UTILIZATION OF VARYING LEVELS OF SUNFLOWER (*Helianthus annuus*) HEADS IN COMPLETE RATIONS FOR SHEEP

BY
MAJJI BALAKRISHNA

THESIS SUBMITTED TO THE
ACHARYA N.G.RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF VETERINARY SCIENCE
IN THE FACULTY OF VETERINARY SCIENCE

DEPARTMENT OF ANIMAL NUTRITION
COLLEGE OF VETERINARY SCIENCE, TIRUPATI
ACHARYA N.G.RANGA AGRICULTURAL UNIVERSITY
RAJENDRANAGAR, HYDERABAD - 500 030

MAY, 1999

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MAY, 1999

CERTIFICATE

Mr. MAJJI BALAKRISHNA has satisfactorily prosecuted the course of research and that the thesis entitled "UTILIZATION OF VARYING LEVELS OF SUNFLOWER (*Helianthus annuus*) HEADS IN COMPLETE RATIONS 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.

Date : 19.5.1999

(Dr. Z. PRABHAKARA RAO)
Major Advisor
Professor and Head
Department of Animal Nutrition
College of Veterinary Science
Tirupati - 517 502

CERTIFICATE

This is to certify that the thesis entitled **"UTILIZATION OF VARYING LEVELS OF SUNFLOWER (*Helianthus annuus*) HEADS IN COMPLETE RATIONS FOR SHEEP"** submitted in partial fulfilment of the requirements for the degree of **"MASTER OF VETERINARY SCIENCE"** of the Acharya N.G.Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Mr. MAJJI BALA KRISHNA** 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. The published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

(Dr. Z. PRABHAKARA RAO)
CHAIRMAN OF THE ADVISORY COMMITTEE

Thesis approved by the Student Advisory Committee

CHAIRMAN : **(Dr. Z. PRABHAKARA RAO)**
Professor and Head
Department of Animal Nutrition
College of Veterinary Science
Tirupati - 517 502

MEMBER : **(Dr. J. RAMA PRASAD)**
Associate Professor
Department of Animal Nutrition
College of Veterinary Science
Tirupati - 517 502

MEMBER : **(Dr. D.SREENIVASA RAO)**
Assistant Professor
Department of Feed and Fodder Technology
College of Veterinary Science
Tirupati - 517 502

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(Majji Balakrishnan)

DECLARATION

I, **MAJJI BALAKRISHNA** hereby declare that the thesis entitled "**UTILIZATION OF VARYING LEVELS OF SUNFLOWER (*Helianthus annuus*) HEADS IN COMPLETE RATIONS FOR SHEEP**" submitted to Acharya N.G.Ranga Agricultural University for the Degree of **MASTER OF VETERINARY SCIENCE** is a result of original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

Date : 19-05-1999.

(MAJJI BALAKRISHNA)

Name of the author	:	MAJJI BALAKRISHNA
Title of the Thesis	:	UTILIZATION OF VARYING LEVELS OF SUNFLOWER (*Helinathus annuus*) HEADS IN COMPLETE RATIONS FOR SHEEP
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Department	:	Department of Animal Nutrition
Major Advisor	:	Dr. Z. PRABHAKARA RAO Ph.D. Professor and Head Department of Animal Nutrition College of Veterinary Science Tirupati - 517 502
University	:	Acharya N.G.Ranga Agricultural University, Hyderabad -30.
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ABSTRACT

An attempt was made to assess the nutritive value of sunflower (*Helianthus annuus*) heads and, the effect of their incorporation in complete feeds on the performance and nutrient utilization in Nellore brown sheep.

The chemical composition of sunflower heads was CP, 8.40 ; EE, 4.10 ; CF, 17.13 ; NFE, 54.92 ; TA, 15.45 and AIA, 1.93 per cent. The fibre fractions were NDF, 27.19 ; ADF, 22.10 ; hemicellulose, 5.09 ; cellulose, 16.01 and lignin, 6.09%. The effective dry matter and protein

degradabilities of sunflower heads were 54.8 and 37.0%, and the RDP and UDP values (g/kg DM) were 31.0 and 53.0, respectively.

The digestibility coefficients estimated using six Nellore brown rams (29.10 ± 0.37 kg) for DM, CP, EE, CF and NFE, respectively were 57.59, 33.31, 70.79, 37.65 and 69.24%. The DCP and TDN contents of sunflower heads were 2.79 and 53.79%, respectively. The balances for N, Ca and P were negative.

Four isonitrogenous (14% C.P) complete rations with sunflower heads replacing groundnut haulms at 0 (CR-1), 20 (CR-2), 40 (CR-3) and 100 (CR-4) per cent levels were formulated and evaluated in a completely randomised experiment using 24 Nellore brown ram lambs (15.32 ± 0.18 kg) in a 90 d growth trial. The ADG (g/d), DMI (g/d) and EFU were 63.73, 656.04, 11.21 ; 76.92, 746.38, 11.40 ; 61.86, 628.78, 11.74 and 67.36, 654.32, 10.61, respectively for CR-1 to CR-4.

The nutrient digestibilities of the complete rations 1-4 using 16 Nellore brown ram lambs (19.5 ± 0.35 kg), were DM, 62.79, 62.73, 63.03, 64.5 ; OM, 65.77, 66.21, 67.61, 68.90; CP, 58.78, 71.99, 62.21, 63.59 ; CF, 43.55, 48.06, 38.92, 43.59; EE, 70.66, 75.21, 78.46, 80.04 and NFE, 77.12, 72.44, 76.36, 75.67, respectively. The digestibility coefficients of cell-wall fractions were NDF, 47.46, 43.77, 48.26, 47.60; ADF, 49.75, 47.14, 38.37, 31.97; hemicellulose, 38.61, 31.21, 45.59, 44.41and cellulose 52.24, 44.92, 44.92, 44.79, respectively for complete rations 1 to 4.

The OM digestibility of CR-4 was the highest and significantly ($P < 0.05$) higher than the lambs fed CR-1 or CR-2. The EE digestibility of CR-3 or CR-4 was higher ($P < 0.05$) than that of CR-1, or CR-2. The

digestibility of ADFand cellulose of CR-1, was higher ($P < 0.05$) than CR-4 while it was lower than CR-4 for hemicellulose ($P < 0.05$).

The balances of N, Ca, P (g/d) in ram lambs fed different complete rations were positive and did not differ.

The DCP and TDN contents of the complete rations 1 to 4 were 8.29, 60.64 ; 10.25, 61.53, 8.77, 63.19 and 8.90, 64.78%, respectively and the difference among treatments were non-significant.

The effective dry matter and protein degradabilities of the complete rations 1 to 4 were 56.2, 42.7 ; 65.2, 44.2 ; 71.2, 37.5 and 52.2, 31.3%, respectively. RDP and UDP values of the complete rations 1 -4 were 42.7, 57.3 ; 44.2, 55.8; 37.5, 62.5 and 31.3, 68.7, respectively.

It is concluded from the present study that groundnut haulms in complete rations of Nellore brown lambs can entirely be replaced by sunflower heads for maintenance and moderate growth.

ABBREVIATIONS USED

ADF	:	Acid detergent fibre
ADG	:	Average daily gain
ADL	:	Acid detergent lignin
AIA	:	Acid insoluble ash
Ca	:	Calcium
CF	:	Crude fibre
CP	:	Crude protein
CR	:	Complete ration
CRD	:	Completely randomised design
DCP	:	Digestible crude protein
DE	:	Digestible energy
DM	:	Dry matter
DMB	:	Dry matter basis
DMI	:	Dry matter intake
EE	:	Ether extract
ED	:	Effective degradability
EFU	:	Efficiency of feed utilization
EPD	:	Effective protein degradability
g	:	gram
g/q	:	grams per quintal
Mcal	:	Mega calories

ME	:	Metabolizable energy
N	:	Nitrogen
NDF	:	Neutral detergent fibre
NFE	:	Nitrogen free extract
OM	:	Organic matter
P	:	Phosphorus
RDP	:	Rumen degradable protein
TA	:	Total ash
TDN	:	Total digestible nutrients
UDP	:	Undegradable protein
$W_{Kg}^{0.75}$	:	Metabolic body weight

INTRODUCTION

CHAPTER - I

INTRODUCTION

The increasing threat of global feed and fodder shortage has led to the new awareness of the need for conservation and reuse of agricultural crop residues and agro-industrial by-products as livestock feeds avoiding competition with human foods and to reduce the production cost of milk, meat and other animal products. The annual requirement of feeds and fodder is estimated to be 32.66 million tonnes of concentrates, 474.07 million tonnes of dry fodder and 490.32 million tonnes of green fodder. However, only 28.46 million tonnes of concentrates, 360.50 million tonnes of dry fodder and 340.30 million tonnes of green fodder are available annually (Jain and Shivatar Singh, 1990). The gap between the availability and requirements of concentrates, dry fodder and green fodder is very wide and there is a shortfall of 4.20 million tonnes of concentrates, 113.57 million tonnes of dry fodder and 150.02 million tonnes of green fodder. In terms of digestible crude protein and total digestible nutrients, the shortfall is 34 per cent and 37 per cent, respectively (Mudgal and Pradhan, 1988).

Complete feeds have particular application in situations where crop residues, agro-industrial by-products and non-conventional feeds are abundant (Reddy, 1988). Minimization of feed cost and maximization of production could be achieved by blending concentrates, mainly locally available by-products and roughage portions to form complete diet. In *ad libitum* feeding the animals often can eat the complete feeds as much as

they like, without any selection. Further, this approach towards feeding of animals, ensures better consumption with desired roughage to concentrate ratio and avoid refusal of unpalatable portions of plant residues.

Sunflower crop can be cultivated throughout the year. Over 2.7 million hectares of land is under sunflower (*Helianthus annuus*) cultivation in India, of which Andhra Pradesh alone constitutes approximately 0.39 million hectares (Anonymous, 1994). For every hectare a tonne of sunflower heads (Capitulum after removal of seeds) is available every year (Anonymous, 1985). Sunflower heads can be used as a source of roughage for sheep. At present sunflower heads are thrown out as waste material. Sunflower heads can be used as unconventional feed ingredient in the complete rations of sheep. Hence, in the present investigation an attempt was made with the following objectives.

1. To evaluate the nutritive value of sunflower heads in Nellore brown sheep.
2. To study the effect of incorporating sunflower heads at different levels in complete rations on
   a. Growth and feed efficiency in Nellore brown lambs.
   b. Nutrient digestibility and nitrogen, calcium and phosphorus balance in Nellore brown ram lambs.
3. To study the degradabilities of dry matter and protein of complete rations containing varying levels of sunflower heads using Nylon bag technique in rumen cannulated steers.

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

Crop residues form a potential energy sources for livestock. The crop of sunflower is cultivated throughout the world. It is grown in Africa, Canada, USA, Argentina, former USSR, Turkey, Chile, China, Europe as a whole, Latin America, India and many other countries. The total world production of sunflower in 1993 was 20,489 thousand metric tonnes from 18,152 thousand hectares of land. The average yield of sunflower at world level is also much higher (1129 kg/ha) as compared to yield in India (625 kg/ha) which is around 57.7 per cent (Vishwa Nath and Chhotey Lal, 1995).

The sunflower owes its economic value to its utility as an oilseed or fodder crop. As a fodder or forage crop, sunflower is fed green or converted into silage which is popular in USA, Canada and in some other countries. The sunflower crop was introduced into India in 1965. The sunflower crop has low water requirements, it can adopt to different seasons and can withstand moderate droughts. The sunflower heads are harvested by hand, sun-dried and mature seeds are rubbed out of the flower centres. The seed kernals are eaten raw.

2.1 Chemical composition

2.1.1 Sunflower heads

Edrees *et.al.* (1976) reported the chemical composition of sunflower heads as protein, 12.50 ; lipids, 1.90 ; ash, 11.80; lignin, 12.0; unsaponified lipid, 1.40 ; steroids, 1.05 ; glycosides, 0.76 and pectic substance, 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.

Saltykova (1977) reported the chemical composition of sunflower heads as CP, 7.11 ; TA, 11.04 and phosphorus, 0.40% on dry matter basis.

The chemical composition of different varieties of sunflower as reported by Seiler (1984) indicated that the crude protein content generally decreased with increasing plant maturity. Leaf and seed calcium and potassium contents 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 arizonensis.*

Reddy *et. al.* (1986) found that the chemical composition of sunflower heads was CP, 7.21 ; EE, 2.86 ; CF, 15.83 ; NFE, 62.63 ; TA, 11.47, Ca, 1.39 and P, 0.18 per cent on DMB.

Gowd *et.al.* (1987) reported 7.22 CP, 2.90 EE, 16.63 CF, 62.65 NFE, 10.60, TA, 1.40 Ca and 0.12% P on dry matter basis in sunflower heads.

Reddy *et. al.* (1989) stated that the chemical composition of sunflower heads was DM, 88.00 ; OM, 89.40 ; CP, 7.22 ; CF, 16.63 ; EE, 2.90 ; NFE, 62.65 ; TA, 10.60 ; Ca, 0.69 and P, 0.10% on DMB.

Proximate composition of sunflower heads reported in the literature was 7.43, 3.27, 17.13, 60.79, 11.38, 0.75 and 0.31 per cent for

CP, EE, CF, NFE, TA, Ca and P, respectively (Madan Mohan *et. al.*, 1997).

Reddy and Reddy (1998) reported the proximate composition of sunflower heads as CP, 7.05 ; EE, 3.51 ; CF, 18.09 ; NFE, 60.67 and TA, 10.68 per cent on dry matter basis.

2.1.2 Silage

Grandhi and Rongoni (1989) reported the chemical composition of sunflower silage of florous 305 and gloriasol varieties were 11.6, 6.25, 27.7 and 38.4 per cent of CP, EE, CF and ADF, respectively.

2.1.3 Straw

Reddy *et. al.* (1987) reported the proximate composition of sunflower straw as DM, 96.70 ; OM, 87.98 ; CP, 2.80 ; CF 31.01 ; EE, 2.00 ; NFE, 52.16 ; TA, 12.03 ; Ca, 0.43 and P, 0.09% on dry matter basis.

Reddy *et. al.* (1989) obtained the chemical composition of sunflower straw as 90.50, 87.97, 2.80, 31.01, 2.00, 62.65, 10.60, 0.69 and 0.10% of DM, OM, CP, CF, EE, NFE, TA, Ca and P, respectively on DMB.

Ramesh Reddy (1992) reported the chemical composition of sunflower straw as 84.77, 5.60, 32.00, 1.91, 45.26, 15.23, 0.53 and 0.12% of DM, CP, CF, EE, NFE, TA, Ca and P, respectively on DM basis.

2.1.4 Stalk

Gomez Cabrera (1977) showed the chemical composition of sunflower stalks as DM, 95.4 ; CP, 2.0 ; EE 2.0 ; ash, 4.5 ; CF, 57.9 and NFE, 33.6 per cent.

2.2 Cell - Wall Constituents

Madan Mohan *et. al.* (1997) reported the forage fibre analysis of sunflower heads as NDF, 32.10 ; ADF, 26.78 ; hemicellulose, 5.32 ; cellulose 16.48 and lignin 8.36%.

