

**EFFECT OF *MORINGA OLEIFERA* LEAF MEAL  
INCORPORATION ON GROWTH PERFORMANCE IN  
NELLORE LAMBS**

*By*

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**ID.No: GVM/2018-012**

**THESIS SUBMITTED TO THE  
SRI VENKATESWARA VETERINARY UNIVERSITY  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE OF  
MASTER OF VETERINARY SCIENCE  
IN THE FACULTY OF VETERINARY SCIENCE  
(LIVESTOCK PRODUCTION MANAGEMENT)**



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**APRIL – 2021**

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

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## ACKNOWLEDGEMENTS

*It is a matter of beatitude and euphoria to grace back and recall the path one travels during the days of hard work and pre-perseverance and it is still great at this juncture to recall the faces and spirit in the form of parents, teachers, friends, near and dear ones. I would consider this work nothing more than incomplete without attending to the task of acknowledging the overwhelming help I received during this endeavor of mine.*

*With an overwhelming sense of pride and genuine obligation, I take this opportunity to express deep due sense of gratitude to the chairman of my Advisory committee, **Dr. M. Kalyana chakravarthi** Associate professor, LFC, N.T.R. C.V.Sc, Gannavaram deserves my fore salutations. I am great fully indebted to him for his excellent guidance, boundless encouragement, keen interest and everlasting patience, love and affection and sustained encouragement throughout my studies, course of research work and preparation of thesis can never be forgotten. Throughout my study period, he sustained me with his parental care and thoughtful advice which helped me to cope with many problematic situations. I consider myself lucky to have such an excellence perceiving, ever cooperative and helpful personality as my guide. It had indeed been my privilege to work under his supervision and I will remain indebted to him.*

*It is really highly fortunate that I got the great opportunity to work under the golden heart personality, **Dr. C.H.Venkata seshaiiah**, Professor and Head, Department of L.F.C, N.T.R. C.V.Sc, Gannavaram, member of my advisory committee. It is beyond my apprehension to express my deep sense of gratitude to him for his skilful and noble guidance, vast experience, unrivalled knowledge, incessant inspiration, stimulating discussion, healthy criticism, unstinting moral support and above all his scientific and humanitarian approach which had left in an everlasting impression on the canvass of my mind and helped me in completing P.G on time.*

*I accord my sincere thanks to **Dr.K. Raja kishore**, Assistant professor, Department of animal nutrition, N.T.R.C.V.Sc, Gannavaram and member of my advisory committee for his constant critical supervision, help and encouragement during the course of investigation.*

*My deepest admiration and heartfelt thanks to **Dr.K.Sudhakar**, Professor and Head, Dept of L P M, N.T.R.C.V.Sc, Gannavaram for his valuable guidance, concrete suggestions, endless patience, constant encouragement and cooperation throughout my research work,*

*I am greatly beholden beyond words to express my deep sense of gratitude from inner core of my heart to **Dr.P.Ashalatha**, Associate professor, **Dr. A.Anitha**, Assiastant professor of L P M Department, N.T.R.C.V.Sc, Gannavaram for their valuable suggestions and help rendered during my research work,*

*I am thankful to Dr. M. Muralidhar, Assistant Professor and Head Department of Animal Genetics and Breeding, C.V.Sc, Garividi, for his valuable guidance and timely help during statistical analysis.*

*The love, affection and patience of my family have been instrumental for me. Mere words cannot express my profound indebtedness to my beloved father Bhujanga Rao, my dear mother Sujatha, my husband Jyothi basu for filling my life with laughter and happiness beyond measure.*

*I am very much grateful to my class mates Kalyani, Ajay, Adhethyan, Venkateswarlu, Keerthana, Shalome, for their timely help for carrying out my research work.*

*It is time to surface out my affection and gratitude to my friends, Likitha sri, Sai, Lavanya for their friendly opulence and help during the course of my study.*

*On a personal account, I would like to pour my heartfelt thanks to my seniors Murali, Jyothsna, Deepthi, Reshma for their help, care, inspiration and sincere advises*

*On a personal account, I would like to pour my heartfelt thanks to my juniors Keerthi, Prasanna, Kalyani and Sumukhi for their cooperation and encouragement during my study period.*

*I was lucky to have brilliant and ever dedicated galaxy of friends who were always willing to help me and have always been source of energy to me Swarna, Pratyusha and Chandini for their lovely friendship, love, help and care since from my childhood.*

*I shall be failing in my duty, if I don't express my thanks to SVVU for providing all the facilities and infrastructure during my course of study.*

*While travelling on this part of education, many hands pushed me forth, learned hearts put me on the right track, I ever rest THANKS to all of them.*

*Any omission in this brief acknowledgement doesn't mean lack of gratitude.*

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## **DECLARATION**

I, **SIVALA DIVYA** hereby declare that the thesis entitled “**EFFECT OF MORINGA OLEIFERA LEAF MEAL INCORPORATION ON GROWTH PERFORMANCE IN NELLORE LAMBS**” submitted to Sri Venkateswara Veterinary University, Tirupati for the degree of **MASTER OF VETERINARY SCIENCE** is the 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.

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Degree to which it is submitted : **M.V.Sc**  
Faculty : **VETERINARY SCIENCE**  
Discipline : **LIVESTICK PRODUCTION MANAGEMENT**  
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Year of Submission : **2021**

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### **ABSTRACT**

The present study was conducted on 18 post weaned Nellore lambs of 3 months old having similar body weights, divided into three groups with 6 lambs in each group for a period of 90 days to study the effect of *Moringa oleifera* leaf meal (MOLM) as a protein supplement on growth performance, haemato-biochemical parameters, faecal egg count and to evaluate the cost economics. MOLM was incorporated in the growing lamb's rations as protein supplement at 0, 15 and 30 per cent levels in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets, respectively. MOLM contained 91.21 per cent dry matter, 88.0 per cent organic matter, 20.94 per cent crude protein, 16.85 per cent crude fibre, 5.70 per cent ether extract, 42.50 per cent nitrogen free extract and 12.0 per cent total ash on dry matter basis.

The study revealed that the dry matter intake values from fourth week to thirteenth week were significantly ( $P < 0.05$ ) higher for T<sub>2</sub> group animals and lower for T<sub>0</sub> group with significant ( $P < 0.05$ ) difference among all the three groups. However, the mean daily dry matter consumption of lambs fed with rations T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were 408.45±24.41, 422.71±24.51 and 430.37±25.96 g, respectively with no significant ( $P < 0.05$ ) difference among the three groups.

The body weights were  $16.71 \pm 0.22$ ,  $17.58 \pm 0.17$  and  $17.84 \pm 0.20$  kg at the end of the experiment in groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively with significant ( $P < 0.05$ ) difference between control group and MOLM supplemented groups (15% and 30% levels). The average weight gains were  $5.02 \pm 0.07$ ,  $5.86 \pm 0.08$  and  $6.13 \pm 0.03$  kg in lambs fed with T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> rations, respectively and the difference among the three groups was significant ( $P < 0.05$ ). The average daily gain (ADG) was  $55.85 \pm 0.73$ ,  $65.11 \pm 1.40$  and  $68.09 \pm 1.93$  g in lambs fed with T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> rations, respectively and significant ( $P < 0.05$ ) difference was noticed among the control and MOLM supplemented groups. It was also revealed that the feed conversion ratio (FCR) was significantly ( $P < 0.05$ ) higher in T<sub>0</sub> group than T<sub>1</sub> and T<sub>2</sub> groups during all the fortnights. The overall mean (FCR) was also high in T<sub>0</sub> group ( $7.27 \pm 0.56$ ) when compared to the other two groups of lambs fed with T<sub>1</sub> ( $6.44 \pm 0.43$ ) and T<sub>2</sub> ( $6.24 \pm 0.39$ ) rations with no significant ( $P < 0.05$ ) difference among them.

There was no significant difference in all haematological parameters except haematocrit value (which was significantly ( $P < 0.05$ ) higher in control group than MOLM supplemented groups) and the remaining haematological parameters *viz.*, WBC count, RBC count, haemoglobin, haematocrit, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration were within the normal physiological range. Similarly all the observed serum biochemical parameters *i.e.*, total protein, albumin, glucose, cholesterol, serum glutamic oxaloacetic transaminase, serum glutamic pyruvic transaminase and blood urea nitrogen were within the normal physiological range.

The EPG count was significantly ( $P < 0.05$ ) lower in MOLM supplemented groups T<sub>1</sub> and T<sub>2</sub> ( $22.22 \pm 8.24$  and  $25.00 \pm 7.13$ ) than control group ( $108.33 \pm 8.33$ ) lambs, at the end of the trial period. The total cost and cost of production per kg body weight gain was lower in T<sub>1</sub> (Rs.111.15) and T<sub>2</sub> (Rs.105.43) group lambs which received concentrate mixture containing MOLM than control (Rs.131.38) group lambs.

Thus, it can be concluded that use of MOLM at 30 per cent level as a protein supplement in the growing lamb's diets found to improve growth performance and beneficial in the way of its anthelmintic effect. Hence the conventional protein supplement in the concentrate mixture of sheep could be replaced with 30% MOLM without any deleterious effects.

## LIST OF SYMBOLS AND ABBREVIATIONS

%	Per cent
/	Per
@	At the rate of
°C	Degree Centigrade
ADG	Average Daily Gain
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
BUN	Blood Urea Nitrogen
CF	Crude Fibre
CP	Crude Protein
DAHD	Department of Animal Husbandry, Dairying and Fisheries
dl	Deci litre
DM	Dry Matter
DORB	Deoiled rice bran
EDTA	Ethylene diamine tetra acetic acid
EE	Ether extract
EPG	Egg per gram
FCR	Feed Conversion Ratio
fl	Femtoliters
g	Gram(s)
GNC	Groundnut cake
GOI	Government of India
Hb	Haemoglobin
HSD	Honestly Significant Difference
IU	International units
L	Liter
LFC	Livestock Farm Complex
Kg	Kilograms
M cal	Mega Calories
MCH	Mean Corpuscular Haemoglobin

MCHC	Mean corpuscular haemoglobin concentration
MCV	Mean corpuscular Volume
mg	Milligram
MJ	Mega joules
ml	Millilitre
MOLM	<i>Moringa oleifera</i> leaf meal
NFE	Nitrogen Free Extract
OM	Organic Matter
P	Probability
PCV	Packed Cell Volume
pg	picogram
RBC	Red Blood Cell
Rs	Rupees
SGOT	Serum Glutamic Oxaloacetic Transaminase
SGPT	Serum Glutamic Pyruvic Transaminase
SE	Standard error
t	Tonnes
TA	Total Ash
Viz	Namely
WBC	White Blood Cell



# CHAPTER I

## INTRODUCTION

Animal husbandry along with agriculture continues to be an integral part of human life since time immemorial. Currently, livestock sector is one of the fastest growing agricultural subsectors in developing countries like India. According to the estimates of Central Statistics Office (CSO), the value of output from livestock sector was about 10,43,656 crore at current prices during 2017-18 which is about 35.5% of the value of output from agriculture and allied sectors (GOI-Annual report 2018-19). India has a vast resource of livestock and poultry which play a crucial role in improving the socio-economic conditions of rural people. India is bestowed with large livestock population of 535.82 million numbers of which 192.52 million are cattle, 109.85 million are buffaloes, 74.26 million are sheep, 148.88 million are goat, and 9.06 million are pigs (GOI, DAHD, 2019).

Meat production in the beginning of twelfth five year plan (2012-2013) was 5.95 million tonnes which has been further increased to 8.1 Million tonnes in the year 2018-19. The increased demand for protein foods in the country is the main driver for such growth, which is more inclusive since small holders and land less farmers account for major share in ownership of livestock.

Sheep is one of the important species of livestock affording to the livelihood of resource poor farmers in rural areas especially where crop and dairy farming are not feasible in arid and semi- arid regions and chiefly in marginal and sub-marginal holdings. It contributes to the farm households not only by acting as a source of livelihood and nutritional security, but also as a moving indispensable asset, which can be liquidated at times of crisis within short time. Sheep with its peculiar habit of lower grazing and higher utilization of crude fibre, can reach to the faraway areas and utilize the vegetation on the lands which are otherwise uncultivable.

Sheep population in India is 74.26 million which accounts 13.85% of total livestock population in the country. Andhra Pradesh with a sheep population of 17.6 millions stands second among the states in India, followed by Karnataka and Rajasthan which occupy 3<sup>rd</sup> and 4<sup>th</sup> ranks, respectively (GOI, DAHD, 2019). In Andhra Pradesh Nellore, Deccani and Bellary are recognized sheep breeds. Nellore is a popular and tallest mutton breed in the country distributed predominantly in Nellore, Prakasam, Anantapur, Kadapa and Chittoor districts of Andhra Pradesh.

Sheep with its multi-facet utility for wool, meat, milk, skins and manure forms the backbone of rural economy and they provide livelihood to two third of rural community. They are very much compatible for breeding because of their hardiness and adaptability to dry conditions. The production potential of sheep and good economic return has attracted many progressive farmers and unemployed youth towards sheep rearing. The major advantages are they have short generation interval, higher rate of prolificacy and huge market demand for their products.

In India there are three types of sheep rearing systems are being practiced viz. Extensive, semi- intensive and intensive types. In extensive system the animals are allowed to graze on common lands and no supplement is provided to the animals. This system is mostly carried out in low rainfall areas (Kochewad *et al.*, 2017). In semi-intensive rearing system the sheep are allowed to graze for a period of 4 to 8 hours and are supplemented with some green or dry fodder and concentrates in order to satisfy the nutrient requirements. In intensive rearing the animals are nurtured indoor. Animals are stall fed with cultivated green fodder and concentrate feed. This system is commonly practiced in commercially organized farms. In India extensive and semi- intensive systems are commonly practiced.

Small scale farmers in developing countries including India are experiencing varied problems that lead to a huge fall in the production from certain livestock species like sheep, goats, cattle and swine. The major factor impeding the productivity is over dependence on poor quality grazing resources that are low in essential nutrients like crude protein, vitamins, minerals and high in lignocelluloses.

Furthermore, overgrazing on limited area has made goat and sheep to be a major cause of deforestation, range land destruction and soil erosion. For such reason extensive management system in India is gradually replaced by semi-intensive and intensive system which has restructured the livestock management system.

In present circumstances the growing population of humans and livestock leads to competition especially for protein rich feedstuffs in livestock ration. Concurrently the availability of feed and fodder is decreasing gradually due to reduction in cultivable land under production which is governed by land-use and unpredictable drought constrain. Several scientists have suggested the feeding of supplements such as concentrates as a part of the ways to improve the productivity of small ruminants. However small holder livestock rearing systems rarely use such concentrate feeds due to

unavailability and high cost of cereal grain or their by product ingredients (Sultana *et al.*, 2015).

In order to alleviate the problems associated with the lack of protein supplement, there is a necessity to look for alternative protein sources that farmers can generate at their farm without incurring additional costs. Hence, it is necessary to look for cheaper, non-conventional feed sources. The non-conventional feeds could partly fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost and contribute to self-sufficiency in nutrients.

In recent years there has been a growing interest in many countries to identify potentially important feed resources among shrubs and trees for inclusion in the ruminant diets. Attention has been given to the use of *Moringa oleifera* leaf meal (MOLM) as a protein source and feed component in animal production especially in goats (Sarwatt *et al.*, 2002; Asaolu *et al.*, 2010, and Moyo *et al.*, 2011) and also for other ruminants (Sarwatt *et al.*, 2000 and Gerbregiorgis and Negesse, 2011).

*Moringa oleifera* is one of the potential tree forage which can be used as livestock feed due to its faster growth and higher nutritional attributes. *Moringa oleifera* is commonly referred to as 'drumstick tree' (describing the shape of its pods) or 'horseradish tree' (describing the taste of its roots), is a member of Moringaceae family which grows throughout most of the tropics, and is native to Sub-Himalayan tracts of North West India, Pakistan, Bangladesh and Afghanistan (Makkar and Becker 1996).

Moringa can be cultivated in versatile conditions including hot, humid, dry tropical and subtropical regions, except for water logged conditions. Its productivity is better under marginal conditions with ample nutritional quality. It is grown all over the subcontinent for its tender pods, leaves and flowers. Moringa is a fast growing tree that is having very low maintenance requirements at late stages, reduces necessity of fertilizers and irrigation and a high capacity to re sprout after harvesting.

India is the largest producer of drumstick which contributes (41%) of the global production followed by other tropical parts of the world. Among Indian states Andhra Pradesh leads in area and production of Moringa followed by Karnataka, Tamilnadu and Maharashtra. The available protein content in Moringa is around 95% either in rumen or in post rumen. The potential digestible protein is around 47% which is much higher than those for various conventional protein supplements like seed meals of coconut, cotton

seed, groundnut, sesame, sunflower etc. The essential amino acid composition of these leaves was comparable with that of soybean (Makkar and Becker 1996). The leaves are highly nutritious containing B vitamins, Vitamin C, pro-vitamin-A as beta- carotene, vitamin K, manganese, iron and several essential amino acids along with other nutrients (Moyo *et al.*, 2011).

Apart from nutritional attributes this tree has medicinal properties such as anti-helminthic, antioxidant, anti-diabetic, anti-cancer, anti-inflammatory and anti-microbial activity. The leaves of *Moringa oleifera* contain negligible amounts of anti-nutritive compounds (tannins, lectins, trypsin inhibitors, saponins etc.). Due to its benefits it is popularly known as “miracle tree”.

However, there is limited literature available to evaluate the potential of *Moringa oleifera* on growth performance of sheep and requires further research to evaluate its use as protein supplement or replacement in the concentrate mixture. In view of the above facts, the present study is undertaken to explore the viability and economic feasibility of *Moringa oleifera* as a partial protein feed replacement in the diets of Nellore weaned lambs with the following objectives.

#### **Objectives of research work**

1. To study the effect of incorporation of *Moringa oleifera* leaf meal on growth performance in Nellore lambs.
2. To assess the effect of *Moringa oleifera* leaf meal incorporation on haemato-biochemical parameters in Nellore lambs.
3. To investigate the anthelmintic effect of *Moringa oleifera* leaf meal in Nellore lambs.
4. To work out the cost per kg weight gain in lambs incorporated with *Moringa oleifera* leaf meal.

## CHAPTER II

### REVIEW OF LITERATURE

In this chapter various aspects of animal diets containing *Moringa oleifera* have been reviewed with the available literature related to the present study under the following headlines.

#### **2.1. Chemical composition of *Moringa oleifera* leaf meal (MOLM)**

Makkar and Becker (1996) investigated nutritional value of whole and ethanol extracted *Moringa oleifera* leaves. They found that crude protein contents of the extracted and unextracted leaves were 43.5 and 25.1%, respectively while the true protein contents of these leaves were 93.8% and 81.3% of the total crude protein and non protein nitrogen contents are 2.7 and 4.7% in extracted and unextracted leaves, respectively. They also reported that all essential amino acids including sulfur-containing amino acids were higher in *Moringa oleifera*.

Aregheore (2002) observed that *M. oleifera* leaves contain 46.1% dry matter of which 88.5% organic matter with 19.3% crude protein, 18.2% neutral detergent fibre and the gross energy is found to be 17.8 MJ/Kg.

Richter *et al.* (2003) reported that crude protein, ether extract, ash, neutral detergent fibre, and acid detergent fibre contents of *Moringa oleifera* leaf meal as 25.0, 10.6, 8.4, 15.9 and 12.6 percent, respectively.

Kakengi *et al.* (2005) found that crude protein content ranged from 265-308 g/kg dry matter (DM) in *Moringa oleifera* leaves (MOL) and seed cake (MOC). *Leucaena leucocephala* and *Moringa oleifera* soft twigs and leaves (MOLSTL) had CP content of 236 and 195 g/kg DM respectively, while *Moringa oleifera* soft twigs alone (MOST) and *Moringa oleifera* bucks (MOB) had 114 and 69.3 g/kg DM, respectively. They revealed that the high crude protein content in MOL and MOLST could be well utilized by ruminant animals.

Sanchez *et al.* (2006) noticed DM 164 g/kg, CP 178 g/kg, NDF 506 g/kg, ADF 376 g/kg and ash 107.6 g/kg in *Moringa oleifera* foliage on dry matter basis.

Asaolu *et al.* (2010) analysed the chemical composition of *Moringa* leaves and found the DM (25%) and CP (22.2%), EE (6.68%), NFE (41.3%), Ash (13.2%), NDF

(28.0%), ADF (28.9%), K (1.26%), Na (0.28%), Ca (1.97%) and P (0.13%) on DM basis.

Asaolu *et al.* (2011) studied chemical composition of *Moringa oleifera* fodder (MO) that shows DM (95.57%), CP (26.74%), EE (8.06%), CF (11.03%), NDF (26.35%), ADF (40.40%), OM (89.83%), NFE (39.53%), Calcium (1.10 g/100g), Phosphorus (0.43 g/100g), Sodium (0.20 g/100g), Potassium (0.20 g/100g), Magnesium (0.20 g/100g), Iron (281.00 g/100g), Manganese (80.0mg/kg), Cu (7.0 mg/kg) and Zn (29.0 mg/kg) .

Moyo *et al.* (2011) assessed the nutritional value of *Moringa oleifera* and reported that the dried Moringa leaves had crude protein levels of 23.76% and 19 amino acids. The fibre consists of neutral detergent fibre (NDF) (34.77%), acid detergent fibre (ADF) (17.15%), acid detergent lignin (ADL) (2.06%) and acid detergent cellulose (ADC) (7.93%). The estimated values of minerals were Calcium (2.78%), Phosphorus (0.64%), Potassium (2.03%), Sodium (0.02%), Zinc (89.17 mg/kg), Copper (21.00%), Iron (356 mg/kg) and also conveyed that values of amino acids, fatty acids, minerals and vitamin profiles reflect a desirable nutritional balance.

Adeniji and Lawal (2012) conducted proximate analysis of *Moringa oleifera* leaves on air-cured basis showed that the leaves contained dry matter (93.4%), crude protein (24.8%), crude fibre (11.1%), ether extract (2.1%), ash (8.7%) and nitrogen free extract (53.5%); with a metabolizable energy of 3316.52 Kcal/kg.

Nouman *et al.* (2012) observed that Moringa leaves contained appreciable amount of crude protein (23.5%), crude fibre (7.5%), dry matter (8.6%), ether extract (3.0%), ash (13.5%), neutral detergent fibre (11.0%) and acid detergent fibre (6.0%).

Adegun and Aye (2013) studied that MOLM contain 88.6% dry matter of which 78.2% organic matter with 22.1% crude protein, 38.5% neutral detergent fibre, 44.4% acid detergent fibre, 6% ash and gross energy is found to be 11.3 MJ/Kg.

Teixeira *et al.* (2014) in their study revealed that whole leaf flour of Moringa contained crude protein (28.7%), fat (7.1%), ash (10.9%), carbohydrate (44.4%) and Calcium (2.97 mg/100g) and Iron (103.1 mg/100g). The protein profile revealed albumin (3.1%), globulins (0.3%), prolamin (2.2%), glutelin (3.5%) and insoluble proteins (70.1%).

Tona *et al.* (2014) in a study of growth performance and nutrient digestibility of West African Dwarf goats fed graded levels of *Moringa oleifera* leaf meal observed that the dry matter (90.46%), crude protein (18.38%), crude fibre (14.04%), ether extract (14.58%), ash (8.38%), organic matter (91.62%), nitrogen free extract (44.71%), neutral detergent fibre (25.68%), acid detergent fibre (14.78%), acid detergent lignin (7.11%), hemicelluloses (10.90%) and cellulose (6.67%).

Allam *et al.* (2015) evaluated the chemical composition of *Moringa oleifera* leaf meal (MOL) and reported that the dry matter content (28.91%), organic matter (88.16%), crude protein (16.52%), ether extract (5.78%), crude fibre (13.14%), nitrogen free extract (52.72%), acid detergent fibre (20.03%), neutral detergent fibre (30.27%) and ash (11.84%) on dry matter basis.

Kholif *et al.* (2015) analysed *Moringa oleifera* for chemical composition and reported that the dry matter content of Moringa leaf meal was found to be 320.2 g/kg wet material of which 88.9% was organic matter with crude protein 24.12 per cent, 33.66% per cent neutral detergent fibre, 27.5 per cent acid detergent fibre, ether extract 4.73 per cent, non-structural carbohydrates 26.39 per cent. They also reported that Moringa leaf meal contains cellulose (19.34%), hemicelluloses (6.16%), total phenolic compounds (5.15%) and tannins (25.63%).

Babeker and Bdalbagi (2015) opined that Moringa leaves contain dry matter (42.7%), crude protein (20.9%), crude fibre (18.5%), neutral detergent fibre (28.5%), acid detergent fibre (18.1%), lignin (7%), ether extract (3.8%), ash (10.5%), gross energy (18.2 MJ/Kg), calcium (26.4%) and phosphorus (2.6%).

Sultana *et al.* (2015) reported that Moringa foliage contains dry matter (77.44%), crude protein (18.26%), acid detergent fibre (32.49%), organic matter (89.33), ether extract (4.15%), ash (10.67%) and metabolizable energy (11.24 MJ/g), Calcium (1.95%), Phosphorus (0.21%).

Fadiyimu *et al.* (2016) noticed that the dry matter content is 21.48% (on fresh basis) of which organic matter (92.46%), crude protein content (29.68%), crude fibre (16.98%), ether extract (5.78%), ash (7.54%) and the nitrogen free extract is 40.11% on dry matter basis in *Moringa oleifera*.

Jiwuba *et al.* (2016) conducted proximate analysis of *Moringa oleifera* leaf meal and revealed the presence of dry matter (87.90%) crude protein (23.24%), crude fibre (15.16%), ether extract (4.15%), ash (6.21%) nitrogen free extract (39.14%) and gross energy (4.03 MJ/g).

Oyedele *et al.* (2016) evaluated *Moringa oleifera* fodder for chemical composition and reported that the dry matter content of Moringa leaf meal was found to be  $28.11 \pm 2.08$  per cent of which  $91.69 \pm 3.29$  per cent was organic matter with crude protein  $29.14 \pm 1.49$  per cent, crude fibre  $10.34 \pm 1.00$  per cent, ether extract  $28.40 \pm 1.95$  per cent,  $8.27 \pm 1.25$  per cent ash,  $23.80 \pm 6.82$  per cent nitrogen free extracts and  $4.48 \pm 0.04$  MJ/kg gross energy.

Damor *et al.* (2017a) found that Moringa leaves contain 77.4% dry matter, 26.3% crude protein, 14.1% ash, 5.7% ether extract and 8.8% crude fibre.

Yusuf *et al.* (2018) conducted the proximate composition (g/kg) of *M. oleifera* meal (leaf plus twigs) and the experimental diets. They reported that *Moringa oleifera* plants (leaves and twig) contain 40.0 g/kg DM moisture, 960.0 g/kg dry matter, 315.0 g/kg DM crude protein, 40.0 g/kg DM ether extract, 355.0 g/kg DM neutral detergent fibre (NDF), 253.0 g/kg DM acid detergent fibre (ADF), and 97.0 g/kg DM total Ash. Moisture content in the experimental diets ranged from 26.0 to 106.0 g/kg DM. DM ranged from 893.0 to 973.0 g/kg DM. Crude protein ranged from 209.0 to 277.0 g/kg DM. Crude fibre ranged from 86.0 to 101.0 g/kg DM. Ether extract ranged from 39.0 to 49 g/kg DM. Total ash ranged from 58 to 690 g/kg DM.

Choudhary *et al.* (2018) observed that the Moringa leaves contained 21.37% crude protein, 6.06% ether extract, 12.3% total ash, 87.13% dry matter and 4.82% crude fibre.

Ghany *et al.* (2019) evaluated the composition of Moringa plant leaves extract and reported that it contains crude protein (26.2%), crude fibre (18.0%), crude fat (3.0%), ash (6.0%) and moisture (10.0%) content.

