56	228.86	60.32
	2	96.11	259.68	57.62	298.17	114.26	183.91	61.68
	3	112.31	303.43	83.36	332.38	127.18	205.20	61.74
	4	129.37	349.56	66.64	412.29	170.24	242.05	58.71
	5	126.59	342.02	66.36	402.25	163.80	238.45	59.28
	6	99.62	269.18	60.24	308.56	117.34	191.22	61.97
	Mean				355.51		214.95	60.62
	± SE							0.57
3	1	33.21	253.81	42.22	244.80	103.21	141.59	57.84
	2	53.51	408.92	71.10	391.33	157.63	233.70	59.72
	3	46.87	358.22	35.00	370.09	173.51	196.58	53.12
	4	44.52	340.20	58.63	326.09	133.03	193.06	59.20
	5	37.30	285.03	22.34	299.99	124.49	175.50	58.50
	6	53.04	405.32	93.69	364.67	159.27	205.40	56.32
	Mean				332.83		190.97	57.45
	± SE							0.99

Table 48b : Acid Detergent Fibre (ADF) digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered		Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		Pellet/ Legume fodder	UTM					
		(g)						
1	1	23.07	391.67	136.71	278.03	133.54	144.49	51.97
	2	23.07	267.49	167.73	122.83	61.83	61.00	49.66
	3	23.07	312.60	135.87	199.80	100.63	99.17	49.63
	4	23.07	353.51	154.14	222.44	102.31	120.13	54.01
	5	23.07	299.87	165.44	157.50	78.48	79.02	50.17
	6	23.07	316.71	134.10	205.68	100.30	105.38	51.24
	Mean				197.71		101.53	51.11
	± SE							0.69
2	1	109.11	294.80	146.78	257.13	84.17	173.00	67.26
	2	102.33	276.50	121.49	257.34	82.33	175.01	68.01
	3	100.66	271.98	131.98	240.66	76.04	164.62	68.40
	4	98.45	266.02	117.91	246.56	75.66	170.80	69.30
	5	102.60	277.22	119.26	260.56	83.69	176.87	67.88
	6	100.81	272.37	114.45	258.73	80.55	178.18	68.87
	Mean				253.50		173.08	68.29
	± SE							0.30
3	1	37.61	287.45	122.41	202.65	79.41	123.24	60.81
	2	34.83	266.21	133.23	167.81	46.70	91.11	54.29
	3	31.21	238.50	124.28	145.43	59.04	86.39	59.41
	4	37.82	289.01	114.11	212.72	84.30	127.42	59.90
	5	34.65	264.77	107.04	192.38	79.50	112.88	58.68
	6	34.40	262.85	109.54	187.71	75.15	112.56	59.97
	Mean				184.78		108.93	58.84
	± SE							0.95

Analysis of variance of acid detergent fibre digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	753.46	376.73	93.48**
Species	1	22.28	22.28	5.53*
Rations x species	2	216.51	108.25	26.86**
Error	30	120.76	4.03	
Total	35	1113.01	31.80	

Rations :	1	2	3
	53.28^{a}	64.46^{c}	58.15^{b}
Species :	**Lambs**	**Kids**	
	[illegible] ^{a}	[illegible] ^{b}	

* Significant ($P < 0.05$)

** Significant ($P < 0.01$)

a, b, c - Values with different superscripts item wise differ significantly.

significantly different among the three rations (P<0.01) and species (P<0.05) of animals.

4.4.4.13 Hemicellulose digestibility : The intake, outgo and digestibility coefficients of hemicellulose among lambs and kids are presented in Table 49 a, b. Average daily intakes of 255.87 and 148.70; 247.06 and 141.45 and 283.21 and 160.58 g with an average digestibility coefficients of 66.56±1.85 and 51.40±1.11; 75.14±2.16 and 70.29±0.61 and 70.07±0.35 and 63.21±1.51 were recorded in lambs and kids fed rations 1, 2 and 3, respectively. The differences in the digestibility coefficients of hemicellulose were highly significant (P<0.01) among the three rations as well as the species of animals.

4.4.4.14 Cellulose digestibility : The average cellulose intake, outgo and digestibility coefficients of experimental animals are given in Table 50 a,b. Average daily intakes of 230.46 and 137.40: 285.09 and 202.52 and 262.88 and 139.91 g with an average digestibility coefficients of 67.26±1.04 and 59.94±0.82; 70.31±0.43 and 76.24±0.76 and 69.53± 0.40 and 66.53± 0.49 were recorded in lambs and kids fed rations 1, 2 and 3, respectively. The cellulose digestibility coefficients recorded were significantly (P<0.01) different among the three rations as well as the species of animals.

Table 49a : Hemicellulose digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder (g)	Offered: UTM (g)	Left over (g)	Total intake (g)	Voided in faeces (g)	Digested (g)	Digestibility Coefficient
1	1	14.80	170.88	33.45	152.23	64.59	87.64	57.57
	2	14.80	301.39	34.00	282.19	91.88	190.31	67.44
	3	14.80	270.56	63.79	221.57	67.59	153.98	69.49
	4	14.80	375.89	47.18	343.51	104.44	239.07	69.60
	5	14.80	297.96	31.70	281.06	88.62	192.44	68.47
	6	14.80	279.38	47.55	246.63	81.96	164.67	66.77
	Mean ± SE				255.87		171.35	66.56 1.85
2	1	23.05	251.00	17.48	256.57	78.94	177.63	69.23
	2	19.64	213.81	23.83	209.62	40.28	169.34	80.78
	3	22.94	249.83	36.06	236.71	44.57	192.14	81.17
	4	26.43	287.81	29.55	284.69	87.71	196.98	69.19
	5	25.86	281.60	28.35	279.08	71.26	207.82	74.47
	6	20.35	221.63	26.27	215.71	51.83	163.88	75.97
	Mean ± SE				247.06		184.63	75.14 2.16
3	1	23.98	208.15	22.99	209.14	63.46	145.68	69.66
	2	38.63	336.69	38.85	336.47	96.65	239.82	71.28
	3	33.84	294.94	21.00	307.78	85.76	222.02	72.14
	4	32.14	280.10	32.45	279.79	79.37	200.42	71.63
	5	26.93	234.68	12.40	249.21	72.19	177.02	71.03
	6	38.29	333.72	55.17	316.84	92.82	224.02	70.70
	Mean ± SE				283.21		201.50	71.07 0.35

Table 49b : Hemicellulose digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	14.80	236.14	50.26	200.68	93.33	107.35	53.49
	2	14.80	161.28	65.94	110.14	53.52	56.62	51.41
	3	14.80	188.47	43.69	132.39	69.64	62.75	47.40
	4	14.80	213.14	74.73	153.21	75.09	78.12	50.99
	5	14.80	180.80	54.88	140.72	70.41	70.31	49.96
	6	14.80	190.95	50.69	155.06	69.53	85.53	55.16
	Mean ± SE				148.70		76.78	51.40 ± 1.11
2	1	22.29	177.74	67.74	132.29	35.50	96.79	73.16
	2	20.91	166.71	45.14	142.48	44.51	98.00	68.76
	3	20.57	163.98	35.64	148.91	44.81	104.10	69.91
	4	20.11	160.39	42.67	137.83	40.90	96.93	70.33
	5	20.96	167.14	43.83	144.27	43.79	100.48	69.95
	6	20.59	164.21	41.90	142.90	42.94	99.96	69.95
	Mean ± SE				141.45		99.38	70.29 ± 0.61
3	1	27.16	173.31	35.80	164.67	71.16	93.51	56.79
	2	25.15	160.50	24.25	161.40	52.98	108.42	67.17
	3	22.53	143.79	33.06	133.26	50.64	82.62	62.00
	4	27.30	174.25	17.15	184.40	62.41	121.99	66.15
	5	25.01	159.63	23.94	160.70	57.12	103.58	64.45
	6	24.83	158.48	24.28	159.03	59.30	99.73	62.71
	Mean + SE				160.58		101.64	63.21 ± 1.51

Analysis of variance of hemicellulose digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	1145.27	572.63	47.05**
Species	1	776.74	776.74	63.82**
Rations x species	2	168.64	84.32	6.93**
Error	30	365.20	12.17	
Total	35	2455.85	70.17	

Rations :	1	2	3
	58.98^{a}	72.72^{c}	67.14^{b}
Species :	**Lambs**	**Kids**	
	70.92^{b}	61.63^{a}	

** Significant ($P < 0.01$)

a, b, c – Values with different superscripts item wise differ significantly.

Table 50a : Cellulose digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder (g)	Offered: UTM (g)	Left over (g)	Total intake (g)	Voided in faeces (g)	Digested (g)	Digestibility Coefficient
1	1	7.26	221.58	43.82	182.02	68.86	116.16	62.78
	2	7.26	286.17	43.94	249.49	82.06	167.43	67.11
	3	7.26	256.90	78.06	186.10	56.82	129.28	69.47
	4	7.26	356.91	60.69	303.48	92.71	210.77	69.45
	5	7.26	282.92	40.90	249.28	78.50	170.78	68.51
	6	7.26	265.27	60.12	212.41	71.70	140.71	66.24
	Mean				230.46		155.86	67.26
	± SE							1.04
2	1	94.11	238.33	26.14	306.30	91.02	215.28	70.28
	2	80.17	203.01	47.51	235.67	69.00	166.67	70.72
	3	93.67	237.22	69.12	261.77	75.12	186.65	71.30
	4	107.91	273.28	45.35	335.84	104.92	230.92	68.76
	5	105.59	267.39	50.09	322.89	98.80	224.09	69.40
	6	83.10	210.44	45.48	248.06	70.98	177.08	71.39
	Mean				285.09		200.12	70.31
	± SE							0.43
3	1	22.56	198.42	26.42	194.56	60.20	134.36	69.06
	2	36.34	319.69	42.67	313.36	91.23	222.13	70.89
	3	31.84	280.05	26.48	285.41	91.08	194.33	68.09
	4	30.24	265.96	36.74	259.46	77.14	182.32	70.27
	5	25.33	222.83	14.57	233.59	70.91	162.68	69.64
	6	36.02	316.88	61.99	290.91	89.60	201.31	69.20
	Mean				262.88		182.86	69.53
	± SE							0.40

Table 50b : Cellulose digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder (g)	Offered: UTM (g)	Left over (g)	Total intake (g)	Voided in faeces (g)	Digested (g)	Digestibility Coefficient
1	1	7.26	306.20	112.55	200.91	77.32	123.59	61.52
	2	7.26	209.12	139.20	77.18	33.64	43.54	56.41
	3	7.26	244.39	112.70	139.95	56.73	83.22	59.46
	4	7.26	276.37	128.47	155.16	58.91	96.45	62.16
	5	7.26	234.43	134.51	107.18	42.64	64.54	60.22
	6	7.26	247.60	110.82	144.04	57.85	86.19	59.84
	Mean				137.40		82.92	59.94
	± SE							0.82
2	1	91.01	230.47	120.02	201.46	45.55	155.91	77.39
	2	85.36	216.16	95.78	205.74	48.84	156.90	76.26
	3	83.96	212.63	100.62	195.97	53.73	142.24	72.58
	4	82.12	207.97	93.10	196.99	44.20	152.79	77.56
	5	85.58	216.72	94.05	208.25	48.83	159.42	76.55
	6	84.08	212.93	90.33	206.68	47.31	159.37	77.11
	Mean				202.52		154.44	76.24
	± SE							0.76
3	1	25.55	224.72	98.10	152.17	54.19	97.98	64.39
	2	23.66	208.12	103.80	127.98	42.65	85.33	66.67
	3	21.20	186.45	98.06	109.59	37.33	72.26	65.94
	4	25.69	225.94	90.17	161.46	52.73	108.73	67.34
	5	23.53	206.99	85.00	145.52	47.51	98.01	67.35
	6	23.36	205.49	86.10	142.75	46.45	96.30	67.46
	Mean				139.91		93.10	66.53
	± SE							0.49

Analysis of variance of cellulose digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S	F
Rations	2	562.96	281.48	111.26**
Species	1	19.27	19.27	7.62**
Rations x species	2	273.97	136.99	54.15**
Error	30	75.76	2.53	
Total	35	931.96	26.63	

Rations :	1	2	3
	63.60^{a}	73.28^{c}	68.03^{b}
Species :	Lambs	Kids	
	69.03^{b}	67.57^{a}	

** Significant ($P < 0.01$)

a, b, c - Values with different superscripts item wise differ significantly.

4.4.4.15 Lignin digestibility : The average lignin intake, outgo and digestibility coefficients are presented in Table 51 a,b. Average daily intakes of 41.59 and 29.90; 49.46 and 36.79 and 50.56 and 33.93 g with an average digestibility coefficients of 28.62±0.41 and 18.76± 0.38; 33.12±1.09 and 22.99±0.66 and 28.51±0.60 and 18.07±0.77 were recorded in lambs and kids fed rations 1, 2 and 3, respectively. Digestibility coefficients of lignin were significantly ($P<0.01$) higher on ration 2 compared to rations 1 and 3. Lignin digestibility was significantly ($P<0.01$) higher in lambs than in kids.

4.4.5 Balance Studies

4.4.5.1 Nitrogen balance : Data on average intake, outgo and retention of nitrogen are given in Table 52 a,b. The average daily intake of 23.02 and 19.96; 22.88 and 19.37 and 29.90 and 22.37 g with an average balance of 12.02±1.02 and 12.32±0.49; 12.52±0.78 and 13.2±0.11 and 14.56±1.48 and 14.93±0.44 g was recorded in lambs and kids fed rations 1, 2 and 3, respectively. All the experimental animals were on positive nitrogen balance and were significantly higher ($P < 0.05$) for ration 3 compared to rations 1 and 2. The positive nitrogen balances recorded were not significantly different between lambs and kids.