Fibre analysis carried out by other scientists showed 32.10, 26.78, 5.32, 16.48 and 8.36 per cent for NDF, ADF, hemicellulose, cellulose and lignin in sunflower heads, respectively (Rao *et. al.*, 1997).

Forage fibre analysis of sunflower heads reported by Reddy and Reddy (1998) revealed 40.57, 28.60, 11.96, 20.47, 5.79 and 2.34 per cent NDF, ADF, hemicellulose, cellulose, lignin and silica, respectively.

2.3 Chemical Composition of Groundnut haulms

Groundnut haulms are the by-products containing the aerial parts of the groundnut (*Arachis hypogeae*) plant which include leaves, stems and other parts.

Musangi and Soneji (1968) reported the chemical composition of groundnut haulms as OM, 93.0 ; CP, 7.0 and CF, 21.0% on DM basis.

Amrith Kumar and Sampath (1974) reported the chemical composition of groundnut haulms as 11.06, 1.41, 35.09, 42.45, 9.99, 0.85 and 0.12 per cent of CP, EE, CF, NFE, TA, Ca and P on DMB, respectively.

The proximate composition of groundnut haulms was 9.90, 2.40, 21.10, 57.30, 9.30, 1.48 and 0.08 per cent for CP, EE, CF, NFE, ash, calcium and phosphorus, respectively (Gohl, 1975).

The proximate composition of groundnut straw as reported by Kearl (1982) was CP, 7.4 ; CF, 53.5 ; NFE, 29.5 ; EE, 1.0 and TA, 8.7% on DMB.

The proximate composition of groundnut haulms as reported by Fomunyam (1985) was 14.6 CP, 20.0 CF, 54.1 NFE, 2.0 EE and 9.3% ash on dry matter basis.

Shukla *et. al.* (1985) observed that the chemical composition of groundnut haulms was 12.8 CP, 3.0 EE, 30.0 CF, 40.70 NFE, 11.93 ash, 2.40 Ca and 0.42% P on DM basis.

Durga prasad *et. al.* (1986) evaluated the chemical composition of groundnut haulms and reported CP, 10.4 ; EE, 1.2 ; CF, 25.4 ; NFE, 50.4 and ash, 12.7% on dry matter basis.

Rama Prasad *et. al.* (1988) reported 82.8, 9.4, 22.5, 1.6, 49.3 and 17.2 % for OM, CP, CF, EE, NFE and TA, respectively on DM basis in groundnut haulms.

Proximate composition of groundnut haulms was reported as 11.45, 23.08, 3.63, 15.91 and 45.93 per cent for CP, CF, EE, TA and NFE, respectively (Narayanaswamy *et. al.*, 1990).

Dried groundnut haulms was found to contain DM, 87.0 ; CP, 11.9 ; EE, 2.2 ; CF, 27.48 ; NFE, 46.3 ; TA, 12.12, Ca 2.32 and P 0.25% on DMB (Mandal *et. al.*, 1993).

Chemical composition of groundnut haulms was reported as 88.04, 88.95, 11.21, 1.53, 23.02, 53.19, 11.05, 1.38 and 0.42% for DM, OM, CP, EE, CF, NFE, TA, Ca and P, respectively (Ramachandra Reddy, 1995).

Dhanunjayudu (1996) observed the chemical composition of groundnut haulms as DM, 89.65 ; OM, 92.28 ; CP, 9.30 ; EE, 1.50; CF, 35.09 ; NFE, 46.39; TA, 7.72; Ca, 2.21 and P, 0.42% on dry matter basis.

Madhavi Latha (1996) reported the chemical composition of groundnut haulms as 8.62, 0.63, 32.16, 46.54, 12.05, 1.04 and 0.18% of CP, EE, CF, NFE, TA, Ca and P, respectively on DMB.

Rao *et. al.* (1997) observed the chemical composition of groundnut haulms as OM, 84.89 ; CP, 9.72; Ca, 1.42 and P, 0.24% on dry matter basis.

2.3.1 Cell-wall constituents of groundnut haulms

Forage fibre analysis of groundnut haulms revealed 44.3, 39.3, 10.50, 31.10 and 5.0% for NDF, ADF, lignin, cellulose and hemicellulose, respectively (Wanapat and Devendra, 1985).

Fibre analysis carried out by Rama Prasad *et. al.* (1988) showed NDF 48.6, ADF 43.0, hemicellulose 5.6, cellulose 25.8, lignin 9.6 and silica 7.5% in groundnut haulms.

The reported cell-wall fractions of groundnut haulms were 43.19, 37.34, 5.85, 34.37 and 5.82% for NDF, ADF, hemicellulose, cellulose and lignin, respectively (Ramachandra Reddy, 1995).

The cell-wall constituents of groundnut haulms as reported by Dhanunjayudu (1996) were NDF, 46.31; ADF, 38.24; hemicellulose, 20.14; cellulose, 28.74 ; ADL, 8.37 and silica, 1.13 per cent.

Forage fibre analysis of groundnut haulm showed 57.39, 44.10, 13.38, 28.20 and 15.81 % of NDF, ADF, hemicellulose, cellulose and lignin, respectively on DMB (Madhavi Latha, 1996).

Rao *et. al.* (1997) reported the forage fibre analysis of groundnut haulms as NDF, 47.26 ; ADF, 26.19 ; hemicellulose, 21.06 ; cellulose, 19.79 and lignin, 44.41 % on dry matter basis.

2.4 Digestibility and Nutritive value of sunflower heads

In a complete diet with 48.5 : 51.5 roughage (sunflower heads) to concentrate ratio the nutrient digestibilities observed were 68.96, 71.83, 67.72, 48.77, 74.18 and 77.32% for DM, CM, CP, CF, EE and NFE, respectively Reddy *et. al.* (1986). Further the DM, OM and NFE digestibilities in the diet containing sunflower head meal were significantly higher ($P < 0.01$) than the control which contained mixed grass as the roughage source. The animals (sheep) were on positive balance for N, Ca and P. The DCP and TDN contents of the sunflower head meal containing ration were 9.12 and 66.64%, respectively.

Sunflower heads were used as sole source of roughage (50%) in complete feeds (Mash and Pellets) for sheep and were compared with conventional type of feeding where 200 g of concentrate mixture / day and paddy straw *ad libitum* were fed. The results indicated higher digestibilities of all the nutrients, balances of nitrogen, calcium and phosphorus and DCP and TDN values with complete rations than the control ration (Gowd *et. al.*, 1987).

Sunflower straws were included at 60% level in complete diet for sheep and goat, the digestibility coefficients were 45.40, 49.03 ; 48.47, 51.18 ; 52.78, 52.95 ; 67.90, 71.64, 37.72, 42.10 and 51.20, 52.55% of DM, OM, CP, EE, CF and NFE, respectively. However, DM and CF digestibilities were significantly ($P < 0.01$) higher in goats compared to sheep. Both sheep and goat were on positive balances of N, Ca and P (Ramesh Reddy, 1992).

The average digestibility coefficients of complete diet for sheep, containing 50% sunflower heads were 59.46, 63.21, 61.10, 49.61, 55.58 and 64.36% for DM, OM, CP, CF, EE and NFE, respectively. All the sheep were on positive balance for N, Ca and P (Reddy *et. al.*, 1989).

Madan Mohan *et. al.* (1997) reported the digestibilities of sunflower heads, in cross bred bulls as DM, 64.98 ; OM, 69.20 ; CP, 44.79 ; EE, 59.46 ; NFE, 76.57 ; NDF, 56.00 ; ADF, 64.84 ; hemicellulose, 49.63 ; cellulose, 52.97 and lignin, 28.36%. The DCP and TDN values were 3.30 and 63.67%, respectively. The bulls were on positive balance for nitrogen, calcium and phosphorus.

When sunflower heads were included at 20% level in a complete diet for crossbred bulls with 40 : 60 roughage to concentrate ratio the digestibilities were 64.84, 67.12, 68.63, 59.63, 50.55, 53.68, 57.86, and 18.46% for DM, OM, CP, NDF, ADF, cellulose, hemicellulose and lignin, respectively. All the experimental animals were on positive balance for N, Ca and P (Rao *et. al.*, 1997).

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 / $W_{Kg}^{0.75}$. Apparent digestibilities of 50, 52 and 51 per cent for OM and 43, 64 and 49 per cent for CP, respectively, were observed.

Reddy *et. al.* (1991) studied the effect of physical processing on the nutritive value and nutrient utilization of sunflower straw in sheep and goat. They recorded higher dry matter intake and digestibilities of DM, OM, CF and EE as well as digestible crude protein ($P < 0.05$) and TDN ($P < 0.05$) values in goats compared to sheep. They also indicated that pelleting had no beneficial effect over the ground straw.

Rai and Shukla (1977) fed unchaffed winter sunflower fodder at 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. The DCP and TDN contents were 7.15 and 64.37%, respectively. The animals were on positive balance for N, Ca and P.

Drackley *et. al.* (1985) reported the results of *in vitro* digestibility of DM and cell-wall of sunflower crop residue as 40.6 and 31.4 per cent, respectively. Sunflower crop residues (SR) a mixture of stalks and heads contained dry matter of 65.4, protein 6.1, NDF, 66.9, ADF 56.6, lignin 15.7 and ash 12.6 per cent. Daily weight gain and propionate in rumen fluid, decreased with the increase in the inclusion of sunflower crop residues in the diet. They suggested that the acceptable level of this crop residue was upto 32% of total ration for growing Holstein - Friesian heifers.

2.5 Nutritive value of Groundnut haulms

Shukla *et. al.* (1985) reported the digestibilities of groundnut haulms in steers as OM, 63.90 ; CP, 54.32 ; EE, 36.25 ; CF, 66.48 and NFE, 65.54%. The DCP and TDN values were 5.67 and 55.77%, respectively.

Wanapat and Devendra (1985) reported for DCP and TDN contents of groundnut haulms as 11.5 and 58.1%, respectively, on dry matter basis.

Studies conducted in Black Bengal goats to evaluate nutritive value of groundnut haulms by Mandal *et. al.* (1993) revealed the digestibility coefficients of DM, OM, CP, CF, EE and NFE as 54.13, 55.23, 42.40, 45.09, 42.40 and 64.02%, respectively. The DCP and TDN values reported were 5.05 and 49.17%, respectively.

Combellas *et. al.* (1974) reported the average digestibilities for dry matter, organic matter, cell contents, crude protein, cell - wall, cellulose, ADF, lignin and hemicellulose of two samples of groundnut crop harvested mechanically and dried as 59.6, 64.2, 65.4, 50.8, 52.2, 55.4, 68.1, 25.7 and 19.6%, respectively.

2.5.1 Degradability of Groundnut haulms

Prasada Reddy and Anjaneya Prasad (1985) conducted studies on protein degradability of groundnut haulms and observed 22.8, 29.8, 34.5, 38.1 and 50.6% disappearance of protein at 3, 6, 9, 15 and 24 h incubation period. The readily soluble protein fraction (a) of groundnut haulms was 18.1%, while the insoluble but degradable fraction (b) was 69.5% with rate constant/h of 0.025 (c). The effective protein degradability of groundnut haulms they reported was 41%.

2.6 Effect of supplementation of sunflower heads for livestock

Saltykova (1977) studied in Precoce ewe lambs, the effect of feeding T_1, sunflower heads (control ration); T_2, with 0.5 kg without 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 diet ie., 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.

Reddy *et. al.* (1989) fed complete feeds containing mixed grass hay (MGH), sunflower straw meal (SSM) and sunflower head meal (SHM) as sole source of roughage (50%) to Nellore ram lambs in a growth (180 days) cum metabolism experiment. Positive N, Ca and P balances were observed. The average daily gains (64.83 ± 5.91 g) were not significantly different among the different treatments.

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

Sheafer (1976) reported that sunflower silage yields as much of DM as corn silage when harvested at bloom but the feeding value was less than for corn silage.

Carter and Jack (1978) reported that the lower feeding value of sunflower silage was due to lower crude protein and higher crude fibre content of the plant.

McGuffey and Schingoethe (1980) compared the feeding value of sunflower whole plant silage with that of corn silage as sole feed in lactating Holstein cows fed sunflower silage produced less milk (20.5 vs 22.4 kg / day) and showed greater fat, less protein, less total solids and less fat corrected milk.

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

Thomas *et. al.* (1982) 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 (17.5 to 17.7 kg) were similar for both the diets. Milk fat content was lower with sunflower than with grass / lucerne silage (3.2 vs 3.6 %) but protein content was not affected.

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

2.7 Effect of complete feeds on nutrient utilization

Interest in complete diet system is increasing in many parts of the world because it offers a means of controlling the ratio of concentrate to roughage and also nutrients consumed, reduces feeding costs and helps in utilizing home grown forages and locally available by-products and wastes. Complete feeds ensure better consumption and avoid refusal of unpalatable materials.

In many developing and under developed countries where there is severe shortage of feed stuffs, ruminants mainly subsist on crop residues, poor quality roughages and agro-industrial by-products. The traditionally recommended feeding systems in these countries have to be looked critically in the present day context and new feeding systems suitable to the current needs have to be developed. To minimize feed costs and labour and to maximize production is the need of the time and could be achieved by blending concentrates mainly locally available by-products and roughage portions of the ration to form a product called complete feed or complete diet. Concentrate and roughage levels may vary from diet to diet so as to meet the optimum nutrient requirement of various categories of ruminants for different purposes of production.

Shortage of feed and forage is a major problem in sheep industry in India. Under the circumstances the concept of complete rations utilizing locally available agro-Industrial by-products may be a feasible feeding system in developing stall feeding methods for commercial sheep production.

Where there is a severe shortage of feed stuffs, the complete feed system would help in utilizing the locally available crop residues, agroindustrial by products and wastes more efficiently for raising livestock. The concept and advantages of using complete feeds have been discussed (Coppock *et. al.*, 1974 ; Owen, 1984).

The level of roughage in the ration did not significantly affect the dry matter intake, rate of gain or feed efficiency in lambs and there was no significant interaction between ration form and roughage level (Beacom *et. al.*, 1973).

The average daily gains of lambs on rations having roughages to concentrate ratios of 22 :78, 30 :70, 38 : 62 and 60 : 40 were 107, 105, 78 and 47 g, respectively (Katiyar *et. al.*, 1974).

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).

The average daily gains were 53, 56 and 69 g in lambs fed rations with hay to concentrate ratio of 80 : 20, 70 : 30 and 60 : 40, respectively (Zaheeruddin, 1978). The digestibilities of DM, OM, EE, CP and NFE increased and that of EE decreased with increase in concentrate component of the ration.

The dry matter intake in lambs increased with increase in the level of concentrate upto 15 kg body weight (Ali *et. al.*, 1979) and there was no significant difference at 25 and 30-35 kg body-weight between groups. Dry matter and protein digestibilities increased with increasing proportion of concentrate in the diet with lambs at 15 kg body weight.

Reddy and Reddy (1981) formulated five complete rations using crop residues and agro-industrial by-products and evaluated in a growth-cum-metabolism experiment with Deccani Lambs. The lambs were allotted to 5 treatment groups randomly. The rations contained 13.70 to

13.79% CP. Average daily gains recorded for rations 1 to 5 were 45, 43, 46, 49 and 61 g, respectively. No significant difference was observed among treatment groups either for ADG or feed intake. No significant difference was observed in digestibility of CP, EE, CF, NFE or nitrogen balance among the treatments. Positive nitrogen, calcium and phosphorus balances were observed.

