JTILIZATION OF SUNFLOWER STRAW AND SUNFLOWER HEADS AS SOLE SOURCE OF ROUGHAGE IN COMPLETE FEEDS FOR SHEEP

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(FEED AND FODDER TECHNOLOGY)

BY

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CERTIFICATE

SRI.P.RAVINDER REDDY has satisfactorily prosecuted the course of research and that the thesis entitled **"UTILIZATION OF SUNFLOWER STRAW AND SUNFLOWER HEADS AS SOLE SOURCE OF ROUGHAGE IN COMPLETE FEEDS FOR SHEEP"** submitted, 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.

(Dr.G.V.NARASA REDDY)
MAJOR ADVISOR

Dated : 3-9-1987

CERTIFICATE

This is to certify that the thesis entitled **"UTILIZATION OF SUNFLOWER STRAW AND SUNFLOWER HEADS AS SOLE SOURCE OF ROUGHAGE IN COMPLETE FEEDS FOR SHEEP"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF VETERINARY SCIENCE** of the **ANDHRA PRADESH AGRICULTURAL UNIVERSITY**, Hyderabad, is a record of the bonafide research work carried out by **SRI P.RAVINDER REDDY** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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

(Dr.G.V.NARASA REDDY)
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P. Ravinder Reddy

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DECLARATION

I, Sri **P.RAVINDER REDDY**, hereby declare that the thesis entitled **"UTILIZATION OF SUNFLOWER STRAW AND SUNFLOWER HEADS AS SOLE SOURCE OF ROUGHAGE IN COMPLETE FEEDS FOR SHEET"** submitted to **ANDHRA PRADESH AGRICULTURAL UNIVERSITY** for the degree of **MASTER OF VETERINARY SCIENCE** is the result of original research work done by me. I also declare that my material contained in the thesis has not been published earlier.

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ABSTRACT

Three complete feeds were formulated using (1) mixed grass hay meal (MGH, control), (2) Sunflower straw meal (SSM) and (3) Sunflower head meal (SHM) as sole source of roughage (50%) and processed into mash. These feeds were tested on Nellore sheep in a 180 days growth trial involving 18 ram lambs (6 in each group) and a metabolic trial involving 9 rams (3 from each group of growth trial), using a completely randomized design, to assess the growth rate, feed efficiency and nutrient utilization. At the end of the experiment, 2 rams from each group were slaughtered to study the carcass characteristics.

The average daily gains were not significantly different among the three treatments though the feed efficiency was higher on feed containing MGH, the cost of feed per kg live weight was lower on feed 3 containing SHM.

Voluntary intake of dry matter was comparable on all the feeds. Significantly higher ($P < 0.05$) digestibilities of nitrogen-free extract were recorded on feed 3 containing SHM. Dry matter, organic matter, ether extract, crude protein and crude fibre digestibilities recorded were not significantly different among the feeds. Positive nitrogen, calcium and phosphorus balances were recorded on all the three complete feeds.

The dressing percentages of carcasses were higher on feed 3 either on live weight basis or on empty body weight basis. The feed containing SHM showed higher bone : meat ratios and lower edible : non-edible organs ratios than the other two feeds.

These results suggested that SSM and SHM can be used as sole source of roughage in place of MGH in the formulation of complete feeds for sheep without affecting the growth rate and nutrient utilization.

CHAPTER I

INTRODUCTION

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In developing countries like India, where there is severe shortage of feedstuffs, ruminants mainly subsists on crop residues and other agro-industrial by-products. 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 are inefficiently utilized by ruminants because of higher lignin content, poor digestibility of fibrous fractions and low nitrogen content apart from low dentiy. Therefore, any attempt to improve the nutritive value of these residues alone or in combination with concentrates would be of much practical and economical value.

The intake and digestibility of crop residues may be increased by reducing particle size by grinding and incorporating in complete feeds. Rearing livestock on complete feeds will have practical importance as it reduces labour requirement, reduces wastages, ensures uniform supply of balanced nutrients to the rumen microorganisms and increases production by converting the poor quality, non-edible by-products into highly nutritious animal products.

Over 3 lakh ha. is under sunflower (Helianthus annus) cultivation in India, of which Andhra Pradesh State alone contributes 28,000 ha. About one tonne each of sunflower straw and sunflower heads (capitalum after removing seeds) are estimated to be available from every hectare of sunflower crop every year as a renovable resource (Anonymous, 1985). Huge quantities of these materials are being thrownout either as waste or used as firewood in some villages.

Hence, an attempt was made to formulate complete feeds utilizing sunflower straw and sunflower heads as sole source of roughage in place of traditionally used mixed grass hay along with other locally available by-products and waste materials and to test these feeds on sheep for voluntary intake, growth rate, feed efficiency, nutrient utilization and carcass characteristics. An attempt was also made to assess the cost of processing and cost of complete feeds.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

2.1 UTILIZATION OF SUNFLOWER PLANT BY-PRODUCTS AS ROUGHAGE SOURCE IN RUMINANT RATIONS :

Crop residues form a potential source of energy for livestock. Sunflower straw and heads (Capitulum after removing seeds) can be used as roughage source in ruminants.

Marx (1974) fed sunflower forage to Holstein calves and obtained daily weight gain of 0.97 kg/day in animals fed with sunflower silage as against 1.05 kg/day in animals fed alfalfa silage.

Sunflower heads contained ash, 11.80; lignin, 12.00; protein, 12.50; lipids, 1.90; unsaponified lipid, 1.40; sterols, 1.05; glycosides, 0.76; pectic substances, 11.85 per cent and after hydrolysis galacturonic acid, 8.00; galactose, 3.40; glucose 1.70; arabinose, 0.13 xylose, 0.70 and rhamnose, 21.00 per cent (Edress et al., 1976). Sheafer (1976) reported that sunflower silage yields as much as DM as corn silage when harvested at bloom but the feeding value was less than corn silage.

When sunflower stalks chopped to 1 and 5 cm (DM, 95.4; crude protein, 2.0; fat, 2.0; ash, 4.5; fibre, 57.9 and nitrogen free extract, 33.6 per cent and gross energy, 4.3 Kcal/kg DM) and fed to 3 precoce sheep, mean daily intake was 23.05 g/kg 0.75 body weight and digestibilities were DM, 42.4; organic matter 49.8; fat, 75.6; fibre, 43.1 and NFE 62.9 per cent. The calculated feeding value was 0.31 Scandinavian feed units/kg. During the trial the sheep lost nitrogen and minerals (Gomez Cabrera, 1977).

Rai and Shukla (1977) fed unchaffed winter sunflower fodder as sole ration for Kankrej bullocks and recorded dry matter intake of 2.1 kg/100 kg body weight; digestibility coefficients of 70.53, 82.80, 51.50 and 74.16 for crude protein, ether extract, crude fibre and nitrogen free extract, respectively and DCP, 7.15 and TDN, 64.37 per cent. The animals were on positive nitrogen, calcium and phosphorus balances.

Saltykova (1977) studied the effect of feeding sunflower heads in precoce ewe lambs by feeding three feeds: T_1, without sunflower heads (control ration); T_2, with 0.5 kg sunflower heads replacing 0.20 kg hay and T_3, with 0.35 kg heads to replace 0.20 kg straw. Weight gain and yield of wool were 15.8 to 31.5 per cent and 9.4 to 16.3 per cent greater with T_2 and T_3 than with T_1. Wool taken from the side was 11.43 to 12.78 per cent stronger with the test diets i.e., T_2 and T_3. He inferred that the improved values of sunflower heads was due to high content of trace elements, upto 183 mg/kg air-dry matter of sunflower heads. He suggested a daily allowance of

350 to 500 g of sunflower heads per animal.

Flores et al. (1978) fed chopped sunflower stalks to appetite to sheep, without or with a supplement of 100 g soyabean oil meal with vitamins and minerals, or after treatment with NaOH solution and the addition of supplements and observed daily DM intake of 23.0, 21.6 and 34.9 g/kg 0.75 body weight, apparent digestibilities of 50, 52 and 51 per cent for organic matter and 43, 64 and 49 per cent for crude protein, respectively.

Megultey and Schingoethe (1980) compared the feeding value of whole plant sunflower silage with that of corn silage as the sole feed in lactating Holsteins. Cows fed sunflower silage produced less milk (22.4 Vs. 26.5 kg/day) and showed greater fat, less protein, less total solids and less fat corrected milk.

Shvechikova (1981) fed cows with control ration (containing maize silage, mixed grass, legume hay, barley straw, wheat meal and dried egg white) and three types of pelleted mixture with sunflower wastes (containing the stems and flower heads) 50, 25 and 40 per cent, oil seed wastes 25, 50 or 40 per cent, while seed wastes 15, 15 or 20 per cent and dried beet 10, 10 or 0 per cent, respectively. The respective average daily milk yield was 12.5, 14.8, 15.7 and 15.6 kg, milk fat content was 3.54, 3.67, 3.70 and 3.71 per cent and protein content was 3.28, 3.19, 3.39 and 3.30 per cent.

Thomas et al. (1982 a) fed concentrate/silage diets (CP 13%) with lucerne/grass or sunflower silage at 40 per cent to Holstein cows. Daily silage DM intake (8.3 to 8.4 kg) and milk yield (7.5 to 7.7 kg) were similar for both diets. Milk fat content was lower with sunflower than with grass/lucerne silage (3.2 Vs. 3.6%) but protein content was not affected. Thomas et al. (1982 b) studied digestion and feeding value of sunflower silage in beef steers in comparison with that of lucerne-grass silage. They observed greater DM intakes by steers fed on sunflower silage and was attributed to the higher DM and lower ADF concentration of the sunflower silage diet compared with the lucerne - grass silage diet. Steers given sunflower silage required slightly more dry matter per kg gain than did steers given lucerne - grass silage (5.84 compared with 5.72 kg).

Boiko et al. (1984) studied the feeding value of sunflower plants (Zhmykhit) cut at the stage of waxy ripeness, with young bulls. The control group was given 40 per cent concentrate, 55 per cent beet pulp and 5 per cent straw and molasses. The test group was given a feed mixture with 20 per cent concentrate, 20 per cent Zhmykhit and the other feeds as in the control group. During the trial period of 120 days each group had taken on average 1,000 feed units and 842 of digestible protein. Average daily body weight gain was 933 and 901 g for the control and test groups, respectively, and the feed conversion efficiency was 9.0 and 9.3 feed units per kg gain.

Seiler (1984) studied the chemical composition of different varieties of sunflower and reported that crude protein contents generally decreased with increasing plant maturity. Calcium, magnesium and potassium contents of leaf and feed were above the nutritionally adequate levels of 2 to 5, 2 and 8 g/kg, respectively. Stem and leaf phosphorus content was sub-optimal for high producing ruminants in all species except Helianthus arzonensis.

Hubbel et al. (1985) found significantly higher milk yield and solids corrected milk in a group of cows given sunflower silage compared to another group given corn silage. There was no significant difference in mean daily dry matter intake between the two groups.

Sunflower heads were used as sole source of roughage (50%) in complete feeds (mash and pellets) for sheep and compared with conventional type of feeding (concentrate mixture 200 g/day and paddy straw ad libitum). The results indicated higher digestibilities of all nutrients, balances of nitrogen, calcium and phosphorus and DCP and TDN values with complete rations than the control ration. The concentration of all nitrogen fractions and TVFA were significantly higher on complete rations than control ration (Gowd, 1986).

Reddy (1986) formulated three complete rations using (1) sunflower straw (50%), (2) sunflower straw (30%) + subabul meal (20%) and (3) paddy straw (50%) and tested on crossbred bulls for nutrient utilization and rumen fermentation pattern. He recorded higher digestibilities for DM, OM, and CF and higher values for all the nitrogen fractions (except food and protozoal N) in the rumen liquor on the ration containing sunflower straw as sole roughage source.

Reddy et al. (1986) fed sunflower heads meal at 48.50 per cent level in complete mash diets for sheep and recorded higher DM, OM and NFE digestibilities; calcium and phosphorus balances and DCP and TDN values than the control diet containing mixed grass hay as roughage source.