Manikrao (2020) analysed the chemical composition of *Moringa oleifera* leaves and reported that it contains 92.12% dry matter, 24.39% crude protein, 6.67% ether extract, 5.57% crude fibre, 12.66% total ash and 0.27% acid insoluble ash.

## 2.2 Growth performance

### 2.2.1 Body weight gains

Aregheore (2002) conducted a feeding trial to investigate the nutritive value and digestibility of *Moringa oleifera*-batiki grass (*Ischaemum aristatum* var. *indicum*) mixtures by feeding *Moringa oleifera* at 20% (M20), 50% (M50) and 80% (M80) of total daily forage allowance and found higher weight gains in the goats fed with M20 (6 kg) and M50 (5.5 kg) over M80 diets. They suggested that *Moringa oleifera* at 20% and 50% levels of total daily forage allowance could be used as a cheap protein supplement in batiki grass based diets for goats.

Sarwatt *et al.* (2002) in the study of substitution of sunflower seed-cake (SSC) with *Moringa oleifera* leaf meal (MOOL) as a supplemental feed in Tanzania, The supplementary treatments were different levels of MOOL, so that the proportions of MOOL to SSC were 0:100 (T<sub>1</sub>), 25:75 (T<sub>2</sub>), 75:25 (T<sub>3</sub>) and 100:0 (T<sub>4</sub>). All animals were fed with low-quality *Chloris gayana* hay as a basal ration. They observed significantly ( $P>0.05$ ) higher final body weights in T<sub>3</sub> and T<sub>4</sub> groups when compared to remaining groups.

Murro *et al.* (2003) conducted a study in growing Black head persian male sheep by replacing cotton seed cake in the concentrate mixture with *Moringa oleifera* leaf meal at 0 (M0), 33.3 (M33), 66.6 (M66) and 100% (M100). They found that there was no significant difference ( $P>0.05$ ) in final body weights in *Moringa* leaf meal supplemented groups when compared to control group animals.

Asaulo *et al.* (2012b) found that mean final body weight for animals on *Moringa* based multinutrient blocks (MMNB) supplementations (8.70 kg) was significantly ( $P<0.05$ ) higher than those of the animals on the reference supplements and *i.e.*, cassava peels (8.00 kg) and corn starch residues (7.80 kg) which showed no statistical difference.

Moyo *et al.* (2012) found that, there was significantly higher final body weight ( $P<0.05$ ) in Xhosa lop-eared goats fed with *Moringa oleifera* leaves (MOL) and sunflower cake (SC) as compared to other animals fed on grass hay (GH). Feeding MOL or SC improved the growth performance of goats in an almost similar way, which

indicates that *Moringa oleifera* could be used as an alternative protein supplement in goats.

Mahamoud (2013) conducted an experiment on Rahamni lambs fed with three different diets *viz.*, control group lambs were fed R<sub>1</sub> contained Clover hay (CH) (1% of live body weight) plus concentrate feed mixture CFM (3% of live body weight), while the experimental lambs were fed CH plus 25 % *Moringa oleifera* stems from CFM (R<sub>2</sub>) and 25% *Moringa oleifera* stems from CH plus CFM (R<sub>3</sub>). The total body weight gains for lambs fed R<sub>1</sub>, R<sub>2</sub> and R<sub>3</sub> were 18.46, 20.14 and 19.05 kg, respectively with non significant differences among groups.

Tona *et al.* (2014) studied the growth performance and nutrient digestibility of West African dwarf goats fed graded levels of *Moringa oleifera* leaf meal and observed final body weight gains of 1.29 kg, 0.98 kg, 1.02 kg and 1.39 kg for 0%, 5%, 10% and 15% *Moringa oleifera* leaf meal, respectively. The results showed that the West African dwarf goats fed the concentrate diet with 15% level of inclusion of *Moringa oleifera* leaf meal had a significantly higher body weight gain than those on the 5% and 10% inclusion levels.

Babeker and Bdalbagi (2015) found significant ( $P<0.05$ ) improvement in body weight in Sudan Nubian goats at the end of experiment in group B which were offered 20 % than group A (0 %) and C (50%) levels of *Moringa oleifera* leaves. Total body weight gain increased significantly ( $P<0.05$ ) in group B as compared to group A and C.

Sultana *et al.* (2015) studied the feeding value of *Moringa oleifera* foliage as replacement to conventional concentrate diet in Bengal goats. In this trial, thirty growing male goats were divided into five groups with six animals in each group. The five dietary treatments consisted of varying proportions of *Moringa* foliage (MF) and concentrate (C), namely, T<sub>1</sub> (100MF: 0C), T<sub>2</sub> (75MF:25C), T<sub>3</sub> (50MF:50C), T<sub>4</sub> (25MF: 75C) and T<sub>5</sub> (0MF:100C). The study showed that highest average live weight was found in goats fed with T<sub>2</sub> diet while the lowest was found in goats fed with T<sub>5</sub> diet at the end of the trial. They opined that *Moringa* foliage may be a replacer of conventionally mixed concentrate up to 75% level for feeding Bengal male goats.

Fadiyimu *et al.* (2016) observed the feed intake, growth performance and carcass characteristics of West African Dwarf sheep fed *Moringa oleifera*, *Gliricidia sepium* or *Cassava* fodder as supplements to *Panicum maximum*. Sheep were allotted to

four dietary treatments: 1: 100% *P. maximum* (control), 2: 75% *P. maximum* + 25% *M. oleifera*, 3: 75% *P. maximum* + 25% *G.sepium*, 4: 75% *P. maximum* + 25% Cassava leaves. Growth rates were 6.53, 11.31, 8.34 and 12.74 g/day for T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub>, respectively. It was concluded that *Moringa oleifera* is a suitable alternative to *Gliricidia sepium* as supplement in small ruminant diets.

Suliman *et al.* (2016) observed final body weights of 42 kg, 42.4 kg for dried Moringa leaves fed growing lambs at 30 g and 60 g/day, respectively when compared to control group.

Oyedele *et al.* (2016) studied nutrient digestibility and growth performance of West African Dwarf (WAD) goats fed foliage combinations of *Moringa oleifera* and *Gliricidia sepium* with equal proportions of a low-cost concentrate. These groups include concentrate with 100% *Gliricidia* and 100% Moringa, respectively (LC: G100 M0, LC: G0M100), concentrate with *Gliricidia* and Moringa combinations at 75 to 25%, 50 to 50% and 25 to 75%, respectively (LC: G75M25, LC: G50M50, LC: G25 M75). Study revealed that growth performance indices (total weight gain and daily growth rate) were highest for animal on feeding 100% *Moringa oleifera* and 0% *Gliricidia sepium* in comparison with 100% *Gliricidia sepium* diet.

Babiker *et al.* (2017) conducted a comparative study on feeding value of Moringa leaves diet (MOD) as a partial replacement for alfalfa hay diet (AHD) in ewes and goats. Results showed that total body weight gain was significantly ( $P < 0.01$ ) higher in lambs fed MOD than that fed AHD.

Bushara *et al.* (2017) reported that total body weight gains in Sudanese Desert rams were 4.7, 3.3 and 7.1 kg in RP (mixture of range plants), MPSL (*Moringa oleifera* pods, stems and leaves) and RP + MPSL (mixture of range plants; *Moringa oleifera* pods, stems and leaves) groups, respectively. It was resulted that, diets containing mixture of rangeplants + *Moringa oleifera* pods, stems and leaves supported better growth performance signifying that inclusion of MPSL in fattening ram's diet, improved weight gain.

Damor *et al.* (2017a) studied the effect of feeding different levels of *Moringa oleifera* leaves on growth performance of Mehsana kids. The average daily body weight gain in kids were higher ( $P < 0.001$ ) in T<sub>3</sub> (100% *Moringa oleifera* leaves) followed by group T<sub>2</sub> (50% concentrate mixture + 50 % *Moringa oleifera* leaves) and T<sub>1</sub> (100%

concentrate mixture). They opined that, the feeding of dried *Moringa oleifera* leaves replacing conventional concentrate mixture improved body weights and average daily body weight gain without affecting feed intake and overall health of Mehsana kids.

Syed Ali (2017) studied the replacement of cotton seed cake (CSC) to the extent of 50% with dried *Moringa oleifera* leaf meal in the concentrate mixture under intensive system of goat rearing and reported that the average initial and final body weights were found to be 14.79, 14.89 kg and 19.26, 19.44 kg in T<sub>0</sub> and T<sub>1</sub> (50%) groups, respectively which did not differ significantly between both groups.

Haridas (2018) studied the effect of supplementation of *Moringa oleifera* leaf meal on the performance of the growing sheep in which the cotton seed cake in the concentrate mixture was replaced with 10 % and 20 % *Moringa oleifera* leaf meal and observed that treatment groups had high body weight gain than control but it was statistically non significant.

Manmohan Kumar (2018) studied the effect of feeding *Moringa oleifera* leaf powder (MOLP) on growth performance of growing female Black Bengal goat and found significantly higher body weight in T<sub>2</sub> (15% MOLP) when compared to T<sub>0</sub> (0% MOLP), T<sub>1</sub> (10% MOLP), T<sub>2</sub> (20% MOLP) groups under intensive and semi-intensive systems of management.

Padma Meel (2018) in an experiment of feeding drumstick (*Moringa oleifera*) dry leaves on growth performance of Sirohi kids reported significantly higher weight gain in T<sub>4</sub> (75% level), T<sub>5</sub> (100% level) and T<sub>3</sub> (50%) group kids when compared with other groups T<sub>2</sub> (25% level) and T<sub>1</sub> (0% level).

Yusuf *et al.* (2018) conducted an experiment by including *Moringa oleifera* leaf meal in the commercial feed supplement at level of 0, 50, and 100 g/kg dry matter. Study revealed that *Moringa oleifera* leaf meal in the supplement did not significantly affect weight gain. The study also reported that feeding the commercial supplement with MOLM up to 100 g/kg DM does not affect the nutritional status, growth performance and health of the goats while it decrease the feed cost per gain.

Ghany and Eraky (2019) found that significant ( $p < 0.05$ ) weight gains were obtained in broilers fed *Moringa oleifera* at 1% level than other treatments at higher levels (5% and 7.5%) and recommended using of dietary level of 1% MOLP (*Moringa*

*oleifera* leaf powder) to improve performance, intestinal health, and immune competence.

Jagritisrivastav (2019) conducted a study to investigate the effect of supplementation of *Moringa oleifera* leaves on nutrient utilization and growth performance in goats and observed a significantly higher total body weight gain in experimental kids supplemented with *Moringa oleifera* leaves at the level of 15% of complete feed.

Manikrao (2020) studied the effect of feeding *Moringa oleifera* leaf meal (MLM) based diets on productive performance of growing Deccani sheep in intensive and semi-intensive farming system and reported that the total weight gain was significantly ( $P<0.01$ ) higher in T<sub>2</sub> group lambs fed with 25% MLM based diet which was comparable to that of T<sub>1</sub> (0% MLM) and T<sub>3</sub> (50% MLM) groups.

### **2.2.2 Average daily gain**

Aregheore (2002) conducted a feeding trial in growing goats to investigate the nutritive value and digestibility of *Moringa oleifera*-batiki grass (*Ischaemum aristatum* var. *indicum*) mixtures by feeding *Moringa oleifera* at 20% (M20), 50% (M50) and 80% (M80) of total daily forage allowance and recorded significantly ( $P<0.05$ ) higher daily weight gains in M20 followed by M50 and M80 groups.

Sarwatt *et al.* (2002) conducted the study of substitution of sunflower seed-cake (SSC) with *Moringa oleifera* leaves as a supplemental feed in Tanzania. The supplementary treatments were different levels of MOOL, so that the proportions of MOOL to SSC were 0:100 (T<sub>1</sub>), 25:75 (T<sub>2</sub>), 75:25 (T<sub>3</sub>) and 100:0 (T<sub>4</sub>). They observed that there was no significant difference in average daily gains in *Moringa* supplemented groups when compared to control group.

Murro *et al.* (2003) conducted a study in growing Black head persian male sheep by replacing cotton seed cake in the concentrate mixture with MOLM at 0 (M0), 33.3 (M33), 66.6 (M66) and 100% (M100) levels. They found significantly higher average daily weight gain in M100 group (62.1g/d) than remaining groups.

Asaulo *et al.* (2012b) found that mean daily weight gains for animals on *Moringa* based Multinutrient blocks (MMNB) supplementations (38.10 g/day) was significantly ( $P<0.05$ ) higher than those of the animals on the reference supplements

(23.81 g/day and 28.57 g/day) *i.e.* cassava peels, with corn starch residues which showed no statistical difference.

Moyo *et al.* (2012) found that, there was significant increase in average daily weight gain ( $P < 0.05$ ) in Xhosa lop-eared goats fed with *Moringa oleifera* leaves (MOL) and sunflower cake (SC) as compared to other animals fed on grass hay (GH). They also opined that *Moringa oleifera* could be used as an alternative protein supplement in goats.

Mahamoud (2013) conducted an experiment on Rahamni lambs fed with three different diets *viz.*, control group lambs were fed R<sub>1</sub> contained Clover hay (CH) (1% of live body weight plus concentrate feed mixture CFM (3% of live body weight), while the experimental lambs were fed CH plus 25 % *Moringa oleifera* stems from CFM (R<sub>2</sub>) and 25% *Moringa oleifera* stems from CH plus CFM (R<sub>3</sub>). The average daily gains for lambs fed R<sub>1</sub>, R<sub>2</sub> and R<sub>3</sub> were 205.13, 223.8 and 211.77 g respectively with non significant differences among groups.

Tona *et al.* (2014) reported that the West African dwarf goats fed with concentrate diet containing 15% level of inclusion of MOLM had a significantly higher rate of growth than those on the 5% and 10% inclusion levels.

Babeker and Bdalbagi (2015) found significant ( $P < 0.05$ ) improvement in average daily body weight gain in Sudan Nubian goats in group B which were offered 20% than group A (0%) and C (50%) levels of *Moringa oleifera* leaves at the end of experiment.

Sultana *et al.* (2015) evaluated the feeding value of *Moringa oleifera* foliage (MF) as replacement to conventional concentrate (C) diet in Bengal goats. The study showed that highest average daily live weight gain was found in T<sub>2</sub> (75MF:25C) group while the lowest was found in T<sub>5</sub> (0MF:100C). They opined that *Moringa* foliage may be a replacer of conventionally mixed concentrate for feeding Bengal male goats.

Suliman *et al.* (2016) observed significantly higher average daily gains of 182 g/day, 184.67 g/day for dried *Moringa* leaves (MOL) fed growing lambs at 30 g and 60 g/day, respectively when compared to control group (0 g MOL).

Babiker *et al.* (2017) conducted a comparative study on feeding value of Moringa leaves diet (MOD) as a partial replacement for alfalfa hay diet (AHD) in ewes and goats. Results showed that average daily gain was significantly ( $P<0.01$ ) higher in kids and lambs fed MOD than that fed AHD indicating replacement of alfalfa with *M. oleifera* which had a positive effect on growth performance of kids and lambs.

Damor *et al.* (2017a) reported that the average daily body weight gain in kids were higher ( $P<0.001$ ) in T<sub>3</sub> (100% *Moringa oleifera* leaves) group followed by T<sub>2</sub> (50% concentrate mixture + 50 % *Moringa oleifera* leaves) and T<sub>1</sub> (100% concentrate mixture) groups.

Syed Ali (2017) reported that average daily gain was marginally higher in T<sub>1</sub> (50% Moringa replacement) group than control group goats but it was statistically non-significant.

Haridas (2018) observed the effect of supplementation of MOLM on the performance of the growing sheep in which the cotton seed cake in the concentrate mixture was replaced with MOLM at 10 % and 20 % levels and observed that there was no significant difference in average daily gain among the control group and Moringa supplemented groups.

Manmohan Kumar (2018) studied the effect of feeding *Moringa oleifera* leaf powder (MOLP) on growth performance of growing female Black Bengal goat and found significantly higher average weight gain in T<sub>2</sub> (15% MOLP) when compared to T<sub>0</sub> (0% MOLP), T<sub>1</sub> (10% MOLP), T<sub>3</sub> (20% MOLP) groups under intensive and semi-intensive systems of management.

Padma Meel (2018) reported significantly higher average daily gain in T<sub>4</sub> (75% level), T<sub>5</sub> (100% level) and T<sub>3</sub> (50%) group kids when compared with other groups T<sub>2</sub> (25% level) and T<sub>1</sub> (0% level) fed with Moringa.

Jagritisrivastav (2019) conducted a study to investigate the effect of supplementation of *Moringa oleifera* leaves on nutrient utilization and growth performance in goats and observed a significant difference in average daily weight gain when experimental kids were supplemented with *Moringa oleifera* leaves at the level of 15% of complete feed.

Manikrao (2020) studied the effect of feeding *Moringa oleifera* leaf meal (MLM) based diets on productive performance of growing Deccani sheep in intensive and semi-intensive farming system and reported that the total average daily gain was significantly ( $P < 0.01$ ) higher in T<sub>2</sub> group lambs fed with 25% MLM based diet compared to that of T<sub>1</sub> (0% MLM) and T<sub>3</sub> (50% MLM) groups.

### 2.2.3 Dry Matter Intake

Aregheore (2002) reported that there was no significant difference in daily dry matter intake in control group and Moringa supplemented (at 20%, 50% and 80% of total daily forage allowance) group goats.

Sarwatt *et al.* (2002) reported that goats provided with treatment diet containing 75% of Moringa + 25% Sunflower seed cake (T<sub>3</sub>) had significantly ( $P < 0.01$ ) higher DMI than the rest of the goats in the other treatments, followed by those provided with treatment T<sub>4</sub> (Moringa 100%), T<sub>1</sub> (Sole sunflower seed cake), and then T<sub>2</sub> (Moringa 25% + 75% sunflower seed cake). However, the goats in the T<sub>1</sub> and T<sub>2</sub> treatment diets did not differ significantly ( $P < 0.05$ ).

Murro *et al.* (2003) found that the dry matter intake and digestibility were higher in Moringa replacement groups (at 33%, 66% and 100%) compared to control group in Black head Persian male sheep.

Manh *et al.* (2005) observed lower dry matter intake in goats offered *Moringa oleifera* (MO) as compared to *Leucaena leucocephala* (LL) irrespective of feeding method. The results inferred that MO when used as sole fodder needed adoption time as compared to LL and there was no health problem during the experimental period either MO or LL feeding.

Sanchez *et al.* (2006) evaluated the effect of different levels of foliage of *Moringa oleifera* to creole dairy cows on intake, digestibility, milk production and consumption. The animals were fed with *Brechiara brizantha* hay *ad libitum* with or without supplementation of *Moringa oleifera* Lam. *Moringa oleifera* Lam is given @ 2-3 kg to the cows. The total dry matter intake of cows supplemented with 2 kg DM and 3 kg DM of Moringa to *B. brizantha* hay-based diet had significantly ( $P < 0.05$ ) higher than the intake of the unsupplemented cows.

Asaolu *et al.* (2010) found that the total DM intake values were 54.6, 59.6 and 59.6 g/kg<sup>0.75</sup> for the animals on 100 GNH (Groundnut hay), 50 Bamboo: 50 Groundnut hay (50BAM:50GNH) and 50 Moringa: 50 Groundnut hay (50MOR:50GNH), respectively and there was no significant difference observed among the groups.

Fadiyimu *et al.* (2010) studied the effect of different level of inclusion of Moringa leaves in five rations and found the DM intake was significantly ( $P < 0.05$ ) lowered at high inclusion (>50%) level in West African Dwarf sheep.

Asaolu *et al.* (2011) studied the utilization of *Moringa oleifera* fodder (MO) in combination with *Leucaena leucocephala* (LEU) and *Gliricidia sepium* (GLI) fodders in West African Dwarf goats (WAD) by feeding three experimental diets *viz.*, 50MO:50LEU, 50MO:50GLI and 100MO. Their study revealed that there was no significant difference in DM intake among the three experimental groups.

Adegun *et al.* (2011) found that the dry matter intake in WAD sheep were 38.4, 40.6, 42.8 and 42.3 g/day in control (Panicum+Cassava peels), Moringa multi nutrient block (MMNB), Gliciridia-based multi nutrient blocks, (GMNB) and *Leucaena Leucocephala* multi nutrient blocks (LMNB), respectively.

Asaulo *et al.* (2012b) evaluated performance of grazing West African Dwarf goats on Moringa multi nutrient block supplementation and found a significant difference ( $P < 0.05$ ) in supplement intakes, *viz.*, 11.08, 23.61 and 34.53 g/kg<sup>0.75</sup> in MMNB, CPL (Cassava peels) and CSR (Corn starch residues), respectively.

Moyo *et al.* (2012) reported that, there was significant increase in feed intake ( $P < 0.05$ ) in animals fed with *Moringa oleifera* leaves (MOL) and sunflower cake (SC) as compared to animals fed on grass hay (GH).

Adegun and Aye (2013) observed the dry matter intake was increased with increasing level of replacement of cotton seed cake with *Moringa oleifera* (0 to 100%) in a concentrate mixture fed to the West African Dwarf sheep

Tona *et al.* (2014) studied the growth performance and nutrient digestibility of West African Dwarf goats fed graded levels of MOLM replacing protein supplement in concentrate feed. They found that the DMI was higher in 15% (D<sub>4</sub>) replacement level followed by 10% (D<sub>3</sub>) and 5% (D<sub>2</sub>) replacement levels of MOLM.

Babeker and Bdalbagi (2015) found significant ( $P<0.05$ ) increase in feed intake in group B (20% Moringa) than group A(0% Moringa) and C (50% Moringa) in Sudan Nubian goats.

Kholif *et al.* (2015) reported that lactating Anglo-Nubian goats fed on M15 (15% MLM) and M20 (20% MLM) diets showed higher feed intake ( $P<0.05$ ). They concluded that inclusion rate of 15% MLM (replacing sesame meal) in the diet was the most suitable level for lactating goats.

Sultana *et al.* (2015) found that the dry matter intake (DMI) of the goats in control group was significantly higher than the DMI of Moringa foliage supplemented groups.

Jiwuba *et al.* (2016) in study of feeding different level of Moringa leaves to WAD does found that average dry matter intake was significantly ( $P<0.05$ ) higher with goats fed 15% level.

Kholif *et al.* (2016) observed significantly ( $P<0.05$ ) higher intakes of DM, OM, CP, NSC, NDF, ADF and cellulose in goats fed silage and fresh *Moringa oleifera* biomass as compared to those fed with Sesame meal as sole diet.

Zinder *et al.* (2016) studied the effect of feeding lactating cows with ensiled mixture of *Moringa oleifera* (MO), wheat hay and molasses on digestibility and milk production. The experimental study revealed that voluntary DM intake of cows, fed control total mixed ration (TMR) tended to be 1.22% higher than that of the MO-TMR fed cows.

Ahmad *et al.* (2017) found that the DMI was increased with increased level of DMOL in the ration up to 15% in buffalo calves.

Syed Ali (2017) observed no significant difference in mean daily dry matter intake between ration M0 (Basal diets with GNC) as control and M50 (GNC replaced with 50% Moringa) treatment group in goats.

Damor *et al.* (2017a) conducted an experiment in kids by allotting three experimental treatments *viz.*, T<sub>1</sub> (100% concentrate mixture), T<sub>2</sub> (50% concentrate mixture + 50 % Moringa leaves) and T<sub>3</sub> (100% Moringa leaves). They reported that the

dry matter intake of the kids in all the groups were similar without any significant changes.

Jagritisrivastav (2019) conducted a study to investigate the effect of supplementation of *Moringa oleifera* leaves on nutrient utilization and growth performance in goats and observed a non-significant difference in DMI and digestibility of dry matter and crude protein when experimental kids supplemented with *Moringa oleifera* leaves at the level of 15% of complete feed.

#### **2.2.4 Feed conversion ratio**

Aregheore (2002) investigated the nutritive value and digestibility of *Moringa oleifera*-batiki grass (*Ischaemum aristatum* var. *indicum*) mixtures in goats by feeding *Moringa oleifera* at 0% (M0), 20% (M20), 50% (M50) and 80% (M80) of total daily forage allowance and found no significant difference in feed conversion ratio among the experimental groups.

Mahamoud (2013) conducted an experiment on Rahamni lambs fed with three different diets *viz.*, control group lambs were fed R<sub>1</sub> contained Clover hay (CH) (1% of live body weight plus concentrate feed mixture CFM (3% of live body weight), while the experimental lambs were fed CH plus 25 % *Moringa oleifera* stems from CFM (R<sub>2</sub>) and 25% *Moringa oleifera* stems from CH plus CFM (R<sub>3</sub>). Rations containing *Moringa oleifera* stems (R<sub>2</sub> and R<sub>3</sub>) had achieved higher feed efficiency than control rations but it was not significant.

Tona *et al.* (2014) studied the growth performance and nutrient digestibility of West African Dwarf goats fed graded levels of MOLM and observed feed conversion ratios of 16.78, 20.94, 22.29 and 17.22 for 0%, 5%, 10% and 15% MOLM respectively. The results showed that the West African dwarf goats fed the concentrate diet with 15% level of inclusion of MOLM had a significantly higher feed efficiency than those on the 5% and 10% inclusion levels that was comparable with the control group.

Babeker and Bdalbagi (2015) found significantly ( $P < 0.05$ ) higher feed conversion ratio in group B (20% *Moringa* leaves) as compared to group A (0% *Moringa* leaves) and C (50% *Moringa* leaves) Sudan Nubian goats.

Sultana *et al.* (2015) studied the feeding value of *Moringa oleifera* foliage as replacement to conventional concentrate diet in Bengal goats. The five dietary

treatments consisted of varying proportions of Moringa foliage (MF) and concentrate (C), namely, T<sub>1</sub> (100MF: 0C), T<sub>2</sub> (75MF:25C), T<sub>3</sub> (50MF:50C), T<sub>4</sub> (25MF: 75C) and T<sub>5</sub> (0MF:100C). The study showed that highest feed efficiency was found in goats fed with T<sub>2</sub> diet while the lowest was found in goats fed with T<sub>5</sub> diet but it was not significant.

Fadiyimu *et al.* (2016) studied the feed intake, growth performance and carcass characteristics of West African Dwarf sheep fed *Moringa oleifera*, *Gliricidia sepium* or *Cassava* fodder as supplements to *Panicum maximum*. Sheep were allotted to four dietary treatments: 1: 100% *P. maximum* (control), 2: 75% *P. maximum* + 25% *M. oleifera*, 3: 75% *P. maximum* + 25% *G.sepium*, 4: 75% *P. maximum* + 25% *Cassava* leaves. They reported that the FCR was significantly lower in treatment 2 and 4 compared to treatment 1.

Suliman *et al.* (2016) observed significantly lower feed conversion ratio in growing lambs supplemented with Moringa leaves at the rate of 30g/day (R<sub>2</sub>) and 60g/day (R<sub>3</sub>) compared to control group (0 % Moringa).

Oyedele *et al.* (2016) studied nutrient digestibility and growth performance of West African Dwarf (WAD) goats fed foliage combinations of *Moringa oleifera* and *Gliricidia sepium* with equal proportions of a low-cost concentrate. Study revealed that FCR of goats was significantly higher in control group compared to Moringa supplemented groups.

Bushara *et al.* (2017) reported significantly higher FCR in Sudanese Desert rams fed with MPSL (*Moringa oleifera* pods, stems and leaves) compared to RP (mixture of range plants) and RP + MPSL (mixture of range plants; *Moringa oleifera* pods, stems and leaves), respectively.

Syed Ali (2017) studied the replacement of CSC to the extent of 50% with dried MOLM in the concentrate mixture under intensive system of goat rearing and reported that there was no significant difference in FCR of control group and Moringa fed group of goats.