Gabrovska and Ganovski (1982) reported that the digestibility of dry matter, organic matter, crude protein and minerals in lambs was great with mainly concentrate diet than with mainly roughage diet.

Four complete rations formulated by blending *stylo hemata* hay with conventional concentrate mixture in ratios of 60 : 40 (CR-1), 50 : 50 (CR-2), 40 : 60 (CR-3) and 30 : 70 (CR-4) were evaluated using Nellore brown lambs. Increasing the level of concentrate mixture in the complete ration did not affect N retention or the nutritive value. They concluded that mixing *stylo hemata* hay with a concentrate mixture in a ratio of 40: 60 (CR-3) was superior to other complete ration for growing and finishing ram lambs (Reddy *et. al.*, 1982).

Krishna Mohan and Naidu (1984) formulated two complete rations containing and berseem hay in 60 : 40 (CR-1) and 50 : 50 (CR-2) ratio and evaluated by individual and group feeding of crossbred ram lambs. Methods of feeding did not affect nutrient digestibilities. Average daily gain and N retention were significantly higher ($P < 0.05$) in lambs fed 60 : 40 than 50 : 50 concentrate to roughage ratio.

Mohan *et. al.*, (1985) fed rations containing groundnut straw 40, 50 or 60 per cent with concentrates to weaner lambs and recorded no

differences in nitrogen retention, weight gain and feed efficiency decreased gradually as the per cent of groundnut haulm increased in the ration.

Reddy *et. al.* (1988) compared complete feed containing 35 per cent sunflower straw with a conventional diet containing concentrate mixture and mixed grass hay fed separately in cross bred cows. The voluntary feed intake was comparable in both the rations. But conventional ration showed higher digestibilities of all the nutrients except ether extract. Production of FCM, fat and SNF were 37.0, 10.6 and 2.6 per cent higher on sunflower straw based diet. DM intake per kg FCM and cost of feed per kg FCM were lower by 26.8 and 27.9 per cent on complete feed containing sunflower straw.

An experiment was carried out with Nellore ram lambs fed horse gram hay at 100 (CR-1), 80 (CR-2), 60 (CR-3) and 40 (CR-4) per cent along with concentrate mixture and observed higher ($P < 0.01$) DM, OM, CP, EE, NFE, NDF and hemicellulose digestibilities for CR-3 and CR-4 than CR-1 or CR-2 and higher CF digestibility for CR-2 than that of CR-3 or CR-4. Higher N retention g/d, DCP and TDN of rations were observed in lambs fed with roughage to concentrate ratio of 60 : 40 or 40 : 60 than in lambs fed rations with roughage to concentrate ratio of 100 : 0 and 80 : 20 (Jawahar Reddy, 1989).

Jayanth Kumar *et. al.* (1989) studied the effect of inclusion of cowpea hay in complete rations on nutrient utilization and growth performance in sheep. The roughage to concentrate ratio maintained was 70 : 30 (CR-1), 60 : 40 (CR-2), 50 : 50 (CR-3) and 40 : 60 (CR-4). They reported that level of cowpea hay had no effect on ADG, DMI and feed/

gain. Further it was observed that CP and EE digestibilities of CR-4 were higher than CR-1 or CR-2 Higher ($P < 0.05$) NDF and cellulose digestibilities were observed with complete rations containing 70% roughage and 30% concentrates. It was found that level of roughage source (cow pea hay) has no affect on the nitrogen retention in lambs. They concluded that a ration containing 70% cowpea hay and 30% concentrate mixture was economical for growing lambs and finishing Nellore lambs.

Narayana Swamy *et. al.* (1990) evaluated three isonitrogenous complete rations CR-1, to CR-3 containing 50% (w/w) of groundnut haulms (CR-1), banyan tree leaves (CR-2), or red gram straw (CR-3) in ram lambs. The ADG reported for CR-3 was significantly ($P < 0.05$) higher than those of CR-1 or CR-2. Positive nitrogen, Ca and P balances were reported in lambs fed different treatments. Significantly lower DM, OM, CP and CF digestibilities were reported in lambs fed CR-2 than those fed CR-1 or CR-3 and the digestibilities of CR-1 and CR-3 for DM, OM and CP were non-significant.

Satynarayana (1990) observed significantly lowered CF, NDF, hemicellulose, cellulose ($P < 0.01$) and lignin ($P < 0.05$) digestibilities in Nellore ram lambs fed Gliricidia leaf meal replacing cow pea hay in complete rations with a roughage to concentrate ratio of 60 : 40 and reported that digestibilities of DM, OM, CP, EE, NFE and ADF were non-significant among different treatments. It was also observed that N retention expressed as percent intake or per cent absorbed was non-significant among different treatments.

Prasad *et. al.* (1991) fed groundnut haulms based complete diet *ad libitum*, for Mandya, Mandya synthetic, Nellore and Nellore synthetic rams weaned at 90 days. Body weight at 180 days of age averaged 18.05, 23.79, 20.01 and 26.53 kg, respectively and feed conversion efficiency were 13.5, 14.5, 14.6 and 14.7.

Ganesh (1995) studied the replacement value of Amaranthus whole plant meal in comparison with groundnut haulms in sheep fed complete rations with concentrate to roughage ratio of 50 : 50 and observed no significant difference for DM, OM, CP, CF, NDF, ADF, hemicellulose and cellulose among different complete rations. The nitrogen and calcium retention expressed as g/d, per cent of intake or per cent of absorbed were not affected by replacing groundnut haulms with Amaranthus whole plant meal. They concluded that groundnut haulms can be incorporated in complete rations upto 45% without any adverse effect for sheep.

Dhanunjayudu (1996) formulated four complete rations containing leguminous hay (cow pea hay, sunhemp hay, groundnut haulms and horsegram bhoosa) and concentrate mixture in 60 : 40 ratio. The apparent digestibility of DM, OM, CP, NFE and hemicellulose in ewes fed four complete rations were not statistically significant. Significantly higher ($P < 0.05$) crude fibre digestibility was observed in ewes fed CR-4 in which horse gram bhoosa was the roughage source when compared to ewes fed CR-3 in which groundnut haulms was the roughage source. The average daily gains observed in CR-1 to CR_4 was 87.95, 62.50, 72.38 and 98.17 g, respectively.

Madhavi Latha (1996) observed the average daily gain of 52.74 g in sheep fed with a complete ration containing 60 : 40 roughage (groundnut haulms) to concentrate ratio. The digestibility coefficients of DM, NFE for CR-1 were significantly higher than those of CR-2, CR-3 and CR-4 rations.

MATERIALS AND METHODS

CHAPTER - III

MATERIALS AND METHODS

The research work was carried out in the department of Animal Nutrition, College of Veterinary Science, Tirupati, Andhra Pradesh, to evaluate the nutritive value of sunflower heads (capitulum, removed after seeds) and also to study the effect of inclusion of sunflower heads at varying levels in the complete ration for sheep on the nutrient digestibility and growth rate. In addition to sunflower heads, groundnut haulms, maize, groundnut cake, deoiled rice bran, mineral mixture and vitamin supplements were used in the metabolism and growth experiments.

3.1 Procurement of ingredients

Dried sunflower heads were procured from villages around Proddatur, Cuddapah district. Dried groundnut haulms were procured from villages around Tirupati and Regional Agricultural Research Station, Tirupati, Chittoor district. Maize, groundnut cake and deoiled rice bran were purchased from Regional Poultry demonstration and Research farm, Chittoor

Experiment 1

3.2 Nutritive value evaluation of sunflower heads

Nutritive value of sunflower heads was assessed in a metabolism experiment using six Nellore brown rams (29.10 ± 0.37 kg) fed with sunflower heads as sole feed. The rams were dewormed with panacur before the start of the experiment. They were penned (2 m x 1 m) individually during the preliminary period and shifted to metabolism cages two days prior to and during collection period.

The rams were fed at 8.30 a.m. and 2.30 p.m. every day. A 14 day preliminary period and a 7 day collection period were observed. During collection period, faeces voided in 24 h was collected with the help of faecal collection bags harnessed to the rams. The daily urine output of each animal was collected in glass bottles kept at the bottom of each metabolism cages and measured. Few drops of concentrate hydrochloric acid were added to each urine collection bottle daily as a preservative. Samples of feed, faeces and urine were preserved for further analysis.

Experiment 2

3.3 Growth study

To study the effect of replacing groundnut haulms with sunflower heads at different levels in complete rations, on the growth performance a completely randomised design experiment was conducted for 90 days using 24 Nellore brown lambs (15.32 ± 0.18 kg). The lambs were divided into four groups of six animals each and were allotted to one of the rations at random. The lambs were housed in individual pens (2 m x 1 m), each provided with a water and a feeder. The complete rations were offered *ad libitum* twice daily at 8.30 a.m. and 2.30 p.m. The left overs were weighed on the next morning to calculate the respective rations actually consumed by the lambs. The lambs were weighed at weekly intervals before the morning feed was offered to record the rate of growth.

Experiment 3

3.4 Nutrient utilization and nitrogen balance of ram lambs fed complete rations containing various levels of sunflower heads.

3.4.1 Preparation of complete rations :

Dried sunflower heads (*Helianthus annuus*) ground in a hammer mill through medium mesh screen (8 mm) were used in the preparation of complete rations. Four isonitrogenous rations were formulated keeping the roughage to concentrate ratio at 60 : 40. Groundnut haulms was the sole roughage source in all the complete rations. Complete ration-1 (CR-1) containing maize (20%), groundnut cake (13.5%) deoiled rice bran (3.5%) and mineral mixture (3.0%) was used as the control ration. Complete rations 2, 3 and 4 contained 20, 40 and 60% of ground sunflower heads respectively replacing groundnut haulms. To make the complete rations isonitrogenous, groundnut cake and deoiled rice bran levels were marginally adjusted. Vitablend was added to the rations @ 25 g/q.

3.4.2 Metabolism trial

16 Nellore brown ram lambs (19.50 ± 0.35 kg) which are taken from the growth trial were used to evaluate the complete rations for their nutrient digestibility and nitrogen balance. The ram lambs were confined to individual pens of 2 m x 1 m with facilities for individual feeding and watering. A 14-day preliminary and a 7 day collection periods were observed.

The ram lambs were allotted to one of the complete ration, at random and fed *ad libitum* twice daily at 8-30 a.m. and 2-30 p.m. The left overs were weighed on the next day morning to estimate the exact quantity of the respective complete rations consumed. The rams were shifted to metabolism cages two days prior to and during the collection period. The live weights of the rams were recorded before the start and at the end of each period prior to offering feed and water. Fresh drinking water was made available all the time. During each period of metabolism trial faeces voided in 24 h was collected with the help of faecal collection bags harnessed to the ram lambs. The daily urine output of each animal was measured by collecting in the glass bottles kept at the bottom of each metabolism cage. Few drops of concentrate hydrochloric acid were added to each urine collection bottle daily as a preservative. Samples of feed, faeces and urine were preserved for further analysis.

Experiment 4

3.5 In situ dry matter / protein degradability of sunflower heads and the complete rations

In situ evaluation of dry matter and protein degradability of sunflower heads and complete rations was carried out using nylon bag technique. Nylon bags of 15 x 7 cm with a pore size of 28-30 µm were used for incubating feed samples in the rumen of fistulated steers.

Samples of dried sunflower heads and complete rations were ground in a laboratory wiley mill using a medium mesh screen of 2 mm. The ground materials were stored in air tight screen capped plastic bottles. Five grams of ground feed sample was taken in each bag. Bags were closed and secured with a nylon string after placing a glass marble in it to prevent from floating on the rumen digesta. Five bags each were

incubated in the ventral sac of rumen of five steers (385 ± 5.82 kg). Bags were secured with the help of a 60 cm long nylon string to allow free movement of the bags in the rumen. At the end of 12, 24, 36, 48 and 72 h incubation, the bags were removed from the rumen, washed under tap water and dried to a constant weight at 70°C for 48 h in a forced draft oven and the per cent dray matter / protein disappearance was calculated. The constants a, b and c of McDonald model (1981) were derived by iterative least square analysis with the aid of a computer (Microtech - PC - 486). An out flow rate (K) value of 0.05 / h was used.

3.6 Collection of samples

3.6.1 Feed :

Samples of sunflower heads and experimental rations offered were collected daily and composited for chemical analysis. The left over feed during each day of the collection period was weighed and aliquots were taken for chemical analysis.

3.6.2 Faeces :

Faeces voided by each adult ram during 24h was weighed at 8.30 a.m. and a 5% aliquot was composited in polythene bags and frozen in a deep freeze. At the end of each collection period representative faecal samples were oven dried, ground through medium mesh screen of a Wiley mill and placed in air tight polythene bottles until analysed.

3.6.3 Urine :

Urine voided by individual rams during 24 h was measured at 8.30 a.m. and 2% aliquot of urine was composited in glass bottles and kept in refrigerator till analysed.

3.7 Chemical analysis :

Samples of sunflower heads, groundnut haulms, maize, groundnut cake and deoiled rice bran were analysed for proximate principles (AOAC, 1980). Samples of fresh faeces and aliquots of urine were used to determine the nitrogen content. The cell - wall constituents of ground nut haulms, sunflower heads and faeces were determined as per the procedure of Goering and Van Soest (1970). Calcium and phosphorus in feed samples and dung were determined by the method suggested by Talapatra *et. al.* (1940). Calcium and Phosphorus in urine was estimated by using the methods of Ferro and Ham (1957) and Fiske and Subba Row (1925), respectively.

3.8 Statistical analysis

The data were subjected to analysis of variance (Snedecor and Cochran, 1968).

RESULTS

CHAPTER - IV

RESULTS

4.1 Chemical composition of sunflower heads

The chemical composition of sunflower heads used in the experiment is presented in Table 1 and the chemical composition of Sunflower heads as reported by various authors is presented in Table 2. Sunflower heads used in the present investigation contained 8.40, 4.10, 17.13, 54.92 and 15.45 per cent of CP, EE, CF, NFE and TA, respectively on DMB. The calcium and phosphorus contents of the sunflower heads were 2.69 and 0.33%, respectively.

4.1.1 Cell - Wall Constituents

The cell-wall constituents of sunflower heads is presented in Table 3. The per cent NDF, ADF, hemicellulose, cellulose and ADL were 27.19, 22.10, 5.09, 16.01 and 6.09, respectively.

4.2 Digestibility coefficients of nutrients and nutritive value of sunflower heads

The average dry matter intake of rams fed sunflower heads as sole feed was 673 g/d or 2.31 kg / 100 kg body weight. The digestibility coefficient of the different nutrients were 57.59, 33.31, 70.79, 37.65 and 69.24%, respectively for DM, CP, EE, CF and NFE (Table 4). The DCP and TDN values of sunflower heads were 2.79 and 53.69%, respectively (Table 4).