2.2 EFFECT OF COMPLETE FEEDS ON NUTRIENT UTILIZATION

The concept of feeding complete feeds to livestock is quite recent and is becoming popular. The use of complete feed is an efficient method for controlling the ratios of the various feed ingredients and nutrients, for administering minute amounts of ingredients and ingredients that are not palatable.

Complete mixed feeds have the potential advantages of providing uniform feed at all times for all animals in a pen, minimising labour requirements and maximising automation (Rakes, 1969).

Bhattacharya and Pervez (1973) reported no significant differences in the digestibilities of various nutrients with the urea (0, 1 and 2%) supplemented rations containing 50 per cent wheat straw or barley hay compared to their respective controls containing soyabean meal as sole protein supplement. However, the crude fibre, energy and ether extract digestibilities tended to increase on urea supplementation but nitrogen retention and metabolizable energy values did not differ significantly among treatments.

Complete feeding system envisages blending of forages/agricultural wastes, concentrates, minerals and vitamin supplements in a balanced ration and this provides a way of avoiding individual preferences as existing with conventional feeding systems (Coppock *et al.*, 1974).

Very good results could be achieved with complete diets containing large amounts of waste roughage by a favourable combination of physical processing of feeds, with methods of stimulating rumen bacterial activity and an appropriate method of feeding. Complete feeds are widely used on large scale forms for cattle and sheep for fattening and milk production in almost all East European countries (Todorov, 1975).

In complete feeding system, with simultaneous ingestion of forage and concentrate, farmers could design diets of high energy concentration without the problem of acidosis (Journet and Remond, 1976).

Palfii et al. (1976) fed 3 groups of sheep with concentrates and green feed or a complete feed mixture containing 30 per cent ground straw in loose or pelleted forms and reported the average daily gains of 115, 201 and 157 g and 9.6, 6.1 and 8.2 feed units for each kg weight gained. At slaughter the yield of carcass was 44.4, 46.8 and 45.4 per cent for the three treatments.

Gill (1979) indicated the importance of relative inclusion rates of forage and concentrates in determining the response to more even distribution of nutrients input.

Feeding of sheep kept in stalls on complete feed mixture reduced the rearing time of high-class lambs and thereby decreased the expenditure on feeds (Kvetkovskii and Stashchenko, 1982).

Patel and Sharma (1983) reported that intake of straw, concentrates and total dry matter was 6.67 and 5.78 kg; 6.83 and 10.18 kg and 13.51 and 15.96 kg, respectively, on 50 : 50 and 35:65, straw to concentrate ratios. The digestibilities of dry matter, organic matter and nitrogen-free extract were increased ($P<0.05$) and intakes of total digestible nutrients and digestible crude protein were higher ($P<0.01$) on high concentrate ration.

In a feeding experiment with crossbred calves, Reddy and Reddy (1983 a) observed 38.3 and 64.2 per cent increase in growth rate, respectively on complete feed mash and pellets containing 68 per cent forest grass compared to control ration containing concentrate mixture and forest grass. In another study, Reddy and Reddy (1983 b) observed significantly increase in milk production in crossbred cows without any effect on milk fat percentage on complete feeds (mash and pellets) containing 47.5 per cent forest grass as compared to conventional ratio containing *ad libitum* chopped hybrid napier green fodder and concentrate mixture at the rate of 1 kg for every 2.5 kg milk production.

Laxminarayana and Reddy (1986) formulated complete feeds (Mash and pellet) with woodpulp waste as roughage source (48.5%) and compared with a conventional ration containing 1.5 kg concentrate mixture and urea-mollasses enriched woodpulp waste *ad libitum* in crossbred calves. Complete feeds improved the voluntary intake, digestibilities of CP, CF and EE, nitrogen balance, DCP and TDN values than the conventional type of feeding.

Reddy *et al*. (1986) compared complete feeds (mash and pellets) containing wheat straw as sole roughage source (50%) with conventional ration containing concentrate mixture 200 g per day per animal and *ad libitum* urea-mollases enriched wheat straw in sheep and observed higher values for DM intake, digestibilities of all nutrients, balances of N, calcium and phosphorus and concentrations of all nitrogen fractions and TVFA in rumen fluid of animals fed on complete feeds.

2.3 GROWTH AND FEED EFFICIENCY IN SHEEP :

Orskov et al. (1971) studied the effect of ad libitum intake of diets varying in protein from 11.0 to 19.4 per cent on the performance and body composition at different live weights in lambs. The mean voluntary feed consumption was less at all weights for the lambs given 19 per cent protein than those on other diets. Average daily gain on low, medium and high protein diets was 191, 228 and 330 g for males and 177,225 and 301 g for females. Intake of feed per kg gain for the whole experiment increased with increased live weight until slaughter and the feed efficiency was higher at higher protein intake. Patnayak (1971) observed the effects of intermittent energy restriction on growth rate and feed efficiency in sheep and observed that the lambs fed to appetite gained significantly faster than those on restricted feeding. Younis et al. (1973) studied the effect of different levels of energy intake by altering roughage to concentrate ratio to rations of fattening lambs. The lambs were given 31.1, 42.4 and 54.4 per cent of dry matter as concentrate and obtained an average daily gain of 87, 119 and 116 g, respectively.

Craddock *et al.* (1974) studied the effect of feeding 2 dietary protein levels (10.5 and 13.5%) and . dietary energy levels (50 : 50 and 80 : 20 ratio of concentrate to roughage) in sheep and found that increasing protein levels resulted in high average daily gains and improved feed efficiencies. Feed efficiency improved as energy levels increased and the average daily gain was 0.20 and 0.19 kg and the feed required per kg gain was 9.37 and 8.24 kg, respectively.

Pilla *et al.* (1975) fed diets supplying 2900 or 2300 Kcal ME/kg and 18, 15 or 12 per cent crude protein levels to sheep. They found that groups given the diet containing more energy gained 235 to 250 g daily against 219 to 222 g with less energy and the feed intake was lower on high energy diet. Protein content had little effect on growth rate or feed conversion, but the amount of protein used per unit of growth was high in the groups fed high protein diets.

Calatoiu *et al.* (1977) studied the extent of roughage component in the feed for intensive fattening of lambs and concluded that 30 to 40 parts of lucerne hay + 20 or 30 parts of maize cobs, 35 parts concentrate and 5 parts minerals and vitamins in diet would give an average daily gain of 155 to 165 g with an intake of 6.0 to 6.5 feed units/kg gain.

Kulik *et al.* (1978) studied the productivity of young sheep which were fed to appetite on 4 complete pelleted diets each having 40 per cent straw and 48, 42, 35 and 29 per cent grass meal + 11, 17, 24 and 30 per cent concentrate and observed average daily gains of 112.7, 131.3, 154.9 and 177.1 g and feed intakes of 8.63, 7.61, 6.89 or 6.22 feed units/kg gain, respectively.

Sastry and Mahajan (1978) gave sheep chopped clover hay + rye grass (1 : 2 ratio) with or without concentrate supplementation and reported a 60 per cent increase in weight gain when roughages were supplemented with concentrate.

Ali et al. (1979) fed Muzaffarnagari lambs on diets with a ME content of 1.8, 2.0, 2.1 or 2.3 Mcal per kg feed. The proportion of concentrate to roughage differed among diets but DCP levels were not altered. It was observed that lambs fed 2.0, 2.1 or 2.3 Mcal/kg feed took 345, 193 or 137 days to attain a body weight of 25 kg and lambs fed 1.8 Mcal/kg did not gain beyond 30 kg even after 471 days.

Maheswari and Patnayak (1981) studied the growth and efficiency of native and crossbred lambs under 2 levels of energy and protein and concluded that consumption of DCP and TDN in the ratio of 8.5 at an intake level of 3 g DCP per kg live weight produced highest growth.

Reddy and Reddy (1981) fed four complete mash rations containing crop residues and agro-industrial by-products to Deccani sheep and recorded ADG of 43 to 51 g and feed per kg gain of 11.37 to 14.07 kg.

Growth rate and utilization of nutrients at 2 levels of feed intake were studied in crossbred kids by Jaikishan et al. (1982). The first group of animals were fed 300 grams concentrate + 200 g of wheat straw to meet the digestible protein requirements as per the Morrison (1959) standards. Second group of animals were fed 450 g of concentrate mixture 200 g of wheat straw to supply more DCP than group I. The average daily gain was 41 g/day for the first group whereas it was 71 g/day for kids receiving approximately one and half times more nutrients (group II). The quantity of dry matter and DCP per unit gain in body weight was less for the later group and the retention of nitrogen in group II was significantly (P<0.01) higher than that of group I.

Sehgal et al. (1983) studied the feed lot performance of Sonadi and its crosses with Dorset and Suffolk by feeding two rations containing roughage to concentrate ratio of 50 : 50 and 30 : 70 and found that protein content higher than 13.8 per cent was of little use to the growing lambs.

Vahidulla (1984) fed four isonitrogenous complete feeds replacing groundnut cake nitrogen with koobabul leaf meal nitrogen at 0, 33, 67 and 100 per cent levels to Nellore lambs and recorded average daily gain of 72 to 93 g and feed per gain of 7.69 to 9.11 kg.

Joji Reddy and Reddy (1985 a) fed Nellore lambs with complete feeds (mash Vs.pellet) containing sorghum straw or mixed grass hay and compared with a group maintained on grazing. They recorded ADG to 55 to 58 g on mash and 86 to 92 g on pellets as against 56 g on grazing. Dry matter intake per kg of gain was 9.68 to 10.39 for pellets and 12.45 to 12.77 for mash rations.

Srinivasa Rao et al. (1986) fed four complete rations containing 40 and 50 per cent of untreated and 1 per cent urea treated paddy straw along with 60 and 50 per cent concentrates and recorded no significant difference in average daily gain (77 to 106 g) but higher ($P<0.05$) feed efficiency was observed in lambs fed the complete ration containing 60 per cent concentrate and 40 per cent untreated paddy straw. The average cost of feeding the lambs per kg weight gain ranged from Rs.7.24 to 8.59 in different groups of animals fed with the four complete rations.

2.4 CARCASS CHARACTERISTICS IN SHEEP :

Hammond (1932) reported that the various compounds of the body of sheep differed from breed to breed especially between early maturing and late maturing one. Late maturing breeds registered a lighter proportion of the organs due to differences in carcass percentages between late and early maturing types.

Vais (1964) recorded that age and body weight did not affect the relative weight of the major meat cuts of the mutton marines.

Kulkarni et al. (1965) stated that the bone and muscle percentage varied significantly among the breeds and Mandya was superior compared to Bikanari crossed with Magra and Magra type sheep. They also observed that the dressing per cent among Mandya to be significantly higher as compared to Bikanari Magra and Magra breeds.

Pillai (1966) recorded that the average percentages of muscle and bone were 64.25 and 19.07, respectively, in adult Mandya sheep.

Field et al. (1967) in their study on Rambouillet, Columbia and Corriedale lambs recorded that heavier rams had a higher dressing percentage than light lambs. Kinsman (1967) stated that light weight lambs had lower dressing percentages.

Osman and Shafei (1967) observed that the leg, loin and rack, respectively, formed 26.9, 13.1 and 14.4 per cent when the slaughter weight was 34.23 kg among Sudan desert sheep.

Lohse and Kallweit (1968) have indicated that the carcasses consisted of 60 per cent lean, 25 per cent fat and 15 per cent bone, thus giving lean to fat ratio of 1 : 0.42 in black headed mutton fat lambs of Germany.

Further, they reported an average dressing per cent of 45 in the above breed.

Oliver and Carpenter (1968) reported that an increase in bone weight was accompanied by a proportionate increase in lean weight in lambs. Rouse et al. (1968) observed that the per cent lean of the carcass remained constant while the per cent fat increased with corresponding decrease of bone with an increase in live weight among Texas and California lambs.

Chatterjee et al. (1969) reported that in respect of Bannur lambs and non-Bannur lambs raised under similar conditions of management the average dressing percentages were 53 and 48 when their slaughter weights were 25.0 and 20.4 kg, respectively. They also reported that the wholesale cut percentages for leg, loin and shoulder were 34, 13 and 22, respectively, for non-Bannur lambs. According to them, the values for separable lean, bone and fat, respectively, were 46.15, 23.95 and 26.50 per cent in Bannur lambs as against the corresponding figures of 50.50, 31.36 and 15.96 per cent in others.

