

*Affectionately dedicated to
my beloved parents who have
strived to make me what I am*

Tetemke

**EFFECT OF FEEDING DIFFERENT LEVELS OF CRUDE
PROTEIN ON GROWTH PERFORMANCE AND CARCASS
TRAITS IN DECCANI LAMBS**

By

Tetemke Kidane Gebrehiwot

Reg. No. 05/236 (II)

A Thesis submitted to

**MAHATMA PHULE KRISHI VIDYAPEETH
(AGRICULTURAL UNIVERSITY),
RAHURI- 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA STATE, INDIA**

in partial fulfilment of the requirements

for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

ANIMAL SCIENCE

**DEPARTMENT OF ANIMAL SCIENCE AND DAIRY SCIENCE
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-423 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA**

2008

M. P. K. V., LIBRARY, RAHURI
ACC No. T-6463
Call No. 636/TET

**EFFECT OF FEEDING DIFFERENT LEVELS OF CRUDE
PROTEIN ON GROWTH PERFORMANCE AND
CARCASS TRAITS IN DECCANI LAMBS**

By

TETEMKE KIDANE GEBREHIWOT

Reg. No. 05/236 (II)

A Thesis submitted to

**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI- 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA STATE (INDIA)**

in partial fulfilment of the requirements for the degree

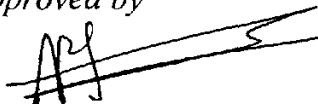
of

MASTER OF SCIENCE (AGRICULTURE)

in

ANIMAL SCIENCE

Approved by




Dr. A. P. Fernandes

Chairman and Research Guide



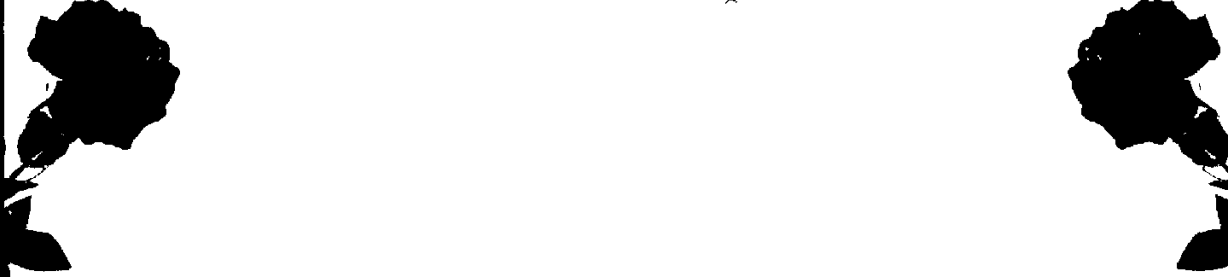
Dr. B. R. Ulmek
Committee Member



Dr. D. P. Kaledhonkar
Committee Member

**DEPARTMENT OF ANIMAL SCIENCE AND DAIRY SCIENCE
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-423 722**

2008



*Affectionately dedicated to
my beloved parents who have
strived to make me what I am*

Tetemke





v

Dr. A. P. FERNANDES

M. Sc. (Agri.), Ph. D.,

Senior Scientist,

Network Project on Pandharpuri Buffalo,

Zonal Agricultural Research Station, Shenda Park, Kolhapur,

Mahatma Phule Krishi Vidyapeeth, Rahuri.

CERTIFICATE

This is to certify that the thesis entitled, “**EFFECT OF FEEDING DIFFERENT LEVELS OF CRUDE PROTEIN ON GROWTH PERFORMANCE AND CARCASS TRAITS IN DECCANI LAMBS**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **ANIMAL SCIENCE**, embodies the results of a *bona-fide* research work carried out by **Mr. Tetemke Kidane Gebrehiwot**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigations and source of literature has been duly acknowledged.

Place : MPKV, Rahuri

Dated: 15/03/2008

(A. P. FERNANDES)

Chairman and Research Guide

Dr. C. B. GAIKWAD

Associate Dean,

Post Graduate Institute,

Mahatma Phule Krishi Vidyapeeth,

Rahuri – 413 722, Dist. Ahmednagar,

Maharashtra, India



CERTIFICATE

This is to certify that the thesis entitled, “**EFFECT OF FEEDING DIFFERENT LEVELS OF CRUDE PROTEIN ON GROWTH PERFORMANCE AND CARCASS TRAITS IN DECCANI LAMBS**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **ANIMAL SCIENCE**, embodies the results of a *bona-fide* research work carried out by **Mr. Tetemke Kidane Gebrehiwot**, under the guidance and supervision of **Dr. A. P. Fernandes**, Associate professor, Network Project on Pandharpuri buffalo, ZARS, Kolhapur. It is sufficiently high standard to warrant its submission to the University for the award of the said degree. No part of the thesis has been submitted for any other degree or diploma.

Place : MPKV, Rahuri

Dated: 24/12/2008

(C. B. Gaikwad)

Associate Dean (PGI)

CANDIDATE'S DECLARATION

*I hereby declare that this thesis or part
thereof has not been submitted by me
or another person to any other
University or Institute
for a Degree or
Diploma.*

Place : MPKV, Rahuri

Dated : 15 / 03 / 2008


(Tetemke kidane)

ACKNOWLEDGMENTS

Words can not express my profound sense of gratitude and devoted thanks to respected Chairman of my Advisory Committee and Research Guide, Dr. A. P. Fernandes, Senior scientist, MPKV, Kolhapur, for his scholastic teaching, intellectual inspiration, dualistic and insightful guidance, practical wisdom, constant encouragement, constructive and keen criticism and unfailing enthusiasm in the course of this investigation and preparation of the manuscript.