Table 1 Chemical composition (%) of sunflower heads[a]

Dry matter	86.92
Organic matter	84.55
Crude protein	8.40
Ether extract	4.10
Crude fibre	17.13
Nitrogen free extract	54.92
Total ash	15.45
Acid insoluble ash	1.93
Calcium	2.69
Phosphorus	0.33

[a] On dry matter basis except for dry matter

Table 2 Chemical composition of sunflower heads as reported by various authors

DM	OM	CP	EE	CF	NFE	TA	AIA	Ca	P	Reference
86.92	84.55	8.40	4.10	17.13	54.92	15.45	1.93	2.69	0.33	Present investigation
—	—	12.50	1.90	—	—	11.80	—	—	—	Edrees *et. al.* (1976)
—	—	7.11	—	—	—	11.04	—	—	0.4	Saltykova (1977)
—	88.53	7.21	2.86	15.83	62.63	11.47	0.26	1.39	0.18	Reddy *et. al.* (1986)
—	—	9.00	5.00	21.00	—	—	—	—	—	Delic *et. al.* (1987)
88.29	89.40	7.22	2.90	16.63	62.65	10.60	1.05	1.40	0.12	Gowd *et. al.* (1987)
88.00	89.40	7.22	2.90	16.63	62.65	10.60	1.05	0.69	0.10	Reddy *et. al.* (1989)
87.90	88.62	7.43	3.27	17.13	60.79	11.38	0.92	0.75	0.31	Madan Mohan *et. al.* (1997)
87.90	88.62	7.43	3.27	17.13	60.79	11.38	0.92	0.75	0.31	Rao *et. al.* (1997)
90.47	89.32	7.05	3.51	18.09	60.67	10.68	—	—	—	Reddy and Reddy (1998)

Table 3 Fibre components of sunflower heads (% of DM)

Neutral detergent fibre	27.19
Acid detergent fibre	22.10
Hemicellulose	5.09
Cellulose	16.01
Acid detergent lignin	6.09

Table 4 The average digestibility coefficients of organic nutrients and nutritive value of sunflower heads

Nutrient digestibility (%)	
DM	57.59 ± 1.64
CP	33.31 ± 2.06
EE	70.79 ± 2.57
CF	37.65 ± 2.14
NFE	69.24 ± 1.95
Nutritive value (%)	
DCP	2.79 ± 0.42
TDN	53.79 ± 1.29

Table 5 **Digestibility (%) of cell - wall fractions of sunflower heads**

NDF	27.10 ± 3.0
ADF	23.97 ± 3.44
Hemicellulose	40.74 ± 2.47
Cellulose	20.37 ± 3.32

Table 6 Balance of N, Ca and P in sheep fed sunflower heads as a sole feed

		N	Ca	P
Metabolic body weight of sheep	12.32	—	—	—
Intake (g/d)		9.04	18.1	2.21
Excretion (g/d)				
Faecal		5.99	17.21	1.08
Urinary		4.33	1.73	1.96
Total (g/d)		10.32	18.94	3.04
Retention (g/d)		-1.28 ± 0.51	-0.77 ± 0.14	-0.82 ± 0.14

The digestibility coefficients of cell-wall fractions of sunflower heads is presented in Table 5. The average digestibility coefficient of cell - wall fractions of sunflower heads were 27.10, 23.96, 40.74 and 20.37 per cent, respectively, for NDF, ADF, hemicellulose and cellulose.

The sunflower heads when fed as a sole ration to the rams resulted in a negative balance for N (-1.28 ± 0.51), Ca (-0.77 ± 0.14) and P (-0.82 ± 0.14) (Table 6).

4.3 ***In situ*** **evaluation of sunflower heads Dry matter / protein disappearance.**

In situ evaluation of sunflower heads was carried out by suspending nylon bags filled with ground sunflower heads in the rumen of fistulated steers for 12, 24, 36, 48 and 72 h. The average dry matter and protein disappearance values for the corresponding hours of incubation were 53.15, 68.19, 78.86, 82.43, 83.4% and 32.84, 51.44, 68.45, 75.95 and 78.32%, respectively (Table 7).

4.3.1 Effective degradability

The constants 'a' (readily soluble), 'b' (insoluble but degradable fraction with time) and 'c' (rate constant / h) were 17.63, 67.51, and 0.0613 ; 0.00, 82.67, and 0.0486 respectively, for dry matter and protein fractions of sunflower heads. The effective degradability values were 54.8 and 37.0, respectively, for dry matter and protein of sunflower heads.

Table 7 **Average *in situ* dry matter / protein disappearance and effective dry matter / protein degradability (EPD) of sunflower heads**

Incubation (h)	DM disappearance (%)	Protein disappearance (%)
12	53.15 ± 3.50	32.84 ± 2.70
24	68.19 ± 2.11	51.44 ± 1.39
36	78.86 ± 1.33	68.45 ± 1.77
48	82.43 ± 1.23	75.95 ± 0.84
72	83.41 ± 1.35	78.32 ± 0.65
Effective degradability		
a	17.63	0.00
b	67.51	82.67
c	0.0613	0.0486
ED (%)	54.8	37.0

a = readily soluble,
b = insoluble but degradable with time
c = rate constant / h

4.4.1 Chemical composition of feed ingredients

The chemical composition of different feed ingredients used in the preparation of complete feeds is presented in Table 8. The chemical composition of groundnut haulms was 9.07, 1.32, 32.08, 45.43 and 12.10 per cent, respectively for CP, EE, CF, NFE and TA on DMB. The chemical composition of maize grain used was CP, 11.40 ; EE, 2.53 ; CF, 2.80 ; NFE, 81.30 and TA, 1.97 per cent, on dry matter basis. The CP, EE, CF, NFE and TA contents of groundnut cake and deoiled rice bran were 45.41, 15.84; 6.42, 0.70; 7.05, 18.20; 34.73, 48.69 and 6.39, 16.57 per cent, respectively on DMB.

4.4.2 Calcium and Phosphorus contents of feed ingredients

Among the feed ingredients used for formulating complete rations, sunflower heads contained the highest amount of calcium and lowest amount of phosphorus (Table 8). The calcium and phosphorus contents of maize and groundnut haulms were 0.20, 1.04 and 0.23 and 0.20 per cent, respectively.

4.5 Ingredient Composition of Complete rations

Four complete rations were formulated with 60 : 40 roughage to concentrate ratio. Groundnut haulms was the roughage component and maize (20), groundnut cake (13.5), deoiled rice bran (3.5) and mineral mixture (3%) formed the concentrate part. Groundnut haulms was replaced at 0 (CR-1), 20 (CR-2), 40 (CR-3) and 100% (CR-4) levels by sunflower heads in the experimental rations (Table 9). To make the rations isonitrogenous the proportions of groundnut cake and DORB were marginally adjusted.

Table 8 Chemical composition (%) of feed ingredients in complete rations[a]

	DM	CP	CF	EE	NFE	Total ash	AIA	Ca	P
Groundnut haulms	91.53	9.07	32.08	1.32	45.43	12.1	6.79	1.04	0.20
Sunflower head meal	86.92	8.40	17.13	4.10	54.92	15.45	1.93	2.69	0.33
Maize grain (ground)	91.86	11.40	2.80	2.53	81.30	1.97	0.46	0.20	0.23
Groundnut cake (Expeller)	92.72	45.41	7.05	6.42	34.73	6.39	2.26	0.22	1.03
Rice bran (Solvent extraction)	92.36	15.84	18.20	0.70	48.69	16.57	9.52	0.35	1.81

[a]On dry matter basis except for dry matter.

Table 9 **Ingredient composition (%) of complete rations containing varying levels of sunflower heads**

Feed stuffs	CR-1	CR-2	CR-3	CR-4
Groundnut haulms	60	40	20	0
Sunflower head meal	0	20	40	60
Maize grain (ground)	20	20	20	20
Groundnut cake (Expeller)	13.5	12.0	12.5	13.0
Rice bran (solvent extraction)	3.5	5.0	4.5	4.0
Mineral mixture[a] with salt	3	3	3	3
Vitablend[b]	<---------- 25 g ---------->			

[a] Mineral mixture with salt contained Ca 22%, P 9%, NaCl 22%, Cobalt 0.01%, Copper 0.06%, Iron 0.4%, Iodine 0.2%, Zinc 0.15% and Mn 0.09%

[b] Vitablend AD_3 vitamin feed supplement each gram contained Vit A 50, 000 IU and vitamin D_3 5,000 IU.

4.5.1 Chemical composition of complete rations

The chemical composition of complete rations on DMB is presented in Table 10. The dry matter content of the complete rations 1 to 4 varied from 88.7 to 93.2%. There was no variation in per cent organic matter and crude protein from among the rations. The CF content wss highest in CR-1 (21.7%) and lowest in CR-4 (12.6%). The ether extract (4.2%) content wss highest in the CR-4 and lowest in the CR-1 (2.5%). Nitrogen free extract content in the complete rations increased with increased percentage of sunflower heads in the ration. Total ash and AIA contents of the complete rations ranged from 11.15% to 12.59% and 2.52% to 4.40%, respectively. Calcium percentage increased gradually from CR-1 to CR-4 while the phosphorus content varied from 0.48% to 0.52% among the complete rations.

4.5.2 Cell-wall constituents of complete rations

The cell-wall constituents of complete rations is presented in Table 11. The per cent NDF and ADF values in complete rations 1 to 4 were 45.26, 35.96 ; 39.92, 31.47 ; 37.89, 27.93 and 33.06, 22.29, respectively. The NDF and ADF contents of CR-3 and CR-4 were lower by 7.37, 8.03 and 12.2, 13.67 percentage units, respectively compared to CR-1. Higher hemicellulose content was observed in CR-4 (10.76) followed by CR-3 (9.96), CR-1 (9.3) and CR-2 (8.45%). However, cellulose content was highest in CR-1 (28.6%) and least in CR-4 (16.2%). Acid detergent lignin levels decreased from 7.41 to 6.12% in CR-1 to CR-4 due to decreased proportions of groundnut haulms.

Table 10 Chemical composition (%) of complete rations[a]

	CR-1	CR-2	CR-3	CR-4
Dry matter	93.20	91.02	90.93	88.65
Organic matter	88.85	88.55	88.03	87.41
Crude protein	14.12	14.25	14.12	14.01
Crude fibre	21.69	21.57	15.46	12.58
Ether extract	2.46	2.82	3.77	4.20
Nitrogen free extract	50.58	49.91	54.68	56.62
Total ash	11.15	11.45	11.97	12.59
Acid insoluble ash	4.40	4.17	2.66	2.52
Calcium	1.39	1.83	2.11	2.56
Phosphorus	0.48	0.47	0.52	0.48

[a]On dry matter basis except for dry matter

Table 11 Cell - wall fractions of complete rations (% of DM)

Nutrient	CR-1	CR-2	CR-3	CR-4	Groundnut haulms
Neutral detergent fibre	45.26	39.92	37.89	33.06	57.14
Acid detergent fibre	35.96	31.47	27.93	22.29	43.29
Hemicellulose	9.30	8.45	9.96	10.76	13.85
Cellulose	28.55	24.32	21.24	16.17	28.21
Acid detergent lignin	7.41	7.15	6.69	6.12	15.08

4.6 In vivo evaluation of complete rations

4.6.1 Growth Experiment

The effect of replacing groundnut haulms with sunflower heads at 0, 20, 40 and 100% levels in complete rations 1 to 4 on the feed intake, growth rate and feed efficiency of 24 Nellore brown lambs (15.32 ± 0.18 kg) for a period of 90 days in a completely randomised design is presented in Table 12.

Lambs fed on CR-2 gained 13.19, 15.06 and 9.56 g higher weights per day compared to those fed CR-1, CR-3 and CR-4, respectively. However, the difference between the ADG of lambs fed different complete rations was non-significant.

The total feed consumed by the lambs fed complete rations 1 to 4 was 62.70, 73.50, 61.70 and 65.50 kg, respectively. Although the lambs fed CR-2 consumed higher quantity of feed, the difference between the feed consumption by the lambs fed different rations were non-significant. Dry matter intake (g/d) of lambs fed complete rations 1-4 was 656.04, 746.38, 628.78 and 654.32 , respectively. Dry matter intake expressed in kg / 100 kg body weight or g / $W_{Kg}^{0.75}$ of lambs fed complete rations 1 to 4 were 3.59, 74.15 ; 3.90, 81.55 ; 3.39, 70.49 and 3.63, 74.75, respectively. However, dry matter intake of lambs expressed in g/d, kg/100 kg body weight and g/ $W_{Kg}^{0.75}$ did not show any significant difference among different treatments.

The amount of feed required per unit gain (feed : gain ratio) was not varied in CR-1 to CR-4. However the difference among the lambs fed different complete rations was non-significant. The cost per kg feed (Rs. / kg) and cost per kg live weight gain (Rs. / kg) for CR-1 to CR-4 were 3.24, 36.33, 3.11, 35.48 ; 3.06, 35.94 and 3.01, 31.94, respectively.

Table 12 Growth performance of Nellore brown lambs fed different proportions of sunflower heads in the complete rations[a]

	CR-1	CR-2	CR-3	CR-4	SEM
Initial body weight (kg)	15.26 ± 1.31	15.43 ± 1.10	15.73 ± 0.83	14.86 ± 1.33	—
Final body weight (kg)	21.06 ± 1.54	22.43 ± 0.97	21.36 ± 0.76	21.00 ± 1.71	—
Weight gain (kg)	5.80 ± 0.58	7.00 ± 0.87	5.63 ± 0.73	6.13 ± 0.48	0.68
Average daily gain (g)	63.73 ± 6.47	76.92 ± 9.56	61.86 ± 8.12	67.36 ± 5.36	7.49
Total feed consumed (kg)	62.70 ± 6.02	73.50 ± 6.79	61.70 ± 3.28	65.50 ± 6.76	5.87
Average daily feed consumption (g/d)	689 ± 66.21	808 ± 74.70	678 ± 36.15	720 ± 74.35	64.8
Dry matter intake (g/d)	656.04 ± 62.34	746.38 ± 68.72	628.78 ± 32.26	654.32 ± 65.65	58.9
Dry matter intake (g / $W_{Kg}^{0.75}$ / d)	74.15 ± 3.43	81.55 ± 4.48	70.49 ± 3.28	74.75 ± 3.46	3.72
Dry matter / 100 kg body weight (kg)	3.59 ± 0.12	3.90 ± 0.16	3.39 ± 0.16	3.63 ± 0.14	0.15
Feed efficiency	11.21 ± 1.24	11.40 ± 1.79	11.74 ± 1.27	10.61 ± 0.45	1.28
Cost of feed (Rs. / kg)	3.24	3.11	3.06	3.01	—
Cost per kg live weight gain (Rs. / kg)	36.33 ± 4.01	35.48 ± 5.57	35.94 ± 3.89	31.94 ± 1.36	—

a, no significant difference between the treatments

4.6.2 Nutrient digestibility

The data on nutrient digestibility of ram lambs fed four complete rations are presented in Table 13. The average DM digestibility values were 62.8, 62.7, 63.0 and 64.5% for complete rations 1 to 4, respectively. The difference between the DM digestibility among the rations was non-significant.

The average OM digestibility values were 65.77, 66.21, 67.61 and 68.90% for complete rations 1 to 4, respectively. The per cent digestibility of OM of CR4 was signifcantly higher ($P < 0.05$) than that of CR-1 or CR-2 while the differnce between the CR-3 and CR-4 was non-significant.

The apparent digestibility of CP for the complete rations 1 to 4 were 58.8, 71.9, 62.2 and 63.6%, respectively. Inclusion of sunflower heads at any level in complete rations had no significant effect on the CP digestibility.