Haridas (2018) studied the effect of supplementation of MOLM on the performance of the growing sheep in which the cotton seed cake in the concentrate mixture was replaced with 10% and 20% *Moringa oleifera* leaf meal and observed that the FCR value was statistically not significant among the three groups.

Manmohan Kumar (2018) studied the effect of feeding *Moringa oleifera* leaf powder (MOLP) on growth performance of growing female Black Bengal goat and found no significant difference in FCR among all experimental groups T<sub>0</sub> (0% MOLP), T<sub>2</sub> (15% MOLP) T<sub>1</sub> (10% MOLP), T<sub>3</sub> (20% MOLP) under intensive and semi-intensive systems of management.

Padma Meel (2018) in an experiment of feeding drumstick (*Moringa oleifera*) dry leaves on growth performance of Sirohi kids reported significantly lower feed conversion ratio in T<sub>4</sub> (75% level), T<sub>5</sub> (100% level) and T<sub>3</sub> (50%) group kids when compared with other groups T<sub>2</sub> (25% level) and T<sub>1</sub> (0% level).

Jagritisrivastav (2019) conducted a study to investigate the effect of supplementation of *Moringa oleifera* leaves on nutrient utilization and growth performance in goats and observed no significant difference in FCR when experimental kids supplemented with *Moringa oleifera* leaves at the level of 15% of complete feed.

Manikrao (2020) studied the effect of feeding *Moringa oleifera* leaf meal-based diets on productive performance of growing Deccani sheep in intensive and semi-intensive farming system and reported that the highest FCR (lower value) was observed in T<sub>2</sub> (25% ML) and lowest FCR (higher values) was observed in T<sub>1</sub> (0% ML) and there was no significant difference in FCR among the sheep fed on three experimental diets.

### **2.3 HAEMATOLOGICAL PARAMETERS**

Fadiyimu *et al.* (2010) found that packed cell volume (PCV), hemoglobin (Hb), red blood cell count (RBC) and white blood cell count (WBC) for animals on *Moringa* supplementation were within normal physiological range for healthy sheep, in contrast to those without supplementation which were below the range. The blood profile was best for animals on 25% *Moringa* inclusion in West African Dwarf goats.

Adegun *et al.* (2011) studied haematological parameters in west African dwarf sheep and reported that WBC and neutrophils values were  $10.2 \times 10^3$ ,  $8.3 \times 10^3$ ,  $8.8 \times 10^3$  and  $9.2 \times 10^3/\text{mm}^3$  and 27.5%, 22.8%, 23.7% and 22.8% for control, MMNB (*Moringa oleifera* multinutrient blocks), GMNB (*Gliricidia sepium* multinutrient blocks) and LMNB (*Leucaena leucocephala* multinutrient blocks), respectively. The values for other haematological parameters such as PCV, RBC, platelets, Hb, MCH, MCHC and MCV were significantly higher in the 30% *Moringa* supplemental group than remaining

groups. They opined that intake of multinutrient blocks enhanced the performance of sheep without causing any health hazards.

Asaulo *et al.* (2012b) in an experiment of feeding Moringa multi-nutrient blocks (MMNB), cassava peels (CPL) and corn starch residue (CSR) reported that MMNB supplementation were resulted in significant ( $P<0.05$ ) increase in PCV at the end of the study although all values falls within the range considered normal for clinically-healthy WAD goats. Each of the three supplements resulted in significant ( $P<0.05$ ) increase in haemoglobin and RBC, although the magnitude of the increase was most pronounced with MMNB. Animals on CSR maintained relatively comparable level of WBC at both the commencement and at end of the study. However, CPL supplementation result in higher ( $P<0.05$ ) WBC values at the end of the study where as MMNB supplementation resulted in corresponding lower ( $P<0.05$ ) values. Hence, adoption of the MMNB feeding technology by small ruminant keeper could be a panacea to the nutritional and health hardship faced by the animals during the usually long dry season.

Babeker and Bdalbagi (2015) found significant variations in erythrocyte indices among the groups except Mean corpuscular haemoglobin concentration (MCHC) in 20% Moringa group, which recorded significantly ( $P<0.05$ ) high in all indices of erythrocytes when compared with the other two groups. The leukocyte indices have similar observations for all parameters except total white blood cells count (WBC) which increased significantly ( $P<0.05$ ) in 20% Moringa group ( $6.21 \pm 0.14 \times 10^3 / \mu\text{L}$ ) than 50% Moringa group ( $4.77 \pm 0.34 \times 10^3 / \mu\text{L}$ ) and 0% Moringa group ( $4.21 \pm 0.09 \times 10^3 / \mu\text{L}$ ). Therefore, the study revealed that the *Moringa oleifera* leaf meal could be used to improve livestock system of small ruminants without any adverse effect on the productive performance and blood indices at the 20% diet inclusion level.

Jiwuba *et al.* (2016) studied the effect of feeding different levels of Moringa leaf meal in goats and observed that PCV, RBC, MCV and WBC differed significantly ( $P<0.05$ ) among the treatment groups and recommended that supplementation of *Moringa oleifera* at 15% was optimum in West African Dwarf goats.

Kholif *et al.* (2016) in an experiment with feeding processed *Moringa oleifera* meal in lactating Anglo-Nubian goats reported that the serum cholesterol was decreased while glucose levels were increased compared with control group.

Syed Ali (2017) opined that supplementation of 50% Moringa meal had non-significant effect on erythrocyte and leucocyte indices in growing goats. He also stated that no beneficial and adverse affect on haematological parameters in growing goats with replacement of cotton seed cake with Moringa leaf meal up to 50 percent level in concentrate mixture.

Yusuf *et al.* (2018) opined that supplementation of *Moringa oleifera* leaf meal (MLOM) up to 100g/Kg DM didn't have any effect on RBC, Hb and PCV in goats. They also reported that all blood parameters were within the normal reference ranges for clinically healthy goats.

Manmohan Kumar *et al.* (2018) studied the effect of feeding *Moringa oleifera* leaf powder on growth performance of growing female Black Bengal goat and found that there was no significant difference in hematological profile and all parameters were within normal physiological range under intensive and semi-intensive systems of management.

Padma Meel (2018) in an experiment of feeding drumstick (*Moringa oleifera*) leaves on growth performance of Sirohi kids reported that WBC values, haemoglobin and PCV values were non-significant among groups but improved by increasing levels of *Moringa oleifera* leaves in diet.

Manikrao (2020) reported that there was no significant difference in hematological profile except for mean corpuscular volume which showed significant increase in Moringa supplemented groups at the end of the experiment. He also reported that all parameters were within normal physiological range under intensive and semi-intensive systems of management.

## **2.4 BIOCHEMICAL PARAMETERS**

Mahamoud (2013) conducted an experiment on Rahamni lambs fed with three different diets *viz.* control group lambs were fed R<sub>1</sub> contained Clover hay (CH) (1% of live body weight plus concentrate feed mixture CFM (3% of live body weight), while the experimental lambs were fed CH plus 25 % *Moringa oleifera* stems from CFM (R<sub>2</sub>) and 25% *Moringa oleifera* stems from CH plus CFM (R<sub>3</sub>). They reported that the total proteins in all experimental rations are nearly similar within the normal range and there were insignificant differences in blood globulin, urea and creatinine among

experimental rations. ALT (SGPT) was significantly lower with R<sub>2</sub> whereas R<sub>3</sub> recorded the lowest value of AST (SGOT) compared to R<sub>1</sub> and R<sub>2</sub> with highly significant differences.

Babeker and Bdalbagi (2015) glucose decreased a significantly ( $P < 0.05$ ) in 20% Moringa group when compared to other two groups, while total protein ( $7.71 \pm 0.03$  g/dl) and albumin ( $2.86 \pm 0.10$  g/dl) were highly significant ( $P < 0.05$ ) in 20% Moringa group when compared with other two groups. Therefore, the study revealed that the *Moringa oleifera* leaf meal could be used to improve livestock system of small ruminants without any adverse effect on the productive performance and blood indices at the 20% diet inclusion level.

Kholif *et al.* (2015) observed no significant effect of Moringa supplementation on total protein, albumin, glucose but Serum glutamic oxaloacetic transaminase (SGOT) and Serum glutamic pyruvic transaminase (SGPT) concentrations were increased with 20 % Moringa diet when compared to control diet in Anglo-Nubian lactating goats.

Azzaz *et al.* (2016) reported that there was no significant difference in blood albumin, Alanine aminotransferase (ALT), Aspartate amino transferase (AST) but had significantly higher plasma protein and glucose values than control groups in Rahmani lactating ewes fed with *Moringa oleifera*.

Ahmad *et al.* (2017) found that there was insignificant difference in blood total protein, globulin, creatinine and Alanine aminotransferase (ALT) among experimental rations.

Syed Ali (2017) reported that supplementation of 50% Moringa meal had no effect on serum total protein, albumin, globulin, glucose, SGOT and SGPT. He opined that no beneficial and adverse affect on biochemical parameters in growing goats with replacement of cotton seed cake with 50 percent Moringa leaf meal in concentrate mixture.

Damor *et al.* (2017b) reported serum total protein, albumin and SGOT levels were found to be significantly ( $P < 0.05$ ) higher in *Moringa* fed group as compared to control group. They concluded that *Moringa* leaves are rich in protein and minerals and replacing the concentrate mixture with Moringa leaves in diet of growing Mehsana kids increased concentrations of blood total protein, albumin, SGOT and calcium while decreased level of blood cholesterol.

Yusuf *et al.* (2018) opined that supplementation of MOLM up to 100 g/Kg DM didn't have any effect on total protein in goats. However, blood urea concentration was significantly increased in bucks that were offered MOLM-based diets. They also reported that Alanine transaminase (ALT) and urea were within the normal reference ranges for clinically healthy goats.

Manmohan Kumar (2018) studied the effect of feeding *Moringa oleifera* leaf powder on growth performance of growing female Black Bengal goat and found that there was no significant difference in biochemical profile and all parameters were within normal physiological range under intensive and semi-intensive systems of management.

Padma Meel (2018) in an experiment of feeding drumstick (*Moringa oleifera*) leaves on growth performance of Sirohi kids reported that the serum total protein and serum albumin levels were significantly increase ( $P < 0.05$ ) in 100% MLOM group whereas serum globulin level improved while serum glucose level decreased by increasing levels of *Moringa oleifera* leaves in diet.

Jagritisrivastav (2019) conducted a study to investigate the effect of supplementation of *Moringa oleifera* leaves on nutrient utilization and growth performance in goats and observed a non-significant difference in the values of total serum protein and glucose when experimental goat kids fed Moringa leaves at 15% of complete feed.

Manikrao (2020) reported that there was significant increase in serum protein value in Moringa supplemented Deccani lambs compared to control group at the end of the experimental period. He also reported non significant changes in serum albumin, glucose, SGOT and SGPT values before and after the experiment under both intensive and semi intensive systems of management.

## **2.5 OVICIDAL ACTIVITY**

Max *et al.* (2007) found that feeding of plant leaves containing condensed tannins for 30 days in experimentally infected goats has reduced faecal egg count.

Giri *et al.* (2010) in their study evaluated the anthelmintic activity of various seed extracts of *Moringa oleifera* against adult *Pheretima posthuma* and reported that methanolic seed extract showed significant anthelmintic activity over the petroleum

ether, chloroform and alcoholic extracts in terms of paralysis and death time of earthworms.

Babar *et al.* (2011) studied the anthelmintic activity of leaves of *Moringa oleifera* against gastro intestinal worm in animals exposed to different doses.

Srinivasa *et al.* (2011) investigated the preliminary phytochemical properties and anthelmintic activity of *Moringa oleifera* and revealed the phytoconstituents such as carbohydrate, tannins, flavonoids, triterpenoids and alkaloids in chloroform and methanol extracts. They also found that the chloroform extract of *Moringa oleifera* was more potent than methanol extract on earth worms.

Asaolu *et al.* (2012a) reported the anthelmintic activity of *Moringa* and Bamboo leaves in West african dwarf goats which were suffered from gastrointestinal nematode infection where the treatment was effective after twelfth week.

Nilani *et al.* (2012) studied the anthelmintic effect of *Moringa oleifera* seed oil in *Pheretima posthuma* and reported that *Moringa* oil at a concentration of 25 mg/ml and 50 mg/ml showed death time of 30 minutes and 24 minutes respectively in dose dependent manner.

Moyo *et al.* (2013) noticed anthelmintic activity in goats that were supplemented *Moringa oleifera*, sunflower cake along with hay against *Haemonchus contortus* , *Trichostrongylus colubriformis* and *Oesophagostomum columbianum* with significant reduction in faecal egg count.

Tayo *et al.* (2014) evaluated the in vitro anthelmintic activity of aqueous extract of *Moringa oleifera* against the four different free living stages of *Haemonchus contortus* and found that ethanolic leaf extract was most efficient on eggs by inhibiting  $60.3\% \pm 8.2\%$  and  $92.8\pm 6.2\%$  eggs embryonation at 3.75 and 5 mg/ml respectively with a significant difference ( $P < 0.05$ ), which contributed to obtaining the lowest LC50 value of 0.985 mg/ml. This extract also inhibited  $99\% \pm 2\%$  egg hatching,  $98.8\% \pm 2.5\%$  and  $100\% \pm 0\%$  mortality of L1 and L2 larvae at 5 mg/ml concentration. Infused aqueous extract was more efficient on eggs than on larvae with an IC50 value less than 2 mg/ml and an LC50 value more than 3.5 mg/ml. Macerated aqueous extract showed good activity against the four developmental stages with LC50 values ranging from 2.08 mg/ml for L2 larvae to 2.92 mg/ml for L1 larvae and 2.37 to 2.52 mg/ml for

embryonated and fresh eggs respectively. The current study showed that all three extracts of *M. oleifera* tested possessed potential ovicidal and larvicidal activities against *H. contortus*

Shrihari *et al.* (2016) conducted a study to assess in-vitro and in-vivo anthelmintic activity of aqueous leaf, bark and combined leaf and bark extract of *Moringa oleifera*. In-vivo study revealed that there was significant reduction in EPG (egg per gram) count in goats fed with aqueous leaf and bark extracts of *Moringa oleifera* (at the rate of 300 mg/kg) when compared with other groups. The in-vitro study resulted that aqueous leaf, bark and combined leaf and bark extract was effective in causing paralysis and death of earth worm (*Pheretima posthuma*) indicating anthelmintic activity.

Cabardo and Portugaliza (2017) estimated the anthelmintic potential of *Moringa oleifera* seed ethanolic and aqueous extracts against *Haemonchus contortus* eggs and infective stage larvae (L3). They found that ovicidal activity of ethanolic extract and larvicidal activity of aqueous extract are higher at 15.6 mg/ml and 7.8mg/ml respectively.

Anitha and Sahaya Kalaivani (2018) assessed the anthelmintic activity of aqueous leaf extract and condensed tannins of *Moringa oleifera* by observing paralysis and mortality time of *Tubifex tubifex*. They reported that there was paralysis time of one minute and death time of 2 minutes and 9 minutes in worms exposed to aqueous leaf extract (200 mg/ml) and condensed tannins (1mg/ml) respectively.

Hegazi *et al.* (2018) studied comparative ovicidal activity of *Moringa oleifera* leaf extracts on *Fasciola gigantica* eggs and revealed that *Moringa oleifera* alcoholic and aqueous extracts showed a concentration dependent ovicidal effect on *Fasciola gigantica* non-embryonated and developed eggs. Non-embryonated eggs were more susceptible to aqueous extract (2.6 mg/ml concentration) and developed eggs were more susceptible to ethanolic extract than non-embryonated eggs even at the lowest LC50 (12.38 mg/ml).

## **2.6 COST ECONOMICS**

Adegun and Aye (2013) noticed that *Moringa oleifera* leaf meal has been implicated to replace completely cotton seed cake in concentrate supplements fed to

rams with improvement in growth performance. Reduction in the cost of production due to replacement of cotton seed cake with *Moringa oleifera* leaf meal will increase profit and better the living standards of farmers.

Allam *et al.* (2015) reported that economical evaluation was in favour of the 15% and 30% level incorporation of *Moringa* for soyabean regarding relative percentage of net revenue and relative percentage of cost of feed consumed. They further stated that improvement in animal performance and increase in the net revenue was observed along with a partial solution for the high price of soyabean meal due to inclusion of *Moringa oleifera*.

Ahmad *et al.* (2017) reported that the feed cost per kilogram gain of suckling buffalo calves was significantly ( $P < 0.05$ ) decreased with increasing level of dry *Moringa oleifera* leaves (DMOL) up to 15% supplementation.

Syed Ali (2017) observed that the average cost of feeding of *Moringa oleifera* leaf meal was incorporated at 0% and 50% in the concentrate mixture was found to be Rs. 875.56 and 790.21, respectively and the feeding cost per kg weight gain was Rs. 195.87 and 173.67 in *Moringa oleifera* leaf meal incorporated at 0% and 50% in the concentrate mixture, respectively. The feed cost per kg weight gain was lower in MLM (50% level) compared to MLM (0% level). Lower feeding cost in treatment group also fetched higher profit of Rs. 25.05 per kg body weight gain.

Haridas (2018) found that feed cost/kg weight gain was Rs. 131.96, 131.77 and 126.93 when lambs were fed with M0 (Sole cotton seed cake) M10 (Cotton seed cake replaced with 10% *Moringa*) and M20 (Cotton seed cake replaced with 20% *Moringa*) rations, respectively.

Yusuf *et al.* (2018) estimated the cost economics of *Moringa* based supplements and revealed that the supplemented diets had significantly ( $P < 0.05$ ) lower feed cost per kg of weight gain and higher returns per kg of gain than the control diet. It was suggested that diluting the commercial supplement with MOLM up to 100 g/kg DM does not affect the nutritional condition, growth performance and health condition of the goats but reduced the feed cost per kg weight gain.

## **CHAPTER III**

### **MATERIALS AND METHODS**

The present research work was designed to study the “Effect of *Moringa oleifera* leaf meal incorporation on growth performance in Nellore lambs”.

#### **3.1 LOCATION OF THE STUDY AREA**

The present work on the “Effect of *Moringa oleifera* leaf meal incorporation on growth performance in Nellore lambs” was conducted at the sheep unit, Livestock Farm Complex (LFC), NTR College of Veterinary Science, Gannavaram, Krishna District in Andhra Pradesh.

#### **3.2 EXPERIMENTAL DESIGN**

##### **3.2.1 Selection of experimental animals**

Eighteen post-weaned Nellore lambs in same age and uniform conformation were selected for the present study. They were allocated into three groups (T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>) with 6 lambs per treatment using completely randomized block design. The average body weight and male to female ratio was similar in all groups. All lambs were free from physiological, anatomical and infectious diseases.

##### **3.2.2 Ingredient composition of experimental diets**

All the ingredients used in the preparation of concentrate mixture were procured from the local market. The ingredient composition of experimental diets fed to lambs in different groups *i.e.*, T<sub>0</sub> (Control), T<sub>1</sub> and T<sub>2</sub> consisting of maize, deoiled rice bran, gingly cake, soyabean meal, Moringa leaf meal, mineral mixture and salt is given in Table 1.

##### **3.2.3 Collection of the Moringa leaves**

Moringa leaves were harvested from Moringa plots of the Livestock farm complex, NTR College of Veterinary Science, Gannavaram. The harvested leaves were allowed to dry under shade for three days. The dried leaves were finely grinded to powder form and stored for incorporation in the concentrate mixture.



**Fig 1. Cultivation of *Moringa oleifera* at Livestock farm complex**



**Fig 2. *Moringa oleifera* leaf meal**

**Table 1. Percent ingredient composition of experimental diets**

<b>Ingredient</b>	<b>Control (T<sub>0</sub>)</b>	<b>Treatment 1 (T<sub>1</sub>)</b>	<b>Treatment 2 (T<sub>2</sub>)</b>
Maize	25.5	25.5	25.0
DORB (deoiled rice bran)	33.0	33.0	33.0
Gingly cake	33.5	22.5	12.2
Soya bean meal	5.0	10.2	15.2
Mineral mixture	2.0	2.0	2.0
Salt	1.0	1.0	1.0
MOLM	0.0	5.8	11.6

### **3.3. MANAGEMENT OF EXPERIMENTAL ANIMALS**

Eighteen post-weaned Nellore growing lambs of same age and uniform conformation were selected for the experiment. All experimental lambs were housed separately from other animals in well ventilated shed and provided individual feeder and waterer. The lambs were managed under standard feeding and management practices. The animals were identified by ear tagging for proper recording of experimental data. The lambs were allowed 10 days of acclimatization prior to experimental feeding. The lambs did not show any symptoms of clinical ailment or external injury and were looked quite healthy during whole experimental period.

### **3.4 FEEDING MANAGEMENT OF EXPERIMENTAL LAMBS**

The lambs under control (T<sub>0</sub>) group were fed formulated concentrate mixture (at the rate of 1% of body weight) without Moringa supplementation while, lambs under treatment group T<sub>1</sub> were fed concentrate mixture where in 15% of traditional protein supplement was incorporated with MOLM and T<sub>2</sub> were fed concentrate mixture where in 30% of traditional protein supplement was incorporated with MOLM. The diets were compounded in mash form and fortified with vitamins and mineral supplements.



**Fig 3. Nellore lambs selected for experiment**



**Fig 4. Feeding of experimental diets to the lambs**

**Table.2 Distribution of lambs for growth studies**

<b>Group</b>	<b>S. No</b>	<b>Tag No</b>	<b>Sex</b>	<b>Initial body weight of lambs (kg)</b>
T <sub>0</sub> (Control)	1	R21	M	11.3
	2	E22	F	12.0
	3	R19	M	12.2
	4	E19	F	10.8
	5	R24	M	12.3
	6	E23	F	11.5
Mean±SE				11.68±0.22
T <sub>1</sub> (Treatment )	1	R26	M	11.5
	2	R13	M	12.0
	3	E17	F	12.3
	4	R25	M	11.25
	5	R22	M	12.00
	6	E16	F	11.30
Mean±SE				11.72±0.16
T <sub>2</sub> (Treatment )	1	R20	M	11.30
	2	R11	M	12.00
	3	R15	M	12.50
	4	R23	M	11.56
	5	E18	F	11.60
	6	E20	F	11.35
Mean±SE				11.71±0.17

The feed samples were collected and preserved for the chemical analysis. Allowance of concentrate mixture to be offered was adjusted at fortnightly interval according to change in body weight and growth rate of lambs. The experimental diets were offered daily in morning hours. One third DM requirement was fulfilled by concentrate mixture while remaining two third DM requirements was fulfilled by green roughages (Super napier). During the experimental period all the lambs had free access to fresh, clean and wholesome drinking water. Leftover of feed and fodder, if any, was recorded next day morning at 24 hourly intervals to calculate total dry matter consumption per day.

### **3.5. SAMPLE ANALYSIS**

Dried MOLM as well as the 3 experimental feed samples T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were analysed in duplicate for proximate constituents *viz.*, dry matter, crude protein, ether extract, total ash, crude fibre and nitrogen free extracts as per the methods described by AOAC (2007) and laboratory analysis for chemical composition was carried out at the Department of Animal Nutrition, NTR College of Veterinary Science, Gannavaram.

### **3.6 RECORDING THE BODY WEIGHTS**

Live weight of each animal was recorded prior to the start of the experiment. Subsequently, the body weights of all the 18 lambs were recorded at fortnightly intervals before offering the morning feed using the electronic weighing balance to study the growth rates. The average daily gain (ADG) and the feed conversion ratio (FCR) were calculated for overall trial period.

### **3.7 AVERAGE DAILY GAIN (ADG) AND FEED CONVERSION RATIO (FCR)**

The average daily gain and feed efficiency were calculated by using the following formulas.

$$\text{ADG} = \frac{\text{Final Weight (g)} - \text{Initial Weight (g)}}{\text{Number of days of growth trial}}$$

$$\text{FCR} = \frac{\text{Dry Matter intake (g)}}{\text{Gain in body weight (g)}}$$



**Fig 5. Weighing of experimental lambs using electronic weighing balance**



**Fig 6. Blood collection from jugular vein in experimental animal**

### **3.8 HAEMATOLOGICAL STUDIES**

Various haematological parameters *viz.*, White Blood Cell (WBC) count, Red Blood Cell (RBC) count, haemoglobin, Packed Cell Volume (PCV), Mean corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean corpuscular haemoglobin concentration (MCHC) were determined as per standard methods at Department of Veterinary Pharmacology and Toxicology, NTR College of Veterinary Science, Gannavaram.

#### **3.8.1 Collection of blood samples**

Blood samples were collected for haematological studies before offering feed and water from the experimental lambs at beginning (0 day) and at the end of experiment (3 months). The blood was drawn from jugular vein with all aseptic precautions, using a 20 gauge needle, to avoid disruption of erythrocytes, damage of leucocytes and to allow flow of blood smoothly with a minimum vacuum.

#### **3.8.2 Haematological profile**

For haematological examination, disodium salt of ethylene- diamine- tetra- acetic acid (EDTA) was used as an anticoagulant at the rate of 1 mg per ml of blood. The whole blood was collected in sterilized test tubes containing adequate amount of anticoagulant, Haematological studies *viz.*, WBC count, RBC count, Haemoglobin, PCV, MCV and MCHC were performed soon after collection of blood with the help of auto haematology analyzer (Mindray, Model No. BC- 2800 Vet).

### **3.9 BIOCHEMICAL STUDIES**

Whole blood (10 ml) was collected into test tube without adding the anticoagulant and kept in slanting position for separation of serum. These tubes were incubated for one hour at room temperature. Serum was separated by centrifugation and then transferred into a sterilized plastic vial, labelled and stored at -20<sup>0</sup>C for further analysis. Clean glassware and analytical grade chemicals were used in the study. Blood serum metabolites like glucose, albumin, cholesterol, Blood Urea Nitrogen (BUN) and total protein were analysed to find out the changes if any deviations from normal range due to feeding of Moringa leaf-based diets in different treatment groups. The Serum Glutamic Oxaloacetic Transaminase (SGOT) and Serum Glutamic Pyruvic Transaminase (SGPT) levels were also analysed in the serum as part of liver function



**Fig 7. Analysis of haematological parameters using Haemoanalyser**



**Fig 8. Analysis of serum biochemical parameters using Spectrophotometer**

tests to find out the changes if any due to feeding of Moringa leaf-based diets. The blood biochemical parameters were analyzed using commercial kits (Transasia biomedical test kits) and spectrophotometric method (MULTISKAN GO Thermo spectrophotometer).

### **3.9.1 Total protein**

The collected samples of serum from each group were examined for total protein by following Biuret method using commercial test kit Transasia biomedical at 550 nm wavelength using spectrophotometer.

$$\text{Total protein (g/dl)} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times \text{concentration of standard (g/dl)}$$

### **3.9.2 Serum albumin**

The collected samples of serum from each group were examined for albumin protein by using commercial test kit, Transasia biomedical at 630 nm wavelength using spectrophotometer.

$$\text{Albumin (g/dl)} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times \text{concentration of standard (g/dl)}$$

### **3.9.3 Serum glucose**

The collected samples of serum from each group were examined for glucose by commercial test kit, Transasia biomedical at 505 nm using spectrophotometer as per Trinder's method.

$$\text{Glucose (mg/dl)} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times \text{concentration of standard (mg/dl)}$$

### **3.9.3 Serum cholesterol**

The collected samples of serum from each group were examined for cholesterol by using commercial test kit, Transasia biomedical at 505nm wavelength using spectrophotometer.

$$\text{Cholesterol (mg/dl)} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times \text{concentration of standard (mg/dl)}$$

### 3.9.5 Serum Glutamic Oxaloacetic Transaminase

The collected samples of serum from each group were examined for SGOT by commercial test kit Transasia biomedical by Modified IFCC method at 340 nm wavelength using spectrophotometer.

$$\text{SGOT (IU/L)} = \text{Mean absorbance change/minute} \times \text{factor 3376}$$

### 3.9.6 Serum Glutamic Pyruvic Transaminase

The collected samples of serum from each group were examined for SGPT by commercial test kit Transasia biomedical by Modified IFCC method at 340 nm wavelength using spectrophotometer.

$$\text{SGPT (IU/L)} = \text{Mean absorbance change/minute} \times \text{factor 3376}$$

### 3.9.7 Blood urea nitrogen

The collected samples of serum from each group were examined for BUN by commercial test kit Transasia biomedical by Talke and Schubert method at 340 nm wavelength using spectrophotometer.

$$\text{BUN (mg/dl)} = \frac{\text{Absorbance change of test}}{\text{Absorbance change of standard}} \times \text{concentration of standard}$$

## 3.10 ANTHELMINTIC ACTIVITY

The parasitic load i.e. Egg per gram (EPG) was determined regularly at every month during entire study period. About 5 g of fresh faecal sample from each lamb of all the three groups was drawn directly from the rectum with aseptic condition (using hand gloves). The samples were kept in vials and each vial was marked with the unique identification number and kept in refrigerator at 4°C until further examination. The faecal egg count was performed by a Stoll's technique.