Table 51a : Lignin digestibility in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder (g)	Offered: UTM (g)	Left over (g)	Total intake (g)	Voided in faeces (g)	Digested (g)	Digestibility Coefficient
1	1	2.67	37.16	5.98	33.85	24.59	9.26	27.35
	2	2.67	47.99	5.89	44.77	32.10	12.67	28.29
	3	2.67	43.08	12.29	33.46	24.07	9.39	28.07
	4	2.67	59.86	8.21	54.32	37.95	16.37	30.14
	5	2.67	47.45	5.84	44.28	31.22	13.06	29.49
	6	2.67	44.49	8.31	38.85	29.82	11.03	28.39
	Mean				41.59		11.96	28.62
	± SE							0.41
2	1	17.42	39.97	4.92	52.47	33.36	19.11	36.43
	2	14.84	34.05	7.41	41.48	28.47	13.01	31.37
	3	17.34	39.78	10.36	46.76	31.80	14.96	32.00
	4	19.97	45.83	8.69	57.11	38.05	19.06	33.38
	5	19.54	44.84	8.53	55.85	39.31	16.54	29.62
	6	15.38	35.29	7.60	43.07	27.60	15.47	35.92
	Mean				49.46		16.36	33.12
	± SE							1.09
3	1	10.58	33.28	7.10	36.76	25.78	10.98	29.87
	2	17.05	53.61	11.72	58.94	41.65	17.29	29.34
	3	14.93	46.97	4.54	57.36	42.64	14.72	25.66
	4	14.18	44.60	9.67	49.11	35.03	14.08	28.74
	5	11.88	37.37	3.47	45.78	32.65	13.13	28.68
	6	16.90	53.14	14.62	55.42	39.49	15.93	28.74
	Mean				50.56		14.36	28.51
	± SE							0.60

Table 51b : Lignin digestibility in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in faeces	Digested	Digestibility Coefficient
		(g)						
1	1	2.67	51.35	14.53	39.49	32.01	7.48	18.94
	2	2.67	35.07	16.39	21.35	17.44	3.91	18.31
	3	2.67	40.98	14.05	29.60	23.86	5.74	19.40
	4	2.67	46.35	16.00	33.02	27.38	5.64	17.08
	5	2.67	39.32	16.52	25.47	20.49	4.98	19.57
	6	2.67	41.52	13.72	30.47	24.60	5.87	19.27
	Mean ± SE				29.90		5.60	18.76 0.38
2	1	16.84	38.65	17.23	38.28	29.75	8.51	22.24
	2	15.80	36.25	15.18	36.87	27.55	9.32	25.29
	3	15.54	35.66	16.26	34.94	27.51	7.43	21.26
	4	15.20	34.88	14.43	35.65	27.90	7.75	21.73
	5	15.84	36.35	14.58	37.61	28.35	9.26	24.63
	6	15.56	35.71	13.87	37.40	28.88	8.52	22.78
	Mean ± SE				36.79		8.47	22.99 0.66
3	1	11.98	37.69	11.79	37.88	32.12	5.76	15.20
	2	11.10	34.90	15.69	30.31	24.26	6.05	19.96
	3	9.94	31.27	12.34	28.87	23.30	5.57	19.31
	4	12.05	37.89	11.98	37.98	31.49	6.49	17.09
	5	11.04	34.71	11.56	34.19	28.34	5.85	17.12
	6	10.96	34.46	11.10	34.32	27.55	6.77	19.74
	Mean ± SE				33.93		6.08	18.07 0.77

Analysis of variance of lignin digestibility coefficients in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	167.67	83.84	29.31**
Species	1	925.98	925.98	323.77**
Rations x species	2	0.51	0.26	0.09
Error	30	85.70	2.86	
Total	35	1179.86	33.71	

Rations :	1	2	3
	23.69^a	28.06^b	23.29^a
Species :	Lambs	Kids	
	30.08^b	19.94^a	

** Significant ($P < 0.01$)

a, b - Values with different superscripts item wise differ significantly.

Table 52a : Nitrogen balance in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder (g)	Offered: UTM (g)	Left over (g)	Total intake (g)	Voided in: Faeces (g)	Voided in: Urine (g)	Voided in: Total (g)	Balance (g)
1	1	6.10	15.66	2.02	19.74	6.91	4.59	11.50	+ 8.24
	2	6.10	20.23	1.88	24.45	8.25	3.86	12.11	+12.34
	3	6.10	18.16	4.73	19.53	7.45	0.29	7.74	+11.79
	4	6.10	25.23	2.88	28.45	9.26	3.21	12.47	+15.98
	5	6.10	20.00	1.99	24.11	8.35	3.07	11.42	+12.69
	6	6.10	18.75	3.02	21.83	7.73	3.05	10.78	+11.05
	Mean				23.02				+12.02
	± SE								1.02
2	1	8.72	16.84	1.76	23.80	8.87	1.39	10.26	+13.54
	2	7.43	14.35	2.35	19.43	6.44	3.06	9.50	+ 9.93
	3	8.68	16.77	3.45	22.00	7.25	2.93	10.18	+11.82
	4	10.00	19.32	3.07	26.25	10.00	1.48	11.48	+14.77
	5	9.78	18.90	2.87	25.81	9.50	2.25	11.75	+14.06
	6	7.70	14.87	2.61	19.96	6.80	2.19	8.99	+10.97
	Mean				22.88				+12.52
	± SE								0.78
3	1	11.61	14.02	4.14	21.49	7.48	5.56	13.04	+ 8.45
	2	18.71	22.60	6.89	34.42	11.36	5.52	16.88	+17.54
	3	16.39	19.79	1.48	34.70	11.38	5.59	16.97	+17.73
	4	15.57	18.80	5.82	28.55	9.68	4.82	14.50	+14.05
	5	13.04	15.75	1.86	26.93	8.91	5.37	14.28	+12.65
	6	18.55	22.40	7.64	33.31	11.10	5.28	16.38	+16.93
	Mean				29.90				+14.56
	± SE								1.48

Table 52b : Nitrogen balance in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in: Faeces	Voided in: Urine	Voided in: Total	Balance
		(g)							
1	1	6.10	21.64	3.62	24.12	7.08	3.07	10.15	+13.97
	2	6.10	14.78	4.47	16.41	4.28	1.40	5.68	+10.73
	3	6.10	17.27	3.70	19.67	6.33	1.29	7.62	+12.05
	4	6.10	19.53	4.37	21.26	6.46	1.45	7.91	+13.35
	5	6.10	16.57	4.37	18.30	5.61	1.27	6.88	+11.42
	6	6.10	17.50	3.63	19.97	5.89	1.68	7.57	+12.40
	Mean ± SE				19.96				+12.32 0.49
2	1	8.43	16.29	4.75	19.97	4.49	2.09	6.58	+13.39
	2	7.91	15.28	3.63	19.56	4.56	1.66	6.22	+13.34
	3	7.78	15.03	3.83	18.98	4.33	1.16	5.49	+13.49
	4	7.61	14.70	3.52	18.79	4.25	1.70	5.95	+12.84
	5	7.93	15.32	3.68	19.57	4.64	2.00	6.64	+12.93
	6	7.79	15.05	3.49	19.35	4.51	1.64	6.15	+13.20
	Mean ± SE				19.37				+13.20 0.11
3	1	13.15	15.88	5.00	24.03	6.25	2.36	8.61	+15.42
	2	12.18	14.71	5.32	21.57	5.49	1.51	7.00	+14.57
	3	10.91	13.18	4.89	19.20	4.55	1.31	5.86	+13.34
	4	13.22	15.97	4.45	24.74	6.24	1.94	8.18	+16.56
	5	12.12	14.63	4.42	22.33	5.73	1.81	7.54	+14.79
	6	12.03	14.52	4.20	22.35	5.62	1.76	7.38	+14.97
	Mean ± SE				22.37				+14.93 0.44

Analysis of variance of nitrogen balance in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	42.64	21.45	5.00*
Species	1	1.82	2.09	0.49
Rations x species	2	0.25	0.13	0.03
Error	30	128.56	4.29	
Total	35	173.27	4.95	

Rations :	1	2	3
	12.17^{a}	12.86^{a}	14.75^{b}

* Significant ($P < 0.05$)

a, b - Values with different superscripts item wise differ significantly.

4.4.5.2 Calcium balance : Daily calcium intake, outgo and balance data of the experimental rations are recorded in Table 53 a, b. The average daily intake of 6.64 and 5.51, 7.74 and 5.25 and 9.56 and 5.30 g with an average balance of 1.93±0.17 and 1.93±0.16; 3.18±0.14 and 2.78±0.05 and 2.17±0.20 and 1.81±0.19 g was recorded in lambs and kids fed rations 1, 2 and 3, respectively. All the experimental animals were on positive calcium balance. The positive calcium balances recorded were significantly ($P < 0.01$) higher for ration 2 compared to rations 1 and 3.

4.4.5.3 Phosphorus balance : Data pertaining to phosphorus intake, outgo and retention are given in Table 54 a,b. An average phosphorus intake of 3.06 and 2.76; 1.72 and 1.44 and 1.97 and 1.35 g with an average balance of 1.57±0.09 and 1.67±0.05; 0.59±0.06 and 0.8±0.07 and 0.76±0.11 and 0.65±0.05 g was observed in lambs and kids fed rations 1, 2 and 3, respectively. All the experimental animals were on positive phosphorus balance and were significantly ($P < 0.01$) different among the three rations.

4.4.6 Plane of Nutrition of the Experimental Animals

The data on plane of nutrition of lambs and kids fed different experimental rations are presented in Table 55. The experimental rations 1, 2 and 3 contained

Table 53a : Calcium balance in lambs as affected by different experimental rations

Experimental ration	Animal No.	Offered		Left over	Total intake	Voided in			Balance
		Pellet/ Legume fodder	UTM			Faeces	Urine	Total	
		(g)							
1	1	2.31	4.26	0.82	5.75	3.88	0.05	3.93	+1.82
	2	2.31	5.50	0.80	7.01	4.41	0.05	4.46	+2.55
	3	2.31	4.94	1.49	5.76	4.47	0.02	4.49	+1.27
	4	2.31	6.86	1.07	8.10	6.06	0.05	6.11	+1.99
	5	2.31	5.44	0.79	6.96	4.89	0.04	4.93	+2.03
	6	2.31	5.10	1.13	6.28	4.33	0.03	4.36	+1.92
	Mean				6.64				+1.93
	± SE				0.37				0.17
2	1	4.74	4.58	1.07	8.25	4.63	0.04	4.67	+3.58
	2	4.04	3.90	1.33	6.61	3.84	0.03	3.87	+2.74
	3	4.72	4.56	1.93	7.35	4.32	0.03	4.35	+3.00
	4	5.43	5.26	1.86	8.83	5.39	0.04	5.43	+3.40
	5	5.31	5.14	1.68	8.77	5.29	0.03	5.32	+3.45
	6	4.18	4.05	1.61	6.62	3.74	0.04	3.74	+2.92
	Mean				7.74				+3.18
	± SE				0.42				0.14
3	1	4.64	3.82	1.55	6.91	5.51	0.03	5.54	+1.37
	2	7.48	6.15	2.57	11.06	8.33	0.03	8.36	+2.70
	3	6.55	5.39	0.83	11.11	8.50	0.02	8.22	+2.59
	4	6.22	5.11	2.20	9.13	7.13	0.04	7.17	+1.96
	5	5.21	4.29	0.73	8.77	6.40	0.03	6.43	+2.34
	6	7.41	6.09	3.12	10.38	8.31	0.02	8.33	+2.05
	Mean				9.56				+2.17
	± SE				0.66				0.20

Table 53b : Calcium balance in kids as affected by different experimental rations

Experi-mental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in: Faeces	Voided in: Urine	Voided in: Total	Balance
		(g)							
1	1	2.31	5.89	1.58	6.62	5.31	0.05	5.36	+1.26
	2	2.31	4.02	1.81	4.52	2.52	0.04	2.56	+1.96
	3	2.31	4.70	1.58	5.43	2.95	0.06	3.01	+2.42
	4	2.31	5.31	1.68	5.94	4.05	0.03	4.08	+1.86
	5	2.31	4.51	1.84	4.98	3.13	0.03	3.16	+1.82
	6	2.31	4.76	1.48	5.59	3.31	0.04	3.35	+2.24
	Mean				5.51				+1.93
	± SE				0.30				0.16
2	1	4.58	4.43	3.67	5.34	2.49	0.08	2.57	+2.77
	2	4.30	4.16	2.92	5.54	2.56	0.05	2.61	+2.93
	3	4.23	4.09	3.34	4.98	2.11	0.03	2.14	+2.84
	4	4.13	4.00	3.11	5.02	2.10	0.07	2.17	+2.85
	5	4.31	4.17	3.12	5.36	2.60	0.06	2.66	+2.70
	6	4.23	4.09	3.05	5.27	2.59	0.07	2.66	+2.61
	Mean				5.25				+2.78
	± SE				0.09				0.05
3	1	5.26	4.32	3.01	6.57	4.28	0.04	4.32	+2.25
	2	4.87	4.00	4.36	4.51	3.34	0.05	3.39	+1.12
	3	4.36	3.59	3.73	4.22	2.83	0.03	2.86	+1.36
	4	5.29	4.34	3.65	5.98	3.74	0.04	3.78	+2.20
	5	4.84	3.98	3.47	5.35	3.35	0.03	3.38	+1.97
	6	4.81	3.95	3.60	5.16	3.20	0.02	3.22	+1.94
	Mean				5.30				+1.81
	± SE				0.36				0.19

Analysis of variance of calcium balance in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	8.37	4.19	27.93**
Species	1	0.59	0.59	3.93*
Rations x species	2	0.29	0.15	1.00
Error	30	4.58	0.15	
Total	35	13.83		

Rations :	1	2	3
	1.93[a]	1.98[b]	1.99[a]

** Significant ($P < 0.01$)

a, b - Values with different superscripts item wise differ significantly.