The digestibility values of CF for CR-1 to CR-4 were 43.55, 48.06, 38.92 and 43.59%, respectively. The per cent digestibility of CF of CR-2 was significantly higher ($P < 0.05$) than that of CR-3 while the difference between the CR-2 and CR-4 was non-significant. The average digestibility values of EE for CR-1 to CR-4 were 70.66, 75.21, 78.46 and 80.04%, respectively. The per cent digestibility of EE of CR-3 or CR-4 was significantly higher ($P < 0.05$) than that of CR-1 while the difference between CR-1 and CR-2 or CR-3 and CR-4 were non-significant. The average digestibility values of NFE for CR-1 to CR-4 were 77.12, 72.44, 76.36 and 75.67%, respectively. The per cent digestibility of NFE of CR-1, CR-3 or CR-4 were significantly higher ($P < 0.05$) than that of CR-2.

Table 13 Effect of inclusion of varying levels of sunflower heads on nutrient digestibility of complete rations

	CR-1	CR-2	CR-3	CR-4	SEM
Dry matter	62.79 ± 0.89	62.73 ± 0.71	63.03 ± 0.64	64.53 ± 0.20	0.66
Organic matter*	65.77^{a} ± 1.21	66.21^{a} ± 0.51	67.61^{ab} ± 0.53	68.90^{b} ± 0.31	0.72
Crude protein	58.78 ± 1.81	71.99 ± 5.0	62.21 ± 1.27	63.59 ± 2.89	3.09
Crude fibre*	43.55^{a} ± 2.48	48.06^{ac} ± 2.35	38.92^{ab} ± 1.42	43.59^{ab} ± 0.32	1.86
Ether extract*	70.66^{a} ± 1.19	75.21^{a} ± 1.49	78.46^{ab} ± 1.44	80.04^{ab} ± 2.00	1.56
Nitrogen free extract*	77.12^{a} ± 1.28	72.44^{b} ± 1.41	76.36^{a} ± 0.40	75.67^{a} ± 0.39	0.99

* ^{abc} values bearing different superscripts in a row differ significantly * $P < 0.05$

4.6.3 Digestibility of cell-wall constituents of complete rations

The digestibilities of cell-wall constituents for CR-1 to CR-4 are presented in Table 14.

The data on apparent digestibility of cell-wall constituents revealed that the digestibility of NDF was 47.46, 43.77, 48.26 and 47.60% and that of ADF 49.75, 47.14, 38.37 and 31.97%, respectively, for complete rations 1 to 4. It was observed that level of sunflower heads in complete rations did not affect the digestibility of NDF. The per cent digestibility of ADF of CR-3 or CR-4 were significantly lower ($P < 0.01$) than those of the CR-1 and CR-2. Significant ($P < 0.01$) difference between CR-3 and CR-4 was observed for ADF digestibility. There was no significant difference between CR-1 and CR-2 for ADF digestiility. The average digestibility values in hemicellulose for CR-1 to CR-4 were 38.61, 31.21, 45.59 and 44.41%, respectively. The per cent digestibility of hemicellulose of CR-3 or CR-4 were significantly higher ($P < 0.05$) than those of CR-1 and CR-2. The differences between CR-1 and CR-2 or CR-3 and CR-4 for hemicellulose digestibility were non-significant. The digestibility coefficients of cellulose for complete rations 1 to 4 were 52.24, 44.92, 44.92 and 44.79%, respectively. The per cent digestibility of cellulose of CR-1 was significantly higher ($P < 0.01$) than those of CR-2 and CR-3 or CR-4. The differences among the treatments of CR-2, CR-3 and CR-4 were non-significant.

Table 14 Digestibility (%) of cell - wall fractions of complete rations

	CR-1	CR-2	CR-3	CR-4	SEM
NDF	47.46 ± 1.96	43.77 ± 0.96	48.26 ± 1.41	47.60 ± 0.59	1.33
ADF**	49.75^{a} ± 2.15	47.14^{a} ± 1.32	38.37^{b} ± 0.49	31.97^{c} ± 0.54	1.31
Hemicellulose*	38.61^{ab} ± 4.96	31.21^{a} ± 0.73	45.59^{b} ± 2.14	44.41^{b} ± 4.04	3.39
Cellulose**	52.24^{a} ± 0.78	44.92^{b} ± 0.67	44.92^{b} ± 1.91	44.79^{b} ± 1.70	1.38

^{abc} values bearing different superscripts in a row differ significantly * $P < 0.05$ ** $P < 0.01$

4.7 Balance of nitrogen

The effect of feeding complete rations containing 0-100% of sunflower heads on nitrogen balance in Nellore brown ram lambs is presented in Table 15.

The average nitrogen intake expressed as g/d or g / $W_{Kg}^{0.75}$/ d of ram lambs fed complete rations 1 to 4 was 15.95, 1.72 ; 15.88, 1.65 ; 15.06, 1.60 and 13.55, 1.39, respectively. There was no significant ($P > 0.01$) differences in the N intake, faecal or urinary nitrogen excretion among different treatments. The nitrogen retention expressed as g/d, per cent of intake or per cent of absorbed was 7.29, 45.46, 78.13; 7.62, 50.28, 68.09; 5.95, 39.58, 63.56 and 4.40, 34.80, 54.06 for complete rations 1 to 4, respectively. Nitrogen retention expressed as g/d, per cent of intake or per cent of absorbed did not differ significantly among the four treatments. There was significant difference ($P < 0.01$) between CR-1 and CR-4 or CR-2 and CR-4, but there was no significant difference between the CR-3 and CR-4 for N retention expressed as g / $W_{Kg}^{0.75}$ / d. It was observed that substitution of groundnut haulms by sunflower heads upto 100% level in the complete rations did not affect the N retention in Nellore ram lambs.

4.8 Balance of Calcium

The data on calcium retention in lambs fed complete rations is presented in Table 16. The average daily intake of calcium was 9.81, 12.74, 14.07 and 15.48 g, respectively, for CR-1 to CR-4. The calcium retention expressed as g/day, per cent of intake and per cent of absorbed were 2.41, 25.66, 87.49 ; 2.77, 22.92 , 82.56 ; 2.42, 17.17, 81.61 and 3.14, 20.71, 82.87, respectively for the ram lambs fed CR-1 to CR-4. The differences in calcium retention among the ram lambs fed different complete rations were non-significant.

Table 15 Balance of nitrogen in sheep fed complete rations

	CR-1	CR-2	CR-3	CR-4	SEmeans
Metabolic body weights ($W_{Kg}^{0.75}$)	9.13 ± 0.60	9.47 ± 0.34	9.45 ± 0.43	9.55 ± 0.40	0.45
N intake (g/d)	15.95 ± 2.35	15.88 ± 1.73	15.06 ± 0.28	13.55 ± 2.32	1.87
N intake (g / $W_{Kg}^{0.75}$ / d)	1.72 ± 0.18	1.65 ± 0.12	1.60 ± 0.07	1.39 ± 0.22	0.15
N excretion (g/d)					
Faecal	6.62 ± 1.07	4.69 ± 1.29	5.69 ± 0.21	5.13 ± 1.13	1.01
Urinary	2.04 ± 0.50	3.56 ± 0.87	3.42 ± 0.28	3.89 ± 0.80	0.65
Total	8.66	8.25	9.11	9.02	1.55
N retention					
(g/d)	7.29 ± 1.28	7.62 ± 0.40	5.95 ± 0.26	4.40 ± 0.45	3.39
(g / $W_{Kg}^{0.75}$ / d**)	0.79^{a} ± 0.12	0.80^{a} ± 0.06	0.63^{ab} ± 0.04	0.44^{b} ± 0.04	0.05
per cent of intake	45.46 ± 4.02	50.28 ± 7.18	39.58 ± 1.99	34.80 ± 5.12	4.95
per cent of absorbed	78.13 ± 6.50	68.09 ± 6.15	63.56 ± 2.59	54.06 ± 5.40	5.38

[ab] Values brearing different superscipts in a row differ significantly ** P < 0.01

Table 16 Balance of calcium in sheep fed complete rations

	CR-1	CR-2	CR-3	CR-4	SE mean
Calcium intake (g/d)	9.81 ± 1.44	12.74 ± 1.39	14.07 ± 0.26	15.48 ± 2.65	1.66
Faecal Ca (g/d)	7.04 ± 1.28	9.36 ± 1.43	11.09 ± 0.26	11.66 ± 2.05	1.44
Urinary Ca (g/d)	0.35 ± 0.08	0.56 ± 0.17	0.55 ± 0.07	0.67 ± 0.14	0.12
Ca retention (g/d)	2.41 ± 0.14	2.77 ± 0.17	2.42 ± 0.20	3.14 ± 0.48	0.28
Ca balance (% intake)	25.66 ± 2.36	22.92 ± 3.55	17.17 ± 1.34	20.71 ± 1.04	2.29
Ca balance (% absorbed)	87.49 ± 2.74	82.56 ± 3.68	81.61 ± 1.12	82.87 ± 1.17	2.43

4.9 Balance of Phosphorus

The average daily intake of phosphorus from complete rations 1 to 4 were 3.38, 3.27, 3.46 and 2.89 g, respectively (Table 17). There was no significant difference among the treatments in P intake.

Faecal and urinary excretion of phosphorous did not show any significant difference ($P > 0.01$) among complete rations. Phosphorus retention values (g/d) for CR-1 to 4 were 1.88, 1.87, 2.07 and 1.85, respectively. However, the differences among the treatments were non-significant. Phosphorus retention expressed as % of intake or % of absorbed did not show any significant difference among ram lambs fed the four complete rations.

4.10 Nutritive value of complete rations

The nutritive value of the four complete rations is presented in Table 18. The DCP values of complete rations 1 to 4 were 8.29, 10.25, 8.77 and 8.90, respectively and the DCP content of CR-2 was higher ($P < 0.05$) than that of CR-1, CR-3 or CR-4.

The TDN values of complete rations 1 to 4 were 60.64, 61.53, 63.19 and 64.78, respectively and the TDN content of CR-4 was higher ($P < 0.01$) than that of CR-1 or CR-2.

The digestible energy and metabolizable energy (Mcal / kg) values for CR-1 to CR-4 were 2.66, 2.71, 2.78, 2.85 and 2.15, 2.19, 2.25 and 2.30, respectively. The nutritive ratios for the different complete rations were 1 : 6.33, 1 : 5.07, 1 : 6.20 and 1 : 6.31 for CR-1, CR-2, CR-3 and CR-4, respectively. Grams digestible protein / Mcal DE and grams digestible protein / Mcal ME were 31.14, 37.78, 31.56, 31.20 and 38.51, 46.72, 38.99, 38.56, respectively for CR-1 to CR-4.

4.9 Balance of Phosphorus

The average daily intake of phosphorus from complete rations 1 to 4 were 3.38, 3.27, 3.46 and 2.89 g, respectively (Table 17). There was no significant difference among the treatments in P intake.

Faecal and urinary excretion of phosphorous did not show any significant difference ($P > 0.01$) among complete rations. Phosphorus retention values (g/d) for CR-1 to 4 were 1.88, 1.87, 2.07 and 1.85, respectively. However, the differences among the treatments were non-significant. Phosphorus retention expressed as % of intake or % of absorbed did not show any significant difference among ram lambs fed the four complete rations.

4.10 Nutritive value of complete rations

The nutritive value of the four complete rations is presented in Table 18. The DCP values of complete rations 1 to 4 were 8.29, 10.25, 8.77 and 8.90, respectively and the DCP content of CR-2 was higher ($P < 0.05$) than that of CR-1, CR-3 or CR-4.

The TDN values of complete rations 1 to 4 were 60.64, 61.53, 63.19 and 64.78, respectively and the TDN content of CR-4 was higher ($P < 0.01$) than that of CR-1 or CR-2.

The digestible energy and metabolizable energy (Mcal / kg) values for CR-1 to CR-4 were 2.66, 2.71, 2.78, 2.85 and 2.15, 2.19, 2.25 and 2.30, respectively. The nutritive ratios for the different complete rations were 1 : 6.33, 1 : 5.07, 1 : 6.20 and 1 : 6.31 for CR-1, CR-2, CR-3 and CR-4, respectively. Grams digestible protein / Mcal DE and grams digestible protein / Mcal ME were 31.14, 37.78, 31.56, 31.20 and 38.51, 46.72, 38.99, 38.56, respectively for CR-1 to CR-4.

Table 17 Balance of Phosphorus in sheep fed complete rations

	CR-1	CR-2	CR-3	CR-4	SE mean
Phosphorus intake (g/d)	3.38 ± 0.49	3.27 ± 0.35	3.46 ± 0.06	2.89 ± 0.49	0.39
Faecal P (g/d)	1.13 ± 0.14	0.97 ± 0.16	0.90 ± 0.04	0.71 ± 0.19	0.14
Urinary P (g/d)	0.36 ± 0.08	0.42 ± 0.12	0.48 ± 0.02	0.32 ± 0.09	0.05
P retention (g/d)	1.88 ± 0.33	1.87 ± 0.08	2.07 ± 0.05	1.85 ± 0.25	0.21
P balance (% intake)	54.85 ± 2.00	58.55 ± 3.74	59.87 ± 1.47	65.86 ± 4.09	3.03
P balance (% absorbed)	83.41 ± 4.15	82.56 ± 3.73	81.09 ± 0.88	85.57 ± 2.78	3.15

Table 18 Nutritive value of complete rations

Item	CR-1	CR-2	CR-3	CR-4
Digestible crude protein (DCP) kg / 100 kg*	8.29[a]	10.25[b]	8.77[a]	8.90[a]
Total digestible nutrients (TDN) kg / 100 kg**	60.64[a]	61.53[a]	63.19[ab]	64.78[b]
Nutritive ratio	1 : 6.33	1 : 5.07	1 : 6.20	1 : 6.31
Digestible energy[a] (DE) M cal / kg	2.66	2.71	2.78	2.85
Metabolizable energy[b] (ME) Mcal / kg	2.15	2.19	2.25	2.30
Gram digestible protein / M cal DE	31.14	37.78	31.56	31.20
Gram digestible protein / M cal ME	38.51	46.72	38.99	38.56

[a] value of 4.409 Mcal / kg TDN was used.
[b] value of 0.81 DE was used.
[abc] values bearing different superscripts in a row differ significantly * $P < 0.05$, ** $P < 0.01$

4.11 *In situ* evaluation of complete rations

The dry matter / protein degradability of the four complete rations evaluated in five steers using nylon bag technique is presented in Table 19 and 20.

The DM disappearance of the complete ration 1 or 4 was significantly lower ($P < 0.01$) than that of complete ration 3 at 12 h incubation while no significant difference could be observed among CR-2, 3 or 4 during the same period. At 24 h incubation significantly lower ($P < 0.01$) DM disappearance was observed in CR-2 than that of CR-1, CR-3 or CR-4. The DM disappearance of CR-2 was significantly lower ($P < 0.01$) than that of CR-3 or CR-4 and there was no significant difference between CR-3 and CR-4 at 36 h. At 48 and 72 h there was no significant difference between CR-1 and CR-2 or between CR-3 and CR-4. A significant difference was observed between CR-1 or CR-2 and CR-3 or CR-4 for DM disappearance.