Adam et al. (1970) observed the mean carcass percentages for lean, fat and bone to be 53.5, 30.3 and 16.2 respectively, on physical separation in crossbred Rambouillet rams.

Lambuth et al. (1970) reported that heavier slaughter weight Hamphire black face cross lambs had a higher per cent total fat trim and a lower per cent bone than lighter slaughter weight groups.

Tiwari et al. (1973) revealed that the average dressing percentage was 39.5 at 6 months of age and 40.5 at 9 months in Malpura type male lambs of Rajasthan.

Accardi et al. (1975) studied the differences in meat characteristics of Barbari and Berrichon lambs and found that the carcass yield was 55 per cent for the former and 57.7 per cent for the latter.

Mansour (1975) reported the efficiency of energy utilization for growth of certain body components in relation to level of feeding in sheep when the metabolizable energy intake was 2.04, 2.61 and 3.18 Mcal per day. It was observed that raising the daily intake of metabolizable energy from 2.04 to 2.61 Mcal per day resulted in reduction in the amount of metabolizable energy required per kg gain, empty body weight, carcass and muscle tissue by 15, 16 and 11 per cent, respectively. No gain in bone growth was observed due to increase in energy intake and muscle responded slightly to increase in daily intake of energy while fatty tissue was markedly affected.

Younis et al. (1975) studied the effect of plane of nutrition on feed lot performance and carcass traits of sheep by feeding at 100, 75, 50, 40 or 30 per cent of Morrison standards (1959) and observed that reduced planes of nutrition resulted in significantly lower dressing percentage. However, the fat content of 9-10-11 rib cut was maximum in sheep fed higher planes of nutrition (i.e., 100%).

Katiyar et al. (1977) observed that the difference in carcass characteristics and the proportion of muscle, bone and separable fat under 4 diets, varying in roughage to concentrate ratio, was not significant. Eraso et al. (1978) fed 3 groups of sheep with complete conventional feed alone or 10 or 20 per cent of it replaced by olive pulp residue and noted that the groups did not differ in carcass yield or proportion of carcass cuts or of lean, fat and bone in different cuts.

Mahuyuddin (1979) fed lambs on different rations and slaughtered at different live weights and found that increased slaughter weight increased dressing percentage. Heavier carcass yielded a smaller proportion of muscular cuts and larger proportion of rack, loin, breast and flank.

Prasad et al. (1980) reported 44 and 43 as the dressing percentage in yearling crossbred males after 90 days of feeding, when they were given additional concentrates in different forms as against the control group receiving no concentrate where the dressing percentage was 38.02. The bone meat ratios were 1:2.49, 1:2.44 and 1:2.20 for the groups receiving concentrates and control, respectively.

Khan et al. (1981) reported the dressing percentage to be about 56.3 on empty body weight basis in Muzaffarnagari crossbred sheep. Among the different cuts, they observed leg to be heaviest of all followed by shoulder, loin, ribchop, brest, neck and flank.

Prasad et al. (1981) conducted on new apparel wool and superior carpet wool strain of sheep and reported the dressing percent to be 44.13 and 49.14 per cent, respectively, for the two strains, the weights of leg, loin, rack, shoulder and breast and shank were 1.33, 1.61; 0.36, 0.41; 0.46, 0.56; 0.92, 1.02 and 0.66, 0.82 kg, respectively, for the above mentioned two strains.

Gailli (1982) fed Sudan desert sheep with different roughage to concentrate ratio of 100 : 0, 75 : 25, 50 : 50 and 25 : 75 and noted that the sheep given more concentrates produced heavier carcasses with more lean meat but the carcass composition was similar in all the groups.

Krishna Mohan and Charyulu (1983) studied the carcass characteristics in cross-bred ram lambs fed 2 complete rations having concentrate to roughage ratio of 60 : 40 and 50 : 50. They observed no significant difference in dressing percentage and proportion of bone, meat and fat in the carcasses of the two groups.

Joji Reddy and Reddy (1985 b) observed increased dressing percentage and edible organ weights in sheep fed pelleted feeds containing mixed grass hay/sorghum straw (46%) as roughage source than the corresponding mash rations and grazing groups.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1 EXPERIMENTAL FEEDS :

The following crop residues and feed ingredients were used in the preparation of complete feeds. Sunflower straw (*Halianthus annus*), sunflower heads, mixed grass hay (mainly comprising of *Heteropogon contortus* and *Sehima nervosum*), groundnut cake, rice polishings, wheat bran and molasses.

3.1.1 Processing of Experimental Feeds :

Sunflower straw and sunflower heads (Capitulum after removing seeds) were obtained from the Sunflower Research Station, Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad-30. The sunflower straw and sunflower heads were dried in shade, ground in a hammer mill separately using a 5 mm sieve and designated as sunflower straw meal (SSM) and sunflower head meal (SHM), respectively. The experimental feeds used in the present study were: 1. complete feed (mash) with 50 per cent mixed grass hay (MGH, control), 2. Complete feed (mash) with 50 per cent SSM and 3. Complete feed (mash) with 50 per cent SHM.

The experimental feeds were proportioned in 100 kg batches as per the formulae (Table 1) excluding

Table 1 : Percentage composition of complete feeds

Ingredients	Complete feeds		
	1	2	3
Mixed grass hay	50.0	-	-
Sunflower straw	-	50.0	-
Sunflower heads	-	-	50.0
Groundnut cake	20.0	20.0	20.0
Rice polishings	8.0	8.0	8.5
Wheat bran	10.0	10.0	10.0
Molasses	10.0	10.0	10.0
Urea	0.5	0.5	-
Mineral mixture	1.0	1.0	1.0
Common salt	0.5	0.5	0.5
Rovimix* @ 10 g/Qtl.			
Total	100.0	100.0	100.0

Rovimix : A+D_3 type vitamin supplement containing 50,000 IU of vitamin A and 5,000 IU of vitamin D_3 per gram was added at the rate of 10 g per 100 kg of feed.

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molasses, urea mineral mixture and vitamin supplement and were ground in a hammer mill using 5 mm screen. The ground material was conveyed from the hammer mill to the bucket elevator through a screw conveyor from where it was lifted and conveyed into a hopper over the horizontal mixer through bucket elevator. The 100 kg batch collected in the hopper was dropped into a horizontal mixer. A premix containing mineral mixture and vitamin supplement was dumped into the mixer while mixing. Molasses was pumped from a storage tank to a preheater tank. The preheated molasses was added into the mixer through a dosage tank, while mixing. Urea was added directly to the mixer after dissolving in 500 ml water. The complete feed was mixed for 10 minutes and collected into gunny bags.

3.2 PHYSICAL CHARACTERISTICS :

3.2.1 Bulk Density :

The density of individual ingredients used in this experiment and complete feeds was obtained using one cubic foot dealwood box specially designed for this purpose.

3.2.2 Particle Size :

Modulus of finess and modulus of uniformity of the complete feeds were estimated using a Rotap sieve shaker.

3.3 COST ECONOMICS :

QThe power consumption for various processing methods was calculated as per the formulae suggested by Teraja (1984) and presented in Table 2. Processing cost of complete feeds was calculated taking into consideration of 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 total cost of the complete feeds per quintal was calculated on the basis of processing cost and the prevailing market rate of feed ingredients.

3.4 EXPERIMENT STUDIES :

Experiments conducted are dealt with under the following headings :

1. Growth Studies,
2. Metabolic Studies and
3. Carcass Studies.

3.5 GROWTH STUDIES :

3.5.1 Selection of Animals :

Eighteen Nellore lambs aged about 3 to 4 months, fed previously on whole milk and creep feed were selected from the Livestock Research Station, Rajendranagar, Hyderabad. They were randomly distributed

Table 2 : Average power consumption (KWH) for various processing methods (100 kg)

Method of processing	Complete feeds		
	1	2	3
Grinding	3.405	2.927	2.530
Screw conveyor	0.390	0.345	0.320
Bucket elevator	0.390	0.345	0.320
Blower	0.705	0.713	0.650
Mixing	0.485	0.461	0.420
Total	5.375	4.791	4.240

into three groups so that the initial body weights were similar in all the groups. The particulars of animals and their distribution into three groups are shown in Table 3.

3.5.2 Housing and Management of Experimental Animals :

All the experimental animals were kept under hygienic conditins in well ventilated stalls and not allowed for grazing. The animals were vaccinated against infectious diseases viz., Hemorrhagic septicemia, Enterotoxemia and Rinderpest. They were dewormed by using Halatac (Smith, Kline and French).

3.5.3 Feeding and Watering of Animals :

The three complete feeds were randomly assigned to 3 groups of animals in a 180 day growth trial. All the feeds were allowed ad libitum. The feeds were offered to animals daily at 9 A.M. and 3 P.M. The residues leftover were weighed in the next morning, in this way the exact quantity of feed consumed daily by the experimental animals was recorded throughout the experimental period. Clean water was made available in buckets throughout the experimental period.

3.5.4 Live Weight Records :

The animals were weighed weekly using Avery Weigh Bridge Balance before feed or water was offered.

Table 3 : Scheme of distribution of experimental animals

Complete feeds					
1		2		3	
Animal No.	Weight (kg)	Animal No.	Weight (kg)	Animal No.	Weight (kg)
556	11.0	557	9.5	562	8.0
559	9.6	567	12.0	570[a]	13.0
564[ab]	8.5	569[a]	12.0	567	9.0
528	12.0	532	8.0	526	8.1
537[ab]	8.0	536[ab]	8.0	530[ab]	11.4
533[a]	11.0	534[ab]	11.3	535[ab]	12.0
Mean	10.03		10.13		10.25
S.E. ±	0.65		0.78		0.88

a : used in metabolic studies

b : used in carcass studies

Weights were recorded on two consecutive days and the mean was taken to represent body weight. Average daily gain was calculated by using formula :

$$\text{Average daily gain} = \frac{\text{Final weight - Initial weight}}{\text{Number of days (180)}}$$

3.6 METABOLIC STUDIES :

A digestion and metabolic trial was conducted on 9 Nellore rams (3 from each group of growth trial, Table 3) to assess the nutrient utilization of the three complete feeds during the last week of the growth trial. The animals were kept in hygienic, well ventilated individual cages. Faeces and urine were quantitatively collected during a 7-day collection period. Dry matter content of samples of feed offered and residues were determined daily. Daily records of feed consumption as well as the faeces and urine voided were maintained for 7 consecutive days.

3.6.1 Sampling of Feed and Feed Residues :

Representative samples of each of the complete feed were taken every day before offering to the animals and were pooled for 7 days, ground in a laboratory wiley mill and preserved in polythene bags for subsequent analysis. Representative samples of residues of each animal were collected every day for dry matter estimation.

3.6.2 Collection of Faeces and Urine :

Faeces, as and when voided, were collected carefully into separate containers and closed with tight lids to prevent drying of the faeces. The total quantity of faeces voided during 24 hours period was weighed daily at 9 A.M. The faeces collected was taken from each animal in a bottle (approximately 500 g) and carefully carried to the laboratory for analysis.

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

3.6.3 Aliquoting and preservation of faeces and urine

3.6.3.1 Faeces :

For nitrogen estimation, 1/20th 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 air tight stoppered wide mouthed sample bottles. Daily samples were preserved in the same labelled bottles. After a 7-day collection period, the weights of the samples were recorded.

For dry matter estimation, an aliquot of 1/5th part was taken into the petridishes from the individual animals separately and dried in a hot air oven overnight at 100° to 105°C. The dried samples were pooled, ground in laboratory wiley mill and stored in polythene bags for subsequent analysis.

3.6.3.2 **Urine :**

For nitrogen estimation, 1/50th part of the total urine voided daily by individual animal after thorough mixing was pipetted out in duplicate into Kjeldahl flasks containing 30 ml of concentrate sulphuric acid. The aliquots thus pooled in the flasks were maintained separately for each animal.

Similarly, 1/50th part of total urine was taken in duplicate for mineral estimation in silica crucibles and dried at 100° to 105°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 calcium and phosphorus estimation.

3.6.4 **Analytical Methods :**

A.O.A.C. (1980) analytical methods were followed for estimation of dry matter, crude protein, crude fibre, ether extract, total ash and phosphorus. Estimation of calcium was done according to the method of Talapatra <u>et</u> <u>al</u>. (1940). Digestible and metabolizable energy values were calculated using the factors suggested by NRC (1975).