Table 54a : Phosphorus balance in lambs as affected by different experimental rations

Experi-mental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in: Faeces	Voided in: Urine	Voided in: Total	Balance
		(g)							
1	1	1.95	1.07	0.19	2.83	1.45	0.03	1.48	+1.35
	2	1.95	1.38	0.20	3.13	1.51	0.04	1.55	+1.58
	3	1.95	1.24	0.34	2.85	0.86	0.05	0.91	+1.94
	4	1.95	1.72	0.25	3.42	1.74	0.03	1.77	+1.65
	5	1.95	1.36	0.20	3.11	1.55	0.03	1.58	+1.53
	6	1.95	1.28	0.23	3.00	1.62	0.02	1.64	+1.36
	Mean				3.06				+1.57
	± SE				0.09				0.09
2	1	0.84	1.15	0.17	1.82	1.34	0.02	1.36	+0.46
	2	0.60	0.98	0.20	1.38	0.99	0.03	1.02	+0.36
	3	0.83	1.14	0.27	1.70	0.98	0.03	1.01	+0.69
	4	0.96	1.31	0.31	1.96	1.20	0.02	1.22	+0.74
	5	0.94	1.29	0.27	1.96	1.36	0.03	1.39	+0.57
	6	0.74	1.01	0.26	1.49	0.75	0.02	0.77	+0.72
	Mean				1.72				+0.59
	± SE				0.10				0.06
3	1	0.72	0.95	0.25	1.42	1.05	0.04	1.09	+0.33
	2	1.16	1.54	0.41	2.29	1.49	0.03	1.52	+0.77
	3	1.02	1.35	0.14	2.23	1.30	0.05	1.35	+0.88
	4	0.97	1.28	0.37	1.88	1.07	0.04	1.11	+0.77
	5	0.81	1.07	0.12	1.76	1.07	0.03	1.10	+0.66
	6	1.15	1.52	0.45	2.22	1.02	0.03	1.05	+1.17
	Mean				1.97				+0.76
	± SE				0.14				0.11

Table 54b : Phosphorus balance in kids as affected by different experimental rations

Experimental ration	Animal No.	Offered: Pellet/ Legume fodder	Offered: UTM	Left over	Total intake	Voided in: Faeces	Voided in: Urine	Voided in: Total	Balance
		(g)							
1	1	1.95	1.47	0.38	3.04	1.53	0.01	1.54	+1.50
	2	1.95	1.01	0.45	2.51	0.80	0.01	0.81	+1.70
	3	1.95	1.17	0.38	2.74	0.85	0.03	0.88	+1.86
	4	1.95	1.33	0.41	2.87	1.08	0.02	1.10	+1.77
	5	1.95	1.13	0.47	2.61	1.01	0.03	1.04	+1.57
	6	1.95	1.19	0.34	2.80	1.15	0.02	1.17	+1.63
	Mean				2.76				+1.67
	± SE				0.08				0.05
2	1	0.81	1.11	0.53	1.39	0.70	0.02	0.72	+0.67
	2	0.76	1.04	0.38	1.42	0.70	0.03	0.73	+0.69
	3	0.75	1.02	0.37	1.40	0.61	0.01	0.62	+0.78
	4	0.73	1.00	0.45	1.28	0.56	0.02	0.58	+0.70
	5	0.76	1.04	0.44	1.80	0.65	0.01	0.66	+1.14
	6	0.75	1.02	0.44	1.33	0.52	0.02	0.52	+0.79
	Mean				1.44				+0.80
	± SE				0.08				0.07
3	1	0.82	1.08	0.49	1.41	0.84	0.03	0.87	+0.54
	2	0.76	1.00	0.53	1.23	0.73	0.02	0.75	+0.48
	3	0.68	0.90	0.37	1.21	0.52	0.04	0.56	+0.65
	4	0.82	1.09	0.44	1.47	0.73	0.04	0.77	+0.70
	5	0.75	1.00	0.37	1.38	0.68	0.02	0.70	+0.68
	6	0.75	1.00	0.36	1.39	0.52	0.03	0.55	+0.84
	Mean				1.35				+0.65
	± SE				0.04				0.05

Analysis of variance of phosphorus balance in lambs and kids

Source	d.f	S.S	M.S.S.	F
Rations	2	6.81	3.41	113.67**
Species	1	0.08	0.08	2.67
Rations x species	2	0.12	0.06	2.00
Error	30	1.03	0.03	
Total	35	8.04		

Rations : **1**

1.62^{a} 0.70^{b} 0.71^{b}

** Significant ($P < 0.01$)

a, b - Values with different superscripts item wise differ significantly.

Table 55 : Plane of nutrition of lambs and kids as affected by different experimental rations

Ration	Body weight (kg)	Metabolic body weight $W^{0.75}$ kg	DCP		TDN		DM intake % body weight	DE intake per day (Mcal)	ME intake per day (Mcal)	Intake per unit metabolic body weight			Protein : energy ratio
			% in ration**	Intake/ day (g)	% in ration**	Intake/ day (g)				DM (g)	DCP (g)	ME (kcal)	
						LAMBS							
1	23.87	10.79	11.48[b]	93.93	55.78[a]	457.66	3.42	2.15	1.76	75.58	8.71	163.11	1 : 23
2	21.38	9.94	10.96[a]	91.10	59.56[b]	497.13	3.91	2.34	1.92	84.10	9.16	193.16	1 : 26
3	23.45	10.65	13.26[c]	124.45	59.96[b]	561.35	3.99	2.64	2.16	87.75	11.69	202.82	1 : 21
ICAR* (1985)	25.00	11.18	8.13	65.00	62.50	500.00	3.20	2.20	1.80	71.56	5.81	161.00	1 : 34
						KIDS							
1	20.48	9.67	13.73[a]	87.61	60.27[a]	387.92	3.18	1.76	1.44	66.80	9.06	148.91	1 : 20
2	19.21	9.16	14.26[a]	93.18	68.90[c]	450.06	3.44	1.97	1.62	71.75	10.17	176.86	1 : 21
3	20.01	9.46	16.35[a]	104.53	67.12[b]	429.67	3.21	1.96	1.61	67.78	11.05	170.19	1 : 19
ICAR* (1985)	20.00	9.46	5.00	35.00	57.14	400.00	3.50	1.76	1.44	74.00	3.70	152.22	1 : 50

* Animals gaining 50 g/day.

a,b,c - Values with different superscripts item wise differ significantly.

** Significant ($P < 0.01$).

11.49 and 13.63; 10.90 and 14.26 and 13.29 and 16.32 per cent digestible crude protein in lambs and kids, respectively. The DCP values were significantly ($P < 0.01$) higher on ration 3 compared to other rations. DCP content was significantly ($P < 0.01$) higher in kids than in lambs. The average daily DCP consumed by lambs and kids fed rations 1, 2 and 3 was 93.93 and 87.61; 91.10 and 93.18 and 124.45 and 104.53 g/day, respectively.

The experimental rations 1, 2 and 3 contained 56.00 and 60.34; 59.51 and 68.88 and 59.95 and 67.10 per cent total digestible nutrients (TDN) in lambs and kids, respectively. The percent TDN values were significantly lower ($P < 0.01$) for ration 1 compared to rations 2 and 3. The TDN values were significantly ($P < 0.01$) higher in kids than in lambs. The average daily consumption of TDN by lambs and kids fed rations 1, 2 and 3 was 457.66 and 387.92; 497.13 and 450.06 and 561.35 and 429.67 g, respectively. The estimated intake of dry matter, digestible crude protein and metabolizable energy per unit metabolic body weight ranged from 75.58 to 87.75 and 66.80 to 71.75; 8.71 to 11.69 and 9.06 to 11.05 g and 163.11 to 202.82 and 148.91 to 176.86 Kcal in lambs and kids on rations 1, 2 and 3, respectively.

4.4.6.1 Protein : Energy ratios of experimental rations : The estimated Protein : Energy ratios (digestible crude protein g and digestible energy Kcal) of the experimental rations are presented in Table 55. The Protein : Energy ratios were 1 : 23 and 1 : 20; 1 : 26 and 1 : 21 and 1 : 21 and 1 : 19 among lambs and kids fed rations 1, 2 and 3, respectively.

Data of digestibility coefficients, nutritive value and balances of nutrients are summerized in Table 56 a,b.

Table 56a : Average digestibility coefficients and balances of various nutrients and nutritive value as affected by different experimental rations in lambs

Nutrient	Experimental rations		
	1	2	3
Digestibility coefficients			
DM	60.27 ± 0.58	63.32 ± 0.38	62.91 ± 1.11
OM	62.59 ± 0.64	64.94 ± 0.32	64.40 ± 0.42
CP	65.01 ± 0.77	63.95 ± 1.34	66.51 ± 0.31
CF	65.46 ± 1.17	68.45 ± 1.11	67.96 ± 0.66
EE	72.13 ± 0.55	69.56 ± 1.07	67.26 ± 0.98
NFE	58.27 ± 1.57	61.42 ± 1.27	60.39 ± 0.59
Energy	72.93 ± 0.29	75.79 ± 0.88	75.66 ± 1.02
NDS	67.21 ± 1.12	65.53 ± 1.59	68.71 ± 0.37
NDF	54.32 ± 1.61	62.39 ± 1.28	58.67 ± 0.58
ADF	55.45 ± 1.16	60.62 ± 0.57	57.45 ± 0.99
Hemicellulose	66.56 ± 1.85	75.14 ± 2.16	71.07 ± 0.35
Cellulose	67.26 ± 1.04	70.31 ± 0.43	69.53 ± 0.40
Lignin	28.62 ± 0.41	33.12 ± 1.09	28.51 ± 0.60
Nutritive value (%)			
DCP	11.48 ± 0.09	10.96 ± 0.27	13.26 ± 0.17
TDN	55.78 ± 0.68	59.56 ± 0.29	59.96 ± 0.48
Balances (g/d)			
Nitrogen retention	12.02 ± 1.02	12.52 ± 0.78	14.56 ± 1.48
as % intake	47.50 ± 6.73	54.57 ± 0.84	48.07 ± 1.86
as % absorbed	80.03 ± 4.42	84.62 ± 2.36	74.88 ± 3.39
Calcium retention	1.93 ± 0.17	3.18 ± 0.14	2.17 ± 0.20
as % intake	29.07 ± 2.10	41.27 ± 0.90	22.58 ± 1.12
Phosphorus retention	1.57 ± 0.09	0.59 ± 0.06	0.76 ± 0.11
as % intake	51.51 ± 3.39	34.52 ± 3.76	37.91 ± 3.93

Table 56b : Average digestibility coefficients and balances of various nutrients and nutritive value as affected by different experimental rations in kids

Nutrient	Experimental rations		
	1	2	3
Digestibility coefficients			
DM	63.00 ± 0.58	73.66 ± 0.49	70.02 ± 0.19
OM	67.59 ± 0.53	75.87 ± 0.14	72.16 ± 0.15
CP	70.32 ± 0.84	76.96 ± 0.19	74.92 ± 0.30
CF	68.85 ± 0.75	79.36 ± 0.17	75.18 ± 0.67
EE	74.54 ± 1.00	71.37 ± 0.69	75.67 ± 0.41
NFE	64.70 ± 0.86	71.45 ± 0.86	68.07 ± 0.49
Energy	75.79 ± 0.52	82.70 ± 0.16	82.99 ± 0.21
NDS	76.04 ± 0.91	80.79 ± 0.28	80.59 ± 0.49
NDF	51.92 ± 0.52	68.99 ± 0.21	60.93 ± 0.50
ADF	51.11 ± 0.69	68.29 ± 0.30	58.84 ± 0.95
Hemicellulose	51.40 ± 1.11	70.29 ± 0.61	63.21 ± 1.51
Cellulose	59.94 ± 0.82	76.24 ± 0.76	66.53 ± 0.49
Lignin	18.76 ± 0.38	22.99 ± 0.66	18.07 ± 0.77
Nutritive value (%)			
DCP	13.73 ± 0.36	14.26 ± 0.10	16.35 ± 0.17
TDN	60.27 ± 0.57	68.90 ± 0.82	67.12 ± 0.18
Balances (g/d)			
Nitrogen retention	12.32 ± 0.49	13.20 ± 0.11	14.93 ± 0.44
as % intake	61.98 ± 0.99	68.16 ± 0.69	66.89 ± 0.71
as % absorbed	88.17 ± 1.30	88.56 ± 0.83	89.42 ± 0.62
Calcium retention	1.93 ± 0.16	2.78 ± 0.05	1.81 ± 0.19
as % intake	35.82 ± 3.89	53.08 ± 1.30	33.75 ± 1.96
Phosphorus retention	1.67 ± 0.05	0.80 ± 0.07	0.65 ± 0.05
as % intake	60.83 ± 2.81	54.99 ± 2.43	48.06 ± 3.48

DISCUSSION AND CONCLUSIONS

CHAPTER V

DISCUSSION AND CONCLUSIONS

Experiments were conducted in two phases to evaluate 1. Optimum moisture and incubation period for urea treatment of chopped maize stover and 2. The effect of feeding urea treated maize stover (UTM) alongwith three supplements on growth and nutrient utilization in sheep and goats.