**Fig 9. Collection of faecal sample from experimental lamb**



**Fig 10. Microscopic examination of faecal sample**

### **3.10.1 Procedure of Stoll's technique**

1. One gram of faeces was weighed in a measuring cylinder.
2. Flootation fluid was added up to 15ml mark in the cylinder.
3. The material was transferred into a bowl and mixed well with glass rod to make uniform suspension and was sieved.
4. It was agitated and 0.15ml of the suspension was taken with a measuring pipette and placed on a slide in the form of 2 or 3 drops.
5. It was covered with cover slip and the total number of eggs was counted.
6. EPG was calculated by multiplying the number of eggs obtained by 100 for each species separately.

### **3.11 COMPARATIVE COST ECONOMICS**

Comparative economics was calculated at the end of 13 weeks of experimental period. The cost of concentrate feed was calculated based on actual cost of feed and fodder at livestock farm complex, Gannavaram, Krishna district, Andhra Pradesh. The total feed cost per lamb during the experimental period was calculated and from that feed cost per kg live body weight gain was worked out by dividing the overall cost of diet consumed with total weight gain.

### **3.12 STATISTICAL ANALYSIS**

The data obtained with regard to parameters under study was tabulated and this data was statistically analyzed as per Snedecor and Cochran (1994) for interpretation of the results. Analysis of variance was used to test the significance of variance and the treatment means were tested for significance by Tukey's HSD (Honestly Significant Difference) test.

## CHAPTER IV

### RESULTS

The results of incorporation of *Moringa Oleifera* leaf meal on the performance of growing Nellore lambs were tabulated, statistically analysed and presented in this chapter.

#### 4.1. CHEMICAL COMPOSITION OF MORINGA LEAF MEAL

The values of chemical composition of dried *Moringa oleifera* leaf meal (MOLM) used in experimental rations of Nellore lambs were presented in Table 3. The dry matter (DM) content of *Moringa oleifera* leaf meal was 91.21 per cent. Moringa leaf meal contained 88 per cent organic matter (OM), 20.94 per cent crude protein (CP), 16.85 per cent crude fibre (CF), 5.70 per cent ether extract (EE), 42.5 per cent nitrogen free extract (NFE) and 12 per cent total ash (TA).

**Table 3. Chemical composition of *Moringa oleifera* leaf meal**

S. No	Nutrient	Percentage (on Dry matter basis)
1.	Dry matter	91.21
2.	Organic matter	88.00
3.	Crude protein	20.94
4.	Ether extract	5.70
5.	Crude fibre	16.85
6.	Nitrogen free extract	42.50
7.	Total ash	12.00
8.	Acid insoluble ash	1.85

#### 4.2 CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS

The chemical composition of the experimental rations control (T<sub>0</sub>), treatment 1 (T<sub>1</sub>) and treatment 2 (T<sub>2</sub>) were presented in Table 4. Perusal of the Table 4 revealed that the CP content of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> rations was 21.34, 21.26 and 21.38 per cent, respectively. The EE content was 0.99, 1.24, and 1.18 per cent while CF content was

14.01, 14.08 and 14.28 per cent for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets, respectively. The NFE content was 46.68, 49.01 and 48.92 per cent for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets, respectively. The TA content for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets were 14.10, 11.71 and 11.61 per cent, respectively.

**Table 4. Chemical composition of experimental diets (on % DM basis)**

S.NO	Nutrient	Control (T <sub>0</sub> )	Treatment 1 (T <sub>1</sub> )	Treatment 2 (T <sub>2</sub> )
1.	Dry matter	88.18	88.70	87.75
2.	Organic matter	85.9	88.29	88.39
3.	Crude protein	21.34	21.26	21.38
4.	Ether extract	0.99	1.24	1.18
5.	Crude fibre	14.01	14.08	14.28
6.	Nitrogen free extract	46.68	49.01	48.92
7.	Total ash	14.10	11.71	11.85
8.	Acid insoluble ash	4.96	2.95	2.35

### 4.3. DRY MATTER INTAKE

#### 4.3.1 Average daily dry matter intake from experimental diets

Average daily dry matter consumption values of the lambs fed with the experimental diets T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were presented in Table 5 and graphically represented in Fig. 11. Perusal of the Table 5 revealed that the mean daily dry matter intake of lambs from experimental diets in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups were 104.18 ± 0.56, 109.45 ± 0.4 and 109.64 ± 0.41 g, respectively during the first week with significantly (P< 0.05) higher dry matter intake in the lambs of T<sub>1</sub> and T<sub>2</sub> groups when compared to the lambs of T<sub>0</sub> group.

At second week, the mean daily dry matter intake was found to be significantly (P<0.05) higher in the lambs of the group T<sub>1</sub> than the other two groups. The mean daily dry matter intake values were 116.21 ± 0.30, 123.61 ± 0.43 and 121.98 ± 0.45 g among lambs fed with rations T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively.

At third week, the mean daily dry matter intake was found to be significantly ( $P<0.05$ ) lower in the lambs of  $T_0$  group when compared with  $T_1$  and  $T_2$  groups. The mean daily dry matter intake values recorded were  $128.94 \pm 2.44$ ,  $135.92 \pm 0.41$  and  $134.03 \pm 0.68$  g for the experimental groups  $T_0$ ,  $T_1$  and  $T_2$ , respectively. Similarly the mean daily dry matter intake values were  $142.11 \pm 1.60$ ,  $145.90 \pm 0.38$  and  $147.09 \pm 1.09$  g during fourth week for the groups  $T_0$ ,  $T_1$  and  $T_2$ , respectively with significantly ( $P<0.05$ ) higher intake in  $T_2$  group when compared to that of  $T_0$  group while the dry matter intake of lambs in  $T_1$  group did not differ significantly ( $P<0.05$ ) from  $T_2$  group.

During fifth week, the mean daily dry matter intake values of  $154.70 \pm 0.36$ ,  $156.46 \pm 0.35$  and  $159.82 \pm 1.29$  g for the three groups  $T_0$ ,  $T_1$  and  $T_2$ , respectively. Significantly higher dry matter intake was observed in  $T_2$  group when compared to  $T_0$  and  $T_1$  groups and there was significant difference among the three groups.

During sixth week and seventh week the mean daily dry matter intake was found to be significantly ( $P<0.05$ ) higher in  $T_2$  group than that of lambs in  $T_0$  and  $T_1$  groups. The mean daily dry matter intake values recorded were  $167.65 \pm 0.28$  and  $179.85 \pm 0.11$ ;  $168.25 \pm 0.27$  and  $181.28 \pm 0.25$ ;  $172.68 \pm 0.98$  and  $186.36 \pm 0.99$  g for the experimental groups  $T_0$ ,  $T_1$  and  $T_2$  during sixth and seventh weeks, respectively.

The mean daily dry matter intake values were  $191.64 \pm 0.24$ ,  $194.66 \pm 0.10$  and  $199.86 \pm 0.68$  g for  $T_0$ ,  $T_1$  and  $T_2$ , respectively during eighth week with significantly ( $P<0.05$ ) lower feed intake in the lambs of  $T_0$  group when compared to that of other two groups. Similarly, at ninth week also significantly ( $P<0.05$ ) lower dry matter intake was observed in the lambs of  $T_0$  group with a mean dry matter intake of  $203.25 \pm 0.24$  g from that of  $T_1$  group ( $207.47 \pm 0.51$  g) and  $T_2$  group ( $213.71 \pm 0.93$  g).

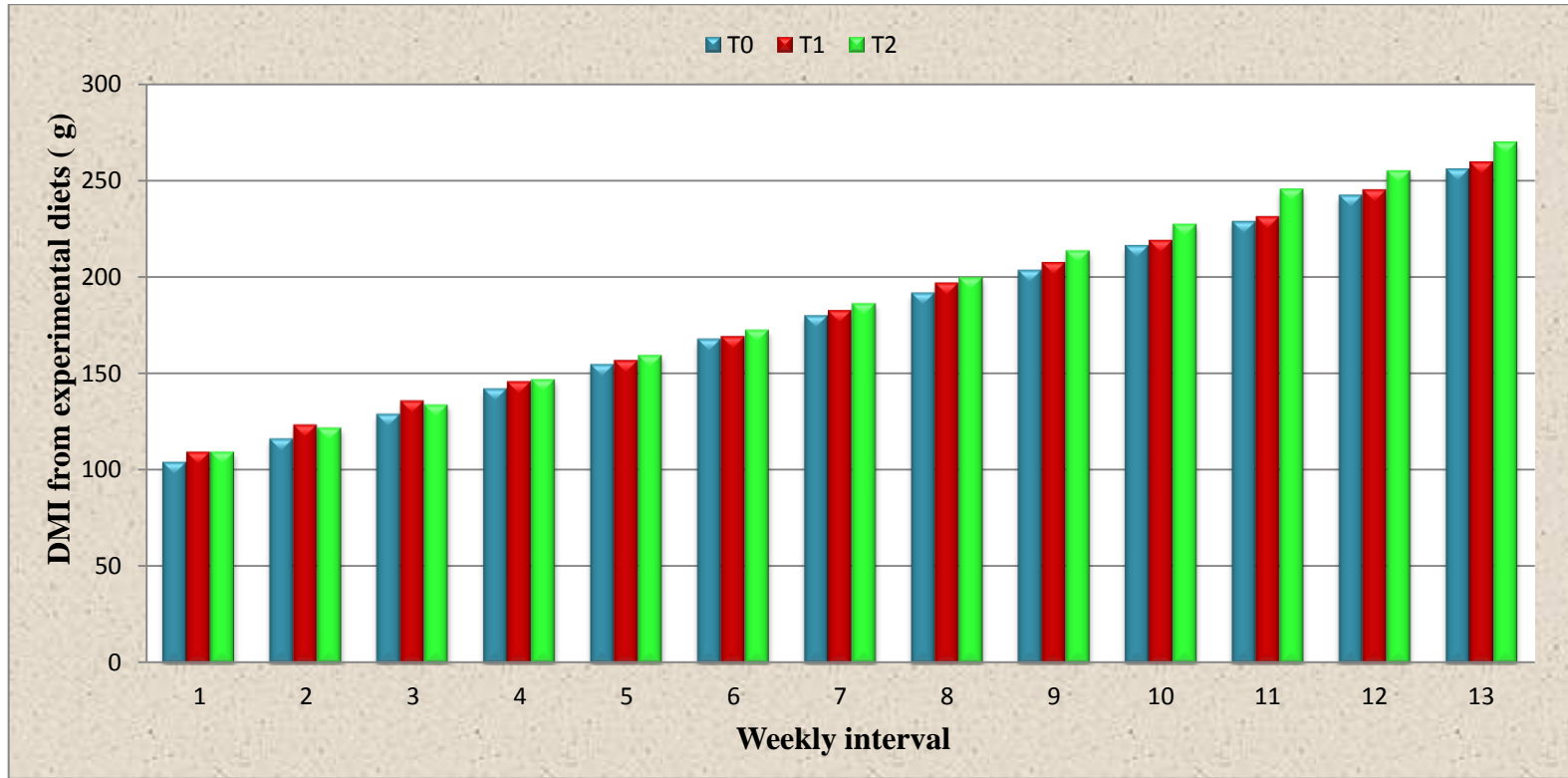
The mean dry matter intake values were  $216.08 \pm 0.53$ ,  $218.92 \pm 0.42$  and  $227.49 \pm 0.88$  g for lambs of  $T_0$ ,  $T_1$  and  $T_2$  groups, respectively during tenth week with significantly ( $P<0.05$ ) higher feed intake in the lambs of  $T_2$  group when compared to that of other two groups.

In the following eleven, twelve and thirteen weeks, significantly ( $P<0.05$ ) lower dry matter intake was observed in the lambs of  $T_0$  group when compared to that of  $T_1$  and  $T_2$  groups. The mean daily feed intake values were found to be  $228.52 \pm 0.44$ ,  $231.06 \pm 0.36$  and  $245.69 \pm 1.11$  g for the lambs of three groups  $T_0$ ,  $T_1$  and  $T_2$ ,

**Table 5. Average values of daily dry matter intake (in grams) from experimental Diets at weekly intervals**

<b>Week</b>	<b>Control (T<sub>0</sub>)</b>	<b>Treatment 1 (T<sub>1</sub>)</b>	<b>Treatment 2 (T<sub>2</sub>)</b>
1	104.18±0.56 <sup>b</sup>	109.45± 0.40 <sup>a</sup>	109.64± 0.41 <sup>a</sup>
2	116.21± 0.30 <sup>c</sup>	123.61± 0.43 <sup>a</sup>	121.98±0.45 <sup>b</sup>
3	128.94±2.44 <sup>b</sup>	135.92±0.41 <sup>a</sup>	134.03±0.68 <sup>a</sup>
4	142.11±1.60 <sup>b</sup>	145.90±0.38 <sup>a</sup>	147.09±1.09 <sup>a</sup>
5	154.70±0.36 <sup>c</sup>	156.46±0.35 <sup>b</sup>	159.82±1.29 <sup>a</sup>
6	167.65±0.28 <sup>b</sup>	168.25±0.27 <sup>b</sup>	172.68±0.98 <sup>a</sup>
7	179.85± 0.11 <sup>b</sup>	181.28±0.25 <sup>b</sup>	186.36±0.99 <sup>a</sup>
8	191.64± 0.24 <sup>c</sup>	194.66 ±0.10 <sup>b</sup>	199.86± 0.68 <sup>a</sup>
9	203.25±0.24 <sup>c</sup>	207.47±0.51 <sup>b</sup>	213.71±0.93 <sup>a</sup>
10	216.08±0.53 <sup>b</sup>	218.92±0.42 <sup>b</sup>	227.49± 0.88 <sup>a</sup>
11	228.52±0.44 <sup>b</sup>	231.06±0.36 <sup>b</sup>	245.69±1.11 <sup>a</sup>
12	242.05±0.37 <sup>b</sup>	245.07± 0.40 <sup>b</sup>	255.16±1.28 <sup>a</sup>
13	255.60±0.41 <sup>b</sup>	259.37± 0.47 <sup>b</sup>	269.98±1.07 <sup>a</sup>
<b>Overall mean±SE</b>	179.29±0.68 <sup>c</sup>	183.25±0.45 <sup>b</sup>	187.95±0.29 <sup>a</sup>

Mean values in the rows bearing different superscripts differ significantly (P<0.05)



**Fig 11. Bar diagram representing the average daily dry matter intake from experimental diets at weekly intervals**

respectively during eleventh week whereas the same were  $242.05 \pm 0.37$ ,  $245.07 \pm 0.40$  and  $255.16 \pm 1.28$  g for the groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively during the twelfth week. During the last week the mean daily dry matter intake values for the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were found to be  $255.60 \pm 0.41$ ,  $259.37 \pm 0.47$  and  $269.98 \pm 1.07$ g, respectively with significantly higher feed intake in the lambs of T<sub>2</sub> group when compared to that of the other two groups.

The overall mean values of daily DMI from concentrate feed for entire experimental period were  $179.29 \pm 0.68$ ,  $183.25 \pm 0.45$  and  $187.95 \pm 0.29$  g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was significantly ( $P < 0.05$ ) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups with significant ( $P < 0.05$ ) difference among the three groups.

#### **4.3.2 Average daily dry matter intake from green fodder**

Average daily dry matter consumption values of the lambs from green fodder (Super napier) among T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups were presented in Table 6 and graphically represented in Fig. 12.

Perusal of the Table 6 revealed that the mean daily dry matter intake of lambs from green fodder in the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were  $173.87 \pm 0.56$ ,  $178.77 \pm 0.42$  and  $179.96 \pm 0.41$  g respectively during the first week with significantly ( $P < 0.05$ ) higher fodder intake in T<sub>1</sub> and T<sub>2</sub> groups when compared to that of T<sub>0</sub> group with no significant difference between the groups.

At second week, the mean daily dry matter intake was found to be significantly ( $P < 0.05$ ) higher in the lambs of the group T<sub>1</sub> and T<sub>2</sub> than T<sub>0</sub> group. The mean daily fodder intake values were  $178.66 \pm 0.36$ ,  $188.06 \pm 0.29$  and  $189.24 \pm 0.46$  g among lambs in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively.

At third week, the mean daily dry matter intake was found to be significantly ( $P < 0.05$ ) lower among the lambs of T<sub>0</sub> group when compared with T<sub>1</sub> and T<sub>2</sub> groups. The mean daily fodder intake values recorded were  $187.54 \pm 0.58$ ,  $197.52 \pm 0.41$  and  $200.37 \pm 0.67$  g for the experimental groups T<sub>0</sub> and T<sub>1</sub> and T<sub>2</sub>, respectively. There was a significant difference among all the groups ( $P < 0.05$ ). Similarly the mean dry matter intake values were  $198.61 \pm 0.28$ ,  $207.64 \pm 0.41$  and  $210.58 \pm 1.09$  g during fourth week

for the groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively with significantly (P<0.05) higher intake in T<sub>2</sub> group when compared to that of T<sub>0</sub> and T<sub>1</sub> groups.

During fifth week, the mean daily dry matter intake values of 207.35± 0.36, 218.31± 0.39 and 221.13±1.29 g for the three groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively with significantly higher dry matter intake was observed in T<sub>2</sub> group when compared to T<sub>0</sub> and T<sub>1</sub> groups with no significant difference between T<sub>2</sub> and T<sub>1</sub> groups.

During sixth week and seventh week the daily dry matter intake was found to be significantly (P<0.05) higher among the lambs in T<sub>2</sub> group when compared with T<sub>0</sub> and T<sub>1</sub> with significant difference among all the three groups. The mean daily fodder intake values recorded were 217.53± 0.29, 228.84±0.31 and 232.48±0.98; 227.76± 0.22, 239.00± 0.39 and 243.29±0.99 g for the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> during sixth week and seventh week, respectively.

The mean dry matter intake values were 238.49 ± 0.24, 249.04 ± 0.38 and 251.65± 0.68 g among the lambs in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively during eighth week with significantly (P<0.05) lower fodder intake in the lambs of T<sub>0</sub> group when compared to that of other two groups. There was a significant difference among all the groups (P<0.05).

During ninth week, the mean daily dry matter intake values of 248.31±0.24, 258.8± 0.88 and 260.98 ± 0.93 g for the three groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively with significantly higher dry matter intake was observed in T<sub>2</sub> group when compared to T<sub>0</sub> and T<sub>1</sub> groups. There was no significant difference between T<sub>2</sub> and T<sub>1</sub> groups

The mean dry matter intake values from green fodder were 257.90 ±0.53, 269.52± 0.73 and 273.14 ±0.88 g among the lambs in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively during tenth week with significantly (P<0.05) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups with significant (P<0.05) difference among the three groups.

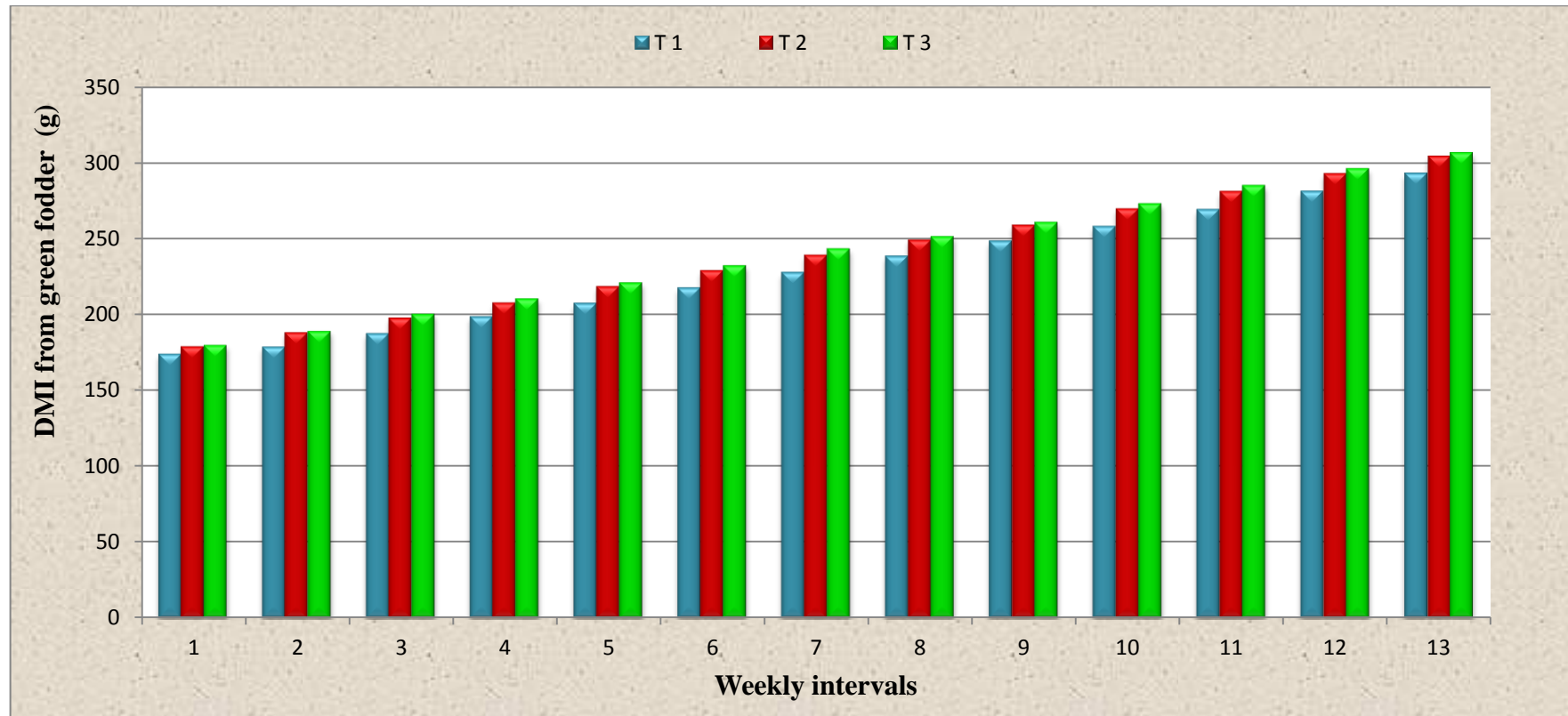
In the following eleven, twelve and thirteen weeks, significantly (P<0.05) lower dry matter intake was observed in the lambs in T<sub>0</sub> group when compared to that of lambs in T<sub>1</sub> and T<sub>2</sub> groups with significant difference among the three groups. The mean daily fodder intake values were found to be 269.02 ± 0.44, 280.87± 0.45 and 285.22±

**Table 6. Average values of daily dry matter intake (in grams) from green fodder at weekly intervals**

Week	Control (T <sub>0</sub> )	Treatment 1 (T <sub>1</sub> )	Treatment 2 (T <sub>2</sub> )
1	173.87± 0.56 <sup>b</sup>	178.77±0.42 <sup>a</sup>	179.96± 0.41 <sup>a</sup>
2	178.66±0.36 <sup>b</sup>	188.06±0.29 <sup>a</sup>	189.24±0.46 <sup>a</sup>
3	187.54±0.58 <sup>c</sup>	197.52± 0.41 <sup>b</sup>	200.37±0.67 <sup>a</sup>
4	198.61 ±0.28 <sup>b</sup>	207.64±0.41 <sup>b</sup>	210.58 ±1.09 <sup>a</sup>
5	207.35± 0.36 <sup>a</sup>	218.31± 0.39 <sup>b</sup>	221.13±1.29 <sup>b</sup>
6	217.53± 0.29 <sup>c</sup>	228.84±0.31 <sup>b</sup>	232.48±0.98 <sup>a</sup>
7	227.76± 0.22 <sup>c</sup>	239.00± 0.39 <sup>b</sup>	243.29±0.99 <sup>a</sup>
8	238.49± 0.24 <sup>c</sup>	249.04 ±0.38 <sup>b</sup>	251.65± 0.68 <sup>a</sup>
9	248.31±0.24 <sup>b</sup>	258.80± 0.88 <sup>a</sup>	260.98 ± 0.93 <sup>a</sup>
10	257.90 ±0.53 <sup>c</sup>	269.52± 0.73 <sup>b</sup>	273.14 ±0.88 <sup>a</sup>
11	269.02 ± 0.44 <sup>c</sup>	280.87± 0.45 <sup>b</sup>	285.22± 1.11 <sup>a</sup>
12	281.04 ± 0.38 <sup>c</sup>	292.58± 0.25 <sup>b</sup>	296.28 ±1.28 <sup>a</sup>
13	293.00± 0.41 <sup>c</sup>	304.02± 0.27 <sup>b</sup>	306.94± 1.07 <sup>a</sup>
Overall mean ± SE	229.16±10.89 <sup>c</sup>	239.46±11.25 <sup>b</sup>	242.42±11.41 <sup>a</sup>

Mean values in the rows bearing different superscripts differ significantly (P<0.05)





**Fig 12.** Bar diagram representing the average daily dry matter intake from green fodder at weekly intervals

1.11g among the lambs of three groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively during eleventh week whereas the same were 281.04 ± 0.38, 292.58± 0.25 and 296.28 ±1.28 g for the groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively during the twelfth week. During the last week the mean daily dry matter intake values from green fodder for the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were found to be 293.00± 0.41, 304.02± 0.27 and 306.94± 1.07 g, respectively.

The overall mean values of daily DMI from green fodder for entire experimental period were 229.16±10.89, 239.46±11.25 and 242.42±11.41g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was significantly (P<0.05) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups with significant (P<0.05) difference among the three groups.

#### **4.3.3 Average total daily dry matter intake**

Average total daily dry matter consumption values of the lambs from experimental diets and green fodder for the three experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were presented in Table 7 and graphically represented in Fig. 13.

Perusal of the Table 7 revealed that the mean values of total daily dry matter intake of lambs from both green fodder and concentrates in the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were 278.05±0.84, 288.22±0.46 and 289.69±0.41 g respectively during the first week with significantly (P < 0.05) higher feed intake in T<sub>1</sub> and T<sub>2</sub> groups when compared to that of T<sub>0</sub> group. Similar trend was observed during second and third weeks.