3.7 CARCASS STUDIES :

Two representative animals from each group (Table 3) were slaughtered at the end of growth trial and various meat characteristics like dressing percentage, proportions of meat, bone and fat in the carcass were studied.

3.7.1 Slaughter Method :

The animals were slaughtered by 'Halal' method after overnight starving. The live weights before their slaughter were recorded. The sticking, legging, dressing and evisceration were performed by adopting the standard procedure described by Gerrand (1964).

The weights of hot carcass, edible (liver, heart, testes, diaphragm, kidney and splenn) and non-edible organs (blood, lungs, trachea, stomach and intestines) were recorded.

The left side of the carcass was then divided into 5 cuts leg, loin, rack, shoulder and neck and foreshank and brisket as suggested by the National Livestock and Meat Board of United States of America (Brandly et al., 1968).

3.7.2 Cutting Standards of Various Wholesale Cuts :

3.7.2.1 Leg :

The leg was taken off from the carcass by cutting with a saw at right angle to back close to the hip bone.

3.7.2.2 **Loin :**

The loin was removed from the carcass from the hip bone to the anterior part of the last rib.

3.7.2.3 **Rack :**

The rack was obtained by cutting from the posterior part of the 12th rib to the anterior part of the 5th rib.

3.7.2.4 **Shoulder and neck :**

This was carved by cutting from the posterior part of the 4th rib to the neck (including the neck).

3.7.2.5 **Foreshank and brisket :**

Before cutting the shoulder and the rack, an incision was made with a knife 4" above the costa-sternal joint and the part was removed with a saw.

The weights of the different wholesale cuts were recorded separately.

3.7.3 **Bone, Separable Fat and Muscles :**

The weights of fat, muscle and bone were recorded separately from the left side of the carcass.

3.8 STATISTICAL ANALYSIS :

Statistical analysis of the data was carried out according to the procedures suggested by Snedecor and Cochran (1968).

CHAPTER IV

RESULTS

CHAPTER IV

RESULTS

Three non cereal based complete feeds were formulated and processed into mash, using grass hay, sunflower straw and sunflower heads as sole roughage source. These three feeds were compared in growth cum metabolic studies using 6 Nellore rams for growth and 3 for metabolic studies in each group. At the end of the experiment, 2 rams from each group were slaughtered to study the carcass characteristics.

4.1 PROXIMATE COMPOSITION OF COMPLETE FEEDS AND ROUGHAGES :

The proximate composition of complete feeds and roughages is presented in Table 4. Mixed grass hay meal, sunflower straw meal and sunflower head meal contained (%) 89.70, 90.50 and 88.00 dry matter; 89.69, 87.97 and 89.40 organic matter; 2.82, 2.89 and 7.22 crude protein; 33.01, 31.01 and 16.63 crude fibre; 2.17, 2.00 and 2.90 ether extract; 51.63, 52.16 and 62.65 nitrogen free extract; 10.37, 12.03 and 10.60 total ash; 0.58, 0.60 and 1.05 acid insoluble ash; 0.75, 0.43 and 0.69 calcium and 0.06, 0.09 and 0.10 phosphorus, respectively.

The complete feeds 1, 2 and 3 contained (%) 86.10, 87.00 and 85.00, dry matter; 85.80, 85.00 and 85.10 organic matter; 12.00, 11.80 and 11.90 crude

Table 4 : Chemical composition of complete feeds and roughages (% dry matter basis)

Nutrients	Complete feeds			Sunflower		Mixed grass
	1	2	3	Straw	Heads	hay
Dry matter	86.10	87.00	85.00	90.50	88.00	89.70
Organic matter	85.80	85.00	85.10	87.97	89.40	89.63
Crude protein	12.00	11.80	11.90	2.80	7.22	2.82
Crude fibre	23.04	20.80	13.88	31.01	16.63	33.01
Ether extract	4.00	3.90	4.50	2.00	2.90	2.17
Nitrogen-free extract	46.76	48.50	54.82	52.16	62.65	51.63
Total ash	14.20	15.00	14.90	12.03	10.60	10.37
Acid insoluble ash	3.96	4.95	5.60	0.60	1.05	0.58
Calcium	1.23	1.16	1.19	0.43	0.69	[illegible]
Phosphorus	0.43	0.40	0.43	0.09	0.10	0.[illegible]6

protein; 23.04, 20.80 and 13.88 crude fibre; 4.00, 3.90 and 4.50 ether extract; 46.76, 48.50 and 54.82 nitrogen free extract; 14.20, 15.00 and 14.90 total ash; 3.96, 4.95 and5.60 acid insoluble ash, respectively. Calcium and phosphorus contents of feeds 1, 2 and 3 were 1.23 and 0.43; 1.16 and 0.40, 1.19 and 0.43 per cent, respectively.

4.2 PHYSICAL CHARACTERISTICS OF COMPLETE FEEDS :

4.2.1 Bulk Density :

The bulk densities of feed ingredients and experimental feeds are presented in Table 5. The bulk density of feed ingredients used in the formulation of the experimental feeds ranged from 3.6 to 25.00 kg/cft. The densities of the processed complete feeds 1, 2 and 3 were 7.1, 6.4 and 7.3 kg.

4.2.2 Particle Size :

The modulus of uniformity of experimental feeds 1, 2 and 3 were 3:3:4, 3:4:3 and 2:3:5, respectively. The modulus of finness were 3.16, 3.39 and 2.63 for experimental complete feeds 1, 2 and 3, respectively.

4.3 COST ECONOMICS :

The data on the cost of processing of the experimental feeds are given in Table 6. The power consumed per two shifts of 8 hours each was 434.80, 436.98 and 415.52 KWH for processing of feeds 1, 2 and 3,

Table 5 : Bulk densities of feed ingredients and complete feeds

Item	(kg/Cft)
Ingredients	
Mixed grass hay meal	4.1
Sunflower straw meal	3.6
Sunflower head meal	4.7
Groundnut cake	16.9
Wheat bran	8.2
Rice polishings	12.5
Urea	20.2
Mineral mixture	25.0
Complete feeds	
1. (50% MGH)	7.1
2. (50% SSM)	6.4
3. (50% SHM)	7.3

Table 6 : Processing cost of complete feeds

Item	Complete feeds		
	1	2	3
1. Direct Charges			
a) Cost of power consumption/day @ ₨.0.45/KWH	195.66	196.62	186.98
(Power consumption/day, KWH)	(434.80)	(436.93)	(415.52)
b) Operator (two) @ ₨.30/- per day	60.00	60.00	60.00
c) Labour (six) @ ₨.15/- per day	90.00	90.00	90.00
2. Fixed cost*	332.33	332.33	332.33
3. a) Total expenditure per day (₨.)	677.99	678.95	669.31
b) Production per day (Tonnes) for 2 shifts of 8 hours each	8.00	9.12	9.80
c) Processing cost per quintal (₨.)	8.47	7.44	6.83

* Fixed costs :

1. Depreciation on building and machinery:
   a) Depreciation @ 5% per year on 1.0 lakh on civil works for 1 year — Rs.5,000.00
   b) Depreciation @ 10% per year on 3.5 lakh on plant machinery — Rs.35,000.00
2. Interest @ 10% on block investment (Rs.3.5 lakh) per year — Rs.45,000.00
3. Insurance @ 0.6% per year — Rs.2,700.00
4. Maintenance @ ₨.1,000/ per month (total working days 300 per year) — 12,000.00

Fixed costs per day — Rs.332.33

respectively. Total cost of energy per day was Rs.185.66, 190.62 and 186.98 for feeds 1, 2 and 3, respectively. The processing cost per quintal was Rs.8.47, Rs.7.44 and Rs.6.83 for the complete feeds 1, 2 and 3, respectively.

The data on the total cost of experimental feeds are presented in Table 7. The existing local market prices were used for calculating the cost of feeds. The cost per quintal of complete feeds 1, 2 and 3 inclusive of processing cost was Rs.127.41, Rs.116.38 and Rs.114.97, respectively.

4.1 GROWTH STUDIES :

The data pertaining to weight gains of lambs is given in Table 8 and Fig.1. An average daily gain of 75.17 ± 8.90, 69.00 ± 6.37 and 64.83 ± 5.91 g was observed in animals fed complete feeds 1, 2 and 3, respectively. The statistical analysis of data revealed on significant difference in average daily gain among the different treatment groups.

The data pertaining to feed efficiency and cost of feed per kg live weight gain are presented in Table 9 and Fig.1. Average dry matter consumption and corresponding weight gain of the experimental during the experimental period (180 days) were (kg) 147.75 and 13.72; 142.21 and 12.42 and 130.98 and 11.68 (kg) for groups 1, 2 and 3, respectively.

Table 7 : Cost of complete feeds

Ingredient	Cost per quintal (Rs.)	Experimental feeds		
		1	2	3
Mixed grass hay	70.00	35.00	-	-
Sunflower straw	50.00	-	25.00	-
Sunflower heads	50.00	-	-	25.00
Groundnut cake	260.00	52.00	52.00	52.00
Rice polishing	90.00	7.20	7.20	7.65
Wheat bran	138.00	13.80	13.80	13.80
Molasses	60.00	6.00	6.00	6.00
Urea	250.00	1.25	1.25	-
Mineral mixture	165.00	1.65	1.65	1.[illegible]
Common salt	55.00	0.28	0.28	0.28
Rovimix/kg	176.00	1.76	1.76	1.76
Processing cost/ quintal (Rs.)	-	8.47	7.44	6.83
Total cost/ quintal (Rs.)		127.41	116.38	114.97

Table 8: Average daily gain of sheep as affected by different complete feeds (180 days)

Complete feeds	Animal No.	Initial weight	Final weight	Weight gain	Average daily gain(g)
		----------kg------------			
1	556	11.0	25.9	14.9	83
	559	9.6	20.0	10.4	58
	564	8.5	20.6	12.1	67
	528	12.0	22.5	10.5	58
	537	8.0	21.5	13.5	75
	533	11.1	32.0	20.9	116
	Mean	10.03	23.75	13.72	76.17
	S.E. ±				8.90
2	557	9.5	19.4	9.9	55
	567	12.0	21.0	9.0	50
	569	12.0	28.6	16.6	92
	532	8.0	19.7	11.7	65
	536	8.0	21.1	13.1	73
	534	11.3	25.5	14.2	79
	Mean	10.13	22.55	12.42	69.00
	S.E. ±				6.37
3	562	8.0	17.4	9.4	52
	570	13.0	28.3	15.3	85
	567	9.0	18.4	9.4	52
	526	8.1	22.5	14.4	80
	530	11.4	21.5	10.1	56
	535	12.0	23.5	11.5	64
	Mean	10.25	21.93	11.68	64.8[illegible]
	S.E. ±				5.9[illegible]

Analysis of variance of average daily gain

Source of variation	d.f.	S.S.	M.S.S.	F
Feeds	2	394.79	197.39	0.64^{NS}
Error	15	4641.21	309.41	
Total	17	5036.00		

NS - Non significant.

Table 9 : Average feed efficiency and cost of feed per unit gain of sheep as affected by different complete feeds

Item	Complete feeds		
	1	2	3
Number of animals	6	6	6
Experimental period (days)	180	180	180
Average initial body weight (kg)	10.03	10.13	10.25
Average final body weight (kg)	23.75	22.55	21.93
Average weight gain (kg)	13.72	12.42	11.68
Average daily gain (g)	76	69	65
Average dry matter intake per animal during experimental period (kg)	147.75	142.21	130.98
Average dry matter intake/kg gain (kg)	10.77	11.45	11.21
Cost of feed/kg live weight gain (Rs.)	15.94	15.31	15.16

The average dry matter consumed (kg) per kg live weight gain and the average cost of feed (Rs.) per kg live weight gain of the experimental animals fed complete feeds 1, 2 and 3 were 10.77 and 15.94; 11.45 and 15.31 and 11.21 and 15.16, respectively.

4.5 METABOLIC STUDIES :

4.5.1 Voluntary Feed Intake :

The average dry matter consumption per 100 kg body weight (kg) and per kg metabolic body weight (g) recorded in this experiment (Table 10) were 3.35 and 73.52; 2.89 and 64.08 and 2.69 and 59.78 for sheep fed complete feeds 1, 2 and 3, respectively. The dry matter consumption was not significantly different among the animals fed different complete feeds.