5.1 EFFECT OF UREA TREATMENT OF MAIZE STOVER

Maize stover was chopped to 10 to 12 mm size and then subjected to urea (4%) treatment at different moisture levels (30, 40 and 50%) and incubation periods (1, 2 and 3 weeks) to assess the optimum moisture and incubation periods for the treatment of maize stover. The treated material was subjected to physical and chemical analysis and the results are discussed in the following paras.

5.1.1 Colour

The colour of maize stover changed from yellowish to light brown, brown and dark brown by urea treatment at 30, 40 and 50 per cent moisture levels irrespective of incubation periods. The intensity of brownness increased as the incubation period increased. The treated stover was less coarse and more pliable than untreated one. Saenger *et al*. (1982) observed browning of the corn stover with NH_3 at room temperature. Buettner (1978) demonstrated that the browning of ammoniated wheat straw occured at room temperature and was more severe with increasing rate of ammonia, time of exposure and temperature. The brown and very dark colour at 40 and 50 per cent moisture compared to 30 per cent may be due to high temperature (Table 5) observed in 40 and 50 per cent moisture levels irrespective of the incubation period. Reddy *et al*. (1989a) recorded browning of sorghum straw on urea treatment and anhydrous ammonia treatment and dark brown colour on high moisture treated straw.

Urea ensilage of maize stover carried out in airtight polythene bags appears to be a practicable method as evidenced by the production of good quality treated stover except at 50 per cent moisture which apeared to be thick dark colour.

5.1.2 Temperature

The temperature of UTM (Table 5) recorded was significantly ($P<0.01$) lower on 30 per cent moisture level compared to 40 and 50 per cent moisture levels which were at par. However, the temperature recorded were not significantly different among the three incubation periods indicating that the temperature increased due to fermentation by the end of 1st week and continued till the end of 3rd week. The temperature recorded in this study was in accordance with the temperature reported by Knapp *et al* (1975) and Coombs *et al*. (1989).

5.1.3 pH

pH values ranged from 8.51 to 8.63 and were not affected either by the moisture levels or by the incubation periods indicating that urea treatment of maize stover (Table 6) maintained all the samples in alkaline condition. This was in accordance with the report of Dias - Da - Silva (1988) who reported pH values of 9.1 and 8.9 for urea (6%) treated maize stover at 40 and 50 per cent moisture level, respectively and incubated for 15 days. Mascarenhas-Ferreira *et al*. (1989) reported alkaline pH in urea treated meadow hay irrespective of incubation period.

5.1.4 Organic Matter

The organic matter content (Table 7) was significantly ($P<0.05$) higher at 40 per cent moisture compared to 30 per cent moisture. However, organic matter at 50 per cent moisture was comparable to that of 30 per cent as well as to 40 per cent moisture level. This indicates that moisture level of 40 per cent was optimum for retaining maximum quantity of organic matter.

The organic matter content recorded was significantly (P<0.01) higher at 2nd week. Organic matter content of 1 and 3 weeks was comparable. Increased crude protein content and decreased total ash at 40 per cent moisture and two weeks of incubation period might have reflected in increased organic matter.

5.1.5 Crude Protein

The crude protein content of UTM (Table 8) increased by 108.95, 111.93 and 106.25 per cent at 30 per cent moisture level, 115.77, 121.88 and 113.07 per cent at 40 per cent moisture level and 101.70, 96.73 and 84.23 per cent at 50 per cent moisture level for incubation periods of 1, 2 and 3 weeks, respectively. Crude protein content of UTM recorded was significantly (P<0.01) higher at 30 and 40 per cent moisture levels than at 50 per cent moisture level. However, the CP content was comparable at 30 and 40 per cent moisture levels.

Ramana et al. (1989) reported that the albumen fraction of protein from ammoniated straw was more soluble in water. This might be the probable cause for the decrease in CP content observed at 50 per cent moisture level. The CP values of UTM recorded were not significantly different among the three incubation periods indicating that the incubation period had no effect on CP content of UTM irrespective of moisture levels.

The N_2 retained from added urea was 66.85, 71.20 and 57.61 per cent on maize stover treated at 30, 40 and 50 per cent moisture levels, respectively indicating that 40 per cent moisture was optimum for retaining more N_2 from urea. The N_2 retention from added urea was 66.30, 67.39 and 61.96 per cent at 1, 2 and 3 weeks of incubation, respectively indicating that N_2 retention was more in the first two weeks. The decrease at 3rd week might be due to escape of NH_3 due to prolonged storage. The values of N_2 retention recorded in this experiment were within the range to the value (62.4%) reported by Dias-Da-Silva et al. (1988).

5.1.6 Crude Fibre

Crude fibre content of UTM (Table 9) recorded was significantly ($P<0.01$) lower at 40 per cent moisture compared to 30 and 50 per cent moisture levels, which were at par. However, the CF content of UTM at 40 per cent moisture level was reduced by only 0.57 percentage units. The CF values of UTM recorded were not significantly different among the three incubation periods indicating that incubation period had no effect on CF content of UTM. The decreased CF content of the treated straw was in confirmation with the report of Toro and Majgaonkar (1987) on urea treated rice straw.

5.1.7 Ether Extract

Ether extract values (Table 10) recorded were not significantly affected by moisture levels or by incubation periods indicating that neither the moisture level nor incubation period had any effect on ether extract content of urea treated maize stover. Toro and Majgaonkar (1987) also reported that EE content was not affected by urea treatment of rice straw.

5.1.8 Nitrogen-free Extract

The NFE content of UTM (Table 11) at 50 per cent moisture was significantly ($P<0.01$) higher than at 30 and 40 per cent moisture levels which were at par. Decreased protein at 50 per cent moisture level than the other moisture levels might have reflected in increased NFE content of UTM at 50 per cent moisture level. Incubation period had no effect on NFE content. This was in accordance with the report of Toro and Majgaonkar (1987) who reported that NFE content was not affected by urea treatment of rice straw.

5.1.9 Total Ash

Total ash content (Table 12) was significantly ($P<0.05$) higher at 30 per cent moisture level and lowest at 40 per cent moisture level. Total ash content at 50 per cent level was not significantly different from 30 and 40 per cent moisture levels.

The total ash content was significantly ($P<0.01$) higher at 3 weeks of incubation and lower at 2 weeks of incubation. The total ash content of UTM at 1 week was comparable to that of 2 and 3 weeks of incubation. Increased organic matter content at 40 per cent moisture level and 2 weeks of incubation period might have reflected in lower TA contents. Another reason being the solubulization of minerals at higher moisture level. However, Toro and Majgaonkar (1987) reported that ash content was not affected by urea treatment of rice straw.

5.1.10 Calcium

Calcium values (Table 13) were not significantly different among the moisture levels as well as the incubation periods indicating that neither moisture level nor period of incubation had effect on calcium content of maize stover. Reddy et al. (1989a) reported that calcium content of sorghum straw was not affected by urea and anhydrous ammonia treatments.

5.1.11 Phosphorus

Phosphorus values (Table 14) were comparable on all the moisture levels and at different incubation periods indicating that either moisture level or incubation period had no effect on this mineral. Reddy et al.

(1989a) reported that phosphorus content was not affected by urea treatment of sorghum straw.

5.1.12 Ammonia Nitrogen (NH_3-N)

The NH_3-N (mg/100 g) content (Table 15) recorded was significantly ($P<0.01$) higher with 40 per cent moisture followed by 30 and 50 per cent moisture levels, respectively indicating that 40 per cent moisture was optimum for retaining more NH_3 released from urea.

The NH_3-N content of UTM incubated for 2 and 3 weeks was comparable and significantly ($P<0.01$) higher than that of 1 week. This confirms the earlier reports that 3 weeks period was optimum for ammonia binding to substrate (Sundstol <u>et</u> <u>al</u>., 1978) and that ureolysis occurs upto 14 days (Hassoun <u>et</u> <u>al</u>., 1990).

5.1.13 Neutral Detergent Solubles

The NDS content (Table 16) recorded was highly significant ($P<0.01$) among the three moisture levels. Highest NDS value of 27.22 was observed with 40 per cent moisture followed by 26.07 with 30 per cent moisture and 24.17 per cent with 50 per cent moisture, respectively. This indicate that 40 per cent moisture was optimum for urea treatment where solubulization of minerals and fibre fractions could take place. The increased NDS content was reflected by concomitant decrease in NDF fraction (Dias-Da-Silva, 1988). The decreased NDS at 50 per cent moisture level might be due to seepage of certain water soluble nutrients like crude protein. However, NDS content observed was not significantly different among the three incubation periods indicating that treatment period had no effect on this fraction. This was in accordance with the report of Dias-Da-Silva et al. (1988) in urea treated maize stover.

5.1.14 Neutral Detergent Fibre

The NDF content (Table 17) recorded was significantly ($P < 0.01$) lower at 40 per cent moisture level compared to 30 and 50 per cent moisture levels which were at par indicating that 40 per cent moisture was optimum for treating maize stover with urea. Decreased NDF content on urea treated meadow hay was due to decrease in hemicellulose content and to a lesser extent in lignin content (Mascarenhas-Ferreira et al., 1989). However, the decreased NDF in the present study was reflected by decreased cellulose content without any effect on hemicellulose. Decreased NDF content due to urea treatment was reported by Dias-Da-Silva (1988) in maize stover, Hassoun et al. (1990) in bagasse and Kiangi and Kategile (1981) in low quality roughage.

5.1.15 Acid Detergent Fibre

The ADF content (Table 18) recorded was significantly ($P < 0.01$) lower at 40 per cent moisture level followed by 30 per cent moisture and 50 per cent moisture, respectively. The ADF content of UTM was significantly ($P < 0.05$) different among the three incubation periods. The ADF content gradually decreased from 1 to 3 weeks of incubation period. ADF content followed the same trend as that of NDF. Decreased ADF content on ammoniation of different roughages was reported by Reddy and Reddy (1984). Decreased ADF content on urea treatment compared to ammonia treatment of rye grass hay was reported by Coombs et al. (1989). However, the present results were contradictory to the observation of Hassoun et al. (1990) who reported that urea treatment significantly increased ADF content with moisture and incubation periods.

5.1.16 Hemicellulose

Hemicellulose values (Table 19) recorded were not significantly different among the three moisture levels and also among the three incubation periods. This was in accordance with the report of Craig et al. (1988) who reported little or no loss of hemicellulose due to urea treatment in Alicia Bermuda grass. However, the values recorded in the present study were contradictory to the reports of Mascarenhas-Ferreira (1989) in meadow hays and Hassoun *et al*. (1990) in bagasse who reported decreased hemicellulose on urea treatment.

5.1.17 Cellulose

Cellulose content (Table 20) recorded was highly significant ($P < 0.01$) among the three moisture levels with lowest value at 40 per cent moisture followed by 30 and 50 per cent moisture.

Cellulose content recorded was significantly ($P < 0.01$) different among the three incubation periods which decreased gradually from 1st week to 3rd week. Cellulose content recorded in this experiment followed the same trend as that of ADF and NDF indicating that decreased ADF and NDF was a reflection of solubulization of cellulose. However, these observations were contradictory to the reports of Mascurenhas-Ferreira (1989) in meadow hay, Hassoun *et al*. (1990) in bagasse who recorded increased cellulose content due to urea treatment.

5.1.18 Lignin

Lignin content (Table 21) was significantly ($P < 0.01$) higher at 40 per cent moisture compared to 30 per cent. However, the lignin content at 50 per cent moisture was comparable to that of 30 and 40 per cent moistures indicating that lignin was not much affected by moisture level confirming the report of Tinnimit (1990).

The lignin content of UTM at 3 weeks incubation was significantly (P<0.01) higher but was cmparable at 1 and 2 weeks. This was contradictory to the report of Mascurenhas-Ferreira (1989) who recorded reduced lignin content by increasing the treatment period in meadow hays. However, increase in lignin content on urea treatment of maize straw was reported by Alhasan and Aliyu (1991). No change in lignin content on ammoniation was recorded by Kumar et al. (1982) in bagasse and Reddy and Reddy (1984) in rice straw.

5.1.19 Silica

Silica content (Table 22) of UTM at 50 per cent moisture level was significantly (P<0.01) lower than at 30 and 40 per cent levels. However, silica content was comparable at 30 and 40 per cent moisture levels. Silica content was significantly (P<0.01) higher at 2 weeks of incubation period while it was comparable at 1 and 3 weeks of incubation periods. The increase in silica content compared to untreated maize stover (1.43%) was in confirmation with the report of Alhassan and Aliyu (1991). Increased silica content on ammonia treatment was reported in rice straw, groundnut hulls and sunflower straw by Reddy and Reddy (1984).

5.1.20 *In Vitro* Dry Matter Digestibility

The *in vitro* dry matter digestibility of UTM (Table 23) was comparable at 40 and 50 per cent moisture levels but significantly (P<0.01) higher than at 30 per cent moisture level indicating that a minimum of 40 per cent moisture was required for proper fermentation of maize stover. Yadav and Yadav (1988a) reported that different straws respond differently to gradients of moisture treatment during ammoniation. Mikami *et al*. (1986) reported proportionate increase in IVDMD of straw upto 30 per cent moisture level followed by gradual increase upto 40 per cent level. Raising the moisture content from 20 to 40 per cent increased IVDMD by about 1 per cent in maize, wheat and rice straws treated with different sources of ammonia (Kiangi and Kategile, 1981). However, Waiss *et al*. (1972) indicated that the variation of moisture within the range of 20 to 40 per cent had no important contribution to IVDMD of ammoniated crop residues.