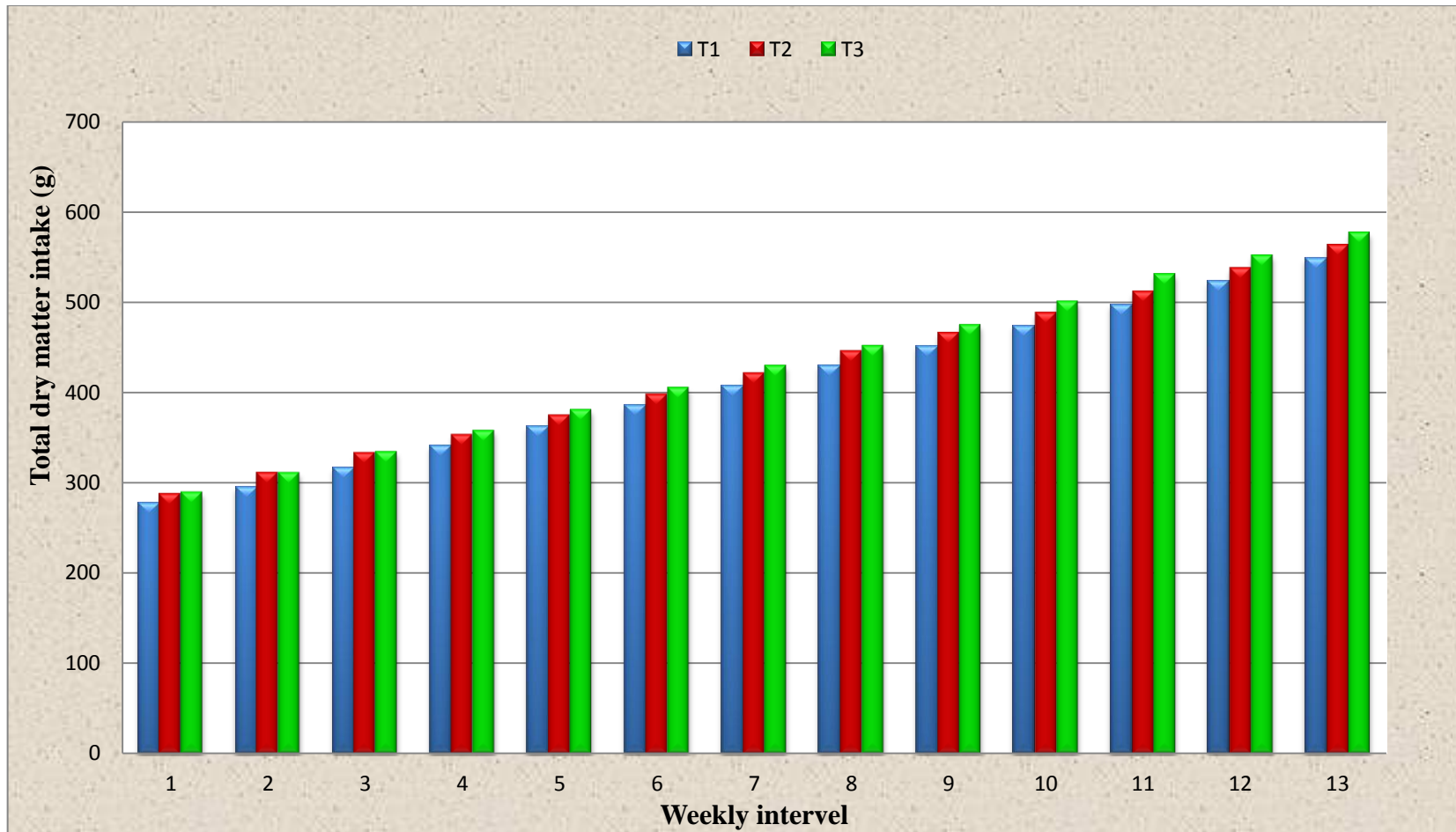
The mean total daily dry matter intake values from fourth week to thirteenth week were significantly higher for T<sub>2</sub> group animals and lower value for T<sub>0</sub> group with significant difference among all the three groups. The values were 340.73±0.34, 353.54±0.76 and 357.67±1.26 g during fourth week and 548.61±1.58, 563.39±0.50 and 576.92±1.34 g during thirteenth week for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups respectively.

The overall mean values of total daily DMI for entire experimental period were 408.45±24.41, 422.71±24.51 and 430.37±25.96 g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was significantly (P<0.05) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups with significant (P<0.05) difference among the three groups.

**Table 7: Average values of total daily dry matter intake (in grams) at weekly intervals**

<b>Week</b>	<b>Control (T<sub>0</sub>)</b>	<b>Treatment 1 (T<sub>1</sub>)</b>	<b>Treatment 2 (T<sub>2</sub>)</b>
1	278.05±0.84 <sup>b</sup>	288.22±0.46 <sup>a</sup>	289.69±0.41 <sup>a</sup>
2	294.88±0.42 <sup>b</sup>	311.67±0.23 <sup>a</sup>	311.21±0.38 <sup>a</sup>
3	316.48±0.51 <sup>b</sup>	333.44±1.04 <sup>a</sup>	334.40±0.48 <sup>a</sup>
4	340.73±0.34 <sup>c</sup>	353.54±0.76 <sup>b</sup>	357.67±1.26 <sup>a</sup>
5	362.04±0.61 <sup>c</sup>	375.03±1.29 <sup>b</sup>	380.82±1.34 <sup>a</sup>
6	385.18±0.46 <sup>c</sup>	398.07±1.01 <sup>b</sup>	405.16±1.19 <sup>a</sup>
7	407.61±0.52 <sup>c</sup>	421.62±1.35 <sup>b</sup>	429.80±1.21 <sup>a</sup>
8	430.13±0.76 <sup>c</sup>	445.91±1.15 <sup>b</sup>	451.52±0.71 <sup>a</sup>
9	451.56±1.71 <sup>c</sup>	466.26±0.47 <sup>b</sup>	474.68±1.14 <sup>a</sup>
10	473.98±1.74 <sup>c</sup>	488.45±1.06 <sup>b</sup>	500.63±1.14 <sup>a</sup>
11	497.55±1.59 <sup>c</sup>	511.93±1.32 <sup>b</sup>	530.91±1.41 <sup>a</sup>
12	523.09±1.71 <sup>c</sup>	537.65±0.92 <sup>b</sup>	551.45±1.63 <sup>a</sup>
13	548.61±1.58 <sup>c</sup>	563.39±0.50 <sup>b</sup>	576.92±1.34 <sup>a</sup>
Overall mean±SE	408.45±24.41 <sup>c</sup>	422.71±24.51 <sup>b</sup>	430.37±25.96 <sup>a</sup>

Mean values in the rows bearing different superscripts differ significantly (P<0.05)



**Fig 13. Bar diagram showing the average total daily dry matter intake at weekly intervals**

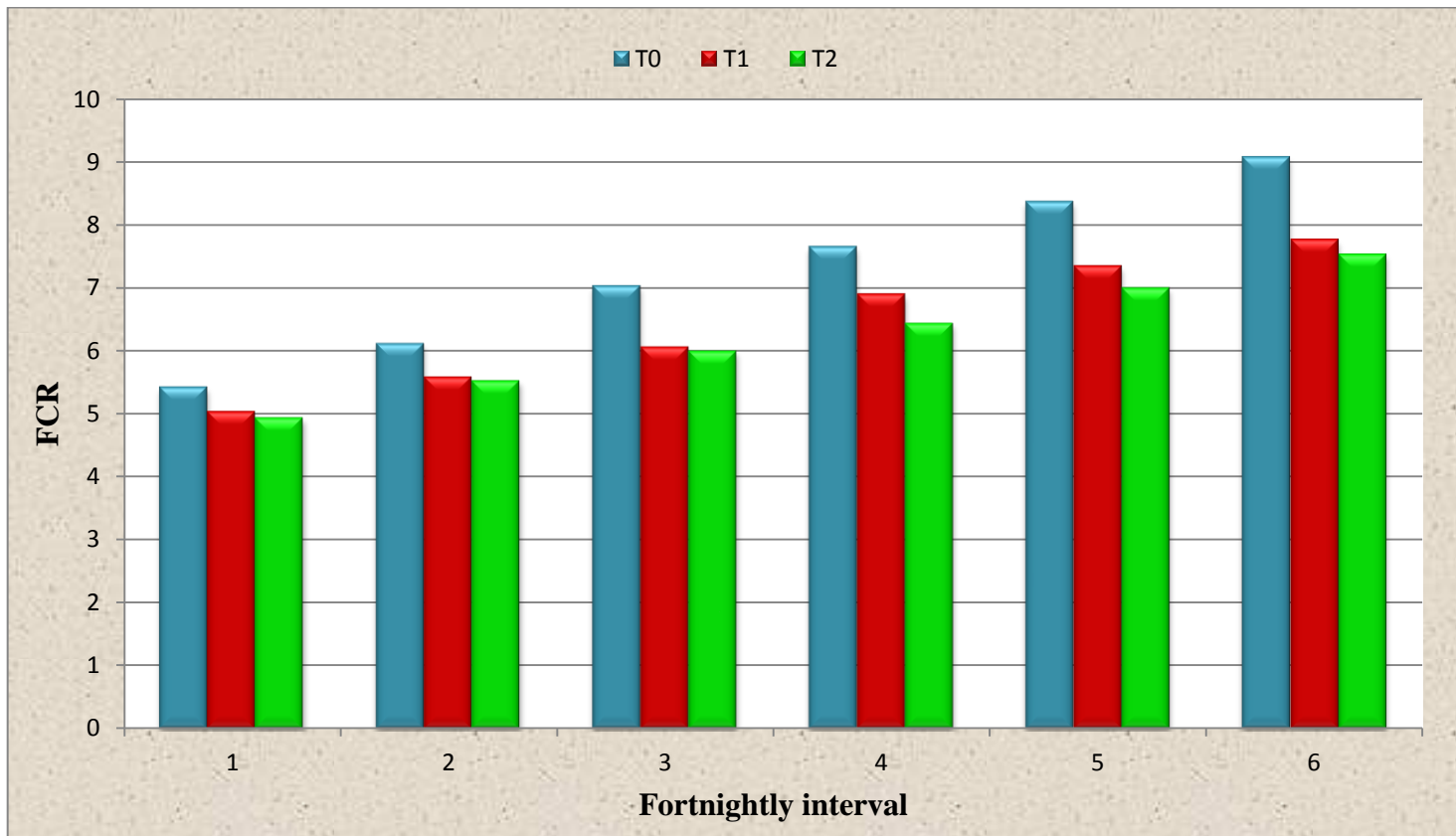
#### 4.4 Feed Conversion Ratio (FCR)

The average FCR's of lambs fed with different experimental rations T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were presented in the Table 8 and graphically represented in Fig. 14. Perusal of table 8 revealed, that the FCR varied from 5.42 ± 0.18 to 9.07 ± 0.17, 5.03 ± 0.11 to 7.75 ± 0.55 and 4.93 ± 0.05 to 7.53 ± 0.09 in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively from the beginning to the end of the experimental period. The overall mean FCR values were 7.27 ± 0.11, 6.44 ± 0.09 and 6.24 ± 0.03 for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively. Further, the FCR values of lambs in T<sub>1</sub> and T<sub>2</sub> groups were significantly (P<0.05) lower when compared to the T<sub>0</sub> group lambs. However, the FCR's of lambs in T<sub>1</sub> and T<sub>2</sub> group did not differ significantly (P<0.05) in any week.

**Table 8. Average fortnightly FCR (FCR = g DM intake / g body weight gain) of lambs fed with different experimental rations**

Fortnight	Control (T <sub>0</sub> )	Treatment 1 (T <sub>1</sub> )	Treatment 2 (T <sub>2</sub> )
1	5.42±0.18 <sup>a</sup>	5.03±0.11 <sup>b</sup>	4.93±0.05 <sup>b</sup>
2	6.11±0.12 <sup>a</sup>	5.57±0.08 <sup>b</sup>	5.52±0.16 <sup>b</sup>
3	7.02±0.31 <sup>a</sup>	6.05±0.15 <sup>b</sup>	5.99±0.06 <sup>b</sup>
4	7.65±0.18 <sup>a</sup>	6.89±0.10 <sup>b</sup>	6.44±0.16 <sup>b</sup>
5	8.36±0.12 <sup>a</sup>	7.34±0.18 <sup>b</sup>	6.99±0.09 <sup>b</sup>
6	9.07±0.17 <sup>a</sup>	7.75±0.55 <sup>b</sup>	7.53±0.09 <sup>b</sup>
Overall Mean± SE	7.27±0.11 <sup>a</sup>	6.44±0.09 <sup>b</sup>	6.24±0.03 <sup>b</sup>

Mean values in the rows bearing different superscripts differ significantly (P<0.05)



**Fig 14. Bar diagram showing the Feed conversion ratio in different fortnightly intervals**



## **4.5 GROWTH PERFORMANCE OF NELLORE LAMBS SUPPLEMENTED WITH MORINGA BASED DIETS**

The growth performance of Nellore lambs fed with the three different rations T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> was presented under following sub-sections:

### **4.5.1 Average fortnightly body weights**

The mean body weights in Nellore lambs were measured on fortnightly basis and the observations were presented in Table 9 and graphically represented in Fig.15.

The mean body weight observed at the end of the first fortnight for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups were 12.48±0.23, 12.62±0.19 and 12.63±0.18 kg, respectively. A comparatively higher gain was observed in T<sub>2</sub> group but no significant difference (P<0.05) was observed among the three groups.

The mean body weights recorded during second fortnight were 13.03±0.23, 13.56±0.18 and 13.59±0.18 kg for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The mean body weight of T<sub>2</sub> group was numerically higher than other two groups. However the differences in average body weight were found to be statistically non-significant during the second fortnight.

During the third fortnight the mean body weights were recorded as 14.13±0.22, 14.55±0.16 and 14.59±0.19 kg for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The mean body weight of T<sub>2</sub> group was numerically higher than other two groups. However, the differences in average body weight were found to be statistically non-significant during the third fortnight.

Similarly at fourth fortnight, the mean body weights recorded for the three groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were 14.97 ± 0.23, 15.51 ± 0.15 and 15.64 ± 0.19 kg, respectively which do not differed significantly (P<0.05) from each other with highest mean body weight in lambs of T<sub>2</sub> group while the lowest was recorded in lambs of T<sub>0</sub> group.

During fifth fortnight, significant difference (P<0.05) was observed in the mean body weight between T<sub>0</sub> and T<sub>2</sub> groups with the means of 15.82±0.23 and 16.73±0.20 kg for T<sub>0</sub> and T<sub>2</sub> groups, respectively while the mean body weight of lambs in T<sub>1</sub> (16.52±0.16 kg) group stands midway with no significant difference (P<0.05) from the other two groups.



Finally, at the end of the experimental period of 90 days, it was found that the mean body weights were  $16.71\pm 0.22$ ,  $17.58\pm 0.17$  and  $17.84\pm 0.20$  kg for the three dietary groups of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively. T<sub>1</sub> and T<sub>2</sub> groups did not differ significantly ( $P<0.05$ ) from each other. However, the mean body weight of T<sub>0</sub> group was found to be  $16.71\pm 0.22$  kg which was lower and differ significantly ( $P<0.05$ ) from the other two groups. The overall mean values of fortnightly body weights for entire experimental period were  $14.16\pm 0.23$ ,  $14.58\pm 0.17$  and  $14.68\pm 0.19$  kg for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was no significant ( $P<0.05$ ) difference among the three experimental groups.

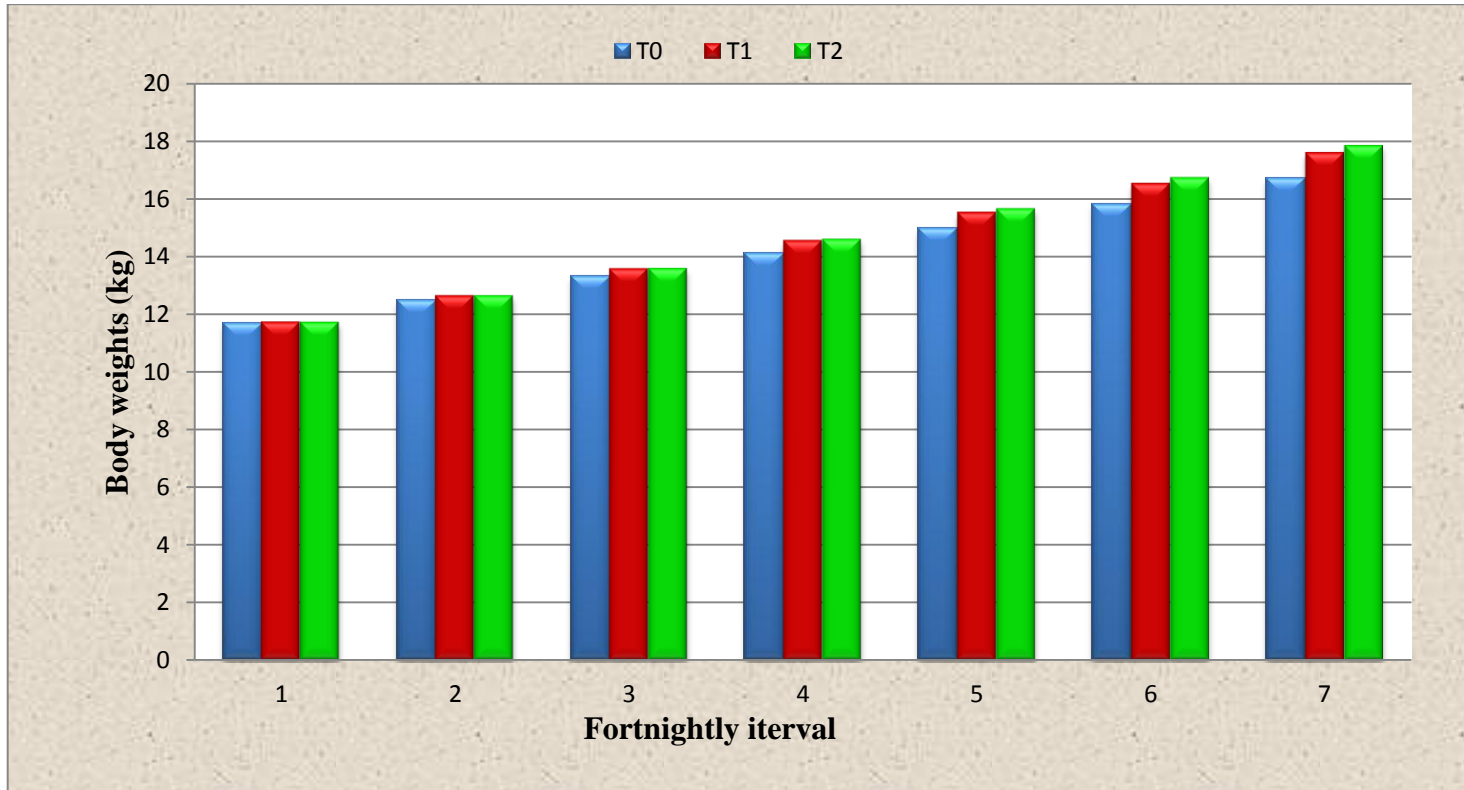
#### 4.5.2 Total body weight gain

The total body weight gains observed at the end of the experiment were  $5.02\pm 0.07$ ,  $5.86\pm 0.08$  and  $6.13\pm 0.03$ kg for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. Statistical analysis of the total weight gain revealed a significant difference ( $P <0.05$ ) among the three experimental diets. Significantly ( $P<0.05$ ) highest weight gain was observed in T<sub>2</sub> group than T<sub>0</sub> and T<sub>1</sub> groups. (Table 9).

**Table 9. Mean values of fortnightly body weights of Nellore lambs fed with different experimental diets**

Fortnight	Control group (T <sub>0</sub> )	Treatment 1 (T <sub>1</sub> )	Treatment 2 (T <sub>2</sub> )
0	$11.68\pm 0.24$	$11.72\pm 0.17$	$11.71\pm 0.19$
1	$12.48\pm 0.23$	$12.62\pm 0.19$	$12.63\pm 0.18$
2	$13.03\pm 0.23$	$13.56\pm 0.18$	$13.59\pm 0.18$
3	$14.13\pm 0.22$	$14.55\pm 0.16$	$14.59\pm 0.19$
4	$14.97\pm 0.23$	$15.51\pm 0.15$	$15.64\pm 0.19$
5	$15.82\pm 0.23^b$	$16.52\pm 0.16^{ab}$	$16.73\pm 0.20^a$
6	$16.71\pm 0.22^a$	$17.58\pm 0.17^b$	$17.84\pm 0.20^b$
Total weight gain	$5.02\pm 0.07^c$	$5.86\pm 0.08^b$	$6.13\pm 0.03^a$
Overall Mean $\pm$ SE	$14.16\pm 0.23$	$14.58\pm 0.17$	$14.68\pm 0.19$

Mean values in the rows bearing different superscripts differ significantly ( $P<0.05$ )



**Fig 15. Bar diagram showing the Average body weight of lambs in different fortnightly intervals**

### 4.5.3 Average daily body weight gains (ADG)

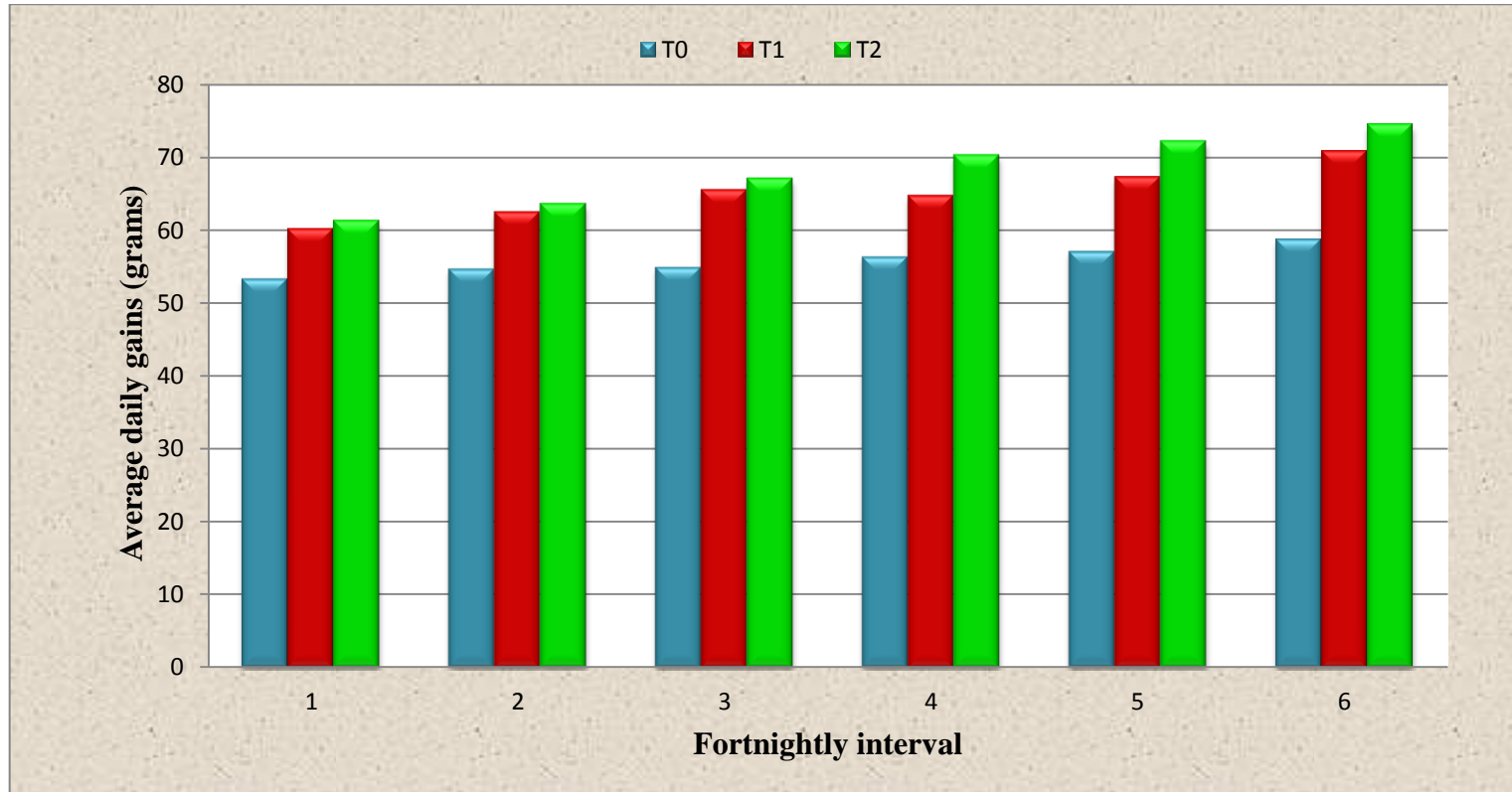
The ADG in Nellore lambs were measured on fortnightly basis and the observations on ADG were presented in Table 10 and graphically represented in Fig.16. The mean ADG observed at the end of the first fortnight for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups were 53.33±1.65, 60.11±3.43 and 61.12±0.73 g, respectively. A comparatively higher gain was observed in T<sub>2</sub> group but no significant difference (P<0.05) was observed between T<sub>1</sub> and T<sub>2</sub> groups while the weight gain of lambs in T<sub>0</sub> was significantly lower from the other two groups.

The ADG recorded during second fortnight were 54.66 ± 1.15, 62.44±0.98 and 63.55±0.78 g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The mean daily body weight gains of T<sub>1</sub> and T<sub>2</sub> did not differ significantly (P<0.05) from each other while the weight gain in lambs was found to be significantly (P<0.05) lower in T<sub>0</sub> group from the other two groups.

**Table 10. Average daily gain of body weight (g/day) of lambs at different fortnightly intervals**

<b>Fortnight</b>	<b>Control group (T<sub>0</sub>)</b>	<b>Treatment 1 (T<sub>1</sub>)</b>	<b>Treatment 2 (T<sub>2</sub>)</b>
1	53.33±1.65 <sup>b</sup>	60.11±3.43 <sup>a</sup>	61.12±0.73 <sup>a</sup>
2	54.66 ± 1.15 <sup>b</sup>	62.44±0.98 <sup>a</sup>	63.55±0.78 <sup>a</sup>
3	54.89±2.58 <sup>b</sup>	65.44±1.67 <sup>a</sup>	67.00±0.85 <sup>a</sup>
4	56.33±1.20 <sup>c</sup>	64.66±0.91 <sup>b</sup>	70.22±0.68 <sup>a</sup>
5	57.11±0.74 <sup>c</sup>	67.22±1.57 <sup>b</sup>	72.11±0.96 <sup>a</sup>
6	58.77±1.17 <sup>b</sup>	70.77± 2.00 <sup>a</sup>	74.44± 0.96 <sup>a</sup>
Overall mean± SE	55.85±0.81 <sup>b</sup>	65.11±0.92 <sup>a</sup>	68.09±0.37 <sup>a</sup>

Mean values in the rows bearing different superscripts differ significantly (P<0.05)



**Fig 16. Bar diagram showing the Average daily body weight gains of lambs during different fortnightly intervals**

Similarly at third fortnight, the ADG of the three groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were 54.89±2.58, 65.44±1.67 and 67.00±0.85 g, respectively with no significant difference (P<0.05) in the mean body weight gains of T<sub>1</sub> and T<sub>2</sub> groups. While the weight gain was found to be significantly (P<0.05) lower in T<sub>0</sub> group compared with the other two groups.

The ADG recorded during the fourth fortnight were 56.33±1.20, 64.66±0.91 and 70.22±0.68 g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively and all the values differed significantly (P<0.05) from each other.

During fifth fortnight, the ADG of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups recorded were 57.11±0.74, 67.22±1.57 and 72.11±0.96 g, respectively. The mean values of all the three groups differed significantly (P<0.05) from each other.

The ADG recorded at last fortnight were 58.77±1.17, 70.77±2.00 and 74.44±0.96 g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was no significant difference (P<0.05) among the two treatment groups T<sub>1</sub> and T<sub>2</sub> while significantly (P<0.05) lower daily weight gain was observed for T<sub>0</sub> group.