The protein disappearance of the complete rations 3 or 4 was significantly lower ($P < 0.01$) than that of complete ration 1 or 2 at 12 h incubation while no significant difference could be observed between CR-2 and CR-3 during the same period (Table 20). At 24, 36 or 48 h no significant difference was observed in the protein disappearance between CR-3 and CR-4. At 24 h incubation protein disappearance of CR-1 was significantly higher ($P < 0.01$) than that of CR-2, CR-3 or CR-4 while there was no significant difference between CR-2 and CR-3. At 36 h incubation protein disappearance of CR-1 was significantly higher ($P < 0.01$) than that of CR-2, CR-3 or CR-4. At 48 h incubation protein disappearance of CR-1 was significantly higher ($P < 0.01$) than that of CR-2, CR-3 or CR-4. The difference in protein disappearance values were

Table 19 : Average *in situ* dry matter disappearance (%) and effective degradability of complete rations

Incubation interval (h)	CR-1	CR-2	CR-3	CR-4	SE means
12**	$58.68^{a} \pm 1.80$	$64.34^{ab} \pm 2.75$	$71.47^{b} \pm 1.52$	$55.91^{a} \pm 2.00$	2.06
24**	$74.07^{a} \pm 0.88$	$72.95^{ab} \pm 1.43$	$78.63^{ac} \pm 1.23$	$76.98^{a} \pm 0.73$	1.10
36**	$77.75^{a} \pm 0.20$	$77.43^{a} \pm 1.08$	$81.80^{b} \pm 0.84$	$82.43^{b} \pm 0.80$	0.80
48**	$79.29^{a} \pm 0.7$	$78.72^{a} \pm 0.89$	$82.30^{b} \pm 0.63$	$83.72^{b} \pm 0.54$	0.63
72**	$80.39^{a} \pm 0.11$	$80.63^{a} \pm 0.76$	$82.91^{b} \pm 0.66$	$84.77^{b} \pm 0.16$	0.50
Effective degradability					
a	7.59	45.46	51.21	0.00	
b	72.45	35.17	31.80	84.54	
c	0.1020	0.0641	0.0843	0.1100	
ED (%)	56.2	65.2	71.2	52.2	

a = readily soluble ; b = insoluble but degradable with time ; c = rate constant / h ; out flow rate (k) = 0.05 / h

^{abc}values bearing different superscripts in a row differ significantly ** $P < 0.01$

Table 20 Average *in situ* protein disappearance (%) and effective degradability protein (EPD) of complete rations

Incubation interval (h)	CR-1	CR-2	CR-3	CR-4	SE means
12**	$41.49^{a} \pm 1.57$	$41.65^{ab} \pm 1.67$	$35.80^{ab} \pm 1.5$	$22.36^{ac} \pm 1.45$	1.51
24**	$74.51^{a} \pm 1.92$	$50.03^{b} \pm 1.35$	$51.67^{b} \pm 1.19$	$54.83^{b} \pm 0.45$	1.33
36**	$80.11^{a} \pm 0.45$	$77.43^{b} \pm 0.46$	$66.78^{c} \pm 0.43$	$68.12^{c} \pm 0.50$	0.46
48**	$81.54^{a} \pm 0.43$	$79.73^{b} \pm 0.23$	$69.08^{c} \pm 0.39$	$69.97^{c} \pm 0.45$	0.38
72**	$83.07^{a} \pm 0.50$	$82.35^{a} \pm 0.46$	$69.74^{b} \pm 0.46$	$70.69^{b} \pm 0.50$	0.24
Effective degradability					
a	0.00	7.05	0.00	0.00	
b	82.30	82.10	72.13	71.60	
c	0.1350	0.0413	0.0625	0.0949	
EPD (%)	42.7	44.2	37.5	31.3	

a = readily soluble ; b = insoluble but degradable with time ; c = rate constant / h ; out flow rate (k) = 0.05 / h

^{abc}values bearing different superscripts in a row differ significantly ** $P < 0.01$

non-significant between CR-1 and CR-2 or CR-3 and CR-4 at 72 h incubation. A significant ($P < 0.01$) difference could be observed between CR-1 and CR-3, CR-2 and CR-3 or CR-2 and CR-4 during the same period.

4.11.1 Effective degradability

The constants a, b and c derived from incubation measurements of dry matter / protein disappearance by iterative least square analysis with the aid of computer are presented in Table 19 and 20.

The readily soluble dry matter fraction was highest (51.21) for CR-3 and CR-4 showed the least (0.00). The insoluble but degradable fraction was highest (84.54) with CR-4 and least (31.80) with CR-3. The effective degradability of dry matter was highest (71.2) in CR-3 while CR-4 had the lowest (52.2). The values were intermediary for CR-2 (65.2) and CR-1 (56.2).

Highest soluble protein fraction (7.05) was observed for CR-2. While there was no readily soluble fraction (a) in CR-1, CR-3 or CR-4 (Table 20). The insoluble but degradable with time fraction 'b' values were 82.30, 82.10, 72.13 and 71.60%, respectively for CR-1, CR-2, CR-3 and CR-4. The effective protein degradability was highest (44.2) for CR-2 and least (31.3%) for CR-4. Complete rations 1 and 3 showed intermediary values (42.7 and 37.5 %) for effective protein degradability.

Table 21 Plane of nutrition of ram lambs fed complete rations

Complete rations	Body weight (kg)	Metabolic body weight (kg)	Intake						Intake / $W_{Kg}^{0.75}$			
			DM		DCP (g)	TDN (g)	DE (M cal)	ME (M cal)	DM (g)	DCP (g)	DE (Mcal)	ME (Mcal)
			(g)	% body weight								
CR-1	19.17	9.13	707	3.64	58.32	431.76	1.89	1.53	76.48	6.33	0.20	0.16
CR-2	20.07	9.47	697	3.43	69.85	427.85	1.88	1.51	72.96	7.57	0.19	0.15
CR-3	20.02	9.45	667	3.36	58.54	421.53	1.85	1.50	70.99	6.24	0.19	0.15
CR-4	20.32	9.55	605	2.93	52.62	391.05	1.72	1.38	62.70	5.46	0.18	0.14
ICAR (1985)	20	9.45	700	3.50	50.0	400.0	1.76	1.42	74.07	5.29	0.18	0.15
Kearl (1982)	20	9.45	660	3.30	30.6	360	1.58	1.27	69.84	3.23	0.16	0.13

4.12 Plane of nutrition of experimental animals

The data on plane of nutrition of ram lambs fed different complete rations are presented in Table 21. The dry matter intake expressed as g/d and as per cent body weight of lambs fed complete rations were 707, 3.64; 697, 3.43; 667, 3.36 and 605, 2.93, respectively for CR-1, CR-2, CR-3 and CR-4. However, the differences in dry matter intake expressed as g/d or per cent of live weight were non-significant among the ram lambs fed different rations. The DCP intake of ram lambs on CR-1, 2 or 3 were higher than that of ram lambs on CR-4, though the differences were non-significant. The TDN intake (g/d) of ram lambs on complete ration 1 was higher followed by ram lambs fed CR-2, CR-3 and CR-4.

Intakes of DM (g) and DCP (g) per kg metabolic body weight were 76.48, 6.33; 72.96, 7.57; 70.99, 6.24 and 62.70, 5.46, respectively, for CR-1, 2, 3 and CR-4. The intake of DE and ME (Mcal/ kg metabolic body weight) were 0.20, 0.16 ; 0.19, 0.15 ; 0.19, 0.15 and 0.18, 0.14, respectively for CR-1 to CR-4.

DISCUSSION

CHAPTER - V

DISCUSSION

A major factor limiting production of high quality proteins through development of the animal industry is the shortage of feedstuffs for these animals. Ruminants will have to depend more on products that cannot be utilized by human population such as crop residues which represent a potential source of energy. Any attempt to improve the intake of these residues alone or in combination with concentrates would be of much practical and economic value in the developing countries like India. It has been estimated that one tonne of sunflower heads are available from each hectare of land under sunflower cultivation in India (Anonymous, 1985). At present, this material is generally thrown out as waste. A knowledge of the comparative nutritive value of sunflower heads and the levels of supplementation required for particular purpose is needed if these heads are to be included as a component of rations for ruminants.

5.1 Chemical composition of sunflower heads

Chemical analysis of sunflower heads showed that the dry matter content was 86.92%. The OM, CP, EE, CF, NFE, TA and AIA on DMB were, 84.6, 8.4, 4.1, 17.1, 54.9, 15.5 and 1.9%, respectively (Table 1). The OM content observed in the present study was lower than the values reported for sunflower heads by Reddy *et. al.* (1986), Gowd *et. al.* (1987), Reddy *et. al.* (1989), Madan Mohan *et. al.* (1997), Rao *et. al.* (1997) and Reddy and Reddy (1998). The crude protein content observed in the present study was lower than that reported (12.5%) by Edrees *et. al.* (1976) and (9.0%) Delic *et. al.* (1987). However, it is higher than the values reported by Saltykova (1977), Reddy *et. al.* (1986), Gowd *et. al.* (1987), Reddy *et. al.* (1989), Madna Mohan *et. al.* (1997), Rao *et. al.*

(1997) and Reddy and Reddy (1998). Seiler (1984) indicated that crude protein content generally decreased with increasing plant maturity. The variation in CP content observed in the present study compared to those reported in literature might be due to variation in the plant maturity. Delic *et. al.* (1987) and Reddy and Reddy (1998) have reported high (21.0, 18.1%) crude fibre values in sunflower heads compared to the CF values observed in the present study, while Reddy *et. al.* (1986) reported a lower value (15.8%). The variation in the reported values of crude fibre also might be due to differences in duration (days) of maturity (Vishwa Nath and Chhotey Lal, 1995).

The EE content sunflower heads reported in the literature ranged from 1.90 (Edrees *et. al.*, 1976) to 5.0% (Delic *et. al.*, 1987). The observed value (4.10%) in the present study is within the range. The NFE content observed in the present study (54.92%) is the lowest compared to the values (60.67 to 62.65%) reported in the literature (Gowd *et. al.*, 1987, Reddy and Reddy, 1998). This might be due to higher protein (8.4%) and TA (15.45%) contents.

The calcium content (2.69%) observed in the present study is higher than all the values reported earlier in the literature for sunflower heads. The lowest value (0.69%) was reported by Reddy *et. al.* (1989). However, the phosphorus content (0.33%) observed in the present investigation is similar to the values reported by Madan Mohan *et. al.* (1997) and Rao *et. al.* (1997). Lower values of 0.12 and 0.10% were reported by Gowd *et. al.* (1987) and Reddy *et. al.* (1989), respectively, while Saltykova (1977) reported 0.4% P in sunflower heads. The AIA content (1.93%) is higher than that reported in literature, which might be due to contamination with soil, since the sunflower heads were

collected directly from the field. Gowd *et. al.* (1987) and Reddy *et. al.* (1989) have reported a value of 1.05% AIA in sunflower heads, while Reddy *et. al.* (1986) reported 0.26% AIA.

The fibre component of sunflower heads (Table 3) in the present study revealed 27.19 NDF, 22.10 ADF, 5.09 hemicellulose, 16.01, cellulose and 6.09% ADL. The NDF and ADF contents observed in the present study are lower than the values reported by Madan Mohan *et. al.* (1997) and Reddy and Reddy (1998). Hemicellulose and cellulose contents observed in the present study are in agreement with the reported values of Madan Mohan *et. al.* (1997) but lower than those reported (11.96%) by Reddy and Reddy (1998). Reddy and Reddy (1998) reported 5.79% ADL in sunflower heads which is similar to the present observation. However, Madan Mohan *et. al.* (1997) reported higher ADL (8.36%) in sunflower heads. The variations observed in the cell-wall fractions might be due to stage of maturation of the sunflower crop at the time of harvest.

5.2 Nutritive value of sunflower heads

Nutritive value of sunflower heads in terms of digestible crude protein (DCP) and total digestible nutrients (TDN) was determined by a conventional metabolism trial using Nellore brown rams (29.1 ± 0.37 kg) fed sunflower heads as sole feed.

The daily dry matter intake of the rams was 673 gm (2.31 kg / 100 kg body weight or 53.84 $g/W_{kg}^{0.75}$). The dry matter recommended for maintenance of rams weighing 29 kg is 725 to 730 g (about 2.5 kg/100kg body weight) according to ICAR (1985) or Kearl (1982). These observations indicate that sunflower heads were not very palatable and

if fed alone may not meet the maintenance requirement (zero growth) of the adult rams. Madan Mohan *et. al.* (1997) opined that the poor palatability of sunflower heads might be due to more fibrous nature of the material. Further, they reported that bulls could not relish this material as sole ration. However, Gomez Cabrera (1977) reported mean daily intake of 23.05 $g/w_{kg}^{0.75}$ body weight when chopped sunflower stalks were fed to Precoce sheep. This indicated that sunflower heads are more palatable than the stalks. The digestibility coefficients for the different nutrients from the sunflower heads observed in the present study were 57.6, 33.3, 70.8, 37.7 and 69.2% for DM, CP, EE, CF and NFE, respectively (Table 4). The DCP and TDN values of sunflower head meal were 2.79 and 53.79%, respectively.

Higher digestibilities of DM (64.98%), CP (44.79%) and NFE (76.57%) and lower digestibility of EE (59.46%) were reported by Madan Mohan *et. al.* (1997) for sunflower heads when fed as sole roughage to crossbred bulls compared to the values obtained in the present study with sheep. Further, they reported higher nutritive value in terms of DCP (3.30%) and TDN (63.67%). Gomez cabrera (1977) reported lower digestibility values for DM (42.4%) and NFE (62.9%) but higher EE (75.6%) and CF (43.1%) values for chopped sunflower stalks in Precoce sheep which indicate that the heads have a higher digestibility than the stalks.

The digestibility coefficients of cell-wall fractions were NDF, 27.1; ADF, 23.97; hemicellulose, 40.75 and cellulose, 20.23% in sunflower heads studied in the present investigation (Table 5). Madan Mohan *et. al.* (1997) reported higher digestibility of cell-wall fractions of sunflower heads in cattle compared to the values obtained in the sheep at present.

The balances of N, Ca and P are presented in Table 6. The results indicate a negative balance (g/d) for N (-1.28), Ca (-0.77) and P (-0.82). From Table 4 it was observed that the digestibility of N was only 33.31%. Lower protein degradability as observed in the present study might have reflected in lower digestibility of N from cell-wall fractions. Added to this, there was higher N excretion from urine resulting in negative balance for N. The negative balances for Ca and P might be due to unavailability of these minerals from sunflower heads. Contrary to the observations of present investigation, Madan Mohan *et. al.* (1997) reported positive balances for N, Ca and P in cross-bred bulls. Gomez Cabrera (1977) who fed chopped sunflower stalks to Precoce sheep reported that they have lost nitrogen and minerals.

5.3 In situ evaluation of sunflower heads

Effective degradability of dry matter / protein of sunflower heads was determined by nylon bag technique. Fifty three per cent of DM has disappeared by 12 h time and further 30% by the end of 72 h. In general, there was a linear increase in DM disappearance of sunflower heads with increase in the interval of incubation period (Table 7).

The soluble dry matter fraction (a) of sunflower heads was 17.63 and that of insoluble but degradable fraction (b) was 34.65 with a rate constant (C) of 0.0613 and the effective dry matter degradability was 54.80 per cent.