4.5.2 Dry Matter Digestibility :

The average dry matter digestibility coefficients (Table 11) recorded for feeds 1, 2 and 3 were 55.33 ± 1.20, 58.25 ± 1.63 and 59.46 ± 0.78 per cent, respectively. The dry matter digestibility was not significantly different among the animals fed different experimental feeds.

4.5.3 Organic Matter Digestibility :

Average organic matter digestibility data of the sheep are given in Table 12. Average daily organic matter intakes were 674.95, 595.52 and 548.69 g with

Table 10 : Dry matter intake by sheep as affected by different complete feeds

Complete feed	Animal No.	Body weight (kg)	Metabolic body weight (kg)	Dry matter intake per Day (kg)	Dry matter intake per 1 x 100 kg body weight (kg)	Dry matter intake per 0.75 kg body weight (g)
1	533	31.50	13.29	904.80	2.87	68.08
	537	20.50	9.63	726.46	3.54	75.44
	564	20.00	9.46	728.72	3.64	77.03
	Mean			786.66	3.35	73.52
	S.E. ±			59.61	0.24	2.71
2	534	25.00	11.16	481.32	1.93	43.12
	536	21.00	9.81	886.47	4.22	90.36
	569	29.00	12.49	734.04	2.53	58.77
	Mean			700.61	2.89	64.08
	S.E. ±			118.15	0.69	13.89
3	530	21.00	9.81	568.58	22.71	57.96
	535	21.50	9.98	538.08	2.50	53.92
	570	29.00	12.49	827.61	2.85	66.26
	Mean			644.76	2.69	59.38
	S.E. ±			91.84	0.04	3.63

Analysis of variance of dry matter intake

Parameter	Source of variation	d.f	S.S.	M.S.	F
DM intake/ 100 kg body weight	Feeds	2	0.69	0.35	0.63^{NS}
	Error	6	3.24	0.54	
	Total	8	3.93		
DM intake/ kg metabolic body weight	Feeds	2	310.95	155.48	0.73^{NS}
	Error	6	1282.92	213.82	
	Total	8	1593.87		

NS - Non significant

Table 11 : Dry matter digestibility in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted in faeces	Digested	Digestibility coefficients (%)
		---------- g	-------------		
1	533	904.80	425.26	479.54	53.00
	537	726.46	312.38	414.08	56.99
	564	728.72	320.64	408.08	55.99
	Mean	786.66			55.33
	S.E. ±	59.61			1.20
2	534	481.32	215.88	265.44	55.15
	536	886.47	354.59	531.88	60.70
	569	734.04	302.85	434.22	58.91
	Mean	700.61			58.25
	S.E. ±	118.15			1.63
3	530	568.58	238.68	329.90	58.02
	535	538.08	217.12	320.96	59.65
	570	827.61	325.20	501.41	60.71
	Mean	644.76			59.46
	S.E. ±	91.84			0.78

Analysis of variance of dry matter digestibility

Source of variation	d.f	S.S.	M.S.S.	F
Feeds	2	27.11	13.56	2.87^{NS}
Error	6	28.34	4.72	
Total	8	55.45		

NS - Not significant

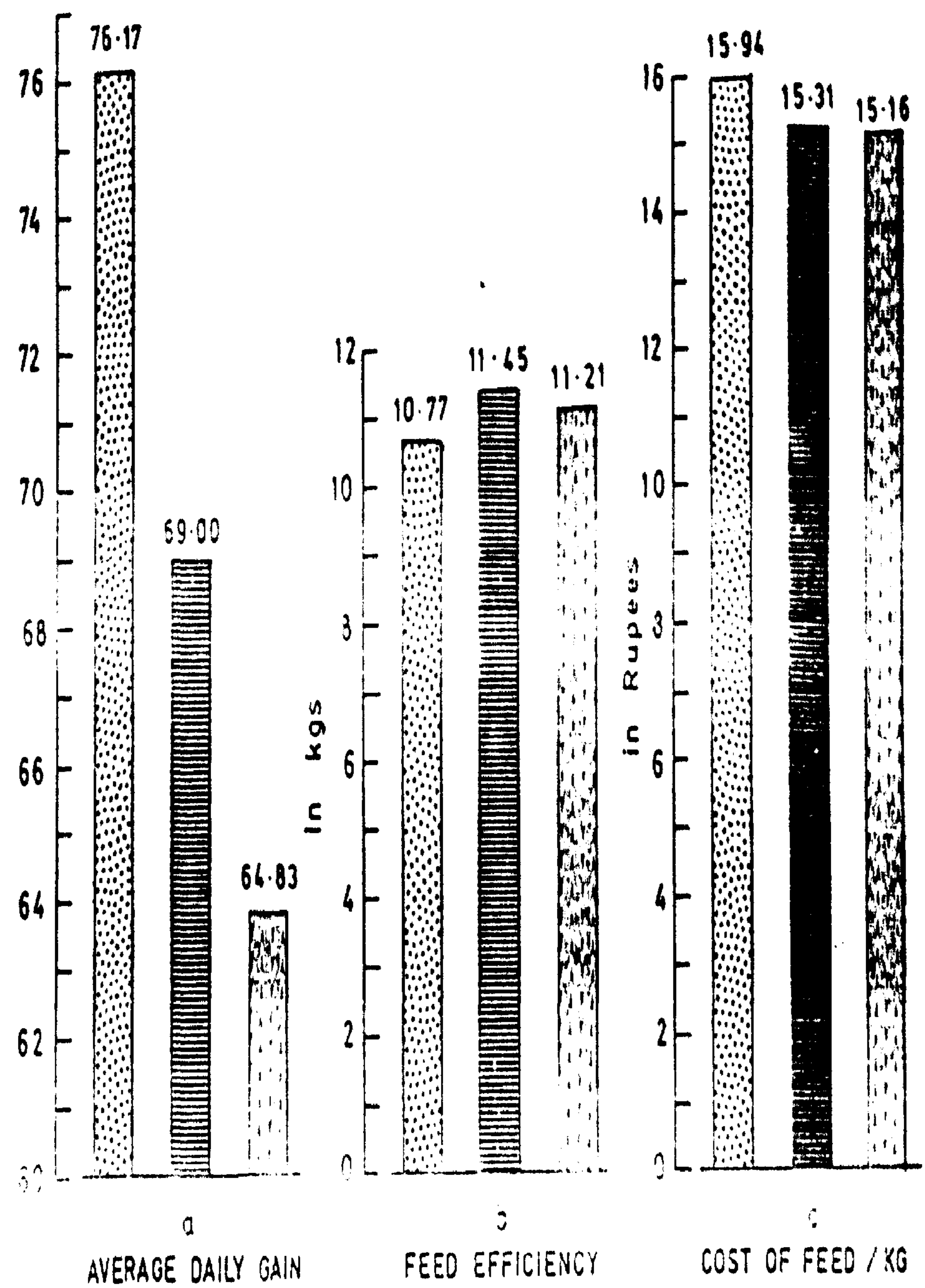

FIG. 4 : GROWTH STUDIES IN NELLORE SHEEP LIVE WEIGHT GAIN

Table 12 : Organic matter digestibility in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted in faeces	Digested	Digestibility coefficients (%)
		----------	g	----------	
1	533	776.32	323.20	453.12	58.37
	537	623.30	248.33	374.97	66.16
	564	625.24	255.66	369.58	59.11
	Mean	674.95			61.21
	S.E. ±	50.69			2.48
2	534	409.12	172.49	236.63	57.84
	536	759.50	293.07	460.43	61.11
	569	623.93	256.94	366.99	58.82
	Mean	595.52			59.26
	S.E. ±	100.43			0.97
	530	483.86	184.98	298.88	61.77
	535	457.91	168.33	289.58	63.24
	570	704.30	253.33	450.97	64.63
	Mean	548.69			63.21
	S.E. ±	78.17			0.82

Analysis of variance of organic matter digestibility

Source of variation	d.f.	S.S.	M.S.S.	F
Feeds	2	23.48	11.74	1.51 NS
Error	6	46.70	7.78	
Total	8	70.18		

NS - Not significant

feeds 1, 2 and 3, respectively. Averge organic matter digestibility coefficients were 61.21 ± 2.48, 59.26 ± 0.97 and 63.21 ± 0.82 per cent among the animals fed complete feeds 1, 2 and 3, respectively. Organic matter digestibility coefficients were not significantly different among the three treatment groups.

4.5.4 Crude Protein Digestibility :

Daily average crude protein intake, outgo in faeces and digestibility coefficients are presented in Table 13. An average crude protein intake of 94.40, 82.52 and 76.73 g with an average digestibility coefficient of 64.43 ± 0.69, 61.36 ± 0.53 and 61.10 ± 1.06 per cent were recorded among the experimental animals, fed complete feeds 1, 2 and 3, respectively. Crude protein digestibility coefficients recorded among different feeds were not significantly different.

4.5.5 Crude Fibre Digestibility :

Daily average crude fibre intake, outgo in faeces and digestibility coefficients are presented in Table 14. The average digestibility coefficient were 50.96 ± 0.62, 52.68 ± 2.44 and 49.51 ± 0.53 per cent, with complete feeds 1, 2 and 3, respectively. The crude fibre digestibility coefficients were not significantly different among the different treatment groups.

Table 13 : Crude protein digestibility in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted in faeces	Digested	Digestibility coefficients (%)
		---------- g ----------			
1	533	108.58	39.09	69.49	64.00
	537	87.18	29.82	57.36	65.79
	564	87.45	31.91	55.54	63.51
	Mean	94.40			64.43
	S.E. ±	7.09			0.69
2	534	56.80	22.34	34.46	60.67
	536	104.60	38.25	66.55	63.43
	569	86.17	34.47	51.70	60.00
	Mean	82.52			61.36
	S.E. ±	19.68			0.53
3	530	67.66	25.44	42.22	62.40
	536	64.03	24.39	39.44	61.91
	570	98.49	40.39	58.10	58.99
	Mean	76.73			61.10
	S.E. ±	10.93			1.06

Analysis of variance of crude protein digestibiliy

Source of variation	d.f	S.S.	M.S.S	F
Feeds	2	16.84	8.42	2.52^{NS}
Error	6	20.03	3.34	
Total	8	36.87		

NS - Not significant.

Table 14 : Crude fibre digestibility in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted in faeces	Digested	Digestibility coefficients (%)
		----------	g	----------	
1	533	263.80	128.30	135.50	51.37
	537	190.31	91.80	98.61	51.76
	564	180.63	90.81	89.83	49.73
	Mean	211.58			50.95
	S.E. ±	26.26			0.62
2	534	119.18	62.50	56.68	57.56
	536	224.01	112.05	111.96	49.98
	569	183.24	89.80	93.44	50.51
	Mean	175.48			52.68
	S.E. ±	30.51			2.44
3	530	92.02	45.59	46.43	50.46
	535	87.44	44.94	42.50	48.61
	570	129.36	65.37	63.99	49.47
	Mean	102.94			49.51
	S.E. ±	13.28			0.53

Analysis of variance of crude fibre digestibility

Source of variation	d.f	S.S.	M.S.S	F
Feeds	2	15.38	7.59	
Error	6	39.84	6.64	1.14^{NS}
Total	8	70.28		

NS - Not significant.

4.5.6 **Ether Extract Difgestibility :**

Ether extract digestibility data are presented Table 15. An average daily intakes of 31.47, 27.32 and 29.02 g and an average digestibility coefficient of 56.18 ± 1.14, 56.05 ± 2.13 and 55.58 ± 1.75 per cent were recorded in sheep received complete feeds 1, 2 and 3, respectively. Significantly differences in ether extract digestibility were not observed among the different feeds.

4.5.7 **Nitrogen-free Extract Digestibility :**

Digestibility data of nitrogen-free extract of the experimental feeds are presented in Table 16. The average daily intakes were 367.84, 339.80 and 353.46 g while the average digestibility coefficients were 60.46 ± 0.17, 60.09 ± 1.19 and 64.36 ± 0.76 per cent on the feeds 1, 2 and 3, respectively. Nitrogen-free extract digestibility coefficients were significantly higher ($P<0.05$) on complete feed 3 compared to other feeds.