The overall mean values of ADG at different fortnights for entire experimental period were 55.85±0.81, 65.11±0.92 and 68.09±0.37 g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was significantly (P<0.05) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups.

## **4.6 HAEMATOLOGICAL PARAMETERS**

Various haematological parameters viz., White Blood Cell (WBC) count, Red Blood Cell (RBC) count, haemoglobin, Packed Cell Volume (PCV), Mean corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean corpuscular haemoglobin concentration (MCHC) values of growing Nellore lambs fed with experimental diets are presented in Table 11 and depicted in the Fig.17.

### **4.6.1 White blood cell count**

The mean WBC levels ( $\times 10^3/\text{mm}^3$ ) before start of the experiment were 16.18±0.55, 15.82±1.06 and 14.05±0.67 in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The WBC ( $\times 10^3/\text{mm}^3$ ) levels after the experiment were 11.72 ± 1.44, 11.55 ± 1.47 and 12.23 ± 1.79 for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. Statistical analysis of the data

revealed that there was no significant difference ( $P < 0.05$ ) in the WBC levels among experimental groups at the end of the experiment.

#### **4.6.2 Red blood cells count**

The mean RBC ( $\times 10^6$ / micro litre) values at the start of experiment were  $11.42 \pm 0.42$ ,  $11.55 \pm 0.51$  and  $11.54 \pm 0.48 \times 10^6$ / micro litre and at the end were  $12.26 \pm 0.26$ ,  $12.79 \pm 0.35$  and  $12.82 \pm 0.32 \times 10^6$ / micro litre in  $T_0$ ,  $T_1$  and  $T_2$  groups, respectively. The results showed no significant difference among the control group and Moringa supplemented groups. The RBC values were numerically higher in  $T_1$  and  $T_2$  groups, whose values were comparable to  $T_0$  group.

#### **4.6.3 Haemoglobin**

The mean estimated haemoglobin values were  $10.65 \pm 0.56$ ,  $9.56 \pm 0.54$  and  $9.0 \pm 0.59$  g/dl before starting the experiment and at the end of the experiment were  $11.20 \pm 0.37$ ,  $10.47 \pm 0.39$  and  $10.01 \pm 0.51$  g/dl in  $T_0$ ,  $T_1$  and  $T_2$  groups, respectively. No significant difference was observed in haemoglobin values among the experimental groups at the end of the trial. Relatively higher haemoglobin (Hb) values were observed in control group lambs ( $T_0$ ) when compare to lambs fed with diet containing Moringa leaf meal ( $T_1$  and  $T_2$ ).

#### **4.6.4 Haematocrit**

The estimated mean haematocrit values in lambs before the start of the experiment were  $31.21 \pm 1.77$ ,  $28.47 \pm 1.62$  and  $26.15 \pm 2.02$  % and at the end of the experiment were  $31.08 \pm 0.42$ ,  $27.98 \pm 1.09$  and  $25.93 \pm 1.35$  % in  $T_0$ ,  $T_1$  and  $T_2$  groups, respectively. The haematocrit values were significantly ( $P < 0.05$ ) higher in  $T_0$  dietary group, whose values were comparable to  $T_1$  group. The lowest haematocrit values were noticed in  $T_2$  dietary group and the values were also comparable with  $T_1$  group.

#### **4.6.5 Mean corpuscular volume**

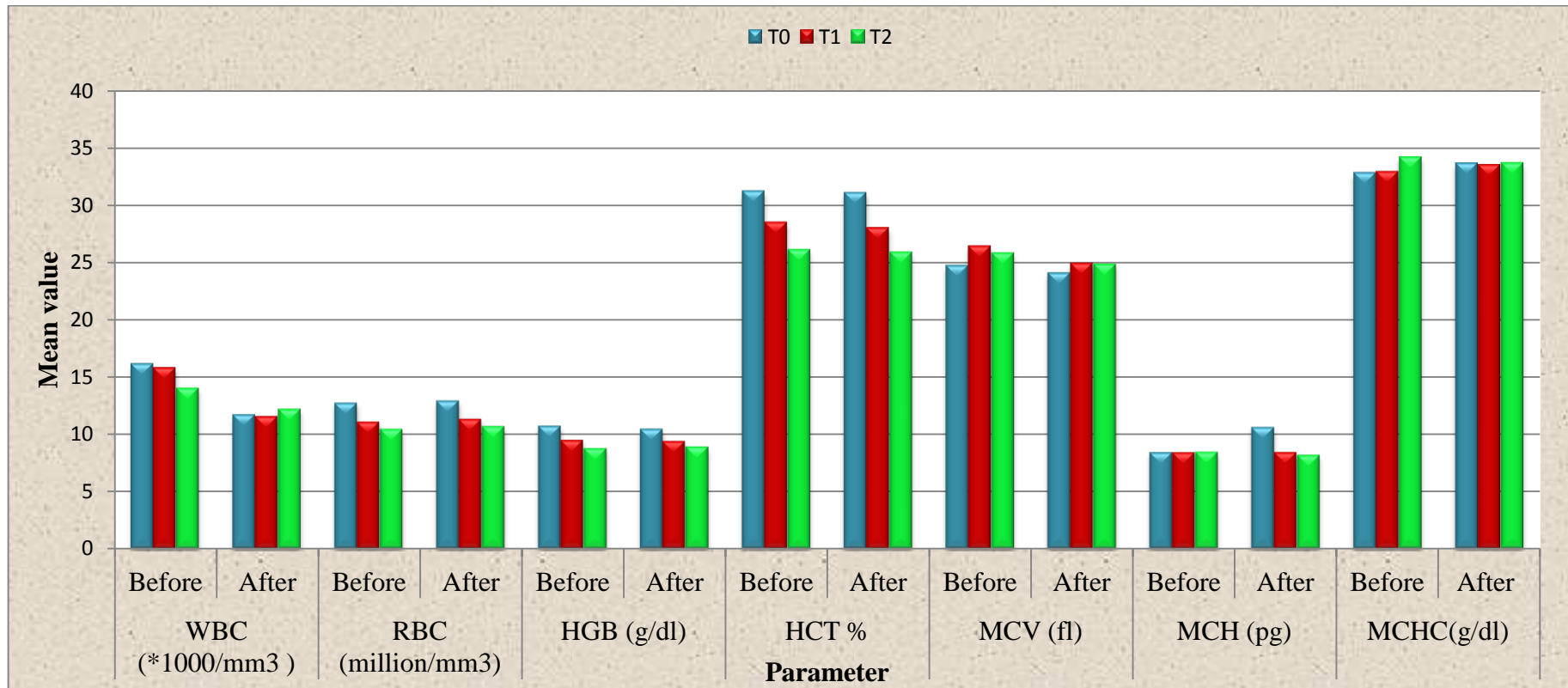
The mean estimated values of mean corpuscular volume (MCV) were  $24.73 \pm 0.66$ ,  $26.38 \pm 0.94$  and  $25.87 \pm 0.94$  fl before starting the experiment and at the end

**Table 11. Effect of feeding Moringa based diets on haematological parameters of Nellore lambs**

Parameter		Control	Treatment 1	Treatment 2	SEM	P-value
<b>WBC</b> (x10 <sup>3</sup> /mm <sup>3</sup> )	<b>Before</b>	16.18± 0.55	15.82±1.06	14.05± 0.67	0.658	0.204
	<b>After</b>	11.72± 1.44	11.55± 1.47	12.23± 1.79	0.161	0.950
<b>RBC (x10<sup>6</sup>/micro litre)</b>	<b>Before</b>	11.42± 0.42	11.55± 0.51	11.54± 0.48	0.257	0.977
	<b>After</b>	12.26± 0.26	12.79± 0.35	12.82± 0.32	0.181	0.391
<b>Hb g/dl</b>	<b>Before</b>	10.65± 0.56	9.56± 0.54	9.00 ± 0.59	0.349	0.147
	<b>After</b>	11.20± 0.37	10.47± 0.39	10.01± 0.51	0.262	0.184
<b>HCT%</b>	<b>Before</b>	31.21± 1.77	28.47± 1.62	26.15± 2.02	1.462	0.405
	<b>After*</b>	31.08±0.42 <sup>a</sup>	27.98±1.09 <sup>ab</sup>	25.93± 1.35 <sup>b</sup>	1.496	0.01
<b>MCV (fl)</b>	<b>Before</b>	24.73±0.66	26.38±0.94	25.87±0.94	0.496	0.405
	<b>After</b>	24.08±0.36	24.90±0.67	24.88±0.32	0.604	0.044
<b>MCH (pg)</b>	<b>Before</b>	8.43± 0.17	8.40±0.16	8.48±0.18	0.023	0.943
	<b>After</b>	10.62±2.56	8.43± 0.17	8.22±0.09	0.767	0.466
<b>MCHC (g/dl)</b>	<b>Before</b>	32.81±0.69	32.85±1.02	34.23±0.63	0.463	0.386
	<b>After</b>	33.65±0.72	33.46±0.94	33.73±0.74	0.437	0.972

Mean values in the rows bearing different superscripts differ significantly (P<0.05)





**Fig 17. Bar diagram showing the haematological parameters of Nellore lambs before and after the experiment**

of the experiment were  $24.08 \pm 0.36$ ,  $24.90 \pm 0.67$  and  $24.88 \pm 0.32$  fl in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. No significant difference was observed in MCV values among the experimental diets. Relatively higher MCV values were observed in lambs fed with diet containing *Moringa* leaf meal (T<sub>1</sub> and T<sub>2</sub>) when compared to control group (T<sub>0</sub>).

#### **4.6.6 Mean Corpuscular Haemoglobin**

The mean estimated MCH values were  $8.43 \pm 0.17$ ,  $8.40 \pm 0.16$  and  $8.48 \pm 0.18$  pg before starting the experiment and at the end of the experiment were  $10.62 \pm 2.56$ ,  $8.43 \pm 0.17$  and  $8.22 \pm 0.09$  pg in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. No significant difference was observed in MCH values among the experimental diets.

#### **4.6.7 Mean Corpuscular Haemoglobin Concentration**

The mean values of MCHC before starting the experiment were  $32.81 \pm 0.69$ ,  $32.85 \pm 1.02$  and  $34.23 \pm 0.63$  g/dl and at the end of the experiment were  $33.65 \pm 0.72$ ,  $33.46 \pm 0.94$  and  $33.73 \pm 0.74$  g/dl in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. No significant difference was observed in MCHC values when the growing lambs fed with experimental diets.

### **4.7 BIOCHEMICAL PARAMETERS**

The blood biochemical parameters *viz.* blood Total protein, albumin, glucose, cholesterol, Serum Glutamic Oxaloacetic Transaminase (SGOT) and Serum Glutamic Pyruvic Transaminase (SGPT), Blood Urea Nitrogen (BUN) levels of growing Nellore lambs fed with experimental diets are presented in Table 12 and depicted in the Fig. 18.

#### **4.7.1 Total Protein**

The estimated values of total protein growing Nellore lambs fed with MOLM based diets is presented in Table.12 and depicted in the Fig. 18. Perusal of table revealed that the mean values for total protein concentrates before start of the experiment were  $6.26 \pm 0.106$ ,  $5.94 \pm 0.22$  and  $6.20 \pm 0.21$  g/dl and were  $6.33 \pm 0.19$ ,  $6.30 \pm 0.26$  and  $6.58 \pm 0.18$  g/dl at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> dietary groups, respectively. Statistical analysis revealed that there was no significant difference ( $P < 0.05$ ) in total protein values among three dietary groups after the experiment.

#### **4.7.2 Serum Albumin**

The estimated values of serum albumin growing Nellore lambs fed with MOLM based diets is presented in Table 12 and depicted in the Fig. 18. Perusal of table revealed that the overall mean values for serum albumin before the start of the experiment were  $2.66\pm 0.35$ ,  $3.25\pm 0.28$  and  $2.73\pm 0.18$  g/dl and were  $2.81\pm 0.27$ ,  $3.26\pm 0.05$  and  $2.94\pm 0.21$  g/dl at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> dietary groups, respectively. Statistical analysis of the data at the end of the experiment revealed a non-significant difference for serum albumin among different experimental groups.

#### **4.7.3 Serum Glucose**

The estimated values of serum glucose growing Nellore lambs fed with MOLM based diets is presented in Table 12 and depicted in the Fig. 18. Perusal of table revealed that the serum glucose concentration in growing Nellore lambs fed with experimental diets were  $75.21\pm 4.06$ ,  $82.40\pm 5.39$  mg/dl and  $68.78\pm 2.89$  and  $80.71\pm 2.86$ ,  $84.94\pm 4.14$  and  $78.17\pm 2.59$  mg/dl for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups before and after the experiment respectively. There was no significant difference among the three experimental groups.

#### **4.7.4 Serum Cholesterol**

The estimated values of serum cholesterol growing Nellore lambs fed with MOLM based diets is presented in Table 12 and depicted in the Fig.18. Perusal of table revealed that the serum cholesterol concentration in growing Nellore lambs fed with experimental diet were  $102.68\pm 6.11$ ,  $126.13\pm 10.69$  and  $98.99\pm 12.94$  mg/dl;  $113.90\pm 9.23$ ,  $141.20\pm 31.60$  and  $108.54\pm 7.51$  mg/dl for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups before and after the experiment, respectively. Statistical analysis revealed that there was no significant difference in serum cholesterol among the experimental groups.

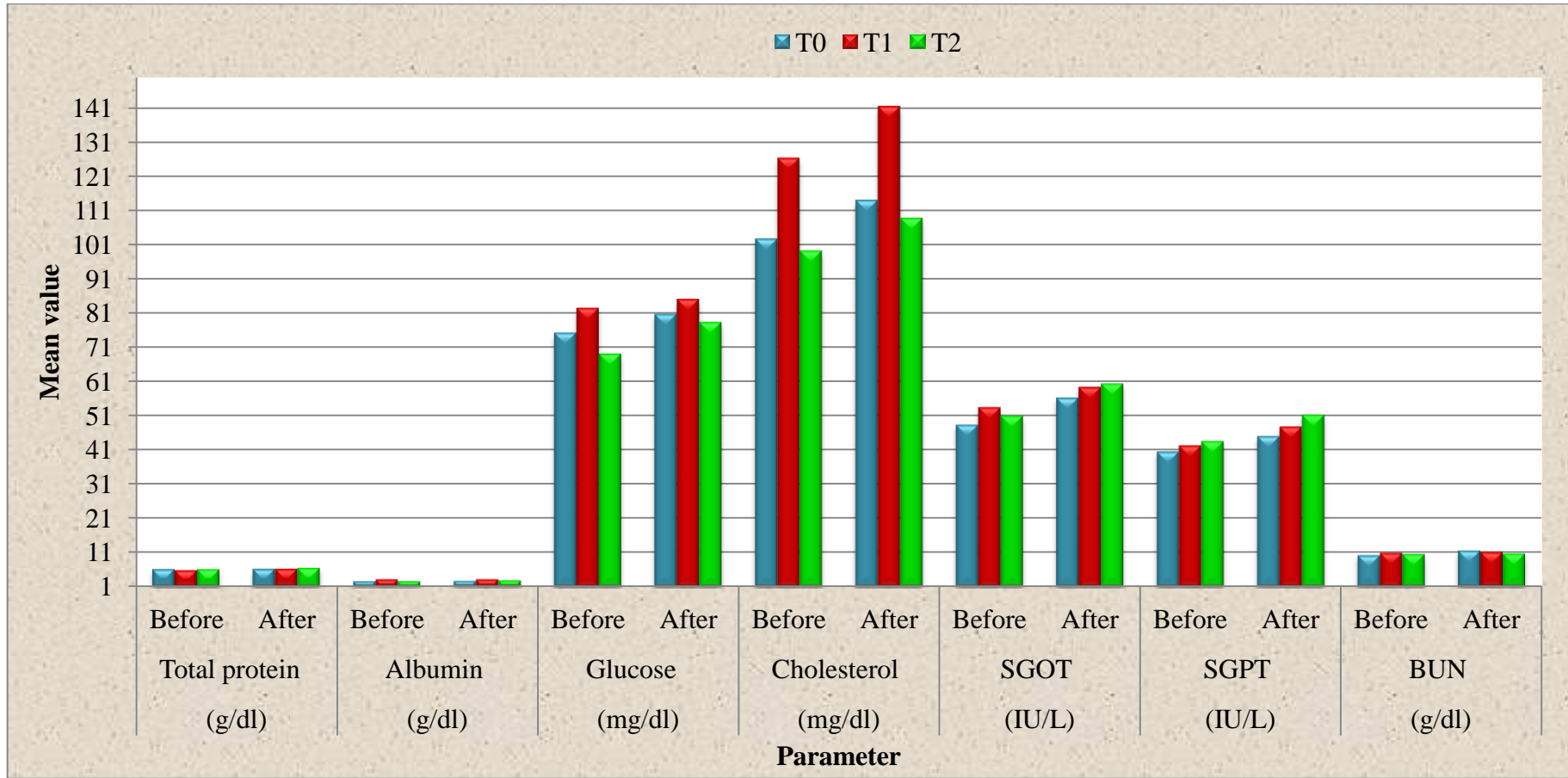
#### **4.7.5 Serum Glutamic Oxaloacetic Transaminase (SGOT)**

The estimated values of Serum Glutamic Oxaloacetic Transaminase (SGOT) growing Nellore lambs fed with MOLM based diets is presented in Table 12 and depicted in the Fig. 18. Perusal of table revealed that the overall mean of (SGOT) values before the start of the experiment were  $48.39\pm 2.56$ ,  $53.45\pm 2.37$  and  $50.92\pm 1.53$  IU/L in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively and the same were rose to  $56.26\pm 1.67$ ,  $59.36\pm 4.32$  and

**Table 12. Effect of feeding Moringa based diets on serum biochemical parameters of Nellore lambs**

Parameter		Control	Treatment 1	Treatment 2	SEM	P-value
Total protein (g/dl)	Before	6.26± 0.11	5.94± 0.22	6.20± 0.21	0.106	0.480
	After	6.33±0.19	6.30±0.26	6.58±0.18	0.190	0.622
Albumin (g/dl)	Before	2.66±0.35	3.25±0.28	2.73±0.18	0.350	0.302
	After	2.81±0.27	3.26±0.05	2.94±0.21	0.273	0.292
Glucose (mg/dl)	Before	75.21±4.06	82.40±5.39	68.78±2.89	4.06	0.109
	After	80.71±2.86	84.94±4.14	78.17±2.59	2.86	0.360
Cholesterol (mg/dl)	Before	102.68±6.11	126.13±10.69	98.99± 12.94	6.11	0.165
	After*	113.90± 9.23	141.20±31.60	108.54±7.51	9.23	0.465
SGOT (IU/L)	Before	48.39±2.56	53.45±2.37	50.92±1.53	1.29	0.297
	After	56.26±1.67	59.36±4.32	60.26±1.97	1.63	0.605
SGPT (IU/L)	Before	40.51±1.95	42.31±2.29	43.55±2.86	1.33	0.673
	After	45.01±2.84	47.82±2.21	51.20±1.61	1.38	0.191
BUN (g/dl)	Before	10.29±1.91	11.00±0.65	10.60±0.35	0.646	0.914
	After	11.69±0.39	11.22±0.66	10.80±0.54	0.309	0.525

Mean values in the rows bearing different superscripts differ significantly (P<0.05)



**Fig 18: Bar diagram showing the serum biochemical parameters of Nellore lambs before and after the experiment**

60.26±1.97 IU/L at the end of the experiment. In the present study, no significant difference was observed in SGOT values among the lambs in all the three experimental diets.

#### **4.7.6 Serum Glutamic Pyruvic Transaminase (SGPT)**

The estimated values of Serum Glutamic Pyruvic Transaminase (SGPT) growing Nellore lambs fed with MOLM based diets is presented in Table 12 and depicted in the Fig. 18. Perusal of table revealed that the mean values recorded for SGPT before start of the experiment were 40.51±1.95, 42.31±2.29 and 43.55±2.86 IU/L and were 45.01±2.84, 47.82±2.21 and 51.20±1.61 IU/L at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> dietary groups, respectively

No significant difference was observed for SGPT levels among the experimental group lambs fed with different experimental diets. However, slight increase was observed in MOLM supplemented lambs (T<sub>1</sub> and T<sub>2</sub>) at the end of experiment when compared to the start of experiment.

#### **4.7.7 Blood Urea Nitrogen (BUN)**

The estimated values of Blood Urea Nitrogen (BUN) growing Nellore lambs fed with MOLM based diets is presented in Table 12 and depicted in the Fig. 18. Perusal of table revealed that the overall mean values for serum albumin (g/dl) before start of the experiment were 10.29±1.91, 11.00±0.65 and 10.60±0.35 and were 11.69±0.39, 11.22±0.66 and 10.80±0.54 at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> dietary groups, respectively. Statistical analysis of the data at the end of the experiment revealed a non significant difference for serum albumin among different experimental diets.

### **4.8 ANTHELMINTHIC EFFECT /OVICIDAL ACTIVITY**

The effect of supplementing MOLM on parasitological egg count of faeces in Nellore lambs was presented in Table 13 and depicted graphically in Fig 19.

The mean EPG (Eggs Per Gram) of faeces recorded were 91.66±7.13 125.00±8.33 and 136.11±7.95 during the first month for the three groups of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively. The EPG count were significantly (P<0.05) lower in T<sub>0</sub> when compared to other groups.

During the second month the mean EPG (Eggs Per Gram) of faeces recorded were  $100.00 \pm 9.62$ ,  $66.66 \pm 7.45$  and  $75.00 \pm 11.98$  for the three dietary groups of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups respectively. The mean EPG count for T<sub>0</sub> group was higher than other two groups but there was no significant ( $P < 0.05$ ) difference in the EPG count among the other two groups

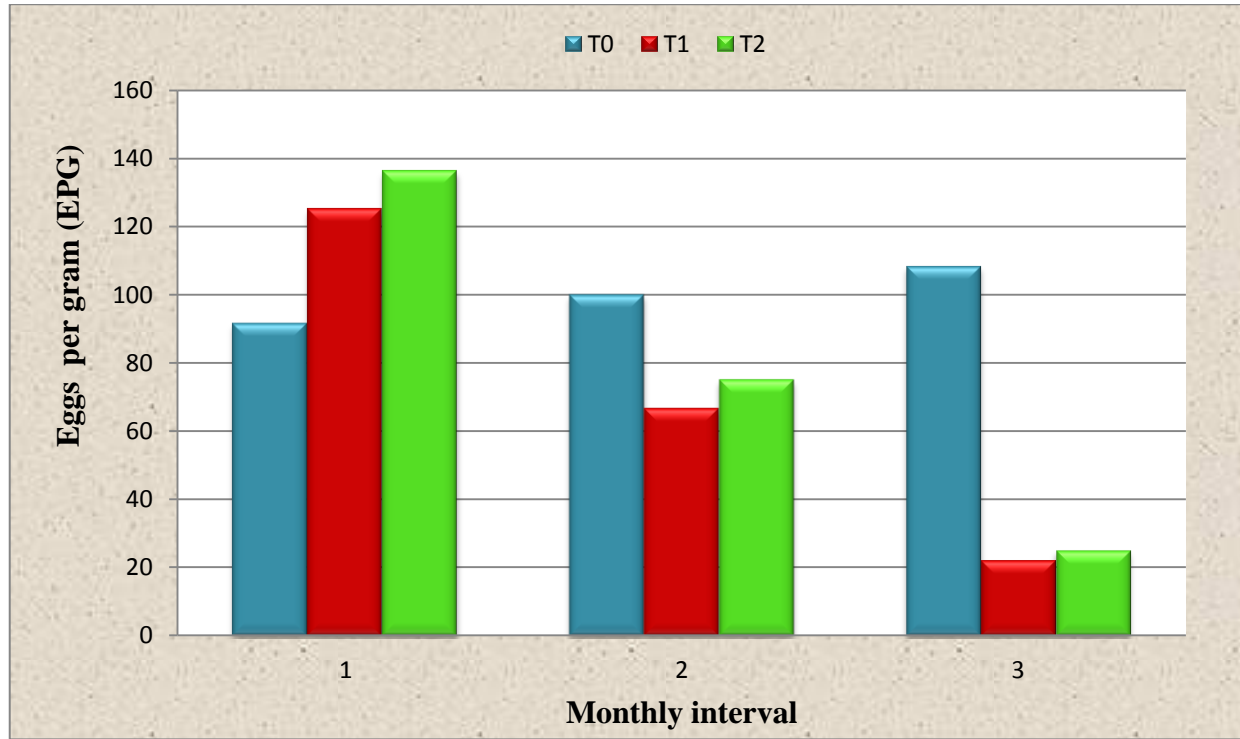
The mean EPG (Egg Per Gram) of faeces recorded were  $108.33 \pm 8.33$ ,  $22.22 \pm 8.24$  and  $25.00 \pm 7.13$  during the third month for the three groups of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively. The EPG count were significantly ( $P < 0.05$ ) higher in T<sub>0</sub> when compared to T<sub>1</sub> and T<sub>2</sub> with no significant difference between the other two groups (T<sub>1</sub> and T<sub>2</sub>).

The overall mean values of EPG for entire experimental period were  $100.00 \pm 7.31$ ,  $71.29 \pm 7.08$  and  $78.70 \pm 8.04$  for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The EPG count were significantly ( $P < 0.05$ ) higher in T<sub>0</sub> when compared to T<sub>1</sub> and T<sub>2</sub>.

**Table.13 Faecal Egg Count (EPG) in Nellore lambs fed with different experimental diets**

<b>Period (Monthly intervals)</b>	<b>Control (T<sub>0</sub>)</b>	<b>Treatment 1 (T<sub>1</sub>)</b>	<b>Treatment 2 (T<sub>2</sub>)</b>
<b>I</b>	$91.66 \pm 7.13^b$	$125.00 \pm 8.33^a$	$136.11 \pm 7.95^a$
<b>II</b>	$100.00 \pm 9.62$	$66.66 \pm 7.45$	$75.00 \pm 11.98$
<b>III</b>	$108.33 \pm 8.33^a$	$22.22 \pm 8.24^b$	$25.00 \pm 7.13^b$
<b>Overall mean <math>\pm</math> SE</b>	$100.00 \pm 7.31^a$	$71.29 \pm 7.08^b$	$78.70 \pm 8.04^b$

Mean values in the rows bearing different superscripts differ significantly ( $P < 0.05$ )



**Fig 19. Bar diagram showing faecal egg count of Nellore lambs at monthly intervals**

#### 4.9 COST ECONOMICS

The cost economics of lambs of different treatment groups was presented in table 14. The cost per kg experimental feed was Rs 26.26, Rs 25.04 and Rs 23.84 for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. Perusal of the table revealed that the total feed intake was 18.54, 18.76 and 19.40 kg for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The total cost of feeding of concentrates and green fodder was Rs 660.64, Rs 651.34 and Rs 646.32 for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The cost of feed per kg body weight gain in growing Nellore lambs fed with experimental diets was Rs 131.34, 111.15 and 105.44, respectively for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets. The total cost and cost of production per one kg of meat was lower in T<sub>1</sub> and T<sub>2</sub> group lambs which received concentrate mixture containing *Moringa oleifera* leaf meal than control group lambs.