There was a linear increase in protein disappearance of sunflower heads by extending the period of incubation in the rumen to 72 h. The average CP disappearance values increased by 18.6, 17.01, 7.5 and 2.37 percentage units by extending the period of incubation from 12 to 24, 36, 48 and 72 h (Table 7), respectively.

It has been observed in the present investigation that sunflower heads had no readily soluble protein fraction. The fractional degradability of insoluble but degradable with time fraction, b (82.67) was higher. The rate constant / h, C was 0.0486 (Table 7). The rumen degradable protein (RDP) and undegradable dietary protein (UDP) of Sunflower head protein were 37.0 and 63.0 g/100 g, respectively. Literature on dry matter / protein degradability of sunflower heads is not available. The UDP value of 63 indicates that this fraction is available at abomasum or not available to the animal leading to a negative balance for N (Table 6) in the present experiment.

5.4 Formulation and preparation of complete rations

The chemical composition of the different feed ingredients used in the complete rations is shown in Table 8. Four isonitrogenous complete rations were formulated by replacing groundnut haulms with sunflower heads at 0 (CR-1), 20 (CR-2), 40 (CR-3), and 100% (CR-4) levels, maintaining a roughage to concentrate ratio of 60:40 (Table 9). The ingredients of the concentrate mixture were maize grain, groundnut cake and rice bran (solvent extracted). The CP values of the different ingredients used in the complete rations were groundnut cake, 45.4, rice bran, 15.84; maize, 11.41 and groundnut haulms, 9.07%. The CP value of groundnut haulms was about similar to that of sunflower heads. The CF content of groundnut haulms (32.08%) was the highest while those of sunflower heads (17.13%) and deoiled rice bran (18.24%) were about similar. Sunflower heads showed highest Ca content followed by groundnut haulms (1.04%). Maize, groundnut cake and rice bran contained 0.20, 0.22 and 0.35% Ca, respectively. The P content was highest (1.81%) in rice bran followed by groundnut cake (1.08%). Groundnut haulms, sunflower head and maize grain contained 0.20, 0.38

and 0.23% p, respectively (Table 8). The chemical analysis of groundnut haulms was carried out in this laboratory. The digestibilities of various nutrients in groundnut haulms were DM, 54.13; CP, 42.40 ; EE, 42.40; CF, 45.09 and NFE 64.02% (Mandal *et. al.*, 1993).

5.4.1 Chemical composition

The chemical composition of complete rations 1 to 4 is presented in Table 10. The crude fibre content of CR-1 (21.69%) or CR-2 (21.57%) was higher than CR-3 (15.46%) or CR-4 (12.58%) which was due to the higher CF content of groundnut haulms (32.01%) included at 60 and 40% levels in CR-1 and CR-2, respectively. The Ca content of CR-3 (2.11%) for CR-4 (2.56%) was higher than those of CR-1 (1.89%) or CR-2 (1.83%) since they contain larger quantity of sunflower head meal. There was no variation in P content of the different complete rations except a slight increase in CR-3. The cell-wall fractions of the complete rations is presented in Table 11. The NDF, ADF, cellulose and ADL contents were highest in CR-1 followed by CR-2, CR-3 and CR-4 which is due to proportion of groundnut haulms included in these rations as the groundnut haulms contained 57.14, 43.29, 28.21 and 15.08% of NDF, ADF, cellulose and ADL, respectively. The hemicellulose percentage of CR-4 was highest followed by CR-3, CR-2 and CR-1.

5.5 Growth study

To assess the effect of incorporating sunflower head meal in place of groundnut haulms in complete rations a 90 d growth trial was conducted with Nellore brown lambs (18.39 kg ± 0.22). Highest average daily gain (ADG) was observed in the lambs fed CR-2 followed by CR-4, CR-1 and CR-3 (Table 12). The daily feed consumption also followed the same trend. The feed efficiency for the different complete rations 1 to 4

was 11.21, 11.4, 11.74 and 10.61, respectively. The differences among the treatments for ADG, daily feed consumption or feed efficiency were non-significant indicating that sunflower head meal could safely be incorporated in the rations of lambs replacing groundnut haulms even upto 100% level. The dry matter intake (g/d) by the lambs was 656, 746, 629 and 654 for complete rations 1 to 4, respectively (Table 12). According to ICAR (1985) the dry matter requirements of lambs weighing 18 kg with 50 g growth per day is 620 g and for 100 g growth 720 g. The lambs fed CR-1 consumed 656 g indicating a growth rate more than 50 g but less than 100 g/day. Kearl (1982) has recommended 608 to 650 g for 50-100 g growth. The present observations of DM consumption by the lambs in CR-1 and CR-4 are within these limits. The lambs fed complete ration CR-2 consumed 746 g and the ADG was 77 g which is in accordance with ICAR (1985) and Kearl (1982) recommendations for lambs with 19 kg body weight growing at the rate of 50 to 100 g per day. The lambs fed CR-3 consumed 629 g of feed with 62 g ADG. This is also within the range for 50 g of growth per day recommended by ICAR (1985) and Kearl (1982) for lambs weighing 19 kg. The DM intake calculated for 100 kg body weight was 3.59, 3.90, 3.39 and 3.63 for complete rations 1-4 and the differences among the rations was non-significant. The DM consumption $/w_{kg}^{0.75}$ was 74, 82, 71 and 75 g/d for complete rations 1-4, respectively and the differences were non-significant among the rations. Cost of the complete feeds per kg were Rs. 3.24, 3.11, 3.06 and 3.01, respectively for complete feeds 1-4. The cost per kg live weight gain was Rs. 36.33, 35.48, 35.94 and 31.94, respectively for complete rations 1 to 4. Thus there is a saving of 2.33, 1.07 and 12.08% in the cost for kg live weight of the sheep by incorporating sunflower head meal at 20, 40 and 60% level in the complete rations. 2-4, respectively.

5.6 Nutrient digestibility

To assess the digestibility of different nutrients from the complete rations 1 to 4 a metabolism trial was conducted taking 4 ram lambs from each group during the growth experiment. The lambs were kept in metabolism cages two days prior to and during the collection period of 7 days. The digestibility of dry matter ranged from 62.73 to 64.53% but was non-significant among the complete rations 1-4. The digestibility of crude protein ranged from 58.78 to 71.99% for complete ration 1 to 4. There was no significant difference among the complete rations 1 to 4. However, significant differences ($P < 0.05$) were observed among the complete rations 1-4 in the digestibilities of OM, CF, EE and NFE (Table 13). Highest digestibility of CF was observed in CR-2 and the lowest in CR-3 which was significant ($P < 0.05$). The EE digestibility was highest in CR-4 followed by CR-3, CR-2 and CR-1. Differences between CR-1 and CR-3 or CR-4 was significant ($P < 0.05$). The NFE digestibility was highest in CR-1 followed by CR-3, CR-4 and CR-2 and the difference between CR-2 and other rations was significant ($P < 0.05$). Reddy *et. al.* (1986) compared a complete ration containing 48.5% sunflower heads (sole source of roughage) with complete rations containing mixed grass hay, mixed grass hay + subabul, subabul + sunflower heads as roughage sources and reported highest digestibilities of DM, OM, CP, EE, NFE ($P < 0.01$) and CF ($P < 0.05$) in the complete ration containing sunflower heads at 48.5% level. The complete ration containing sunflower heads+subabul showed higher values of digestibility in DM, OM and NFE ($P < 0.01$) compared to rations containing mixed grass alone or mixed grass + subabul forming the roughage component. In another experiment Gowd *et. al.* (1987) reported digestibility values of nutrients from complete rations containing paddy straw or sunflower heads as roughage source. The ration containing sunflower heads showed higher

digestibility compared to the one containing paddy straw as roughage source. Reddy *et. al.* (1989) compared a complete ration containing sunflower heads with complete rations containing mixed grass hay or sunflower straw. Significantly higher digestibility of NFE ($P<0.05$) from complete rations containing sunflower heads was reported. For other nutrient digestibility the differences were non-significant. Reddy and Reddy (1998) reported that DM, OM, CP and CF digestibilities of complete rations containing sunflower heads fed to Ongole bull calves were significantly higher ($P < 0.01$) than conventional diet containing concentrate mixture and chopped sorghum straw. The results of the present investigation are in agreement with those cited above.

The digestibility of cell - wall contents is presented in Table 14. The digestibility of NDF is non-significant in the ram lambs fed different complete rations. However, significant differences were observed in the digestibility of other fractions of cell wall. Highest digestibility of ADF ($P < 0.01$) was observed in CR-1 or CR-2 ram lambs compared to CR-3 or CR-4 ram lambs. Ram lambs fed CR-4 showed the lowest digestibility. The difference between CR-3 and CR-4 was significant ($P < 0.01$). Hemicellulose digestibility was highest in CR-3 and lowest in CR-2 fed ram lambs. The differences in digestibility between CR-2 and CR-3 or CR-1 fed ram lambs was significant ($P < 0.01$). However the difference between CR-2, CR-3 and CR-4 fed ram lambs was non-significant. Lignin digestibility showed the same trend as that of cellulose. Higher digestibilities of NDF (58.18, 52.43), ADF (48.52, 44.12), hemicellulose (54.59, 51.72) and cellulose (51.97, 52.45) and lower lignin digestibility (15.01, - %) in crossbred bulls (Rao *et. al.*, 1997) and Ongole bull calves (Reddy and Reddy, 1998), respectively have been reported with complete rations containing sunflower heads as roughage component. This might be due to higher fibre digestibility in cattle compared to sheep.

5.7 Balance of Nitrogen

The balance of N in ram lambs fed complete rations 1-4 is shown in Table 15. The N retention (g/d) was highest in ram lambs fed CR-2 (7.62) followed by CR-1 (7.29), CR-3 (5.95) and CR-4 (4.40). However, the differences were non-significant. Lower protein degradability of CR-4 has reflected in lower N retention. Nitrogen retention when expressed per kg metabolic body weight / d was significantly lower ($P < 0.01$) in ram lambs fed CR-4 compared to CR-1 or CR-2. Higher nitrogen retention in sheep fed complete rations containing 48.5% sunflower heads was reported by Reddy *et. al.* (1986). Gowd *et. al.* (1987) showed higher N retention in sheep fed complete rations containing sunflower heads as sole roughage compared to conventional ration containing concentrate mixture and paddy straw. Rao *et. al.* (1997) observed higher N Balance in crossbred bulls fed complete ration containing sunflower heads than those fed complete ration containing sorghum straw. The present observations are in accordance with the observations cited above.

5.8 Balance of calcium

The balance of Ca in ram lambs fed complete rations 1-4 is shown in Table 16. The Ca retention (g/d) was highest in lambs fed CR-4 (3.14) followed by CR-2 (2.77), CR-3 (2.42) and CR-1 (2.41). However, the differences were non-significant. Higher Ca retention in sheep fed complete ration containing 48.5% sunflower heads was reported by Reddy *et. al.* (1986). Gowd *et. al.* (1987) showed higher Ca retention in sheep fed complete rations containing sunflower heads as sole roughage compared to conventional ration containing concentrate mixture and paddy straw. Rao *et. al.* (1997) observed higher Ca balance in crossbred bulls fed complete ration containing sunflower heads than those fed complete rations containing sorghum straw. The present observations are

in accordance with the observations of Reddy *et. al.* (1986), Gowd *et. al.* (1987) and Rao *et. al.* (1997).

5.9 Balance of Phosphorus

The balance of P in ram lambs fed complete rations 1-4 is shown in Table 17. The P retention (g/d) was highest in lambs fed CR-3 (2.07) followed by CR-1 (1.88), CR-2 (1.87) and CR-4 (1.85). However, the differences were non-significant. Higher P retention in sheep fed complete rations containing 48.5% sunflower heads was reported by Reddy *et. al.* (1986). Higher P retention in sheep fed complete rations containing sunflower heads as sole roughage compared to conventional ration containing concentrate mixture and paddy straw was reported (Gowd *et. al.* 1987). Reddy *et. al.* (1989) reported higher P retention in sheep fed complete ration containing 50% sunflower heads as sole roughage compared to the complete diet containing mixed grass hay. Higher P balance in crossbred bulls fed complete rations containing sunflower heads than those fed complete diet containing sorghum straw was reported by Rao *et. al.* (1997). The present observations are in accordance with observations cited above. Although the balance of Ca and P were negative when sunflower heads were fed as sole feed, the sunflower heads when incorporated into complete feeds, positive balances were recorded for these minerals. The Ca and P supplemented from the concentrates and mineral mixture, supplied adequate quantities of these minerals to result in a positive balance.

5.10 Nutritive value of complete rations

The nutritive value of the complete rations 1 to 4 in terms of DCP, TDN, DE and ME are presented in Table 18. The DCP value of CR-2 (10.25) was highest and CR-1 lowest (8.29) while CR-3 (8.77) and

CR-4 (8.90) were intermediary. The DCP content of CR-2 was significantly higher ($P < 0.05$) than that of CR-1, CR-3 or CR-4. The TDN values of CR-4 (64.78) and CR-3 (63.19) were higher than CR_1 (60.64) or CR-2 (61.53%). The TDN content of CR-4 was significantly higher ($P < 0.01$) than that of CR-1 or CR-2. The DCP value obtained in the present investigation with 60% sunflower head meal in complete ration is lower than the values 9.12% reported by Reddy *et. al.* (1986) in sheep but higher than 8.32% reported by Gowd *et. al.* (1987) and 7.27% reported by Reddy *et. al.* (1989) in sheep or 8.58% (Rao *et. al.* 1997) and 8.89% (Reddy and Reddy, 1998) in cattle where sunflower head meal was the sole source of roughage. The TDN value of 64.78% obtained in the present study is lower than the value (66.64%) reported by Reddy *et. al.* (1986) but higher than the values reported by Gowd *et. al.* (1987), Reddy *et. al.* (1989), Rao *et. al.* (1997) and Reddy and Reddy (1998). Reddy *et. al.* (1986) reasoned that the higher TDN content of complete rations containing sunflower head meal due to its higher energy content. In the present investigation when sunflower head meal was fed as sole roughage a TDN content of 53.79% was recorded which is higher than that of groundnut haulms (49.17%) as reported by Mandal *et. al.* (1993). Gowd *et. al.* (1987) observed higher (< 0.05) TDN value in complete ration containing sunflower head meal and attributed it to better palatability and higher nutrient content and digestibility.

The gram digestible protein / M cal ME was highest in CR-2 (46.72) followed by CR-3 (39.39), CR-4 (38.56) and CR-1 (38.51). The differences between different complete rations for DM, ME gram digestible protein / M cal DE or gram digestible protein / M cal ME were non-significant.

5.11 *In situ* evaluation of complete rations

The dry matter / protein degradability of complete rations was determined by incubating nylon bags containing samples in the rumen of cannulated steers.