4.6 **BALANCE STUDIES :**

4.6.1 **Nitrogen Balance :**

Data of average intake, outgo and retention of nitrogen are given in Table 17. All the sheep were in positive nitrogen balances. The average daily positive nitrogen balances recorded were 2.79, 2.63 and 2.68 g among groups fed complete feeds 1, 2 and 3, respectively.

Table 15 : Ether extract digestibility in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted in faeces	Digested	Digestibility coefficients (%)
		----------	g	----------	
1	533	36.19	16.66	19.53	53.97
	537	29.08	12.51	16.51	56.81
	564	29.15	12.31	16.84	57.77
	Mean	31.47			56.18
	S.E. ±	2.36			1.14
2	534	18.77	7.58	11.19	59.62
	536	34.57	15.15	19.42	56.18
	569	28.63	13.64	14.99	52.36
	Mean	27.32			56.05
	S.E. ±	4.61			2.13
3	530	25.59	12.18	13.41	52.41
	535	24.22	10.06	1.16	58.48
	570	37.24	16.43	20.81	55.87
	Mean	29.02			55.58
	S.E. ±	4.13			1.75

Analysis of variance of Ether extract digestibility

Source of variation	d.f	S.S.	M.S.S	F
Feeds	2	0.59	0.30	0.03^{NS}
Error	6	52.73	8.78	
Total	8	53.32		

NS - Not significant

Table 16 : Nitrogen-free extract digestibility in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted in faeces	Digested	Digestibility coefficients (%)
		g			
1	533	423.09	165.89	257.20	60.79
	537	339.69	134.70	204.99	60.35
	564	340.75	135.44	208.31	60.25
	Mean	367.84			60.46[a]
	S.E. ±	27.63			0.17
2	534	233.44	96.39	137.05	58.71
	536	429.94	161.44	268.50	62.45
	569	356.01	145.58	210.43	59.11
	Mean	339.80			60.09[a]
	S.E. ±	57.30			1.19
3	530	311.70	115.40	196.30	62.98
	535	294.98	104.72	190.26	64.50
	570	453.70	156.03	297.67	65.61
	Mean	353.46			64.36[b]
	S.E. ±	50.35			0.76

a, b - Values with different superscripts differ significantly

Analysis of variance of nitrogen-free extract digestibility

Source of variation	d.f	S.S.	M.S.S	F
Feeds	2	33.61	16.81	
Error	6	12.09	2.01	8.36*
Total	8	45.70		

* Significant ($P<0.05$)

Table 17 : Nitrogen balance in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted			Balance
			Faeces	Urine	Total	
		g				
1	533	17.37	6.00	8.50	14.50	2.87
	537	13.95	4.52	6.68	11.20	2.75
	564	13.99	4.85	6.38	11.23	2.76
	Mean	15.10				2.79
	S.E. ±	1.13				0.03
2	534	9.09	3.32	3.30	6.62	2.47
	536	16.73	5.87	8.04	13.91	2.82
	569	13.78	5.26	5.93	11.19	2.59
	Mean	13.20				2.63
	S.E. ±	2.22				0.10
3	530	10.82	3.82	4.36	8.18	2.64
	535	10.24	3.65	3.97	7.62	2.62
	570	15.76	6.21	6.76	12.97	2.77
	Mean	12.27				2.68
	S.E. ±	1.76				0.05

Analysis of variance of nitrogen balance

Source of variation	d.f	S.S.	M.S.S	F
Feeds	2	0.04	0.02	4.0[NS]
Error	6	0.03	0.005	
Total	8	0.07		

NS - Not significant

The nitrogen balances were not significantly different among the animals fed different feeds.

4.6.2 **Calcium Balance :**

Daily calcium intake, out go and balance data of sheep are recorded in Table 18. All the groups were in positive calcium balance. The average daily calcium balances recorded were 2.21, 1.99 and 1.95 g among the groups fed complete feeds 1, 2 and 3, respectively. The calcium balances were not significantly different among the animals fed different feeds.

4.6.3 **Phosphorus Balance :**

Data pertaining to phosphorus retention are given in Table 19. All the experimental animals were in positive phosphorus balance. The average daily phosphorus balances were 1.10, 0.97 and 1.01 g among the sheep received feeds 1, 2 and 3, respectively. The phosphorus balances observed among the three groups were not significantly different.

The results of digestion and metabolic studies are summarised in Table 20.

4.7 **PLANE OF NUTRITION OF EXPERIMENTAL ANIMALS :**

The data on plane of nutrition of Nellore rams fed different experimental feeds in the digestibility and metabolic studies are presented in Table 21.The digestible

Table 18 : Calcium balance in sheep as affected by different complete feeds

Complete feed	Animal No.	Intake	Excreted Faeces	Excreted Urine	Excreted Total	Balance
		g				
1	533	11.13	7.93	1.10	9.03	2.30
	537	8.93	6.92	0.93	6.85	2.18
	564	8.96	6.04	0.78	6.82	2.14
	Mean	9.67				2.21
	S.E. ±	0.73				0.05
2	534	5.58	2.89	0.67	3.56	1.72
	536	10.28	6.97	1.03	8.00	2.28
	569	8.81	5.69	0.85	6.54	1.97
	Mean	8.12				1.99
	S.E. ±	1.37				0.16
3	530	6.77	4.10	0.84	4.94	1.83
	535	6.40	3.81	0.77	4.58	1.82
	570	9.86	6.69	0.96	7.65	2.20
	Mean	7.68				1.95
	S.E. ±	1.10				0.12

Analysis of variance of calcium balance

Source of variation	d.f	S.S	M.S.S	F
Feeds	2	0.36	0.18	4.91^{NS}
Error	6	0.22	0.04	
Total	8	0.58		

NS - Not significant

Table 19 : **Phosphorus balance in sheep as affected by different complete feeds**

Complete Feed	Animal No.	Intake	Excreted			Balance
			Faeces	Urine	Total	
		-----------	-----------	g	-----------	-----------
1	533	3.89	2.07	0.71	2.78	1.11
	537	3.12	1.40	0.63	2.03	1.09
	564	3.13	1.45	0.59	2.04	1.09
	Mean	3.38				1.10
	S.E. ±	0.25				0.01
2	534	1.93	0.84	0.27	1.11	0.82
	536	3.54	1.63	0.82	2.45	1.09
	569	2.94	1.32	0.61	1.93	1.01
	Mean	2.80				0.97
	S.E. ±	0.47				0.08
3	530	2.44	0.92	0.53	1.45	0.99
	535	2.31	0.79	0.52	1.31	1.00
	570	3.56	1.83	0.69	2.52	1.04
	Mean	2.27				1.01
	S.E. ±	0.40				0.02

Analysis of variance of phosphorus balance

Source of variation	d.f	S.S.	M.S.S	F
Feeds	2	0.02	0.01	1.67 NS
Error	6	0.04	0.006	
Total	8	0.06		

NS - Not significant

Table 20 : Average digestibility coefficients and balances of various nutrients in sheep as affected by different complete feeds

Item	Complate feeds		
	1	2	3
<u>Digestibility coefficients</u> (%)			
Dry matter	55.33	58.25	59.46
Organic matter	61.21	59.26	63.21
Crude protein	64.43	61.36	61.10
Crude fibre	50.95	52.68	49.61
Ether extract	56.18	56.05	55.58
Nitrogen-free extract	60.46[a]	60.09[a]	64.36[b]
<u>Balances</u> (g/day)			
Nitrogen	+ 2.79	+ 2.63	+ 2.68
as % intake	18.65	20.94	22.52
as % absorbed	28.11	33.06	35.49
Calcium	+ 2.21	+ 1.99	+ 1.95
as % intake	22.98	25.98	25.98
Phosphorus	+ 1.10	+ 0.97	+ 1.01
as % intake	32.76	34.35	37.69

a, b - Values with different superscripts differ significantly (P< 0.05)

Table 21 : Plane of nutrition of sheep as affected by different complete feeds

Complete feed	Body weight (kg)	Metabolic body weight (kg)	DCP		TDN		DM intake per 100 kg body wt(g)	DE intake per day (Mcal)	ME intake per day (Mcal)	Intake per unit metabolic body weight			Pr... tein Energy rati...
			% in feed	Intake per day (g)	% in feed	Intake per day (g)				DM (g)	FCP (g)	ME (Kcal)	
1	24.00	10.84	7.73	60.82	52.78	415.20	3.35	1.83	1.50	72.60	5.61	138.00	1:3
2	25.00	11.18	7.22	50.63	51.11	359.08	2.89	1.58	1.29	62.70	4.53	112.00	1:3
3	23.80	10.77	7.27	46.88	55.05	[illegible]	2.69	1.56	1.26	59.69	4.35	119.00	1:3

crude protein contents of complete feeds 1, 2 and 3 were 7.73, 7.22 and 7.27 per cent, respectively. The average digestible crude protein consumed by experimental animals was 60.82, 50.63 and 46.88 g on feeds 1, 2 and 3, respectively.

The total digestible nutrients content of feeds 1, 2 and 3 were 52.78, 51.11 and 55.05 per cent, respectively. The average total digestible nutrients consumed by experimental animals was 415.20, 358.08 and 344.94 g, respectively. The estimated intake of dry matter, digestible crude protein and metabolizable energy per unit metabolic body weight of the experimental animals ranged from 59.89 to 72.60 g, 4.35 to 5.61 g and 112.00 to 138.00 Kcal, respectively.

4.7.1 Protein Engergy Ratio of Experimental Feeds :

The estimated protein energy ratios (digestible crude protein g and digestible energy Kcal) of the experimental feeds are presented in Table 21. The protein : energy ratios were 1:30, 1:31 and 1:33 among the animals fed complete feeds 1, 2 and 3, respectively.

4.8 CARCASS STUDIES :

At the conclusion of growth and metabolic studies, two representative animals from each group were slaughtered to study the effect of these complete feeds on carcass characteristics.

4.8.1 Dressing Percentage :

The dressing percentages of carcass on live weight and empty body weight are given in Table 22. The dressing percentages recorded were 47.15 and 56.60; 47.99 and 57.59; 53.73 and 62.80 on live weight and on empty body weight for animals fed complete feeds 1, 2 and 3, respectively.

4.8.2 Proportions of Wholesale Cuts :

Proportions of wholesale cuts are given in Table 23. The per cent of leg, loin, rack, shoulder and neck and foreshank and brisket in carcass were 36.00, 12.45; 17.20, 23.95 and 10.40 for feed 1, 34.85, 11.30, 16.05, 25.10 and 12.50 for feed 2 and 35.30, 13.15, 15.25, 23.45 and 12.35 for feed 3, respectively.

4.8.3 Proportions of Lean, Bone and Fat :

The proportions of lean, bone, fat and bone : meat ratios as effected by different feeds are given in Table 24. The proportions of lean, bone and fat in the carcass of sheep were 66.02, 20.59 and 13.38 for feed 1, 64.50, 25.87 and 9.62 for feed 2 and 67.91, 22.13 and 9.96 for feed 3, respectively.

The bone : meat ratios in carcass of animals fed complete feeds 1, 2 and 3 were 1:3.86, 1:2.87 and 1: 3.53, respectively.