**Table 14. Cost of feed ingredients (Rs) and cost economics in lambs fed with different experimental diets**

Ingredients	Cost /Kg (Rs)	Control group (T <sub>0</sub> )		Treatment 1 (T <sub>1</sub> )		Treatment 2 (T <sub>2</sub> )	
		Parts (Kg)	Cost (Rs)	Parts (Kg)	Cost (Rs)	Parts (Kg)	Cost (Rs)
Maize	23.00	25.50	586.50	25.50	586.50	25	575.00
DORB	20.80	33	686.40	33	686.40	33	686.40
Gingilly Cake	31	33.5	1038	22.50	697.50	12.2	378.20
Soybean meal	40.35	5.00	201.75	10.20	411.57	15.20	613.32
Dried Moringa leaf meal	1.50	-	-	5.8	8.70	11.6	17.40
Salt	3.5	1.00	3.50	1.00	3.50	1.00	3.50
Mineral mixture	55	2.00	110.00	2.00	110.00	2.00	110.00
Total	-	100.00	2626.65	100.00	2504.17	100.00	2383.82
Cost of feed / Kg	-	-	26.26	-	25.04	-	23.84
Total Feed Intake (Kg)	-	-	18.54	-	18.76	-	19.40
Total concentrate feed Cost (Rs)	-	-	486.86	-	469.75	-	462.49
Cost of Super Napier	2.00		173.78		181.59		183.83
Total Cost	-	-	660.64	-	651.34	-	646.32
Body weight gain (kg)	-	-	5.03	-	5.86	-	6.13
Total Cost/Kg Gain	-	-	131.34	-	111.15	-	105.44

## CHAPTER V

### DISCUSSION

The results of the present study as presented in chapter IV have been discussed under the following the sections.

#### 5.1 CHEMICAL COMPOSITION OF MORINGA OLEIFERA LEAF MEAL

##### 5.1.1 Dry matter

The values of proximate composition of dried *Moringa oleifera* leaf meal (MOLM) used in experimental rations of Nellore lambs were presented in Table 3. The data indicated that the DM content of MOLM was 91.21% which was comparable with the values of 92.12%, 90% and 90.46% as reported by Tona *et al.* (2014), Manikrao (2020) and Ghany *et al.* (2019), respectively.

Relatively higher values of dry matter of 96% (960.0 g/kg), 95.57 and 93.4% were reported by Yusuf *et al.* (2018) Asaolu *et al.* (2011), Adeniji and Lawal (2012), respectively. The dry matter content of MOLM was comparatively higher in the present study than the values of 87.13%, 77.4%, 87.90%, 77.44%, 88.6%, 88.3% as reported by Choudary *et al.* (2018), Damor *et al.* (2017a), Jiwuba *et al.* (2016), Sultana *et al.* (2015), Adegun and Aye (2013) and Kakengi *et al.* (2005), respectively.

The difference of values reported by different authors might be due to the time of harvest, soil type and fertility, proportion of leaf to stem ratio, part of the plant analysed and agro-ecological region where trees are grown.

##### 5.1.2 Crude protein

The crude protein (CP) content of Moringa estimated in the present study was 20.94 per cent which indicated that Moringa could be used as a potential natural protein source in livestock feeds. The CP value obtained in the present study was almost similar to the value of 20.9 and 21.37 per cent as reported Babeker and Bdalbagi (2015) and Choudary *et al.* (2018), respectively.

However, higher values of 25.1, 25.0, 26.5, 22.2, 30.3, 24.8, 23.5, 22.1, 28.7, 24.12, 29.68, 23.24, 29.14, 26.3, 31.5, 26.2, 24.39 per cent were reported by Makkar and Becker (1996), Richter *et al.* (2003), Kakengi *et al.* (2005) Asaolu *et al.* (2010), Moyo *et al.* (2011), Adeniji and Lawal (2012), Nouman *et al.* (2012), Adegun and Aye (2013), Teixeira *et al.* (2014), Kholif *et al.* (2015), Fadiyimu *et al.* (2016), Jiwuba *et al.*

(2016), Oyedele *et al.* (2016), Damor *et al.* (2017a), Yusuf *et al.* (2018), Ghany *et al.* (2020), Manikrao (2020), respectively. Whereas slightly lower values of 19.3, 17.8, 18.38, 16.52, 18.26 per cent compared to the CP value obtained in the present study were reported by Aregheore (2002), Sanchez *et al.* (2006), Tona *et al.* (2014), Allam *et al.* (2015) and Sultana *et al.* (2015), respectively.

The variation in CP content observed in the present study when compared with other workers could probably be attributed to climatic differences, time of harvest, variety, stage of maturity, leaf and stem ratio, various inputs used for Moringa cultivation and the part of the plant analysed.

### **5.1.3 Crude fibre**

In the present study, it was found that the crude fibre (CF) content of Moringa was found to be 16.85 per cent. The CF value obtained in the present study was almost similar to the value of 16.98 per cent as reported by Fadiyimu *et al.* (2016). However a slightly lower values of 11.03, 11.1, 7.5, 14.04, 13.14, 15.16, 10.34, 8.8, 4.82 and 5.57 per cent were reported by Asaolu *et al.* (2011), Adeniji and Lawal (2012), Nouman *et al.* (2012), Tona *et al.* (2014), Allam *et al.* (2015), Jiwuba *et al.* (2016), Oyedele *et al.* (2016), Damor *et al.* (2017a), Choudary *et al.* (2018), and Manikrao (2020), respectively. Comparatively higher values of 18.5 and 18.0 per cent were reported by Babeker and Bdalbagi (2015) and Ghany *et al.* (2019), respectively. The variations observed in CF contents in the present study might be due to stage of maturity, variety, climatic conditions and soil or edaphic factors.

### **5.1.4 Ether extract**

The ether extract content of Moringa leaf meal estimated in the present study was 5.7 per cent which was in close agreement with the values 5.78 per cent, 5.7 per cent as reported by Allam *et al.* (2015), Damor *et al.* (2017a), respectively. However, Richter *et al.* (2003), Asaolu *et al.* (2010), Teixeira *et al.* (2014), Tona *et al.* (2014), Oyedele *et al.* (2016) reported higher values of 10.6, 6.68, 7.1, 14.58 and 28.4 per cent, respectively. Comparatively lower values of 2.1, 3.0, 4.73, 3.8, 4.15, 4.15, 4.0, 6.06, 3.0 and 6.67 per cent were reported by Adeniji and Lawal (2012), Nouman *et al.* (2012), Kholif *et al.* (2015), Babeker and Bdalbagi (2015), Sultana *et al.* (2015), Jiwuba *et al.* (2016), Yusuf *et al.* (2018), Choudary *et al.* (2018), Ghany *et al.* (2019) and Manikrao (2020), respectively. The variation in the EE value reported by different

authors might be due to time of harvest, soil type and fertility, proportion of leaf and stem and agro climatic conditions prevailing in those regions.

#### **5.1.5 Total ash**

The total ash (TA) content of MOLM obtained in this study was 12.0 per cent, which was in close agreement with the values 11.84, 12.3 and 12.66 per cent as reported by Allam *et al.* (2015), Choudary *et al.* (2018) and Manikrao (2020), respectively. The total ash value obtained in the present study was higher than the findings of Richter *et al.* (2003), Sanchez *et al.* (2006), Adeniji and Lawal (2012), Adegun and Aye (2013), Teixeira *et al.* (2014), Tona *et al.* (2014), Babeker and Bdalbagi (2015), Sultana *et al.* (2015), Fadiyimu *et al.* (2016), Jiwuba *et al.* (2016), Oyedele *et al.* (2016), Yusuf *et al.* (2018) and Ghany *et al.* (2019) who reported 8.4, 10.76, 8.7, 6.0, 10.9, 8.38, 10.5, 10.67, 7.54, 6.21, 8.27, 9.7 and 6.0 per cent, respectively. However, Asaolu *et al.* (2010), Nouman *et al.* (2012) and Damor *et al.* (2017a), reported lower values of 13.2, 13.5 and 14.1 per cent, respectively.

The difference of values reported by different authors might be due to the time of harvest, soil type and fertility, leaf to stem ratio and agro-ecological zone where trees are cultivated and cultivation practices adopted in their region.

#### **5.1.6 Nitrogen free extract**

The Nitrogen free extract (NFE) content of Moringa leaf meal recorded in this study was 42.5 per cent, which was in close accordance with the findings of Fadiyimu *et al.* (2016) who reported 41.3 per cent. On contrary to this, lower values of 40.11, 39.14 and 23.80 per cent were reported by Asaolu *et al.* (2010), Jiwuba *et al.* (2016) and Oyedele *et al.* (2016), respectively. However, higher values of 53.5, 44.71 and 52.72 per cent were reported by Adeniji and Lawal (2012), Tona *et al.* (2014) and Allam *et al.* (2015), respectively.

The variations observed in NFE content in the present study is might be due to variety, stage of maturity and cultivation practices adopted in the region.

## 5.2 CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS

The values of proximate composition of the three experimental diets of Nellore lambs were presented in Table 4. From the data, it was observed that all the three rations prepared were isonitrogenous and CP value was confirmed to that of ICAR, 2013 recommendations for lambs. The crude fibre content was similar in the three experimental diets. Total ash content decreased as the level of Moringa increased (0, 15 and 30 per cent) in diets T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, respectively. This might be due to lower TA content in Moringa when compared to the ingredients used in the preparation of control ration.

## 5.3 DRY MATTER INTAKE

### 5.3.1 Average daily dry matter intake from experimental diets

The acceptability of feed is probably one of the prime parameters for ascertaining utility of the non-conventional feed resources (Padma meel, 2018; Manikrao, 2020).

The mean daily DMI of lambs from experimental diets in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups were  $104.18 \pm 0.56$ ,  $109.45 \pm 0.4$  and  $109.64 \pm 0.41$  g, respectively during the first week with significantly ( $P < 0.05$ ) higher feed intake in the lambs fed with T<sub>1</sub> and T<sub>2</sub> rations when compared to that of lambs fed with T<sub>0</sub> ration. During the last week the mean daily DMI values for the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were found to be  $255.60 \pm 0.41$ ,  $259.37 \pm 0.47$  and  $269.98 \pm 1.07$ g, respectively with significantly higher feed intake in the lambs of T<sub>2</sub> group when compared to that of the other two groups.

The overall mean values of daily DMI from concentrate feed for entire experimental period were  $179.29 \pm 0.68$ ,  $183.25 \pm 0.45$  and  $187.95 \pm 0.29$  g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was significantly ( $P < 0.05$ ) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups with significant ( $P < 0.05$ ) difference among the three groups.

The observations made in present study are in accordance with Fadiyimu *et al.* (2016) who reported that dry matter intake increased significantly up to 25% level and decreased with increasing Moringa in diet at 50, 75 and 100 per cent in West African dwarf sheep. Similar findings were reported by Sanchez *et al.* (2006) in cows fed with *Moringa oleifera* leaves.

The present findings are not in agreement with Haridas (2018) and Manikrao (2020) who reported no significant difference in DMI in growing lambs supplemented Moringa based diets.

### **5.3.2 Average daily dry matter intake from green fodder**

The mean DMI of lambs from green fodder in the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were 173.87±0.56, 178.77±0.42 and 179.96±0.41 g respectively during the first week with significantly (P < 0.05) higher fodder intake in T<sub>1</sub> and T<sub>2</sub> groups when compared to that of T<sub>0</sub> group with no significant difference between the groups.

During the last week the mean daily DMI values from green fodder for the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were found to be 293.00±0.41, 304.02±0.27 and 306.94±1.07 g, respectively.

The overall mean values of daily DMI from green fodder for entire experimental period were 229.16±10.89, 239.46±11.25 and 242.42±11.41 for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was significantly (P<0.05) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups with significant (P<0.05) difference among the three groups.

The observations made in present study are in accordance with Fadiyimu *et al.* (2016) who reported that DMI increased significantly by feeding Moringa based diets in goats. The present findings are not in agreement with Haridas (2018) and Manikrao (2020) who reported no significant difference in dry matter intake in growing sheep supplemented Moringa based diets.

### **5.3.3 Average total daily dry matter intake**

The mean values of total DMI of lambs from green fodder and concentrates in the experimental groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were 278.05±0.84, 288.22±0.46 and 289.69±0.41 g, respectively during the first week with significantly (P < 0.05) higher feed intake in the lambs fed with T<sub>1</sub> and T<sub>2</sub> rations when compared to that of lambs fed with T<sub>0</sub> ration with no significant difference between the Moringa fed groups.

The daily DMI values were 548.61±1.58, 563.39±0.50 and 576.92±1.34 g during thirteenth week for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> group, respectively with significant difference among all the groups. The overall mean values of total daily DMI for entire experimental period were 408.45±24.41, 422.71±24.51 and 430.37±25.96 g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups,

respectively. There was significantly ( $P<0.05$ ) higher DMI in the lambs of T<sub>2</sub> group when compared to that T<sub>0</sub> and T<sub>1</sub> groups with significant ( $P<0.05$ ) difference among the three groups. These values met the minimum daily DMI of 3% of body weight recommended for small ruminants (ICAR, 2013).

The observations made in present study are in agreement with Akinyemi *et al.* (2016) who reported that DMI increase significantly up to 25% level and decrease with increasing Moringa in diet at 50, 75 and 100 per cent in West African dwarf sheep. Similar findings were reported by Sarwatt *et al.* (2002), Murro *et al.* (2003), Moyo *et al.* (2012a), Tona *et al.* (2014), Babeker and Bdalbagi (2015) and Suliman *et al.* (2016) in goats. However, Sultana *et al.* (2015), Oyedele *et al.* (2016) and Padma Meel (2018) reported significantly higher DMI at 50% and above higher levels.

The present findings are not in agreement with Manikrao (2020) who reported no significant difference in DMI in growing Deccani lambs supplemented Moringa based diets. Similarly Aregheore (2002), Damor *et al.* (2017), Syed Ali (2017), Manmohan Kumar (2018) and Jagritisrivastav (2019) who reported no significant difference in DMI in goats fed with Moringa based diets. In contrast to our findings Asaulo *et al.* (2012b) in goats reported significantly lowest value with MMNB supplemented group in goats and Mahamoud (2013) reported significantly less intake in R<sub>2</sub> (18.75%) compared with R<sub>3</sub> (6.25%) and control group in sheep.

Significantly higher feed intake in T<sub>2</sub> group could be due to lower fibre content of the Moringa leaves and thereby enhancing the palatability and consumption. The crude fibre in the T<sub>2</sub> ration (30% MOL) was lowest, suggesting that it was highly digestible, leading to higher feed intakes compared with other studies. This intake pattern could be a reflection of the relative acceptability and palatability of these diets. The increased total DMI in this study might also be attributed to the corresponding increase in the CP and Ash (minerals) levels in T<sub>2</sub> ration.

#### **5.4 Feed conversion ratio**

The Feed conversion ratio (FCR) varied from  $5.42\pm 0.18$  to  $9.07\pm 0.17$ ,  $5.03\pm 0.11$  to  $7.75\pm 0.55$  and  $4.93\pm 0.05$  to  $7.53\pm 0.09$  in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively from the beginning to the end of the experimental period. Further the FCR's of lambs fed with T<sub>2</sub> ration were significantly ( $P<0.05$ ) lower when compared to that of the other two groups

fed with T<sub>0</sub> and T<sub>1</sub> rations. However, the FCR's of lambs in T<sub>1</sub> and T<sub>2</sub> groups did not differ significantly (P<0.05) in any week.

The observations made in present study are in agreement with Adegun *et al.* (2011), Adegun and Aye (2013); Tona *et al.* (2014), Suliman *et al.* (2016), Oyedele *et al.* (2016) who reported similar values in sheep. Similarly Padma Meel (2018) reported significantly higher feed efficiency in Moringa supplemented in goats when compared to control group.

The results are in disagreement with Mahamoud (2013), Manikrao (2020) in lambs; Aregheore (2002), Sultana *et al.* (2015), Syed Ali (2017), Manmohan Kumar (2018) and Jagritisrivastav (2019) in goats who observed non significant increase in feed efficiency in Moringa supplemented groups.

The better feed efficiency obtained by feeding T<sub>1</sub> and T<sub>2</sub> diets in the present study might be attributed to the beneficial effects of *Moringa oleifera* which provided stimulator factors and essential nutrients specially protein, energy, minerals and vitamins, that better utilized by sheep and low anti-nutritional factors like tannins . These factors resulted in some change in the digestive function that led to increasing the availability and utilization of nutrients in the rumen and could have a significant impact on the feed utilization and growth rate.

## **5.5 GROWTH PERFORMANCE OF NELLORE LAMBS FED MORINGA BASED DIETS**

### **5.5.1 Average fortnightly body weights**

The dietary inclusion of MOLM as protein supplement at different levels in Nellore growing lambs showed a significant effect on fortnightly body weight. The average body weights changed from 11.68± 0.24, 11.72± 0.17 and 11.71±0.19 kg on day one of experiment to 16.71±0.22, 17.58±0.17 and 17.84±0.20 kg at thirteenth week of experiment in groups T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively with significant difference between control group and Moringa supplemented groups (15% and 30% levels). In the present study the final body weight was highest in 30% inclusion and lowest in 0% Moringa incorporated diet.

Present findings were corroborated with earlier findings of Adegun *et al.* (2011) who reported significantly higher final body weights in Moringa multinutrient blocks

(MMNB) supplemented sheep than control group animals. Asaulo *et al.* (2012b), Moyo *et al.* (2011), Tona *et al.* (2014), Babeker and Bdalbagi (2015), Sultana *et al.* (2015), Suliman *et al.* (2016), Oyedele *et al.* (2016), Damor *et al.* (2017a) and Padma Meel (2018) also reported that feeding of Moringa leaves significantly increased the final body weight in goats.

The results obtained in the present study were not in agreement with reports made by Murro *et al.* (2003), Mahamoud (2013), Haridas (2018), Manikrao (2020), who reported that there was no significant difference in body weights of growing lambs at the end of the experiment. Similarly Sarwatt *et al.* (2002), Sultana *et al.* (2015), Syed Ali (2017), Yusuf *et al.* (2018), Jagritisrivastav (2019) reported non significant changes in final body weights in goats.

The marked variation in weight gain by the animals fed with experimental diets might be attributed to high protein content of *Moringa oleifera* leaf meal. The positive relationship between final body weights and MOLM supplementation could probably a reflection of increasing quality of diets containing high protein, energy and minerals of the dietary organic matter which enhance the growth performance of lambs.

### **5.5.2 Total body weight gain**

The total body weight gains observed at the end of the experiment were  $5.02 \pm 0.07$ ,  $5.86 \pm 0.08$  and  $6.13 \pm 0.03$  kg in lambs fed with T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets, respectively. Highest weight gain was observed in T<sub>2</sub> group lambs than T<sub>0</sub> and T<sub>1</sub> lambs and there was significant difference ( $P < 0.05$ ) among all the groups.

The present observations are in agreement with Adegun *et al.* (2011), Babiker *et al.* (2017), Manikrao (2020) who reported a higher body weight gain in Moringa supplemented growing lambs. Asaulo *et al.* (2012b), Tona *et al.* (2014), Babeker and Bdalbagi (2015), Suliman *et al.* (2016), Oyedele *et al.* (2016), Damor *et al.* (2017), Manmohan Kumar (2018) and Jagritisrivastav (2019) also reported that there was significantly higher body weight gain in goats supplemented with Moringa.

Present findings are not in agreement with Mahamoud (2013) who reported non significant change in the total body weight gain of sheep. Aregheore (2002), Yusuf *et al.* (2018), Syed Ali (2017) also reported non significant changes in total weight gain in Moringa supplemented goats.

Significantly higher body weight gain in the present study might be attributed to high crude protein content in Moringa to be better quality for small ruminants because of its high content of by-pass protein effect.

### **5.5.3 Average daily weight gain**

The overall ADG (g) was  $55.85 \pm 0.81$ ,  $65.11 \pm 0.92$  and  $68.09 \pm 0.37$ g in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively with significantly ( $P < 0.05$ ) higher ADG was observed in T<sub>2</sub> than T<sub>0</sub> and T<sub>1</sub> group lambs with significant difference among the three experimental groups.

The present findings are in concurrence with Murro *et al.* (2003), Adegun *et al.* (2011), Babiker *et al.* (2017) and Manikrao (2020) in sheep when fed with different levels of Moringa oleifera leaves. Similar findings were observed by Aregheore (2002), Asaulo *et al.* (2012b), Moyo *et al.* (2012a), Tona *et al.* (2014), Babeker and Bdalbagi (2015), Suliman *et al.* (2016), Oyedele *et al.* (2016), Damor *et al.* (2017), Padma Meel (2018) and Jagritisrivastav (2019) who reported significant difference in average daily gain in goats fed with Moringa incorporated leaf mixtures.

The present findings were not in agreement with Mahamoud (2013) and Haridas (2018) in growing lambs. Similarly Sarwatt *et al.* (2002), Sultana *et al.* (2015), Syed Ali (2017) and Yusuf *et al.* (2018) reported no significant difference in daily weight gain of growing goats fed with Moringa based diets.

The better ADG in the growing Nellore lambs observed in the present study might be attributed to the rich contents of amino acids, vitamins, minerals and iron in Moringa.

## **5.6 HAEMATOLOGICAL PARAMETERS**

The examination of blood provides the opportunity to clinically investigate the presence of metabolites and other constituents in the body of animals and it plays a vital role in the physiological, nutritional and pathological status of an animal. Blood constituents change in relation to the physiological status of an animal. These changes are often caused by several factors; some of which are genetic and others, non-genetic. Age, sex, breed and management systems are among the factors that influence blood-based parameters of farm animals. (Etim *et al.*, 2014)

### 5.6.1 White blood cells count

The major functions of the white blood cell and its differentials are to fight infections, defend the body by phagocytosis against invasion by foreign organisms and to produce or transport and distribute antibodies for immune response.

The mean WBC levels before start of the experiment were  $16.18 \pm 0.55$ ,  $15.82 \pm 1.06$  and  $14.05 \pm 0.67 \times 10^3/\text{mm}^3$  in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups respectively. The normal WBC for healthier lambs is 7 to  $10 \times 10^3/\text{mm}^3$  (Reece *et al.*, 2015). A slightly higher levels of WBC levels in the lambs before the experiment might be due to presence of infectious organisms (bacteria) in the animals. But the WBC ( $\times 10^3/\text{mm}^3$ ) levels after the experiment were  $11.72 \pm 1.44$ ,  $11.55 \pm 1.47$  and  $12.23 \pm 1.79 \times 10^3/\text{mm}^3$  for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. These values were slightly higher than normal values which may be due to fluctuations in environmental temperature during the experimental period. The higher value in T<sub>2</sub> group may be due to ill health of one of the lamb.

Statistical analysis of the data revealed that there was no significant difference ( $P < 0.05$ ) in the WBC levels among experimental groups at the end of the experiment. However, there was reduction in WBC count when compared to the initial values. The observations indicate that MOLM does not have any adverse effects on immune system of lambs. Normal values of WBC obtained in this study indicates that lambs remained healthy and free from infection.

Similar findings were observed by Adegun *et al.* (2011) in sheep. Syed Ali (2017), Padma Meel (2018), Asaulo *et al.* (2012b) observed no significant changes in WBC count in goats fed with Moringa based diets.

The results obtained in the present study were not in agreement with Manikrao (2020), Babeker and Bdalbagi (2015) Jiwuba *et al.* (2016), Syed Ali (2017) who reported significantly higher values in goats whereas Adegun *et al.* (2011) and Fadiyimu *et al.* (2016) observed significantly lower value of WBC in sheep supplemented with Moringa leaf meal.

### 5.6.2 Red blood cells count

The mean estimated RBC values were at the start of experiment were  $11.42 \pm 0.42$ ,  $11.55 \pm 0.51$  and  $11.54 \pm 0.48 \times 10^6 / \text{micro litre}$  and at the end were  $12.26 \pm 0.26$ ,  $12.79 \pm 0.35$  and  $12.82 \pm 0.32 \times 10^6 / \text{micro litre}$  in lambs fed with T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets, respectively. The results showed no significant difference among the control group and

Moringa supplemented groups. The final values of RBC were numerically higher in T<sub>1</sub> and T<sub>2</sub> dietary groups and whose values were comparable to T<sub>0</sub> group.

Present findings were in agreement with Adegun *et al.* (2011), Fadiyimu *et al.* (2016) in sheep and Syed Ali (2017) in goats who reported numerically slightly higher RBC levels in Moringa supplemented groups but they were not significant.

Present findings were not in agreement with Adegun *et al.* (2011), Manikrao (2020) who reported significantly higher values in Moringa supplemented sheep. Similarly Asaulo *et al.* (2012b), Babeker and Bdalbagi (2015), Padma Meel (2018), Jiwuba *et al.* (2016) reported significant increase in RBC by supplementing Moringa based diets in goats.

The values of RBC at the end of the experiment were within the normal range 9-15 x10<sup>6</sup>/micro litre (Reece *et al.*, 2015). Present findings suggested that the diets supported good health status of lambs and hence the lambs were not anaemic.

### **5.6.3 Haemoglobin**

The mean estimated haemoglobin values changed from 10.65 ± 0.56 to 11.20 ± 0.37; 9.56± 0.54 to 10.47± 0.39 and 9.0± 0.59 to 10.01± 0.51 g/dl at the end of the experiment in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. No significant difference was observed in haemoglobin values among the experimental groups. Relatively higher haemoglobin values were observed in control group lambs (T<sub>0</sub>) when compare to lambs fed with diet containing MOLM (T<sub>1</sub> and T<sub>2</sub>). But the increase in haemoglobin was higher in T<sub>2</sub> group (1.01±0.17) animals when compared with other groups (0.55±0.21, 0.90±0.15 in T<sub>0</sub> and T<sub>1</sub> respectively).

The values of haemoglobin were within the normal range 9- 15 g/dl (Reece *et al.*, 2015) which suggests that inclusion of MOLM in the diet of growing lambs does not have any adverse effect on blood haemoglobin.

Fadiyimu *et al.* (2016), Manikrao (2020) in sheep; Padma Meel (2018), Jiwuba *et al.* (2016), Syed Ali (2017), Manmohan Kumar (2018) in goats reported similar results by feeding Moringa based diets.

The present findings were not in agreement with Adegun *et al.* (2011) who reported significantly higher values of haemoglobin in sheep supplemented with Moringa

Multi Nutrient Blocks. Similarly Asaulo *et al.* (2012b), Babeker and Bdalbagi (2015) reported significantly higher values of haemoglobin in goats fed with Moringa multi nutrient blocks and Moringa leaves, respectively.

#### **5.6.4 Haematocrit**

The mean estimated haematocrit (Packed Cell Volume/ PCV) values in all lambs across the three treatments at the end of the experiment ranged between 25.93 and 31.08 % in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups. The haematocrit values were significantly (P<0.05) higher in T<sub>0</sub> group, whose values were comparable to T<sub>1</sub> group. The lowest haematocrit values were noticed in T<sub>2</sub> group and the values were also comparable with T<sub>1</sub> group. The haematocrit values were within normal range of 27-45 % (Reece *et al.*, 2015). PCV indicate the capability of RBC to deliver oxygen to the tissues and high PCV values have been regarded as sign of healthy and high productive animals. No harmful effect on oxygen delivery to tissues in lambs.

Similar findings were observed by Padma Meel (2018) and Syed Ali (2017) who reported no significant difference in haematocrit values of goats supplemented Moringa based diets.

In contrast to the present findings Adegun *et al.* (2011), Fadiyimu *et al.* (2016) Manikrao (2020) reported significantly higher values of haematocrit in sheep fed with Moringa based diets. Similarly Asaulo *et al.* (2012b), Babeker and Bdalbagi (2015) and Jiwuba *et al.* (2016) reported significantly higher values of haematocrit in goats supplemented with Moringa.

#### **5.6.5 Mean corpuscular volume**

The mean estimated values of Mean corpuscular volume (MCV) were 24.73±0.66, 26.38±0.94 and 25.87±0.94 fl before start of the experiment and at the end of the experiment were 24.08±0.36, 24.9±0.67 and 24.88±0.32 fl in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. No significant difference was observed in MCV values among the experimental groups. Relatively higher MCV values were observed in lambs fed with diet containing *Moringa* leaf meal (T<sub>1</sub> and T<sub>2</sub>) when compared to control group (T<sub>0</sub>). The MCV values observed at the end of the experiment were within the normal range of 28 to 40 fl (Reece *et al.*, 2015).