There was linear increase in DM disappearance in all the complete rations with extension of the incubation period from 12 h to 72 h. The DM disappearance of CR-2 and CR-3 were higher than that of CR-1 or CR-4 at 12 h and 24 h of incubation period. However, at 36 h CR-1 and CR-4 showed higher disappearance values than CR-2 or CR-3. At 12 h incubation the disappearance value of CR-3 was highest and significantly ($P < 0.01$) differently from CR-1 and CR-4. At 24 h of incubation higher ($P < 0.01$) disappearance was observed for CR-3 compared to CR-2. At 36 h CR-3 and CR-4 showed higher ($P < 0.01$) disappearance than CR-1 or CR-2. The disappearance values of CR-1, CR-2, CR-3 and CR-4 at 48 and 72 h showed the same trend as at 36 h. Among the complete rations, highest readily soluble dry matter fraction (a) was observed in CR-3 (51.21) while CR-4 had the least (0.0%). This has resulted in 71.47% of DM disappearance for CR-3 by 12 h incubation and 55.91% DM disappearance for CR-4 at the same period (Table 19).

The highest insoluble but degradable with time fraction (b) was observed with CR-4 (84.54) while CR-3 had the least (31.80). The rate constant 'C' was similar for CR-1 and CR-4 and for CR-2 and CR-3. The observed effective degradability of dry matter was least for CR-4 (52.2%), while for CR-1, CR-2 and CR-3 the values were 56.2, 65.2 and 71.2, respectively.

The trend for protein disappearance of the complete rations followed the same trend of DM disappearance (Table 20). Protein disappearance of CR-1, CR-2 or CR-4 was higher than CR-3 except at 12 h incubation. Significantly higher ($P < 0.01$) protein disappearance values were observed between CR-1 and CR-2 or CR-3 or CR-4 at 24 hr incubation. Differences in protein disappearance values were significant ($P < 0.01$) between CR-1 and CR-2 or between CR-2 and CR-3 or CR-4 at 36 h incubation. The above trend was followed at 48 h incubation. At 72 h incubation the differences in protein disappearance values of CR-1 and CR-2, CR-3 and CR-4 were non-significant.

The highest readily soluble protein fraction 'a' was observed with CR-2 (7.05) while CR-1, CR-3 and CR-4 did not show any value. The insoluble but degradable protein fraction 'b' decreased linearly from CR-1 to CR-4. The trend for DM disappearance values of sunflower head meal alone have reflected in the disappearance values of CR-4 which contained 60% sunflower head meal in the ration. Similarly the ED (%) of DM of sunflower head meal has been reflected in the ED of CR-4. The effective protein degradability values and the balance of N, showed similar trend for complete rations 1-4. Highest effective protein degradability (44.2%) was observed with CR-2 while CR-4 had the least (31.3%). The RDP and UDP (g/100 g) content of protein of CR-1 to CR-4 were 42.7, 57.3 ; 44.2; 55.8 ; 37.5, 62.5 and 31.3, 68.7, respectively.

5.12 Plane of nutrition of experimental animals

Nutrient intake of complete rations is presented in Table 21. The daily DM intake expressed as g/d, per cent of weight or $g/w_{kg}^{0.75}$ have decreased from CR-1 to CR-4 with an increase in the level of sunflower heads in complete ration but the differences among the different rations

were non-significant. The intake of DCP and TDN by ram lambs fed different complete rations did not differ significantly.

As per the nutrient requirements of livestock (ICAR, 1985), the requirements suggested for growing lambs weighing 20 kg body weight are DM 700 g, DCP 50 g and TDN 400 g. Kearl (1982) has recommended 660 g of DM, 30.6 g of DCP and 360 g of TDN for growing sheep of 20 kg body weight.

The intake of nutrients by the lambs fed CR-1 and CR-2 were within the recommended levels of ICAR (1985) for growing rams of 20 kg body weight. The nutrient intakes of lambs fed CR-3 and CR-4 (DCP and TDN) were within the recommended levels of ICAR (1985) except for a marginal shortage of TDN and a shortage of DM in CR-4. The nutrient intake of the lambs fed CR-1 to CR-4 were higher than the recommended levels of Kearl (1982) except for DM for growing sheep of 20 kg body weight.

In the present study, it has been observed that replacement of groundnut haulms with sunflower heads upto 100% level in complete rations (R : C ratio 60 : 40) did not affect the ADG or nutrient digestibility or plane of nutrition in Nellore sheep.

SUMMARY

CHAPTER - VI

SUMMARY

The demand for food grains in India to meet the requirements of the fast growing human population is ever increasing which leaves little scope for cultivation of fodder crops. The farmer will have to depend increasingly on agro-industrial by-products and crop residues to feed his animals. There is an urgent need to explore economical, unconventional feed ingredients in view of escalating cost of livestock feeds. Sunflower is cultivated in 2.7 million hectares in India. For every hectare a tonne of sunflower heads is available every year. At present sunflower heads are thrown out as waste.

In the present investigation, an attempt was made to determine the nutritive value of sunflower heads and to study the effect of their inclusion in complete rations replacing groundnut haulms at 0, 20, 40 and 100% levels on nutrient digestibility and growth performance in sheep and *in situ* DM and protein degradability in steers.

The chemical composition of sunflower heads showed CP, 8.4 ; EE, 4.10 ; CF, 17.13 ; NFE, 54.92 ; TA, 15.45 and AIA, 1.93%. Cell-wall fractions of sunflower heads revealed NDF, ADF, hemicellulose, cellulose and lignin contents as 27.19, 22.10, 5.09, 16.01 and 6.09%, respectively.

The nutritive value of sunflower heads was assessed by conducting a metabolism experiment using six Nellore brown rams (29.10 ± 0.37 kg) fed sunflower heads as a sole feed. The digestibility coefficient for nutrients in sunflower heads were 57.59, 33.31, 70.79, 37.65 and 69.24% for DM, CP, EE, CF and NFE, respectively. The nutritive value was

DCP, 2.79 and TDN, 53.79%. Negative balance for N, Ca and P was observed when sunflower heads were fed alone. This indicated that sunflower heads alone could not support the requirements of N, Ca & P. Hence the effect of incorporation of sunflower heads in complete rations was studied.

For evaluation of DM and protein degradability of sunflower heads, *in situ*, nylon bag technique was adopted using 5 permanently rumen fistulated steers. The average disappearance values for DM were 53.15 ± 3.50, 68.19 ± 2.11, 78.86 ± 1.33, 82.43 ± 1.28 and 83.41 ± 1.35 and for CP 32.84 ± 2.70, 51.44 ± 1.39, 68.45 ± 1.77, 75.95 ± 0.84 and 78.32 ± 0.65 per cent at 12, 24, 36, 48 and 72 h incubation, respectively. The readily soluble fraction (a), insoluble but degradable fraction (b) and rate constant / h (c) were 17.63, 0.00 ; 67.51, 82.67 and 0.0613, 0.0486, respectively, for dry matter and protein fractions of sunflower heads. Sunflower heads protein had 37.0 and 63.0% of RDP and UDP, respectively. The study indicates that the effective degradability of dry matter and protein were 54.8 and 37.0% for sunflower heads, respectively.

Four isonitrogenous complete rations with sunflower heads at 0 (CR-1), 20 (CR-2), 40 (CR-3) and 100 (CR-4) per cent levels replacing groundnut haulms were formulated and evaluated in a completely randomised design using 16 Nellore brown ram lambs (19.50 ± 0.35 kg). The chemical composition of complete rations 1 to 4 for CP, CF, EE, NFE and TA were 14.12, 14.25, 14.12, 14.01 ; 21.69, 21.57, 15.46, 12.58; 2.46, 2.82, 3.77, 4.20 ; 50.58, 49.91, 54.68, 56.62 and 50.58, 49.91, 54.68, 56.62%, respectively. The cell-wall fraction of the complete rations 1 to 4 observed for NDF, ADF, hemicellulose, cellulose and lignin were 45.26,

39.26, 37.89, 33.06 ; 35.96, 31.47, 27.93, 22.29; 9.30, 8.45, 9.96, 10.76; 28.55, 24.32, 21.24, 16.17 and 7.41, 7.15, 6.69, 6.12%, respectively.

The complete rations were evaluated in a completely randomised growth experiment for 90 days using 24 Nellore brown (15.32 ± 0.18 kg) weaner lambs. The ADG (g), DMI (g) and EFU were 63.73, 656.04, 11.21; 76.92, 746.38, 11.40 ; 61.86, 628.78, 11.74 and 67.36, 654.32, 10.61, respectively for CR-1 to CR-4. Highest feed efficiency values were observed in ram lambs fed CR-4 (10.61) than those fed CR-1 (11.21), CR-2 (11.40) and CR-3 (11.74). The feed cost for kg live weight gain were Rs. 36.33, 35.48, 35.94 and 31.94 for CR-1 to CR-4, respectively.

During the growth experiment one ram lamb was selected from each treatment as and when they reach 20 kg body weight and kept in metabolism cages for evaluation of digestibility of nutrients in complete rations. The DM digestibility of CR-4 (64.53%) was higher than that of CR-1 (62.79%), CR-2 (62.73%) or CR-3 (63.03%) but there was no significant difference among the complete rations. The OM digestibility of CR-4 (68.90%) or CR_3 (67.61%) were significantly higher ($P < 0.05$) than that of CR-1 (65.77%) or CR-2 (66.21%). The average CP digestibility was 58.78, 71.99, 62.21, and 63.59%, respectively, for CR-1 to CR-4. Inclusion of sunflower heads even upto 100% level in complete rations did not show any adverse effect on CP digestibility. The CF digestibility of CR-2 (48.06%) was significantly higher ($P < 0.05$) than that of CR-3 (38.92%). There was no significant difference between CR-1 and CR-2, CR-3 or CR-4. The ether extract digestibility of CR-3 (78.46%) or CR-4 (80.04%) were significantly higher ($P < 0.05$) than that of CR-1 (70.66%) and CR-2 (75.21%). NFE digestibility of CR-1 (77.12%), or CR-3 (76.36%) or CR-4 (75.67%) were significantly higher ($P < 0.05$) than

that of CR-2 (72.44%). There was no significant difference between CR-1 and CR-3 or CR-4. The difference in the digestibility of NDF among complete rations 1 to 4 were non-significant. Digestibility of ADF in lambs fed CR-1 (49.75%) or CR-2 (47.14%) was significantly higher ($P < 0.01$) than that of CR-3 (38.37%) or CR-4 (31.97%). The hemicellulose digestibility of CR-3 (45.59%) or CR-4 (44.41%) was significantly higher $P<0.05$) than that of CR-1 (38.61%) or CR-2 (31.21%). Digestibility of cellulose in lamb fed CR-1 (52.24%) was significantly higher ($P < 0.01$) than that of CR-2 (44.92%) or CR-3 (44.92%) or CR-4 (44.79%).

Replacement of groundnut haulms with sunflower heads at varying levels in complete rations did not influence the nitrogen utilization in ram lambs. Nitrogen retention expressed as g/d or g / $W_{Kg}^{0.75}$ for complete rations 1 to 4 were 7.29, 0.79; 7.62, 0.80 ; 5.95, 0.63 and 4.40, 0.44, respectively. Nitrogen retention gram per metabolic body weight in CR-2 was significantly higher ($P < 0.01$) than that of CR-4. Nitrogen retention expressed as per cent of absorbed decreased from CR-1 to CR-4 linearly but the difference were non-significant.

Calcium intake and retention (g/d) in ram lambs fed complete rations 1 to 4 were 9.81, 2.41 ; 12.74 ; 2.77 ; 14.07, 2.42 and 15.48, 3.14, respectively. Phosphorus intake and retention (g/d) in ram lambs fed CR-1 to CR-4 were 3.38, 1.88 ; 3.27, 1.87 ; 3.46, 2.07 and 2.89, 1.85, respectively. The differences in both the intake and retention of Ca and P among the lambs fed different complete rations were non-significant.

The nutritive value of complete rations in terms of DCP and TDN were, 8.29, 60.64; 10.25, 61.53; 8.77, 63.19 and 8.90, 64.78%, respectively for CR-1 to CR-4. The daily total DMI expressed in g/d or per cent of live weight or g / $W_{Kg}^{0.75}$ in ram lambs was 7.07, 3.64, 76.48 ; 697, 3.43, 72.96 ; 667, 3.36, 70.99 and 605, 2.93, 62.70, respectively for CR-1 to CR-4. The intake of DCP and TDN (g) of ram lambs fed CR-1 to CR-4 were 58.32, 431.76; 69.85, 427.85 ; 58.54, 421.53 and 52.62, 391.05, respectively.

The dry matter and protein degradability of the four complete rations were evaluated in five steers using nylon bag technique. The dry matter and protein disappearance showed linear increasing trend in all the complete rations with extension of the incubation period from 12 to 72 h. The readily soluble fraction of dry matter (7.59, 45.66, 51.21 and 0.00) for the complete rations 1 to 4 showed an increasing trend upto CR-3 and a zero degradability was observed in CR-4. The readily soluble fraction of protein for the complete rations 1 to 4 were observed to be, 0.00, 7.05, 0.00 and 0.00. The insoluble but degradable fraction of DM was 72.45, 35.17, 31.80 and 84.54 for the complete rations 1 to 4 respectively. Higher degradability was observed for CR-4 followed by CR-1, CR-2 and CR-3 while the insoluble but degradable fraction of protein (82.30, 82.10, 72.13 and 71.60) for the complete rations 1 to 4 showed a decreasing trend.

The effective degradability of dry matter and the effective protein degradability (EPD) of the complete rations 1 to 4 were 56.2, 65.2, 71.2 52.2% and 42.7, 44.2, 37.5 31.3%, respectively. Highest effective DM degradability was observed in CR-3 followed by CR-2, CR-1 and CR-4. In

case of EPD highest degradability was observed in CR-2 followed by CR-1, CR-3 and CR-4. The RDP and UDP (g/100 g) contents of protein of 42.7, 57.3 ; 44.2, 55.8; 37.5, 62.5 and 31.3, 68.7, respectively.

The following conclusions were drawn from the present study :

1. The nutritive value of sunflower heads in terms of DCP and TDN was 2.79 and 53.79%, respectively.

2. The ADG and EFU in growing lambs fed complete ration 1 to 4 were not significantly different. Inclusion of sunflower heads in place of groundnut haulms reduced the cost (Rs. / kg) of ration by 0.13, 0.18 and 0.23 in CR-2, CR-3 and CR-4, respectively. Cost per kg live weight gain (Rs. / Kg) was 36.33, 35.48, 35.94 and 31.94, respectively for CR-1 to CR-4.

3. Inclusion of sunflower heads at 0, 20, 40 and 100% level replacing groundnut haulms for Nellore brown ram lambs had no significant effect on digestibilities of DM, CP and NDF. There was no adverse effect on N retention in ram lambs fed complete rations containing sunflower heads even upto 100% level.

4. The a, b, c constants of dry matter for the complete rations 1 to 4 were 7.59, 72.45, 0.1020 ; 45.46, 35.17, 0.0641 ; 51.21, 31.80, 0.0843 and 0.00, 84.54, 0.1100, respectively. The effective degradability of dry matter in complete rations 1 to 4 were 56.2, 65.2, 71.2 and 52.2%, respectively. The a, b, c constant of protein for the compete rations 1 to 4 were 0.00, 82.30, 0.1350; 7.05, 82.10, 0.0413 ; 0.00, 72.13, 0.0625 and 0.00, 71.60, 0.949,

respectively. The effective protein degradability for complete rations 1 to 4 were 42.7, 44.2, 37.5 and 31.3 per cent, respectively.

The results of the present investigation indicated that groundnut haulms can be completely replaced by sunflower heads in complete rations without affecting the nutrient digestibility, N retention and growth in Nellore brown sheep.

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