In vitro dry matter digestibility of UTM at 2 weeks incubation period was significantly (P<0.01) higher than at 1 and 3 weeks incubation periods which were at par. This indicate that a minimum period of 2 weeks was required for optimum curing of UTM and that further increase in the incubation period for more than 2 weeks had no beneficial effect. The lower dry matter digestibility at 3 weeks of incubation may be a reflection of decreased OM and increased total ash content at this period. Kiangi and Kategile (1981) reported very small (about 1%) increase in IVDMD between 15 and 30 days reaction time when maize, wheat and rice straws were treated with different sources of ammonia.

The range of IVDMD of UTM recorded in this experiment (46.31 to 50.66) was optimum and comparable to the reported values of Alibes et al. (1983/84) and Joy et al. (1992).

5.1.21 *In Vitro* Organic Matter Digestibility

In Vitro organic matter digestibility observed in this study (Table 24) was highly significant (P<0.01) among the three moisture levels. The organic matter digestibility values at 40 and 50 per cent moisture levels were at par and significantly (P<0.01) higher than that of 30 per cent moisture level indicating that a minimum of 40 per cent moisture was required for obtaining optimum organic matter digestibility. OM digestibility was in accordance with IVDMD. Kiangi and Kategile (1981) reported an increase of about 1 per cent in IVOMD in maize, wheat and rice straws treated with different sources of ammonia when moisture content increased from 20 to 40 per cent. However, ammoniation of crop residuces at 20 - 40 per cent moisture (Waiss et al., 1972) and maize stover at 40 - 60 per cent moisture

(Dias-Da-Silva *et al.*, 1988) had no important contribution to IVOMD.

Though, the *in vitro* organic matter digestibilities of UTM at 1, 2 and 3 weeks of incubation were not significantly different, it followed the same trend as that of IVDMD. Increased IVOMD due to increased time of incubation was reported by Kiangi and Kategile (1981) in maize, wheat and rice straws treated with different sources of ammonia and Dias-Da-Silva *et al.* (1988) in urea treated maize stover.

The results of this study indicate that ammoniation of maize stover resulted in brown to dark brown and more pliable material. Further, the crude protein content was almost doubled with a concomitant reduction in nitrogen-free extract and crude fibre contents. While cell contents increased, fibre fraction especially cellulose content decreased due to urea treatment.

The moisture level of 40 per cent appears to be optimum for urea treatment of maize stover as evidenced by increased OM, CP, NH_3-N, cell contents, IVDMD and IVOMD and decreased total ash, CF and cell wall constituents. Further, UTM at 50 per cent moisture resulted in very dark material with mould growth here and there. Incubation for 3 weeks had no advantage over 2 weeks because of higher OM and cellulose contents and lower total ash and lignin contents and higher IVDMD recorded at 2 weeks incubation. Though, the 2 weeks treatment showed higher IVDMD over 1 week incubation, the latter was at par with the former with regards to the content of all the constituents except cellulose.

Hence, maize stover treated at 40 per cent moisture and incubated for 1 and 2 weeks was further evaluated in digestion experiments using adult sheep and goats to assess the effect of incubation period for UTM on nutrient digestibility and nutritive value.

5.2 DIGESTION STUDIES IN ADULT SHEEP AND GOATS

Maize stover treated with 4 per cent urea at 40 per cent moisture level was incubated for 1 week (ration 1) and 2 weeks (ration 2) were tested for voluntary feed intake and nutrient utilization by feeding to adult sheep and goats *ad libitum* without any supplement.

5.2.1 Voluntary Feed Intake

The dry matter intake (Table 25) was only 62 and 53.33; 66.40 and 58.33 per cent of dry matter requirements suggested by ICAR (1985) for sheep and goats on rations 1 and 2, respectively. This indicate that both the species of animals could not relish urea treated maize stover (UTM) as sole ration. The voluntary dry matter intake was significantly ($P<0.05$) higher in goats than in sheep. This confirms the report of

Chandrasekharaiah (1989) who observed higher voluntary dry matter intake in goats than in sheep on sorghum straw based rations.

The voluntary feed intake was significantly (P<0.01) higher on the maize stover incubated for 2 weeks (ration 2). There was 8.09 and 8.78 per cent increase in daily dry matter intake with ration 2 as compared to ration 1 in sheep and goats, respectively. This indicate that the UTM incubated for 2 weeks (ration 2) was more palatable than that incubated for 1 week (ration 1). Increased pliability and succulant nature of the stover treated for 2 weeks (ration 2) might be the probable cause for higher DM intake recorded on this ration compared to ration 1. The voluntary intakes of dry matter among sheep and goats in this study were comparable to the observations of Joy et al. (1992) and Singh and Negi (1985).

5.2.2 Voluntary Water Intake

The water intake per kg dry matter intake (Table 25) was not significantly different among the two rations indicating that extending the incubation period of UTM from 1 to 2 weeks had no effect on water requirements of animals. Further, the water intake per kg DMI was significantly (P<0.01) higher in sheep than in goats and this may be attributed to species difference. This was in accordance with the report of Govindaiah et al. (1991) with maize stover based rations.

5.2.3 Dry Matter Digestibility

Perusal of the data in Table 26 reveal that the digestibility coefficients of dry matter was significantly ($P<0.01$) higher on ration 2 than on ration 1 in sheep and goats. Increased dry matter digestibility on ration 2 may be due to reaction with lignin-carbohydrate complex (Knapp et al., 1974) by increasing the treatment time.

The digestion coefficients of dry matter among sheep and goats were not significantly different indicating that both species were equally efficient in digesting the UTM. This confirms the report of Govindaiah at al. (1991) on maize stover based rations. The dry matter digestibility coefficients recorded in this study were optimum and comparable to the values recorded by Joy et al. (1992) on urea treated maize stover in Angora breed wethers, Rahman et al. (1987) on urea treated wheat straw in calves and Tuen et al. (1991) on urea treated rice straw in goats.

5.2.4 Organic Matter Digestibility

There was an increase of 8.94 and 9.63 per cent in organic matter intake of ration 2 as compared to ration 1 in sheep and goats, (Table 27) respectively.

and goats. The increased CP digestibility on ration 2 may be due to dissociation of phenolic compounds from cell walls of maize stover, thus making more structural carbohydrates available as an energy source for optimum microbial fermentation of protein in the rumen (Dias-Da-Silva et al., 1988).

Further, the CP digestibility among sheep and goats was not significantly different indicating that both the species were equally efficient in utilizing CP from UTM. The crude protein digestibilities observed in this study were comparable to the values reported by Morris and Mowat (1980) on ammoniated corn stover in steers.

5.2.6 Crude Fibre Digestibility

Crude fibre intake on ration 2 was 7.82 and 8.50 per cent higher in sheep and goats respectively. This might be due to increased pliability due to increased incubation period (2 weeks) compared to ration 1 (1 week). Crude fibre digestibility (Table 29) was significantly ($P < 0.01$) higher on ration 2 as compared to ration 1. The higher digestibility of CF with ration 2 may be due to the disruption of hydrogen bonds between adjacent polysaccharide molecules (Bacon, 1979) and cleavage of ester linkages causing alteration in binding between insoluble corbohydrates (Klopfenstein, 1978).

The crude fibre digestibilities observed in this study among sheep and goats were comparable to the reports of Rahman et al. (1987) in Hariana calves fed with urea treated (4% urea, 55% moisture and stored for 4 weeks) wheat straw as sole feed. Further, the CF digestibility among sheep and goats was not significantly different indicating that both the species of animals were equally efficient in utilizing CF from UTM. This was in agreement with the report of Govindaiah et al. (1991) on maize straw based rations.

5.2.7 Ether Extract Digestibility

Ether exdtract intake on ration 1 was 18.25 and 17.25 per cent higher in sheep and goats, respectively and this may be due to higher EE content of this ration. Perusal of Table 30, indicate that the ether extract digestibility was not significantly different between the two rations indicating that extending the period of incubation from 1 week to 2 weeks had no influence on ether extract digestibility. Further, sheep and goats were comparable in digesting EE from UTM confirming the report of Chandrasekharaiah (1989) on sorghum straw based rations.

5.2.8 Nitrogen-free Extract Digestibility

Nitrogen-free extract intake on ration 2 was 10.01 and 10.70 per cent higher in sheep and goats, respectively and this was in accordance with dry matter intake. Nitrogen-free extract digestibility data (Table 31) indicated that the digestibility of this nutrient was significantly ($P < 0.01$) higher in animals fed ration 2 than ration 1 indicating that extending the incubation period from 1 week to 2 weeks was beneficial. This might be due to the fact that the maize stover incubated for 2 weeks was more pliable compared to that incubated for 1 week. The NFE digestibility recorded on ration 2 in both the species of animals was comparable to the values reported by Rahman et al. (1987) in calves fed urea treated (4% urea, 55% moisture and stored for 4 weeks) wheat straw. The NFE digestibility was comparable in sheep and goats confirming the report of Govindaiah et al. (1991) on maize straw based rations.

5.2.9 Nutritive Value of Urea Treated Maize Stover

Digestible crude protein (DCP) content was significantly ($P < 0.01$) higher on ration 2 than on ration 1 (Table 32) and this may be a reflection of higher crude protein digestibility on ration 2. However, the DCP contents of two rations were higher than the recommended values of 4.80 and 3.89 in sheep and goats, respectively (ICAR, 1985). DCP contents among sheep and goats were not significantly different and was in accordance with their crude protein digestibilities.

The DCP intakes in both the species were lower on ration 1 than on ration 2 and this may be due to lower DCP content of ration 1. However, both the species of animals have met the DCP requirements suggested by ICAR (1985, sheep 30 g and goats 23.33 g) only on ration 2.

Total digestible nutrients (TDN) content was significantly ($P < 0.01$) higher on ration 2 than on ration 1 in both the species (Table 32). This was a reflection of higher digestibilities of all the nutrients on ration 2 compared to ration 1 in both the species. While TDN content was lower than the recommended values of ICAR (1985, sheep 48 and goats 44.44%) on ration 1. The TDN content of ration 2 was at par with recommended level in sheep and higher than the recommended value in goats.

The TDN intakes of both the rations in sheep and goats were lower than the recommended levels (ICAR, 1985). This may be due to lower dry matter intake from both the rations than the recommended level. Further, the lower TDN intake on ration 1 than on ration 2 in both the species may be attributed to lower digestibilities of all the nutrients recorded on ration 1.

The results of digestion trial in sheep and goats showed that the digestibilities of all the nutrients from urea treated maize stover incubated for 2 weeks were higher than that incubated for 1 week. Hence, incubation period of 2 weeks was selected for experiments in the second phase to evaluate effect of feeding UTM on growth and nutrient utilization in lambs and kids.

5.3 UTILIZATION OF UREA TREATED MAIZE STOVER IN LAMBS AND KIDS

Eighteen weaned Nellore lambs and eighteen weaned local kids (6 in each group) were used to study the effect of the following three rations on growth and nutrient utilization using a randomized block design.

1. Urea treated maize stover + concentrate feed pellet
2. Urea treated maize stover + sun hemp hay meal in 70 : 30 ratio and
3. Urea treated maize stover + subabul leaf meal in 70 : 30 ratio.

5.3.1 Processing of Experimental Feeds

The production performance of the mill for the pelleting of concentrate feed was 857 kg/hr and this production rate was optimum, against the capacity of the plant one tonne/hour, because poultry droppings, a less dense material was used upto 30 per cent level. Similar production rate was reported by Govindaiah (1989), Goud (1986) and Malla Reddy (1991). The production performance for chopping of maize stover and sunhemp hay was 500 and 469 kg/hr, respectively. The low production performance of sunhemp hay than maize stover was mainly due to its fibrous nature.

5.3.2 Chemical Composition of the Experimental Rations

The chemical composition of untreated maize stover (Table 33) was comparable to poor quality crop residues. The chemical composition of maize stover recorded in this study was comparable to that of Govindaiah _et al_. (1991), Alibes _et al_. (1983/84), Chauhan (1985) and Brzoska and Mucha (1985).

Urea treatment of maize stover resulted in increased crude protein which was reflected by decreased CF and NFE. Urea treatment resulted in increase of cell contents and corresponding decrease in cell wall constituents (NDF, ADF and cellulose). The chemical composition of UTM recorded in this study was comparable to the reports of Morris and Mowat (1980), Alibes _et al_. (1983/84), Alhassan and Aliyu (1991) and Joy _et al_. (1992).

The chemical composition of dried poultry droppings used in this study was comparable to the reports of Lowman and Knight (1970), Jayal and Misra (1971), Reddy and Prasad (1982) and Fontenot *et al.* (1983). The chemical composition of sunhemp hay used in this study was comparable to the values reported by Katiyar and Ranjhan (1969), Reddy and Murthy (1972) and Venkata Rao (1989). The chemical composition of subabul leaf meal used in this study was comparable to the reports of Singh and Mudgal (1967), D'mello and Fraser (1981), Dharma Raju (1983), Dogra *et al.* (1986), Bhaskar *et al.* (1987), Gupta *et al.* (1988), Yadav and Yadav (1988b) and Srinivasulu (1990). Gross energy content of leguminous fodders (sunhemp hay meal and subabul leaf meal) used in this study was comparable to the reports of Rangnekar *et al.* (1983) and Costa *et al.* (1991).

5.3.3 Cost Economics

The total cost of processing (Table 34) of maize stover, sunhemp hay and concentrate feed (pellet) was Rs. 1.15, 1.24 and 13.40 per quintal. The processing (which involvd chopping only) cost of maize stover and sunhemp hay meal was comparable. The higher processing cost of concentrate feed (pellet) compared to maize stover and sunhemp hay meal may be due to extra processing required, like grinding and pelleting for former. However, the cost of processing of concentrate (Rs. 13.40) was higher than that recorded by Govindaiah

(1989) and Malla Reddy (1991) due to increased cost of power, diesel and labour wages.