Similar findings were observed by Syed Ali (2017) who reported no significant difference in the values of MCV in Moringa supplemented goats. Present findings were not in agreement with findings of Adegun *et al.* (2011), Fadiyimu *et al.* (2016), Manikrao (2020) in sheep and Babeker and Bdalbagi (2015) in goats who reported significantly higher values of MCV in Moringa supplemented groups.

#### **5.6.6 Mean corpuscular haemoglobin**

The mean estimated Mean Corpuscular Haemoglobin (MCH) values were  $8.43 \pm 0.17$ ,  $8.4 \pm 0.16$  and  $8.48 \pm 0.18$  pg before starting the experiment and at the end of the experiment were  $10.62 \pm 2.56$ ,  $8.43 \pm 0.17$  and  $8.22 \pm 0.09$  pg in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. No significant difference was observed in MCH values among the experimental groups. Relatively higher MCH values were observed in control group lambs (T<sub>0</sub>) when compared to lambs fed with diets containing *Moringa* leaf meal (T<sub>1</sub> and T<sub>2</sub>). Present findings were within the normal range 8 to 12 pg (Reece *et al.*, 2015) which suggested that inclusion of MOLM in diets of growing lambs does not have any adverse affect on MCH.

These findings are in agreement with results of Fadiyimu *et al.* (2016) in sheep, Manikrao (2020) in growing Deccani lambs who reported non significant difference in MCH values in Moringa supplemented groups. Similarly Syed Ali (2017) reported no significant changes in MCH value in goats supplemented with dried Moringa leaf meal.

In contrast to these results Adegun *et al.* (2011) reported significantly higher value of MCH in sheep and Babeker and Bdalbagi reported significantly higher values of MCH in goats supplemented with Moringa multinutrient blocks.

#### **5.6.7 Mean corpuscular haemoglobin concentration**

The values of mean corpuscular haemoglobin concentration (MCHC) values before starting the experiment were  $32.81 \pm 0.69$ ,  $32.85 \pm 1.02$  and  $34.23 \pm 0.63$  g/dl and at the end of the experiment were  $33.65 \pm 0.72$ ,  $33.46 \pm 0.94$  and  $33.73 \pm 0.74$  g/dl in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. It was observed that there was no significant difference in MCHC values among the three experimental groups and all the values were within the normal physiological range of 31-34 mg/dl for healthy animals (Reece *et al.*, 2015).

Present findings are in agreement with results of Fadiyimu *et al.* (2016) in sheep, Manikrao (2020) in growing Deccani lambs who reported non significant difference in

MCHC values in Moringa supplemented groups. Similarly Syed Ali (2017) reported no significant changes in MCHC value in goats supplemented with dried Moringa leaf meal.

In contrast to these results Adegun *et al.* (2011) reported significantly higher value of MCHC in sheep supplemented with Moringa multinutrient blocks.

## **5.7 BIOCHEMICAL PARAMETERS**

### **5.7.1 Total Protein**

The mean values for total protein concentrates before start of the experiment were  $6.26 \pm 0.106$ ,  $5.94 \pm 0.22$  and  $6.20 \pm 0.21$  g/dl and were  $6.33 \pm 0.19$ ,  $6.30 \pm 0.26$  and  $6.58 \pm 0.18$  g/dl at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. Statistical analysis revealed that there was no significant difference ( $P < 0.05$ ) in total protein concentrates among three groups after the experiment. These results are comparable to the normal range of sheep 6.0-7.9g/dl (Kaneko *et al.*, 2008).

Present findings are corroborated with Mahamoud (2013), Kholif *et al.* (2016), Syed Ali (2017), Ahmad *et al.* (2017), Manmohan Kumar (2018) and Jagritisrivastav (2019) who reported non-significant difference in total protein when different levels of *Moringa oleifera* leaves were fed to animals.

The results observed were not in agreement with findings of Babeker and Bdalbagi (2015) Suliman *et al.* (2016) and Padma Meel (2018) in goats; Manikrao (2020) in Deccani lambs who reported significantly higher values of total protein in Moringa supplemented groups.

The numerically higher values of total protein in Moringa supplemented groups might be due to presence of several antioxidants which increases blood total protein by decreasing corticosterone secretion and limiting protein catabolism. Further, presence of some phyto-chemicals in Moringa leaves are beneficial as they impact some qualities of rumen undegradable protein, thus improving protein availability and utilization.

### **5.7.2 Serum Albumin**

The overall mean values for serum albumin were  $2.81 \pm 0.27$ ,  $3.26 \pm 0.05$  and  $2.94 \pm 0.21$  g/dl at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively.

Statistical analysis of the data at the end of the experiment revealed a non-significant difference for serum albumin among different experimental groups.

The mean values of serum albumin is numerically higher in T<sub>1</sub> and T<sub>2</sub> than control group. Supplementation of Moringa resulted in increased serum albumin content as it contains several antioxidants which may results in better immune response. The serum albumin levels were within the normal range 2.40-3.00 g/dl (Kaneko *et al.*, 2008).

The observations in the present study were in concurrence with Syed Ali (2017), Manikrao (2020) who reported no significant difference in level of albumin with feeding Moringa leaves at different levels in the diet of goats and Deccani lambs respectively.

Present findings are in disagreement with the findings of Babeker and Bdalbagi (2015), Suliman *et al.* (2016), Damor et al. (2017b), Padma Meel (2018) reported significantly higher values of albumin by feeding of Moringa based diets.

It was inferred from the present study that there was no significant effect of Moringa oleifera leaf meal inclusion in concentrate mixture on serum albumin and thereby no effect on the role of serum albumin on colloidal osmotic pressure of fluids and protein for growth.

### **5.7.3 Serum Glucose**

The serum glucose concentration in growing Nellore lambs fed with experimental diets at the end of the experiments were 80.71±2.86, 84.94±4.14 and 78.17±2.59 mg/dl for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively

There was no significant difference among the treatment groups and the glucose levels were within the normal physiological range of 50-80 (mg/dl) for healthy lambs (Kaneko *et al.*, 2008). From the present findings it was observed that supplementation of MOLM does not have any adverse effect on serum glucose levels.

Present findings were in agreement with Damor *et al.* (2017b) and Manikrao (2020) who reported non significant difference in serum glucose values in Deccani lambs and Mehsana kids respectively. Similarly Syed Ali (2017), Padma Meel (2018) and Jagritisrivastav (2019) who reported no significant change in serum glucose

values in Moringa supplemented goats. In contrast to the present findings Suliman *et al.* (2016) observed significantly lower value for serum glucose in Moringa supplemented lambs than others.

However, Babiker and Bdalbagi (2015) reported significantly higher value for glucose at 50% protein replacement level of Moringa supplementation in goats and Babiker *et al.* (2017) reported significantly higher serum glucose in Moringa supplemented ewes and goats than alfa alfa dietary group which are in not agreement with present findings.

#### **5.7.4 Serum cholesterol**

The serum cholesterol concentration in growing Nellore lambs fed with experimental diet were  $102.68 \pm 6.11$ ,  $126.13 \pm 10.69$  and  $98.99 \pm 12.94$  mg/dl and  $113.90 \pm 9.23$ ,  $141.20 \pm 31.60$  and  $108.54 \pm 7.51$  mg/dl for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups before and after the experiments, respectively. Statistical analysis revealed that there was no significant difference in serum cholesterol among the experimental groups.

This result is comparable with values obtained by Kholif *et al.* (2015) who reported that there was no significant difference in serum cholesterol in goats fed experimental rations containing *Moringa oleifera* (at 50%, 75% and 100%) when compared to control group animals.

However, Suliman *et al.* (2016) reported significantly lower value in Moringa fed group than control group lambs. On the contrary Babiker *et al.* (2017) reported significantly higher value of serum cholesterol in Moringa dietary group than alfa alfa hay dietary group of ewes and goats.

All the values were within the normal physiological range of 60-150 mg/dl (Kaneko *et al.*, 2008). From the present findings it was observed that supplementation of MOLM does not have any adverse effect on serum cholesterol levels.

#### **5.7.5 Serum Glutamic Oxaloacetic Transaminase (SGOT)**

Blood plasma transaminase enzymes activity are the most important indicators of liver cells activity where increased the concentration of these enzymes indicate the destruction of tissue activity (Molander *et al.* 1957).

The overall mean of SGOT values before start of the experiment were  $48.39 \pm 2.56$ ,  $53.45 \pm 2.37$  and  $50.92 \pm 1.53$  IU/L in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively and

the same were elevated to  $56.26 \pm 1.67$ ,  $59.36 \pm 4.32$  and  $60.26 \pm 1.97$  IU/L at the end of experiment.

In the present study no significant difference was observed for SGOT levels among the experimental group lambs fed with different experimental feeds. However, slight increase was observed in MOLM supplemented lambs ( $T_1$  and  $T_2$ ) at the end of experiment when compared to the start of experiment.

The present findings are in agreement with Manikrao (2020) who reported non significant difference in SGOT levels when growing lambs were fed with experimental diets containing *Moringa oleifera* (25% and 50% replacement levels). Similarly Syed Ali (2017), Manmohan Kumar (2018) and Jagritisrivastav (2019) reported non significant difference in SGOT values in goats fed with Moringa based diets.

Present findings were not in agreement with findings of Mahamoud (2013), Suliman *et al.* (2016) in growing lambs and Damor *et al.* (2017b) in Mehsana kids who reported significantly higher values of SGOT in Moringa fed group than control group animals.

All the values obtained at the end of the experiment were within the normal physiological range of 32-84 IU/L (Kaneko *et al.*, 2008). Thus the observations revealed that inclusion of *Moringa oleifera* leaf meal in the diet of growing lambs did not alter liver function.

#### **5.7.6 Serum Glutamic Pyruvic Transaminase**

The mean values recorded for Serum Glutamic Pyruvic Transaminase (SGPT) before start of the experiment were  $40.51 \pm 1.95$ ,  $42.31 \pm 2.29$  and  $43.55 \pm 2.86$  IU/L and were  $45.01 \pm 2.84$ ,  $47.82 \pm 2.21$  and  $51.20 \pm 1.61$  IU/L at the end of the experiment for  $T_0$ ,  $T_1$  and  $T_2$  groups, respectively.

No significant difference was observed for SGPT levels among the experimental group lambs fed with different experimental feeds. However, slight increase was observed in MOLM supplemented lambs ( $T_1$  and  $T_2$ ) at the end of experiment when compared to the beginning of experiment but it was not significant.

The present findings are in agreement with Manikrao (2020) reported no significant difference in SGPT when growing lambs were fed with experimental diets containing *Moringa oleifera* (25% and 50% replacement levels). Similarly Damor *et al.* (2017), Syed Ali (2017), Manmohan Kumar (2018) and Jagritisrivastav (2019) reported no significant difference in SGPT in goats fed with Moringa based diets.

The present findings were not corroborated with Mahamoud (2013), Suliman *et al.* (2016) who reported significantly lower value of SGPT values in Moringa fed group than other group of growing lambs.

All the values obtained at the end of the experiment were within the normal physiological range of 31-58 IU/L (Kaneko *et al.*, 2008). Thus the observations revealed that inclusion of *Moringa oleifera* leaf meal in the diet of growing lambs did not alter liver function.

#### **5.7.7 Blood urea nitrogen**

The overall mean values for Blood Urea Nitrogen (BUN) before start of the experiment were  $10.29 \pm 1.91$ ,  $11.00 \pm 0.65$  and  $10.60 \pm 0.35$  mg/dl and were  $11.69 \pm 0.39$ ,  $11.22 \pm 0.66$  and  $10.80 \pm 0.54$  mg/dl at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. Statistical analysis of the data at the end of the experiment revealed a non-significant difference for BUN among different experimental groups. The BUN values after the experiment were within the normal physiological range of 8-20 mg/dl in sheep. (Kaneko *et al.*, 2008).

The present findings are in agreement with Mahamoud (2013) who reported nonsignificant differences in Moringa supplemented growing lambs. Similarly Manmohan Kumar (2018) and Jagritisrivastav (2019) reported non significant differences in BUN values in goats supplemented with Moringa based diets. In contrast to the present findings Suliman *et al.* (2016) reported significantly higher value of BUN in growing lambs supplemented with dried Moringa leaves at the rate of 60g/day.

## 5.8 ANTHELMINTHIC EFFECT/ OVICIDAL ACTIVITY

The mean EPG (Eggs Per Gram) of faeces recorded were  $91.66 \pm 7.13$ ,  $125.00 \pm 8.33$  and  $136.11 \pm 7.95$  during the first month and were  $108.33 \pm 8.33$ ,  $22.22 \pm 8.24$  and  $25.00 \pm 7.13$  during the third month for the three groups of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively. The EPG count was significantly ( $P < 0.05$ ) higher in T<sub>0</sub> when compared to T<sub>1</sub> and T<sub>2</sub> with no significant difference between T<sub>1</sub> and T<sub>2</sub> groups.

Present findings were in agreement with Moyo *et al.* (2013) who reported significantly lower FEC values (*Haemonchus contortus*, *Trichostrongylus colubriformis*, *Oesophagostomum columbianum*) in Moringa supplemented group than grass hay supplemented group. Similarly Shrihari *et al.*, (2016) reported significant reduction in EPG count in goats fed with aqueous leaf and bark extracts of *Moringa oleifera* (at the rate of 300 mg/kg) when compared with other groups

Present findings were not in agreement with Asaolu *et al.* (2012a) who noticed no significant reduction in FEC (faecal egg count) in animals supplemented with Moringa foliage at 50% replacement level of groundnut hay.

Feeding of *Moringa oleifera* in the present study decreased helminth infection which could be due to its high crude protein levels. Dietary supplements high in protein have been reported to improve the immune response of animals, thereby decreases helminth infection (Arsenos *et al.*, 2009). Any increase in the intestinal protein supply is known to improve host homeostasis and its immune response against helminths.

Arsenos *et al.* (2009) suggested that improvement in the dietary protein improves the capacity of infected goats to develop effective immunological response to infection and enhance the onset of parasite rejection. Furthermore, MOLM based diets contained considerable amount of protein (21.26 and 20.19%) that could have increased availability of protein for digestion and absorption resulted in the improvement of body condition and host-resistance to the helminths.

The MOL diet also contained considerable amounts of polyphenolic compounds that may have contributed to the anthelmintic effect (Srinivasa *et al.*, 2011). Polyphenolic compounds have been reported to bind fecal egg proteins and inhibit egg hatching and larval development (Torres-Acosta and Hoste, 2008). Copper oxide wire

particles have been reported to reduce *Haemonchus contortus* loads in sheep and goats (Watkins, 2003). Watkins (2003) reported that when copper dissolves in the abomasums and provides an environment not conducive for the survival of the *H. contortus*. Similarly the higher dietary copper content in MOL diet could be speculated to have reduced *H. contortus* in the current study, as they have the same anthelmintic effect as copper oxide wire particles.

The low helminthic infection in lambs supplemented with MOLM in the present study suggests that nutrition has an influence on the response of lambs to helminth challenge. The use of forage plants having anthelmintic effect also promote the production of organic meat which is preferred by consumers for health reasons.

## **5.9 COST OF PRODUCTION**

The cost of feed per kg body weight gain in growing Nellore lambs fed with experimental diets was Rs 131.38, 111.15 and 105.43, respectively for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. The total cost and cost of production per one kg of meat was lower in T<sub>1</sub> and T<sub>2</sub> group lambs which received concentrate mixture containing MOLM than control group lambs (Table 13).

Similar findings were observed by Syed Ali (2017) who observed profit of Rs. 22.20 by replacing cotton seed in concentrate feed by 50% (12.50% of total ration) with Moringa leaf meal. Padma Meel (2018) reported more net profit Rs.162.89 by feeding Moringa leaf meal at 75% replacement level of total concentrate feed. Manikrao (2020) reported T<sub>2</sub> diet containing Moringa leaf meal at 25% replacement level of Ground nut cake was more economical than control diet which is in agreement with present findings. Adegun and Aye (2013), Haridas (2018) reported significant reduction in cost per kg live weight gain with increasing level of *Moringa oleifera* which are in agreement with present findings.

The total cost and cost of production per one kg of meat which was lower in Moringa supplemented group than control group could be due to less cost of cultivation of Moringa, in addition to higher digestibility of nutrients and better feed efficiency of supplemented diets used in present study. Thus the present results indicate improvement in profit on incorporation of traditional protein supplements in the concentrate feed of growing lambs with MOLM.

## CHAPTER VI

### SUMMARY

The present research work was conducted on 18 Nellore lambs of 3 months age of almost similar body weights which were divided into three groups *i.e.*, T<sub>0</sub> (Control), (T<sub>1</sub>) (15% Moringa incorporation level) and T<sub>2</sub> (30% Moringa incorporation level) with six lambs in each group for a period of 90 days to evaluate the effect of incorporation of *Moringa oleifera* leaf meal (MOLM) on the growth performance, haemato-biochemical parameters, ovidal activity and to work out the cost economics.

The required quantity of Moringa during the experiment was harvested from the farm, dried and finely grinded to prepare leaf meal. Three experimental diets were prepared by using MOLM and offered @ 1 % of body weight along with *ad libitum* green fodder.

The proximate composition of MOLM revealed that, the dry matter (DM) content of MOLM was 91.21 per cent. MOLM contained 88 per cent organic matter (OM), 20.94 per cent crude protein (CP), 16.85 per cent crude fibre (CF), 5.7 per cent ether extract (EE), 42.5 per cent nitrogen free extract (NFE) and 12 per cent total ash (TA). The cost of Moringa cultivation was calculated and the cost of one kg Moringa leaf meal was found to be Rs. 1.50/-.

It was observed from the chemical composition of the experimental rations T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> that the CP content was 21.34, 21.26 and 20.19 per cent, CF content was 14.01, 14.08 and 11.38 per cent, EE content was 0.99, 1.24, and 1.18 per cent, NFE content was 46.68, 49.01 and 52.83 percent, TA content was 14.10, 11.71 and 11.61 per cent, respectively.

The observations on body weight gains, efficiency of feed utilization were recorded on fortnightly basis while the feed intake was recorded on daily basis. Blood samples from the experimental lambs were collected at beginning (0 day) and at the end of the experiment for the estimation of haemato-biochemical parameters *viz.*, WBC count, RBC count, haemoglobin, haematocrit, MCV, MCH, MCHC, total protein, serum albumin, serum glucose, serum cholesterol, SGOT, SGPT and BUN. Faecal samples were collected at the end of the first month (30 days), second month (60 days)

and third month (90 days) for the estimation of EPG count. The cost economics were evaluated by calculating the cost of production per kg body weight gain in the growing lambs.

The mean daily dry matter intake of growing lambs from fourth week to thirteenth week were significantly higher for T<sub>2</sub> group animals and lower value for T<sub>0</sub> group with significant difference among all the three groups. However, the overall mean daily dry matter consumption in lambs fed with rations T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> were 408.45±24.41, 422.71±24.51 and 430.37±25.96 g, respectively and the difference was non-significant among the three groups. The overall mean daily dry matter intake from concentrate feed were 179.29±13.53, 183.25±13.27 and 187.95±14.55 g and from green fodder were 229.16±10.89, 239.46±11.25 and 242.42±11.41 g for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. There was no significant difference observed in the mean daily dry matter intake from both concentrate feed and green fodder.

By studying the growth performance, it was observed at the end of the experimental period that the mean final body weights were significantly (P <0.05) higher in T<sub>2</sub> (17.84±0.20 kg) group compared to T<sub>0</sub> (16.71±0.22 kg) and T<sub>1</sub> (17.58±0.17 kg) groups. Similarly, total body weight gains observed at the end of the experiment were 5.02±0.07, 5.86±0.08 and 6.13±0.03 kg in lambs of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively and there was a significant difference (P <0.05) among the three experimental groups with higher weight gain was in T<sub>2</sub> group lambs than other groups.

It was noticed that average daily body weight gains were 55.85±0.73, 65.11±1.40 and 68.09±1.93g in lambs of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively and no significant difference noted between T<sub>1</sub> and T<sub>2</sub> groups, while significantly (P<0.05) lower weight gain was observed in lambs of T<sub>0</sub> group. It was also revealed that the FCR was significantly (P<0.05) higher in T<sub>0</sub> group than T<sub>1</sub> and T<sub>2</sub> groups during all the fortnights. But overall mean FCR of all fortnights in lambs of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups was 7.27±0.56, 6.44±0.43 and 6.24±0.39, respectively with no significant difference among them.

By studying the haematological parameters, it was noticed that the White Blood Cells (WBC) levels at the end of the experiment were 11.72± 1.44 x10<sup>3</sup>/mm<sup>3</sup>, 11.55± 1.47 x10<sup>3</sup>/mm<sup>3</sup> and 12.23± 1.79 x10<sup>3</sup>/mm<sup>3</sup> for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively and there was no significant difference (P < 0.05) among experimental groups. The mean

Red Blood Cells (RBC) values were  $12.26 \pm 0.26 \times 10^6$  / micro litre,  $12.79 \pm 0.35 \times 10^6$  / micro litre and  $12.82 \pm 0.32 \times 10^6$  / micro litre in lambs fed with T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> diets, respectively and there was no significant ( $P < 0.05$ ) difference among the control and Moringa supplemented groups. The estimated mean haemoglobin values at the end of the experiment were  $11.20 \pm 0.37$ ,  $10.47 \pm 0.39$  and  $10.01 \pm 0.51$  g/dl in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively and there was no significant ( $P < 0.05$ ) difference observed in haemoglobin values among the experimental groups. The estimated mean haematocrit values were significantly ( $P < 0.05$ ) higher in T<sub>0</sub> ( $31.08 \pm 0.42$  %) group, whose values were comparable to T<sub>1</sub> ( $27.98 \pm 1.09$  %) group. The lowest haematocrit values were noticed in T<sub>2</sub> ( $25.93 \pm 1.35$  %) group and the values were also comparable with T<sub>1</sub> group.

The Mean Corpuscular Volume (MCV) at the end of the experiment was  $24.08 \pm 0.36$ ,  $24.9 \pm 0.67$  and  $24.88 \pm 0.32$  fl in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively with no significant ( $P < 0.05$ ) difference was observed in MCV values among the experimental groups. Relatively higher MCV values were observed in lambs fed with diet containing *Moringa* leaf meal (T<sub>1</sub> and T<sub>2</sub>) when compared to control group (T<sub>0</sub>). The Mean Corpuscular Haemoglobin (MCH) values at the end of the experiment were  $10.62 \pm 2.56$ ,  $8.43 \pm 0.17$  and  $8.22 \pm 0.09$  pg in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. No significant ( $P < 0.05$ ) difference was observed in MCH values among the experimental groups. The Mean Corpuscular Haemoglobin Concentration (MCHC) values at the end of the experiment were  $33.65 \pm 0.72$ ,  $33.46 \pm 0.94$  and  $33.73 \pm 0.74$  g/dl in T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively with no significant ( $P < 0.05$ ) difference among the three experimental groups.

The study of biochemical parameters resulted that the estimated values of serum total protein and albumin in growing Nellore lambs were  $6.33 \pm 0.19$ ,  $6.30 \pm 0.26$  and  $6.58 \pm 0.18$  g/dl;  $2.81 \pm 0.27$ ,  $3.26 \pm 0.05$  and  $2.94 \pm 0.21$  g/dl for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively and there was no significant difference ( $P < 0.05$ ) in total protein and serum albumin values among the three experimental groups. Similarly there was no significant difference in serum glucose (ranged from  $78.17 \pm 2.59$  to  $84.94 \pm 4.14$  mg/dl) and cholesterol concentration (ranged from  $108.54 \pm 7.51$  to  $126.13 \pm 10.69$  mg/dl) among the experimental groups.

The estimated values of Serum Glutamic Oxaloacetic Transaminase (SGOT) were  $56.26 \pm 1.67$ ,  $59.36 \pm 4.32$  and  $60.26 \pm 1.97$  IU/L and values of Serum Glutamic

Pyruvic Transaminase (SGPT) were  $45.01 \pm 2.84$ ,  $47.82 \pm 2.21$  and  $51.20 \pm 1.61$  IU/L at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups, respectively. In the present study, no significant difference was observed in SGOT and SGPT values among the lambs in all the three experimental groups and were within the normal physiological range. Thus from the observations it was revealed that inclusion of *Moringa oleifera* leaf meal in the diet of growing lambs did not alter liver function.

The estimated values of Blood Urea Nitrogen (BUN) were  $11.69 \pm 0.39$ ,  $11.22 \pm 0.66$  and  $10.80 \pm 0.54$  mg/dl at the end of the experiment for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> dietary groups, respectively with no significant difference between them. All the values of biochemical parameters were within the normal physiological range which indicate that the incorporation of *Moringa oleifera* leaf meal does not affect the health condition of growing lambs.

By studying anthelmintic effect of *Moringa oleifera* it was found that, the mean EPG (Egg Per Gram) of faeces recorded were  $108.33 \pm 8.33$ ,  $22.22 \pm 8.24$  and  $25.00 \pm 7.13$  at the end of 90 days trial period for the three groups of T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub>, respectively. The EPG count were significantly ( $P < 0.05$ ) higher in T<sub>0</sub> when compared to T<sub>1</sub> and T<sub>2</sub> with no significant difference observed in Moringa supplemented groups (T<sub>1</sub> and T<sub>2</sub>) which indicate that inclusion of Moringa in growing lamb's diet will reduce the helminthic parasitic load.

The study of cost economics revealed that, the cost per kg body weight gain in growing Nellore lambs fed with experimental diets was Rs. 131.34, 111.15 and 105.44, respectively for T<sub>0</sub>, T<sub>1</sub> and T<sub>2</sub> groups which suggests that the total cost and cost of production per one kg of meat was lower in T<sub>1</sub> and T<sub>2</sub> group lambs which received concentrate mixture containing *Moringa oleifera* leaf meal than control group lambs.

Based on the results obtained from the present study the conclusions derived are as follows:

1. The chemical analysis indicated that the Moringa leaf meal is rich in CP content and could be used as an alternative natural protein source in livestock feeds.
2. The study revealed that the incorporation of MOLM as protein supplement at the rate of 30 per cent in the conventional concentrate ration improved the weight gains in Nellore lambs.

3. Body weight and average daily gains were significantly higher in lambs fed with 30% of MOLM while, the observed feed conversion efficiency was significantly higher with 30% of *Moringa oleifera* leaf meal.
4. The mean daily dry matter intake was higher in lambs fed with experimental diet containing 30% MOLM incorporation than 15% and 0% incorporated diets.
5. Feeding of MOLM didn't affect the haematological parameters viz., WBC count, RBC count, haemoglobin, haematocrit, mean corpuscular volume, mean corpuscular haematocrit, mean corpuscular haemoglobin concentration.
6. Incorporation of MOLM as protein supplement did not have any negative effect on serum biochemical parameters viz. total protein, albumin, glucose, cholesterol, SGOPT, SGPT and BUN levels in lambs. This indicate that feeding of MOLM does not cause any adverse affect on the health of the lambs.
7. Inclusion of MOLM in diet of growing lambs significantly reduced the EPG count at 30% level which suggests Moringa has anthelmintic properties. However, further research is needed to find out the antiparasitic attributes of *Moringa oleifera*.
8. The average feed cost per kg body weight gain in growing Nellore lambs fed with MOLM incorporated diet (30%) was found to be more economical. Hence, it is recommended that conventional protein supplement in the concentrate mixture of sheep could be replaced with 30% MOLM to reduce the cost of feeding.

Hence it can be concluded that the scope for incorporation of *Moringa oleifera* leaf meal as an unconventional natural protein feed source in diets of growing lambs is feasible and economical at 30 per cent level and recommended without any negative harmful effects. However, further research using large number of lambs with similar objective is needed before giving final recommendation regarding the use of *Moringa oleifera* leaf meal as a feed ingredient in growing lamb's diet.

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