Table 22 : Dressing percentage of carcasses of sheep as affected by different complete feeds

Complete Feed	Animal No.	Live weight at slaughter	Empty body weight	Carcass weight	Dressing per cent on live weight	Dressing per cent on empty body weight
		------------	kg	----------		
1	537	22.00	17.97	10.25	47.09	57.66
	564	21.00	17.85	9.60	47.20	55.54
	Mean	21.50	17.91	9.93	47.15	56.60
2	534	23.50	19.77	11.58	49.27	58.57
	536	20.00	16.50	9.24	46.70	56.60
	Mean	21.75	18.14	10.41	47.99	57.59
3	535	23.00	19.75	11.60	50.43	58.73
	530	20.50	17.48	11.40	57.02	66.87
	Mean	21.75	18.74	11.50	53.73	62.80

Table 23 : Proportions (%) of wholesale cuts in the carcasses of sheep as affected by different complete feeds

Complete feed	Animal No.	Carcass weight (kg)	Leg	Loin	Rack	Shoulder and neck	Foreshank and brisket
			%				
1	537	10.25	36.30	11.80	16.40	25.00	10.40
	564	9.60	35.70	12.90	18.00	22.90	10.40
	Mean	9.93	36.00	12.35	17.20	23.95	10.40
2	534	11.58	36.00	11.00	15.00	26.20	11.60
	536	9.24	33.70	11.60	17.10	24.00	13.40
	Mean	10.41	34.85	11.30	16.05	25.10	12.50
3	535	11.60	35.60	13.10	16.40	21.90	12.70
	530	11.56	35.00	13.20	14.10	25.00	12.00
	Mean	11.58	35.30	13.15	15.25	23.45	12.35

Table 24 : **Proportions of lean, bone and fat in the carcasses of sheep as affected by different complete feeds**

Complete feed	Animal No.	Carcass weight (kg)	Proportions of Lean	Bone	Fat	Bone: meat ratio
			----------(%)----------			
1	537	10.25	65.21	22.82	11.96	1:3.38
	534	9.60	66.85	18.35	14.79	1:4.45
	Mean	9.93	66.03	20.59	13.38	1:3.86
2	534	11.58	65.29	25.22	9.47	1:2.97
	536	9.24	63.71	26.51	9.76	1:2.77
	Mean	10.41	64.50	25.87	9.62	1:2.87
3	535	11.60	66.82	23.15	10.02	1:3.32
	530	11.56	68.99	21.11	9.89	1:3.74
	Mean	11.58	67.91	22.13	9.96	1:3.53

4.8.4 Edible and Non-edible Organs :

The per cent weights of edible organs, non-edible organs and the ratios of edible : non-edible organs in the carcasses of sheep as effected by different complete feeds are given in Table 25. The per cent weights of edible organs and non-edible organs in animals fed complete feeds 1, 2 and 3 were 3.42 and 8.28, 3.22 and 8.38 and 3.47 and 6.85, respectively.

The ratios of edible : non-edible organs in the carcass of animals fed complete feeds 1, 2 and 3 were 1: 2.42, 1:2.60 and 1:1.97, respectively.

The results of slaughter studies are summarized in Table 26.

Table 25 : Effect of different complete feeds on edible and non-edible organs

Complete feed	Animal No.	Slaughter weight	Weight of edible organs	Weight of edible organs / Slaughter weight x 100	Weight of non-edible organs (kg)	Weight of non-edible organs / Slaughter weight x 100	Edible : non-edible ratio
1	537	22.00	0.73	3.32	1.81	8.23	1: 2.48
	564	21.00	0.74	3.52	1.75	8.33	1: 2.37
	Mean	21.50	0.74	3.42	1.78	8.28	1: 2.42
2	534	23.50	0.70	2.98	1.66	[illegible]	1: 2.67
	536	20.00	0.69	3.45	1.75	8.75	1: 2.53
	Mean	21.75	0.70	3.22	1.82	[illegible]	1: 2.60
3	535	23.00	0.83	3.61	1.67	7.26	1: 2.02
	530	20.50	0.68	3.32	1.30	6.34	1: 1.91
	Mean	21.75	0.76	3.47	1.49	6.85	1: 1.97

Table 26 : Carcass characteristics of sheep as affected by different complete feeds

Item	Complete feeds 1	2	3
1. Dressing percentage			
a) Live weight	47.15	47.99	53.73
b) Empty body weight	56.60	57.59	62.80
2. Proportions of wholesalecuts (%)			
a) Leg	36.00	34.85	35.30
b) Loin	12.35	11.30	13.15
c) Rack	17.20	16.05	15.25
d) Shoulder & neck	23.95	25.10	23.45
e) Foreshank & brisket	10.40	12.50	12.35
3. Proportions of lean, bone and fat (%)			
a) Lean	66.02	64.50	67.91
b) Bone	20.59	25.87	22.13
c) Fat	13.38	9.62	9.96
d) Bone : Meal ratio	1:3.86	1:2.87	1:3.53
4. Per cent of edible organs	3.42	3.22	3.47
5. Per cent of non-edible organs	8.28	8.38	6.85
6. Edible : Non-edible organs ratio	1:2.42	1:2.60	1:1.97

CHAPTER V

DISCUSSION AND CONCLUSIONS

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DISCUSSION AND CONCLUSION

Three complete feeds (non cereal based) were formulated and processed into mash using MGH, SSM and SHM as sole source of roughage for sheep. A 180 day growth trial involving 18 Nellore lambs (6 in each group) and a metabolic trial involving 9 rams (3 from each group of growth trial) were conducted to assess the growth rate, feed efficiency, nutrient utilization. Carcass characteristics were also studied by slaughtering 2 rams from each group at the end of the experiment.

5.1 EXPERIMENTAL FEEDS :

5.1.1 Processing of Complete Feeds :

The capacity of the pilot plant is one tonne per hour for concentrate feeds. However, this production capacity could not be achieved in processing complete feeds used in this experiment due to the incorporation of fibrous materials at 50 per cent level. The production performance of the mill for the formulae processed worked out on an average 500, 570 and 613 kg per hour for complete feeds 1, 2 and 3, respectively. The low production rate of complete feeds may be attributed to the poor flow characteristics of MGH, SSM and SHM due to their low density, particle shape and size. However, the higher production rate on complete feed 3 than other two feeds indicate SHM used in this feed offered less resistance in processing most probably due to their lower crude fibre level (Table 4). Similar results were reported by Joji Reddy and Reddy (1985 a) while processing complete feeds for ruminants using sorghum straw/mixed grass hay as sole source of roughage.

5.1.2 Chemical Composition :

The chemical composition (Table 4) of SSM was comparable to that of MGH, a low grade roughage. The chemical composition of SHM (7.22% CP, 62.65% NFE and 16.63% CF) indicate that it was superior to low grade crop residues including sunflower straw (Gomez Cabrera, 1977). The lowest crude fibre content of complete feed 3 was a reflection of lowest crude fibre content of SHM used in this feed as roughage source.

5.2 PHYSICAL CHARACTERISTICS :

5.2.1 Bulk Density :

The densities of MGH, SSM and SHM were 4.1, 3.6 and 4.7 kg/Cft, while those of complete feeds 1, 2 and 3 were 7.1, 6.4 and 7.3 respectively (Table 5). By incorporating the roughages (50%) in complete feeds, the densities were increased by 58, 56 and 64 per cent for MGH, SSM and SHM respectively. This indicate that light fibrous materials could be improved in their bulk densities by incorporating in complete feeds which will have longer retention in rumen resulting in improved digestibility.

5.2.2 Particle Size :

The values of modulus of finess (which is indicative of coarseness of the particles) and modulus of uniformity (which indicates the distribution of feed particles in coarse, medium and fine mesh screens) indicate that complete feed containing SHM had more fine particles and that complete feed containing MGH had more coarse particles. This may be attributed to brittleness and fibre characteristics of the roughages used in the respective feeds.

5.3 COST ECONOMICS :

The total cost of processing (Table 6) of complete feeds 1, 2 and 3 were Rs.8.47, 7.44 and 6.83, respectively. There was an increase of Rs.4.69, Rs.3.66 and Rs.3.05 for processing of complete feeds 1, 2 and 3, respectively, per quintal as compared to Rs.3.78 per concentrate mixture recorded by Gowd (1986). The higher processing cost was due to inclusion of MGH, SSM and SHM, low density fibrous materials at 50 per cent level which in turn reflected on the performance at processing points (grinding and mixing) and increased wages for operator and labour.

5.4 GROWTH STUDIES :

Average daily gains observed in this experiment 76.17, 69.00 and 64.83 g/day on complete feeds 1, 2 and

3, respectively (Table 8) were not significantly different. However, the complete feed 1 had 10.39 and 17.49 per cent higher gains than the feeds 2 and 3, respectively, while feed 2 had 6.43 per cent higher gains than feed 3. The decreased trend of ADG from complete feed 1 to 3 was in accordance with increased proportions of fine particles in the feeds. The increased fineness of particles in feeds 2 and 3 might have made them more dusty and hence less palatable. This might have resulted in decreased dry matter intake (Table 9) and hence decreased ADG. However, the average daily gains recorded in this experiment were comparable to the values reported by Vahidulla (1984) on complete feed containing subabul meal and Jojireddy and Reddy (1985 a) on complete feeds containing sorghum straw/mixed grass hay as roughage source indicating that the growth rates recorded in this study were optimum and these complete feeds provided the required nutrients for growth. However, these values were lower than the ADG reported by Orskov et al. (1971), Craddock et al. (1974), Pilli et al. (1978) and Kulik et al. (1978). This may be attributed to the breed differences of sheep and to the composition of feeds used in these experiments. The values were higher than the values reported by Reddy and Reddy (1981) on complete feeds based on crop residues and agro-industrial by-products indicating that these feeds were superior in supplying the nutrients required for growth.

The dry matter intake/kg gain (feed efficiency) recorded in this study of 10.76, 11.46 and 11.21 kg for feeds 1, 2 and 3, respectively, were not significantly different indicating that all feeds were equally efficient in obtaining weight gains in lambs. The feed efficiency values were optimum and comparable to the values reported by Reddy and Reddy (1981) on complete feeds containing crop residues and agro-industrial by-products, Vahidulla (1984) on complete feeds containing Koobabul meal and Jojireddy and Reddy (1985 a) on sorghum straw/mixed grass hay based complete feeds.

The cost of feed per kg live weight gain values (Rs.) 15.94, 15.31 and 15.16 on complete feeds 1, 2 and 3, respectively, were comparable and were within reasonable limits. The decreased trend in cost of feed per kg gain from complete feed 1 to 3 was a reflection of decreased cost of these feeds (Table 9).

The results of growth study indicate that sunflower straw and sunflower heads can be incorporated as sole source of roughage in complete feeds for lambs without any effect on growth rate, and feed efficiency along with a marginal decrease in cost of feed per kg live weight gain in place of conventional mixed grass hay.

5.5 METABOLIC STUDIES :

5.5.1 Voluntary Feed Intake :

The dry matter intakes as per cent of body weight (Table 10) for feeds 1, 2 and 3 were 3.35, 2.89

and 2.69 kg, respectively. The dry matter intakes were not significantly different among the complete feeds. However, there was an increase of 15.92 and 24.54 per cent in dry matter intake on complete feed 1 compared to complete feeds 2 and 3, respectively. This may be attributed to the higher proportions of coarse particles in that feed and also to ad libitum feeding. Hubbel et al. (1985) observed no significant difference in mean dry matter intake of cows fed with sunflower silage and corn silage. An average daily dry matter intake of 23 g/kg 0.75 was observed in sheep feed chopped sunflower stalks as sole feed (Gomez Cabrera, 1977 and Flores et al., 1978).

5.5.2 Dry Matter Digestibility :

The digestibility coefficients recorded among the three treatment groups (Table 11) were not significantly different. However, the digestibilities were slightly higher (3.5 to 4.0%) on feeds 2 and 3 than on control feed indicating that SSM and SHM were more digestible than MGH. Reddy (1986) recorded higher dry matter digestibilities for cattle fed on complete feed containing sunflower straw as sole source of roughage than conventional ration containing paddy straw as roughage source. Reddy et al. (1986) recorded significantly higher (P<0.01) dry matter digestibility in sheep fed complete feed containing sunflower heads than that containing mixed grass hay.

5.5.3 **Organic Matter Digestibility :**

Organic matter intake (Table 12) decreased from complete feed 1 to 3 as a result of decreased dry matter intake on these rations. Organic matter intake was 13.34 and 23.01 per cent higher on complete feed than complete feeds 2 and 3 respectively.

Average organic matter digestibilities were 61.21, 59.26 and 63.21 for complete feeds 1, 2 and 3, respectively (Table 12). Digestibility of organic matter was not significantly different among the feeds. However, the feed containing SHM showed 3.27 and 6.68 per cent higher organic matter digestibilities than the feeds containing MGH and SSM, respectively. If there were no associative affects between SHM and other dietary components, this increase will account for 6.54 and 13.36 per cent higher organic matter digestibility of SHM over MGH and SSM, respectively, in sheep. Flores et al. (1978) reported the organic matter digestibility of chopped sunflower stalks as 49.8 per cent. Reddy et al. (1986) reported significantly higher (P<0.01) organic matter digestibility on complete feed containing SHM compared to that containing MGH.