5.3.4 Growth Studies

The average daily gain (ADG) recorded on all the three rations (Table 36 a,b) was not significantly different. However, the ADG on ration 2 was 18.36 and 14.18 per cent lower compared to rations 1 and 3, respectively, which were at par indicating that sunhemp hay was inferior to concentrate feed (pellet) and subabul leaf meal in promoting growth in lambs and kids. Subabul leaf meal was comparable to concentrate feed (pellet) in supporting the growth in both species. The higher ADG in both the species on ration 1 might be due to increased propionic acid production in the rumen due to the presence of poultry litter in concentrate feed (Fernandez and Hughes-Jones, 1981 and Marrufo, 1984). High protein content in subabul leaf meal (30.18%) compared to sunhemp hay meal (18.87%) might have contributed for higher ADG on ration 3 compared to ration 2. Improved growth rates in rams by supplementing urea treated rice straw with leucaena leaves was reported by Cheva-Isarakul (1990). The weight gains on ration 1 was within the range reported by Abu-Izzeddin and Lakpini (1985) in lambs fed with dried poultry waste based concentrate feeds. The ADG in lambs and kids recorded in this study was comparable to that reported by Adejumo and Ademosun (1991) on Leucaena leucocephala and Panicum maximum leaves based diets.

The average daily gains of lambs were significantly ($P < 0.01$) higher compared to kids indicating that the formar utilized these rations better than the latter for growth purpose. The lower DM intake in kids compared to lambs (Table 37) might have also contributed for low ADG recorded in the former. The ADG recorded in lambs and kids was optimum and comparable to the reported ADG of Katiyar et al. (1972) on different roughage : concentrate ratios, Zaheeruddin (1977) on different hay and concentrate rations and Reddy (1983) on mixed grass hay and sorghum straw based complete rations (pellets) in lambs and Venkatramana (1991) on different protein : energy ratios in kids.

The DM intake per kg weight gain (Feed efficiency) was 19.97 and 18.74 and 6.47 and 5.76 per cent lower with ration 1 compared to ration 2 and 3 in both species indicating that concentrate feed was superior to leguminous fodders (sunhemp hay meal and subabul leaf meal). Feed required/kg gain on ration 3 was 14.43 and 13.77 per cent lower compared to ration 2 in lambs and kids, respectively indicating that ration 3 containing subabul leaf meal was superior to ration 2 containing sunhemp hay meal. The feed efficiency values were optimum and comparable to the reports of Craddock et al.

(1974) in lambs fed different roughage : concentrate ration, Ninova (1979) in lambs fed lucern hay and concentrate based rations and Reddy (1983) in lambs fed mixed grass hay and sorghum straw based complete rations. However, feed required per unit weight grain was 23.16 per cent lower in lambs compared to kids indicating that the former were superior in utilizing these rations. Superiority of lambs over kids in utilizing nutrients for growth prupose was reported by Adejumo and Ademosun (1991).

The cost of feed per kg live weight gain (Table 37) was Rs. 1.88 and 3.40 and 2.46 and 4.05 higher on ration 1 compared to rations 2 and 3 in lambs and kids, respectively and was a reflection of higher cost of concentrate feed used in ration 1 compared to sunhemp hay meal and subabul leaf meal. However, the cost of feed/kg gain was lower than the reported values of Reddy (1983) and Venkata Ramana (1991). Cost of feed/kg gain was Rs. 0.58 and 0.65 less on ration 3 compared to ration 2 in lambs and kids, respectively and was a reflection of low DM intake/kg gain on ration 3. Cost of feed per kg gain was Rs. 3.31 less in lambs compared to kids.

The results of growth study indicate that concentrate feed had better feed efficiency compared to sunhemp hay meal or subabul leaf meal though the cost of feed/kg gain was more on this ration. Further, subabul leaf meal was superior to sunhemp hay meal in supporting growth in lambs and kids. Lambs were superior to kids in utilizing the nutrients from these rations for growth purpose.

5.3.5 Metabolic Studies in Lambs and Kids

5.3.5.1 Voluntary Feed intake : The voluntary DM intake recorded on ration 1 was significantly ($P < 0.01$) lower than on rations 2 and 3 which were at par (Table 38 a, b). The DM intake was 10.33 and 8.33 per cent less on ration 1 compared to rations 2 and 3, respectively. This indicate that UTM which was fed separately in ration 1 was less palatable to the experimental animals. Further, mixing of leguminous fodders (sunhemp hay in ration 2 and subabul leaf meal in ration 3) with UTM might have increased the palatability and thus resulted in higher DM intake on these rations. Kodandaramireddy (1986) reported increased dry matter intakes on Berseem hay + wheat straw based complete feeds compared to conventional rations in crossbred bulls.

The voluntary dry matter intake (Table 38 a, b) was significantly ($P < 0.01$) higher in lambs than in kids. The DM intake was 14.94 per cent higher in lambs compared to kids. These results were in agreement with the report of Adejumo and Ademosun (1991) who reported that goats ate less than sheep when fed with different levels of fresh Leucaena leucocephala leaves and chopped fresh Panicum maximum. Reddy et al. (1992) reported higher DMI/100 kg body weight in sheep than in goats fed with sugarcane bagasse.

5.3.5.2 **Voluntary Water Intake** : Voluntary water intake/kg DMI in lambs and kids (Table 38 a, b) was significantly ($P < 0.01$) higher on ration 1 compared to rations 2 and 3, which were at par. Water intake was 28.97 and 27.19 per cent higher on ration 1 compared to rations 2 and 3, respectively. This might be due to the use of pellets in ration 1 instead of leguminous fodders in rations 2 and 3. Increased water intake on sorghum straw based pelleted ration was reported by Chandrasekharaiah (1989) in sheep and goats. Water intake/kg DMI in lambs was significantly ($P < 0.01$) higher than in kids. Water intake was 29.76 per cent higher in lambs compared to kids. Increased water intake in sheep than in goats was observed by Govindaiah (1989) on maize stover based rations.

5.3.5.3 **Dry matter digestibility** : Perusal of the data in Table 39 a,b indicate that the digestion coefficients of dry matter among the three rations were significantly ($P < 0.01$) different. The dry matter digestibility observed was higher for ration 2 followed by ration 3 and ration 1. The DM digestibility was 6.85 and 4.83 per cent less on ration 1 compared to rations 2 and 3, respectively. Ration 2 recorded 2.02 per cent higher DM digestibility than ration 3. This indicate that inclusion of legume fodders in the rations 2 and 3 increased the dry matter digestibility compared to concentrate pellets in ration 1. Further, sunhemp hay meal was better utilized than subabul leaf meal. The dry matter digestibilities recorded in this experiment were comparable to those reported by Smith and Calvert (1976) on soyabean meal/poultry excreta based rations in sheep, Balaraman and Venkata Krishnan (1974) on sunhemp hay meal based rations in sheep and Cheva-Isarakul (1990) on urea treated rice straw supplemented with fresh leucaena leaves in rams.

The dry matter digestibility was significantly ($P < 0.01$) higher in kids than in lambs. The dry matter digestibility was 6.72 per cent higher in kids compared to lambs. Higher DM digestibilities in goats than in sheep was observed by Devendra (1982) on Leucaena leucocephala based rations, Chandrasekharaiah (1989) on Jowar straw based rations, Reddy et al. (1991) on sunflower straw based rations and Reddy et al. (1992) on sugar cane bagasse based rations.

5.3.5.4 Organic matter digestibility : The data in Table 40 a,b indicate that there was an increase of 11.97 and 6.26 per cent in organic matter intake on ration 3 compared to rations 1 and 2, respectively. The

OM intake was 5.37 per cent higher on ration 2 compared to ration 3. The differences in OM contents of concentrate and leguminous fodders as well as OM intake on different rations might be the reason for differences in OM intake. Further, OM intake was 34.11 per cent higher in lambs compared to kids and this was in accordance with DM intake.

The organic matter digestibility was significantly ($P < 0.01$) higher on ration 2 followed by ration 3 and 1. The OM digestibility was 2.13 and 5.32 per cent higher on ration 2 compared to ration 3 and 1, respectively. The OM digestibility on ration 3 was 3.19 per cent higher than on ration 1. These results indicate that the organic matter from leguminous fodders (sunhemp hay meal and subabul leaf meal) were better utilized compared to concentrate pellets. Further, the OM from sunhemp hay meal was better utilized than that from subabul leaf meal. These results were in accordance with the report of Malla Reddy (1991) who indicated that organic matter from sunhemp hay based complete diets was better utilized compared to subabul forage meal based complete diets in crossbred bulls. The organic matter digestibility recorded in this experiment was comparable to those reported by Smith and Calvert (1976) on poultry excreta based rations in sheep, Balaraman and Venkata Krishnan (1974) on sunhemp hay based rations in rams and Chakraborty and Ghosh (1988) on subabul based rations in goats.

The apparent digestibility coefficient for organic matter was significantly ($P < 0.01$) higher in kids than in lambs. The organic matter digestibility was 7.89 per cent higher in kids compared to lambs. Higher organic matter digestibility in goats than in sheep was recorded on *Leucaena leucocephala* based rations (Devendra, 1982), Jowar straw based rations (Chandrasekharaiah, 1989), sunflower straw based rations (Reddy *et al*., 1991) and sugar cane bagasse based rations (Reddy *et al*., 1992).

5.3.5.5 Crude protein digestibility : There was an increase of 21.62 and 23.72 per cent in crude protein intakes of ration 3 compared to rations 1 and 2, respectively (Table 41 a,b) and this may be attributed to high crude protein content of subabul leaf meal (30.18%) in ration 3 compared to concentrate pellet in ration 1 and sunhemp hay meal in ration 2 (21.13 and 18.87%). Further, the CP intake was 22.84 per cent higher in lambs compared to kids and this was in accordance with DM intake.

The digestibility coefficients of crude protein were comparable between 2 and 3 rations, but significantly ($P < 0.01$) higher than ration 1 irrespective of the species indicating that the CP from leguminous fodders was more soluble compared to crude protein from concentrate pellet containing poultry droppings. Though, the crude protein content was higher in subabul leaf meal than in sunhemp hay meal, the digestibility of crude protein was comparable on both the rations. This may be attributed to the presence of an antimetabolite, mimosine in subabul leaf meal which reduced the crude protein digestibility in buffaloe calves (Akbar and Gupta, 1985) and in crossbred bulls (Reddy et al., 1987). The CP digestibility recorded in this study was comparable to those reported by Parigi-Bini (1969) on diets containing dehydrated layer waste in sheep, Smith and Calvert (1976) on dried poultry excreta containing rations in sheep, Katiyar and Ranjhan (1969) on sunhemp hay based rations in Kherigarh bullock, Jayal and Johri (1977) on sunhemp hay meal based rations in goats, Chakraborty and Ghosh (1988) on subabul leaf meal based rations in goats and Cheva-Isarakul (1990) on rations containing urea treated rice straw and fresh leucaena leaves in rams.

The CP digestibility coefficients were significantly ($P < 0.01$) higher in kids than in lambs. The crude protein digestibility was 8.91 per cent higher in kids compared to lambs. Crude protein digestibility was higher in goats than in sheep when fed with rations containing *Leucaena leucocephala* (Devendra, 1982), Jowar straw (Chandrasekharaiah, 1989) and sugar cane bagasse (Reddy et al., 1992).

5.3.5.6 Crude Fibre Digestibility : There was an increase of 13.80 and 11.17 per cent crude fibre intake on ration 2 compared to rations 1 and 3, respectively (Table 42 a,b) and this may be attributed to high crude fibre content of sunhemp hay meal compared to concentrate pellet and subabul leaf meal. Further, CF intake was 41.54 per cent higher in lambs than in kids and this was in accordance with DM intake.

The crude fibre digestibility was significantly (P<0.01) lower for ration 1 compared to rations 2 and 3 indicating that crude fibre from leguminous fodders (sunhemp hay meal and subabul leaf meal) was better utilized compared to concentrate pellets. Higher CF digestibility on ration 2 compared to ration 3 indicate that the CF from sunhemp hay meal was more digestible than that from subabul leaf meal. The CF digestibility recorded in this study confirms the reports of Parigi-Bini (1969) and Zgajner (1975) on dried layer waste based rations in sheep, Katiyar and Ranjhan (1969), Balaraman and Venkatakrishnan (1974) and Jayal and Johri (1977) on sunhemp hay based rations in sheep and Devendra (1982) on Leucaena leucocephala based rations in sheep and goats and Chakraborty and Ghosh (1988) with subabul in goats.

The crude fibre digestibility in kids was significantly (P < 0.01) higher than in lambs. Higher crude fibre digestibility in goats than in sheep was recorded on rations containing *Leucaena leucocephala* (Devendra, 1982), Jowar straw (Chandrasekharaiah, 1989), sunflower straw (Reddy *et al*., 1991) and sugarcane bagasse (Reddy *et al*., 1992).

5.3.5.7 Ether extract (EE) digestibility : There was an increase of 63.28 and 48.21 per cent in ether extract intakes on ration 3 compared to 1 and 2 rations, respectively (Table 43 a,b). Further, the EE intake was 10.16 per cent higher on ration 2 compared to ration 1. This may be attributed to differences in their EE contents and DM intakes. Ether extract intake was 27.45 per cent higher in lambs than in kids and this was in accordance with DM intake.

The digestibility coefficients of ether extract observed in this study were comparable between rations 2 and 3, but significantly (P < 0.01) lower than ration 1 irresepctive of the species. These results indicate that ether extract from leguminous supplements used in this study was less digestible than that from concentrate pellets. This might be due to the presence of pigments like chlorophyll, xanthophyll etc., in the leguminous fodders which cannot be digested by the animals but accounted in EE fraction. Parigi-Bini

(1969) recorded higher EE digestibility in sheep (78.7 to 85.7%) on rations containing concentrates compared to the EE digestibility recorded by Chakraborty and Ghosh (1988) in goats (75.06%) fed on subabul foliage ad libitum and Venkata Rao (1989) in sheep (75.32%) fed on complete feed containing NB21 and sunhemp hay.

The ether extract digestibility coefficients were significantly ($P < 0.01$) higher in kids than in lambs. This confirms the reports of Reddy et al. (1991) on sunflower straw based rations and Reddy et al. (1992) on sugarcane bagasse based rations.

5.3.5.8 Nitrogen-free extract digestibility : There was an increase of 13.20 and 12.57 per cent in nitrogen-free extract intakes on ration 3 compared to rations 1 and 2, respectively (Table 44 a,b), which were at par. The higher nitrogen-free extract intake on ration 3 may be due to higher NFE content in subabul leaf meal (43.05%) and also higher dry matter intake on this ration. Though the dry matter intake on ration 2 was higher than on ration 1, the lower NFE content of sunhemp hay meal compared to concentrate feed might be the probable cause for comparable NFE intakes on these two rations. NFE intake was 35.27 per cent higher in lambs than in kids and this was in accordance with DM intake.

The nitrogen-free extract digestibility was significantly ($P < 0.01$) higher on ration 2 followed by ration 3 and 1 irrespective of the species. These results indicate that nitrogen-free extract from leguminous fodders was better digested than that of concentrate pellets. Further, the NFE from sunhemp hay meal was more digestible than that of subabul leaf meal. This confirms the reported values of NFE digestibility by Parigi-Bini (1969) and Salo et al. (1975) on rations containing poultry waste in sheep, Katiyar and Ranjhan (1969), Reddy and Murthy (1972) in bullocks and Balaraman and Venkatakrishnan (1974) in rams fed on sunhemp hay and Chakraborty and Ghosh (1988) in goats and Gupta et al. (1989) in bulls fed on rations containing subabul leaf meal.

The apparent digestibility of nitrogen-free extract was significantly ($P < 0.01$) higher in kids than in lambs. Higher nitrogen-free extract digestibilities were observed in goats than in sheep on rations containing jowar straw (Chandrasekharaiah, 1989), sunflower straw (Reddy et al., 1991) and sugar cane bagasse (Reddy et al., 1992).

5.3.5.9 Energy digestibility : There was an increase of 11.41 and 7.03 per cent in energy intakes on ration 3 compared to rations 1 and 2, respectively (Table 45 a,b). Further, the energy intake was 4.09 per cent higher on ration 2 compared to ration 1 and this was in accordance with the energy contents of concentrate pellet (3.51 kcal/g), sunhemp hay meal (4.01 kcal/g) and subabul leaf meal (4.15 kcal/g) in the resepctive rations. Further, the energy intake was 34.63 per cent higher in lambs than in kids and this was in accordance with DM intake.

The digestion co-efficients of enrgy observed in this study were comparable between 2 and 3 rations, but significantly ($P < 0.01$) higher than on ration 1 irrespective of the species. The energy digestibility was 4.89 and 4.97 per cent higher on rations 2 and 3, respectively compared to ration 1. The higher digestibility of energy on rations 2 and 3 may be attributed to high energy content of leguminous supplements compared to concentrate pellets and also to higher dry matter digestibilities recorded on these rations. The energy digestibilities observed in this study were within the range reported by Morris and Mowat (1980) in Hereford Angus yearling steers on ammoniated corn stover and Lowman and Knight (1970) in sheep on poultry waste and barley based rations.

The digestibility of energy was 5.70 per cent higher in kids compared to lambs. Significantly ($P < 0.01$) higher digestibility of energy in kids than in lambs might be due to the fact that kids utilized fibrous residues more efficiently as compared to lambs as reflected by higher CF digestibility recorded in kids (Table 45 a,b). Several reports indicated that goats were more efficient digesters of forage, especially the fibre fraction, than other domestic animals (Ademosun, 1970 a, b; Gihad, 1976b; Devendra, 1977 a, b; Sharma and Rajora, 1977).

5.3.5.10 Digestibility of Neutral Detergent Solubles (NDS) : There was an increase of 13.39 and 22.72 per cent in NDS intakes on ration 3 compared to rations 1 and 2, respectively (Table 46 a,b) and the NDS intake was 8.23 per cent higher on ration 1 compared to ration 2. The differences in NDS intakes were due to differences in NDS content and DM intake on different rations. Further, the NDS intake was 20.28 per cent higher in lambs compared to kids and this was in accordance with DM intake.

Perusal of Table 46 a,b indicated that the digestibility coefficients of neutral detergent solubles (NDS) on ration 3 were significantly ($P < 0.01$) higher than on ration 1. However, the digestibility coefficients of NDS among the rations 2 and 3 and rations 1 and 2 were not significantly different. This indicate that NDS from subabul leaf meal was more digestible followed by sunhemp hay meal and concentrate pellets.

The apparent digestibility coefficient for NDS was significantly (P<0.01) higher in kids than in lambs. The NDS digestibility was 11.99 per cent higher in kids compared to lambs. Higher NDS digestibility in goats than in sheep was observed on rations containing jowar straw (Chandrasekharaiah, 1989) and sugarcane bagasse (Reddy et al., 1992).

5.3.5.11 Digestibility of Neutral Detergent Fibre (NDF) : There was an increase of 11.05 and 4.99 per cent in NDF intake on ration 2 compared to rations 1 and 3, respetively (Table 47 a,b), while the NDF intake was 5.77 per cent higher on ration 3 compared to ration 1 and this was in accordance with the NDF contents of concentrate pellet (20.98%), sunhemp hay meal (47.04%) and subabul leaf meal (23.78%) in the respective rations. Further, the NDF intake was 43.24 per cent higher in lambs than in kids and this was in accordance with DM intake.

The NDF digestibility was significantly (P < 0.01) higher on ration 2 followed by rations 3 and 1. These results indicate that NDF from leguminous fodders used in these rations was better digested than that from concentrate pellets. Further, the NDF from sunhemp hay meal was better digested than that from subabul leaf meal. NDF digestibility followed the same trend as that of crude fibre digestibility. The NDF digestibilities recorded in this experiment were comparable to the reported values of Morris and Mowat (1980) on ammoniated corn stover in Hereford Angus steers, Venkataramana et al. (1989) on urea treated bajra stover based ration in rams and Chakraborty and Ghosh (1988) on subabul foliage in goats.

The digestibility coefficients for NDF were significantly ($P < 0.01$) higher in kids than in lambs. This was in agreement with the report of Chandrasekharaiah (1989) on jowar straw based rations.

5.3.5.12 Digestibility of Acid Detergent Fibre (ADF) : There was an increase of 19.08 and 17.66 per cent in ADF intake on ration 2 compared to rations 1 and 3, respectively (Table 48 a,b). Further, the ADF intake was 1.21 per cent higher on ration 3 compared to ration 1. The ADF intake was in accordance with the ADF contents of concentrate pellet (12.78%), sunhemp hay meal (39.06%) and subabul leaf meal (13.81%) in respective rations. Further, the ADF intake was 57.55 per cent higher in lambs than in kids and this was in accordance with the DM intake.

The ADF digestibility coefficients were significantly ($P < 0.01$) higher on ration 2 followed by rations 3 and 1. These results indicate that ADF from leguminous fodders (sunhemp hay meal and subabul leaf meal) was better digested than that from concentrate pellets. Further, sunhemp hay was superior to subabul leaf meal with regards to ADF digestibility. The ADF digestibility was in accordance with CF and NDF digestibilities. The ADF digestibility recorded in this study was in accordance with the reports of Morris and Mowat (1980) in Hereford steers fed on ammoniated corn stover, Wanapat et al. (1985 a) in crossbred calves fed on urea treated rice straw and Venkataramana et al. (1989) in rams fed on urea treated bajra stover.

The apparent digestibility coefficient of ADF was significantly ($P < 0.01$) higher in kids than in lambs. These results were in agreement with the report of Chandrasekharaiah (1989) on sorghum straw based rations. However, Reddy et al. (1991) and Reddy et al.(1992) did not find any difference between sheep and goats in ADF digestibility when fed rations based on sunflower straw and sugarcane bagasse, respectively.

5.3.5.13 Hemicellulose Digestibility : There was an increase of 9.69 and 14.23 per cent in hemicellulose intake on ration 3 compared to rations 1 and 2, respectively (Table 49 a,b). Further, the hemicellulose intake was 4.13 per cent higher on ration 1 compared to ration 2. Hemicellulose intakes were in accordance with the hemicellulose contents of concentrate pellets, sunhemp hay meal and subabul leaf meal in the respective rations. Further, the hemicellulose intake was 74.42

per cent higher in lambs than in kids and this was in accordance with DM intake.

The hemicellulose digestibility coefficients were significantly ($P < 0.01$) lower on ration 1 compared to rations 2 and 3 indicating that the hemicellulose from leguminous fodders used in this experiment (sunhemp hay meal in ration 2 and subabul leaf meal in ration 3) were better digested than that from concentrate pellets. Further, the hemicellulose digestibility was higher on ration 2 compared to ration 3 indicating that sunhemp hay meal was superior to subabul leaf meal with regards to hemicellulose digestibility. Hemicellulose digestibility recorded in this study was in accordance with the reports of Chakraborty and Ghosh (1988) in goats fed on subabul foliage, Venkata Rao (1989) in sheep fed on NB21 and sunhemp hay and Venkataramana et al.(1989) in rams fed on urea treated bajra straw and concentrates.

Hemicellulose digestibility was significantly ($P < 0.01$) higher in lambs than in kids. However, no significant difference between sheep and goats in hemicellulose digestibility was found on rations containing jowar straw (Chandrasekharaiah, 1989), maize stover (Govindaiah, 1989), sunflower straw (Reddy et al., 1991) and sugarcane bagasse (Reddy et al., 1992).

5.3.5.14 Cellulose Digestibility : There was an increase of 32.56 and 21.06 per cent in cellulose intake on ration 2 compared to rations 1 and 3, respectively (Table 50 a,b). Further, the cellulose intake was 9.50 per cent higher on ration 3 compared to ration 1. Cellulose intake was in accordance with the cellulose contents of concentrate pellets, sunhemp hay meal and subabul leaf meal in the respective rations. Further, the cellulose intake was 62.24 per cent higher in lambs than in kids and this was in accordance with DM intake.

The cellulose digestibility coefficients were significantly ($P < 0.01$) lower on ration 1 compared to rations 2 and 3. These results indicate that cellulose from legumes (sunhemp hay meal and subabul leaf meal) was better digested than that from concentrate pellet. Further, significantly higher cellulose digestibility on ration 2 compared to ration 3 indicate that sunhemp hay was superior to subabul leaf meal with regards to cellulose digestibility. Cellulose digestibility followed the same trend as that of CF, NDF and ADF. The cellulose digestibility recorded in this experiment was comparable to that recorded by Singh and Gupta (1984) in Murrah buffaloes fed with urea treated wheat straw and concentrate, Venkata Rao (1989) in sheep fed with complete feed containing NB 21 and sunhemp hay and Venkataramana et al. (1989) in rams fed with urea treated bajra straw and concentrate mixture.

The digestibility coefficient for cellulose recorded in this study was significantly (P < 0.01) higher in lambs than in kids. These results were in accordance with the report of Govindaiah et al. (1991) on maize straw based rations. However, no significant difference between sheep and goats in cellulose digestibility was observed on rations containing jowar straw (Chandrasekharaiah, 1989), sunflower straw (Reddy et al., 1991) and sugarcane bagasse (Reddy et al., 1992).

5.3.5.15 Lignin Digestibility : There was an increase of 20.64 and 2.08 per cent in lignin intake on ration 2 compared to rations 1 and 3, respectively (Table 51 a,b). The lignin intake was 18.18 per cent higher on ration 3 compared to ration 1. Lignin intakes were in accordance with the lignin contents of concentrate pellet, sunhemp hay meal and subabul leaf meal in respective rations. Further, lignin intake was 40.73 per cent higher in lambs than in kids and this was in accordance with DM intake.

Lignin digestibility was significantly (P<0.01) higher on ration 2 compared to rations 1 and 3 which were comparable (Table 51 a,b). These results indicate that lignin from sunhemp hay in ration 2 was better digested than that of subabul leaf meal in ration 3 and concentrate pellets in ration 1. The lignin digestibilities in the present study were comparable to the reported values of Drozdenko and Novgorodov (1985) in the diets of young cattle, Venkataramana et al. (1989) in urea treated bajra straw based rations of rams and Reddy et al. (1991) in sunflower straw based rations in sheep and goats.

The lignin digestibility was significantly (P<0.01) higher in lambs than in kids. This was in accordance with the report of Reddy et al. (1991) on sunflower straw based rations. However, no significant difference between sheep and goats with regards to lignin digestibility was observed on rations containing maize straw (Govindiah, 1989) and sugarcane bagasse (Reddy et al., 1992).

5.3.6 **Balance Studies**

5.3.6.1 **Nitrogen balance :** Positive nitrogen balances were recorded in all the experimental animals indicating that all the experimental rations met the nitrogen requirements of the lambs and kids (Table 52 a,b). This was in accordance with the report of Lawlor et al. (1981) who recorded positive nitrogen balances in sheep by feeding ammoniated straws with concentrates of medium to low CP content. Positive nitrogen balances were recorded by Abu-Izzeddin and Lakpini (1985) in ram lambs fed on concentrate mixture containing different levels of poultry waste in place of cotton seed cake and Yerana et al. (1978) in sheep fed on Leucaena leucocephala as sole feed. Significantly (P<0.05) higher nitrogen balances were recorded on ration 3 compared to other rations in lambs as well as in kids. This may be attributed to higher crude protein intake on this ration compared to other two rations. The nitrogen balances on ration 1 and 2 were at par indicating that sunhemp hay meal can provide the nitrogen required for lambs and kids comparable to that of concentrate pellet. Nitrogen retention as per cent intake and per cent absorbed was not significantly different among the three rations.