5.5.4 **Crude Protein Digestibility :**

Slightly higher intakes of crude protein were observed on complete feed 1 than 2 and 3 (Table 13) as a reflection of higher dry matter intake on this feed.

Digestibilities were not significantly different among the 3 feeds indicating that the crude protein from SSM and SHM was fairly digestible and that these roughages had no adverse effect on crude protein digestibility of other ingredients. Slightly higher crude protein digestibility recorded on complete feed 1 indicate that the protein from MGH was more soluble than that of SSM and SHM. Flores et al. (1978) reported crude protein digestibility of sunflower stalks in sheep as 43 per cent.

5.5.6 Crude Fibre Digestibility :

Crude fibre intake was lower in feed 3 because of its low crude fibre content (Table 14). The higher crude fibre intakes on control feed over feed 2 was partly due to its higher crude fibre content and partly to higher dry matter intake on this feed.

The crude fibre digestibilities of the animals fed different complete feeds were not differing significantly. Flores et al. (1978) reported the crude fibre digestibility of chopped sunflower stalks as 43.1 per cent. Reddy (1986) reported crude fibre digestibility of 50.76 per cent in crossbred bulls fed complete ration containing 50 per cent SSM. Reddy et al. (1986) reported no significant differences among the complete feeds containing MGH and SHM in sheep.

5.5.6 Ether Extract Digestibility :

Ether extract intake (Table 15) was higher on complete feed 1 due to higher dry matter intake on this feed than complete feeds 2 and 3. Though the dry matter intake was less, the higher ether extract intake on complete feed 3 than complete feed 2 was a reflection of higher ether extract content of SHM compared to SSM.

Ether extract digestibilities were not significantly different among the animals fed complete feeds 1, 2 and 3 (Table 15) indicating that ether extract from all the rations was equally digestible. The ether extract digestibilities recorded in this investigation were comparable to the values reported by Reddy (1986) in cattle fed complete feed containing sunflower straw and Johjireddy and Reddy (1985 a) in sheep fed complete feed containing mixed grass hay. However, these values were lower than the values reported by Gomez Cabrera (1977) in sheep fed on sunflower stalks and Reddy et al. (1986) fed sheep with complete feeds containing mixed grass hay and sunflower heads.

5.5.7 Nitrogen-free Extract Digestibility :

The higher nitrogen-free extract intakes (Table 16) recorded on control feed may be attributed to increased dry matter intake on that feed.

Nitrogen-free extract digestibility was significantly higher ($P<0.05$) on complete feed 3 compared to other two feeds which were comparable indicating that nitrogen-free extract from SHM was more digestible than that of MGH and SSM. The nitrogen-free extract digestibility of complete feed 2 containing SSM was comparable to the results reported by Gomez Cabrera (1977) in sheep fed sunflower stalks as sole feed. Reddy et al. (1986) observed higher nitrogen-free extract digestibility in sheep fed complete feed containing sunflower heads than that containing mixed grass hay. However, nitrogen-free extract digestibilities were reported by Reddy (1986) in cattle fed complete feed containing sunflower straw and Jojireddy and Reddy (1985 a) in sheep fed complete feed containing mixed grass hay.

5.6 BALANCE STUDIES :

5.6.1 Nitrogen Balance :

The differences in nitrogen intake (Table 17) were due to differences in dry matter intakes among the feeds.

All experimental animals on all the feeds were on positive nitrogen balance (Table 17). Nitrogen retention did not differ significantly with all the three complete feeds. Higher nitrogen retention as per cent of intake and as per cent of absorbed on complete feed 3 indicate better utilization of absorbed nitrogen by matching supply of energy as a result of higher digestibility of nitrogen-free extract. These results also indicate that SSM and SBM had no negative effect on nitrogen utilization. Gomez Cabrera (1977) observed nitrogen loss with chopped sunflower stalks in precoce sheep.

5.6.2 Calcium Balance :

Decreased trend of calcium intakes (Table 18) from complete feed 1 to 3 may be due to differences in dry matter intakes among the feeds.

The calcium balances were not significantly different among the three complete feeds. All the experimental animals on all the three feeds showed positive calcium balances indicating that all the feeds could meet the calcium requirements of the experimental animals. Slightly higher calcium balance observed on feed 1, may be due to variation in intake among the groups. However, Gomez Cabrera (1977) reported negative values of calcium in sheep fed sunflower stalks as sole feed.

5.6.3 Phosphorus Balance :

Slightly higher phosphorus intakes observed on complete feed 1 (Table 19) might be due to higher dry matter intakes on that feed.

All the experimental animals on all the feeds showed marginally positive phosphorusbalances indicating that the animals could meet phosphorus requirements. The balances were not differing statistically among the different feeds indicating that phosphorus from MGH, SSM and SHM were equally utilized by the experimental animals. Gomez Cabrera (1977) observed loss of minerals with sunflower stalks in precoce sheep.

5.7 PLANE OF NUTRITION OF EXPERIMENTAL ANIMALS :

Digestible crude protein (DCP) percentages were not significantly different among the different feeds (Table 21). The differences in DCP intakes on different feed were due to differences in dry matter intakes.

The total digestible nutrients (TDN) percentages were not significantly different among the different feeds. However, the complete feed 3 containing SHM had 2.? and 3.94 per cent higher TDN values than complete feeds 1 and 2, respectively, and this may be attributed to higher nitrogen-free extract digestibility (4%) on that ration than the other two feeds. The differences in TDN intakes among the feeds may be attributed to the differences in TDN contents and also to dry matter int

Results of metabolic studies revealed that the crop residues, sunflower straw and sunflower heads can be successfully incorporated in complete feeds as sole roughage source without any effect on nutrient utilization in sheep in place of conventionally used mixed grass hay.

5.8 CARCASS STUDIES :

5.8.1 Dressing Percentage :

The mean weight of slaughter ranged from 21.[illegible] to [illegible].75 kg (Table 22). This may be due to lower initial body weight of animals at the beginning of growth trial (10.[illegible] to 10.25 kg). The mean carcass yield for animals of different treatments ranged from 9.93 to 11.50 kg. The mean dressing percentage on live weight basis and empty body weight were 47.15 and 56.60; 47.99 and 57.59 and 5[illegible] and 62.80 per cent respectively on feeds 1, 2 and 3. An increase of about 6 per cent in dressing per cent was observed in animals fed complete feed 3 compared to those fed on other two feed in which it was comparable. The lower dressing percentage of animals fed complete feeds containing MGH and SSM may be due to their higher crude fibre and lower nitrogen-free extract contents of these feeds (Table 4) compared to the complete feed containing SHM. Preston and Willis (1974) and Price et al. (1978 and 1980) recorded reduced dressing percentages on high roughage diets and was attributed to increased gut fill and reduced amount of carcass fat. Lower per cent of non-edible organs (Table 25) recorded on feed 3 may be another reason for higher dressing per cent on this feed. The dressing percentage values recorded in this study were comparable to the values reported by Chatterjee et al. (1969) and Prasad et al. (1981).

5.8.2 **Carcass Cuts :**

The proportions of leg, loin, rack, shoulder and neck and foreshank and brisket (Table 23) were comparable among the three treatment group. Proportions of leg were higher in all the groups followed by shoulder and neck, rack, loin and foreshank and brisket. The higher proportions of leg observed in this study indicates that this part of the carcass was well developed. The results were in accordance with the findings of Osman and Shafei(1967) and Prasad et al. (1[illegible]).

5.8.3 **Lean, Bone and Fat Proportions :**

The proportions of lean was higher in all feeds followed by bone and fat (Table 24). The proportions of lean, bone, fat or bone : meat ratios were optimum and comparable to the proportions recorded by Jojireddy and Reddy (1985 b) in Nellore rams fed complete feeds containing mixed grass hay/sorghum straw. Slightly higher proportions were observed for lean on feed 3, bone on feed 2 and fat on feed 1. This may be attributed to differences in composition of complete feeds(highest fibre and lowest nitrogen-free extract on feed 1 and lowest CF and highest nitrogen-free extract and fat on feed 3). These proportions were in accordance with the findings of Pillai (1966), Lohse and Kallweit (1968) and Chatterjee et al. (1969). The higher ratios of bone : meat on feeds 1 and 3 indicate that MGH and SHM were more effcient in depositing meat than SSM.

Bone : meat ratios (1:2.87 to 1:3.86) obtained in this study were higher than those obtained by Prasad et al. (1980) indicating that all the feeds used in this study were efficient in formation of higher quality of meat in proportions to bone.

5.6.4 **Edible and Non-edible Organs :**

The per cent of non-edible organs (Table 25) was lower on feed 3 than the other two feeds which were comparable while the per cent of edible organs was comparable on all the feeds. This resulted in lower value of edible : non edible organs ratio on feed 3 than the other two feeds.

The results of the carcass studies indicate that the complete feed 3 showed higher dressing percentage with lesser proportions of non-edible organs and higher proportion of lean with lesser proportion of fat indicating that SHM was superior to MGH and SSM in getting desirable carcass characteristics.

The results of this investigation indicate that sunflower straw and sunflower heads are potential roughage sources comparable to mixed grass hay and could be utilized in complete feeds for sheep without any deleterious effects on growth rate, feed efficiency, nutrient utilization and carcass quality. Further, sunflower heads could form a better quality carcass.

CHAPTER VI

SUMMARY

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SUMMARY

Three isonitrogenous, non cereal based complete feeds were formulated using (1) mixed grass hay (MGH), or (2) sunflower straw meal (SSM) or (3) sunflower head meal (SHM), as sole source of roughage (50%) and processed into mash.

The processing cost of complete rations was worked out to be Rs.8.47, Rs.7.44 and Rs.6.83 per quintal for feeds 1, 2 and 3, respectively. The cost of above feeds were Rs.127.41, Rs.116.38 and Rs.114.97 per quintal, respectively. Though, the capacity of the feed processing plant was one tonne per hour for conventional concentrate feeds the production of complete feeds was only 500, 570 and 613 kg per hour due to inclusion of light, low density roughage materials MGH, SSM and SHM in the complete feeds at 50 per cent level. These complete feeds were tested in a 180 day growth trial involving 18 Nellore ram lambs (6 in each group) weaned at 2-3 months of age and a metabolic trial involving 9 rams (3 from each group of growth trial) using a completely randomized design, to study the effect of the feeds on growth, feed efficiency, nutrient digestion and utilization. At the end of the experiment, 2 representative rams from each group were slaughtered to study the carcass characteristics.

The average daily gains were 76.17, 69.00 and 64.83 g for feeds 1, 2 and 3, respectively. Dry matter intake per kg gain (kg) and cost of feed (Rs.) per kg gain on complete feeds 1, 2 and 3 were 10.77 and 15.94; 11.45 and 15.31 and 11.21 and 15.16 respectively. Average daily gains were not significantly different among the feeds. Though the feed efficiency was better on feed 1, the cost of feed per kg live weight gain was lower on feed 3.

Voluntary intake of dry matter was not significantly different among the sheep fed with different feeds indicating that all the feeds were equally palatable. Significantly higher ($P<0.05$) digestibility of nitrogen-free extract was observed on feed 3. Digestibilities of dry matter, organic matter, ether extract, crude protein and crude fibre were comparable on all the feeds. All the experimental animals were on positive nitrogen, calcium and phosphorus balances without any significant difference among the feeds. Higher digestible crude protein, total digestible nutrients and digestible energy intakes were observed on feed containing MGH due to higher dry matter intake.

The dressing percentages of carcasses were higher on feed 3 either on live weight basis or on empty body weight basis. The proportions of leg in the carcass were higher followed by shoulder and neck, rack, loin and foreshank and brisket on all the feeds. The bone : meat ratios of the rams fed three complete feeds ranged from 1: 2.[illegible]7 to 1 : 4.45 with highest ratio on feed 3. Highest proportions were observed for lean on feed 3, for bone on feed 2 and for fat on feed 1. The ratios of edible non edible organs were lowest on feed 3.

The results of this study indicated that SSM, SHM are potential roughage sources comparable to MGH and could be utilized in the formulation of complete feeds for growing sheep without any deleterious effects on nutrient utilization and carcass quality.

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