Nitrogen balance was not significantly different between lambs and kids. Though the nitrogen intake was less in kids, the retention was equal to that of lambs. However, nitrogen retention as per cent intake and per cent absorbed was significantly (P<0.01) higher in kids than in lambs indicating that kids were efficient in retaining the absorbed nitrogen. The energy required for trapping the nitrogen by rumen microbes might have been provided by the extrra energy available as a result of higher digestibilities of CF, EE and NFE in kids compared to lambs. No significnat difference in nitrogen retention between sheep and goats was observed on maize stover based rations (Govindaiah, 1989) and Jowar straw based rations (Chandrasekharaiah, 1989).

5.3.6.2 Calcium balance : All the experimental animals on all the experimental feeds recorded positive calcium balance (Table 53 a,b) suggesting that all the rations met the calcium requirements of lambs and kids. The positive calcium balances recorded in this study were comparable on rations 1 and 3 but significantly ($P<0.01$) lower than those recorded on ration 2. Calcium retention as per cent intake was also higher ($P<0.01$) on ration 2 but comparable on rations 1 and 3. This indicate that sunhemp hay present in ration 2 was much efficient in providing the Ca required by animals compared to concentrate pellet and subabul leaf meal. Positive calcium balances were recorded by James (1978) in goats fed with subabul based ration, Reddy and Reddy (1985) in crossbred calves and Reddy and Reddy (1986) in Murra buffaloes fed with ammoniated cotton straw rations, Singh and Barsaul (1985) in heifers fed urea treated wheat straw, Jaikishan et al. (1986) in goats fed leucaena leaves based ration, Bhaskar et al. (1987) in calves fed leucaena based ration Rahman et al. (1987) in calves fed urea treated wheat straw.

Calcium retention was not significantly different between lambs and kids. However, calcium retention as per cent intake was significantly ($P<0.01$) higher in kids than in lambs indicating that kids were more efficient in utilizing the calcium taken in feed. No significant difference in calcium retention between sheep and goats was observed on maize stover based rations (Govindaiah, 1989).

5.3.6.3 Phosphorus balance : The experimental animals on all the experimental rations were on positive phosphorus balance (Table 54 a,b) indicating that all the experimental rations met the phosphorus requirements of lambs and kids. Positive phosphorus balances were recorded by James (1978) in goats fed with subabul based ration, Singh and Barsaul (1985) in heifers fed urea treated wheat straw, Reddy and Reddy (1985) in crossbred calves and Reddy and Reddy (1986) in Murrah buffaloes fed ammoniated cotton straw rations, Jaikishan <u>et al</u>. (1986) in goats fed leucaena leaves based ration, Bhaskar <u>et al</u>. (1987) in calves fed leucaena based ration, Rahman <u>et al</u> (1987) in calves fed urea treated wheat straw.

Phosphorus retention (g/d) and Phosphorus retention as per cent intake was significantly (P<0.01) higher on ration 1 but comparable between rations 2 and 3. This was in accordance with phosphorus intakes. These results indicate that concentrate feed was superior to leguminous fodders used in this experiment in providing the phosphorus.

Phosphorus retention was comparable in both the species. However, the phosphorus retention as per cent intake was singnificantly (P<0.01) higher in kids than in lambs indicating that kids were more efficient in utilizing the phosophorus taken in feed. No significant difference in phosphorus retention between sheep and goats was observed on Jowar straw based rations (Chandrasekharaiah, 1989).

5.3.7 Plane of Nutrition

The data pertaining to plane of nutrition of the experimental animals are presented in Table 55. The DM intake/100 kg body weight was significantly (P<0.01) higher in lambs than in kids. DM intake was higher on rations 2 and 3 compared to ration 1 in lambs as well as kids indicating that the rations containing leguminous fodders were well relished by the animals. All the lambs met the DM requirements suggested by ICAR (1985). However, kids have not met the requirements.

Digestibile crude protein (DCP) content was (P<0.01) higher on ration 3 compared to 1 and 2 rations in lambs as well as in kids. This may be due to higher crude protein content of subabul leaf meal in ration 3 compared to sunhemp hay meal in ration 2 and concentrate pellets in ration 1. The DCP content of ration 1 and 2 was comparable indicating that sunhemp hay meal has suppled DCP equal to that of concentrate pellets.

The DCP content was significantly (P<0.01) higher in the rations of kids than in lambs and this may be attributed to higher crude protein digestibility in the latter. This was in agreement with the reports of

Reddy *et al*. (1991) on sunflower straw based rations and Reddy *et al*. (1992) on sugar cane bagasse based rations.

The DCP content and intakes on all the experimental rations were higher than the recommended levels of ICAR (1985) for lambs and kids and this may be due to higher crude protein content of UTM and also due to leguminous forage supplements used in this study. Higher DCP intake on ration 3 compared to rations 1 and 2 in both the species may be due to high crude protein content of subabul leaf meal used in the ration 3.

Total digestible nutrients (TDN) content was significantly ($P<0.01$) lower on ration 1 compared to rations 2 and 3 which were comparable in both the species. This was a reflection of lower digestibilities of all the nutrients on ration 1 compared to rations 2 and 3. This indicate that leguminous fodders used in this experiment (sunhemp hay meal and subabul leaf meal) were superior in supplying required energy to the experimental animals of both the species than the concentrate pellets. Though, the ration 2 containing sunhemp hay meal recorded higher digestibilities of OM, CF, NFE and fibre fractions, the TDN content was comparable on both the rations.

The TDN content was less than the recommended levels (ICAR, 1985) on all the rations in lambs. However, the lambs have met the TDN requirements on rations 2 and 3 due to higher DM intake. Though the TDN content was higher than the recommended levels of ICAR (1985) on all the rations in kids, they have met the TDN requirements on rations 2 and 3 only. This was due to lower DM intake than the recommended level in kids on all the rations. The lower TDN intake on ration 1 compared to rations 2 and 3 in both the species may be due to lower TDN content as a result of lower digestibilities of all the nutrients.

The DE and ME intakes were higher than the recommended levels of ICAR (1985) on rations 2 and 3 in both the species. Though kids have met the DE and ME requirements on ration 1 but lambs could not meet the energy requirements. This was a reflection of lower TDN contents recorded on ration 1 particularly in lambs.

DM intake per unit metabolic body weight was higher than the requirements in lambs but lower than the requirements for kids. All the experimental animals have met the DCP and ME requirements per unit metabolic body weight.

The protein : energy ratios were narrower than the suggested level of ICAR (1985) on all the rations in lambs and kids indicating energy dilution in all the rations.

The results of metabolic trials indicate that rations 2 and 3 containing leguminous fodders were superior to ration 1 containing concentrate feed. Though, the DM intake was more in lambs, kids were superior in utilizing the nutrients from these rations.

The results of this study indicate that 40 per cent moisture and 2 weeks incubation period were optimum for treating maize stover with urea. Further, supplementation of urea treated maize stover with leguminous fodders particularly subabul leaf meal was beneficial rather than concentrate feed containing 30 per cent poultry droppings for optimum growth and nutrient utilization in lambs and kids.

SUMMARY

CHAPTER VI

SUMMARY

To improve the nutritive value of maize stover by urea treatment, experiments were conducted in two phases to evaluate 1. Optimum moisture level and incubation period for urea treatment of chopped maize stover and 2. The effect of feeding urea treated maize stover (UTM) on growth and nutrient utilization in lambs and kids.

Chopped maize stover was subjected to urea (4%) treatment at three different moisture levels (30, 40 and 50%) and three incubation periods (1, 2 and 3 weeks) to evaluate optimum moisture level and incubation period. The samples were tested for physical and chemical characters and *in vitro* dry matter and organic matter digestibilities.

The moisture level of 40 per cent was optimum for urea treatment of maize stover as evidenced by increased OM, CP, NH_3-N, cell contents, IVDMD and IVOMD and decreased total ash, CF and cell wall constituents. Further, at 50 per cent moisture the treatment resulted in very dark material with mould growth here and there. Incubation for 3 weeks had no advantage over 2 weeks because of higher OM and cellulose contents and lower total ash and lignin contents and higher IVDMD recorded

at 2 weeks of incubation. Though, the 2 weeks incubation showed higher IVDMD over one week incubation, the latter was at par with the former with regards to the content of all the constituents except cellulose. Hence, maize stover treated at 40 per cent moisture and incubated for one week (ration 1) and 2 weeks (ration 2) was further evaluated by feeding as sole ration to adult sheep and goats in dig ion experiments using a Randomized Block Design to assess their nutritive value.

Dry matter ke/100 kg body weight was more (P<0.01) among the animals fed ration 2 in both the species while goats consumed significantly (P<0.01) higher dry matter than sheep. digestibilities of all the nutrients except ether extract were significantly (P<0.01) higher on ration 2 than on ration 1. Digestible crude protein (DCP) and total digestibile nutrients (TDN) contents were also significantly (P<0.01) higher on ration 2 in sheep and goats. Digestibilities of all the nutrients and the nutritive value were not significantly different between sheep and goats.

The results of digestion trial in adult sheep and goats showed that 4 per cent urea treated maize stover at 40 per cent moisture level and incubated for 2 weeks was superior to that incubated for 1 week and the same was used in the second phase to evaluate its effect on growth and nutrient utilization in lambs and kids.

Eighteen weaned Nellore lambs and eighteen weaned local kids (6 in each group) were used in a Randomized Block Design to study the effect of three rations viz., 1. UTM + concentrate pellets containing 30 per cent poultry droppings (ration 1) 2. UTM + sunhemp hay meal in 70 : 30 ratio (ration 2) and 3. UTM + subabul leaf meal in 70 : 30 ratio (ration 3) on growth and nutrient utilization.

The processing cost of maize stover, sunhemp hay meal and concentrate pellet was Rs. 1.15, 1.24 and 13.40 per quintal, respectively. The cost (inclusive of processing cost) of the UTM, concentrate pellet, sunhemp hay meal and subabul leaf meal was Rs. 149.79, 279.35, 76.24 and 120 per quintal, respectively.

In growth study, the average daily gains (ADG) were 85.22, 68.48 and 81.89 g in lambs and 53.44, 44.72 and 50.00 g in kids fed rations 1, 2 and 3, respectively. The ADG recorded on all the rations was not significantly different irrespective of the species. However, the ADG of lambs were significantly ($P<0.01$) higher compared to kids. Dry matter intake (kg) per kg gain and cost of feed (Rs.) per kg gain were 5.49 and 11.61; 6.86 and 9.73 and 5.87 and 9.15 in lambs and 7.20 and 15.95; 8.86 and 12.55 and 7.64 and 11.90 in kids fed rations 1, 2 and 3, respectively. Ration 1 containing concentrate feed had better feed efficiency compared to other rations, though the cost of feed/kg gain was more on this ration. Further, subabul leaf meal was superior to sunhemp hay meal in supporting the growth in lambs and kids. Lambs were superior to kids in utilizing the nutrients from these rations for growth purpose.

At the end of the growth trial, a metabolic trial was conducted on all the animals of growth study. Dry matter intake/100 kg body weight was less ($P<0.01$) on ration 1 compared to rations 2 and 3, which were at par. Lambs consumed significantly ($P<0.01$) more dry matter and water than kids.

The digestion coefficients of dry matter, organic matter, crude fibre, nitrogen-free extract, neutral detergent fibre, acid detergent fibre, hemicellulose and cellulose of the ration 2 were significantly ($P<0.01$) higher when compared to rations 1 and 3 irrespective of the species. However, the digestibility coefficients of the above nutrients were significantly ($P<0.01$) higher on ration 3 compared to ration 1. The digestibility coefficients of crude protein and energy on ration 1 were significantly ($P<0.01$) lower than on rations 2 and 3, which were at par. The digestibility coefficient of ether extract on ration 1 was significantly ($P<0.01$) higher than on rations 2 and 3, which were at par. The neutral detergent solubles digestibility was significantly (P<0.01) higher on ration 3 than on ration 1, however, there was no significant difference between rations 1 and 2 as well as 2 and 3. The digestibility coefficients of lignin on ration 2 were significantly (P<0.01) higher than on rations 1 and 3 which were at par. Further, the digestibility coefficients of all the nutrients except hemicellulose, cellulose and lignin were significantly (P<0.01) higher in kids than in lambs. Positive nitrogen, calcium and phosphorus balances were recorded in all the experimental animals on all the experimental rations.

The DCP content was significantly (P<0.01) higher on ration 3 followed by rations 2 and 1 in lambs and the same was significantly (P<0.01) higher on ration 3 than on rations 1 and 2 which were at par in kids. The TDN content was significantly (P<0.01) higher on rations 2 and 3 than on ration 1 in lambs and the same was significantly (P<0.01) higher on ration 2 followed by ration 3 and 1 in kids.

The DCP and TDN contents were significantly (P<0.01) higher in the rations of kids than in lambs. All the experimental animals met the DCP and TDN requirements on all te experimental rations except for TDN on ration 1.

These results indicate that 40 per cent moisture and 2 weeks incubation period were optimum for treating maize stover with urea. Supplementation of leguminous fodders particularly subabul leaf meal to urea treated maize stover was beneficial rather than concentrate feed for optimum growth and nutrient utilization in lambs and kids.

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