I am extremely thankful to member of my Advisory Committees, Dr. B. R. Ulmek, Ex-Head, Department of Animal Science and Dairy Science and the now Associate Dean, College of Agriculture, Pune, and Dr. D. P. Kaledhonkar, Assistant Professor, Department of Statistics, MPKV, Rahuri for their valuable and timely suggestions, critical comments and encouragement during the course of the research work.

I am highly obliged to Dr. A. S. Jadhav, Dean Faculty of Agriculture and Dr. C. B. Gaikwad, Associate Dean, PGI, MPKV, Rahuri for providing necessary facilities and supports during the course of my study in the University.

I wish to extend my sincere thanks to Dr. Y. G. Fulpagare, Senior Scientist and In-charge Head, Department of Animal Science and Dairy Science and , MPKV, Rahuri, for his valuable suggestions, guidance and providing necessary facilities and supports during the course of my research work.

I am deeply thankful to Dr. S. D. Mandakmale, Senior Scientist and Dr. V. E. Narwade , Network Project on Sheep Improvement, MPKV, Rahuri, for their guidance, constant inspiration and making facilities available for successful completion of this investigation. I am thankful to all the farm workers, especially Mr. Pawar and Mr. Jagtap for their helps rendered during data collection.

I wish to express my sincere thanks to Dr. U. Y. Bhoite, Associate Professor, Department of Animal Science and Dairy Science, MPKV, Rahuri for his guidance and encouragement.

I am thankful to the past and present authors, whose literature has been cited.

I am thankful to the Government of Ethiopia, particularly the Ministry of Education for awarding the scholarship and providing me the opportunity to do my Master's degree in abroad.

I am also thankful to Mekelle University for giving me the opportunity to pursue a Master's degree and leave of absence.

I would like to express my gratitude to Mr. Gamini Wickramarathe, Sri Lankan Ph.D. student for his best wishes, comments and encouragements.

I also wish to express my appreciation to my dear friends and Colleagues, Mr. Ali Mohammed, Mr. Alemayehu Tadesse and all international students at MPKV, Rahuri for their encouragement and company during the course of my study in India.

I take this golden opportunity to express my heartiest thanks to Mr. Seifu Gebrehiwet and Mr. Fisseha Adhanom for their continuous encouragement and support to my parents.

I am extremely indebted to my mother Akheza Kahsay; my brothers Mr. Gebre-Egzihabiher, Mr. Gebrehiwot, Mr. Hailay, Mr. Fisseha and my sister Mrs. Beriha , who took pains to bring me up to this stage and with out their love, affection, care and blessings, I would never have made it this far.

Upon completion of a final draft of my master's degree thesis, I certainly recall my late father Mr. Kidane Gebrehiwot who sacrificed his life building the ladder. 'Ayani', your last wish have been fulfilled, may your soul rest in peace.

Place : MPKV, Rahuri

Date : 15 / 03 / 2008

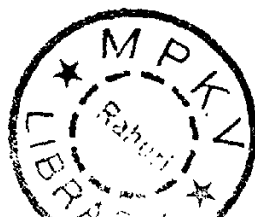

(Tetemke Kidane)

CONTENTS

Title	Page No.
CANDIDATE'S DECLARATION.....	iv
CERTIFICATE	
Research Guide.....	v
Associate Dean (P.G. I).....	vi
ACKNOWLEDGMENTS.....	vii
CONTENTS.....	ix
LIST OF TABLES.....	xii
LIST OF FIGURES.....	xiii
LIST OF PLATES.....	xiii
LIST OF ABBREVIATIONS/SYMBOLS.....	xiv
ABSTRACT.....	xv
1. INTRODUCTION.....	1
2. REVIEW OF LITRERATURE.....	5
2.1 Dry mattre intake.....	5
2.2 Growth performance.....	7
2.2.1 Effect of level of protein on DM intake and growth performance.....	9
2.2.2 Effect of sex on intake and growth performanc.....	11
2.2.3 Feed conversion efficiency and feed gain ratio.....	12
2.3 Digestibility of feed nutrients.....	14
2.4 Protein utilization by sheep.....	15
2.5 Nitrogen balance.....	16
2.6 Correlation of body weight with body measurments.....	17
2.7 Blood urea nitrogen and total blood protein.....	19
2.8 Carcass traits.....	21
2.8.1 Effect of intensive feeding on dressing percentage.....	22
2.8.2 Percent of carcass cuts.....	23

2.9	Organoleptic evaluation of mutton	24
2.9.1	Flavour	24
2.9.2	Juiciness	25
2.9.3	Texture	25
2.9.3	Colour	26
3.	MATERIAL AND METHODS	27
3.1	Experimental location and climate	27
3.2	Description of experimental animals used.....	27
3.3	Preparation of experimental diets	28
3.4	Animals and their management	30
3.5	Methods adopted for recording of observations	31
3.5.1	Feed intake and growth performance	31
3.5.2	Feed conversion efficiency (FCE) and feed gain ratio(FGR).....	31
3.5.3	Digestibility trial	32
3.5.4	Laboratory analysis.....	33
3.5.5	Blood biochemical profile	33
3.5.6	Body measurement	34
3.5.7	Carcass evaluation	34
3.5.7.1	Procedure followed for slaughtering	34
3.5.7.2	Organoleptic evaluation	34
3.5.8	Economics.....	37
3.6	Statistical analysis.....	37
4.	RESULTS AND DISCUSSION	39
4.1	Feed intake, growth performance and feed efficiency.....	39
4.1.1	Dry matter and crude protein intake	39
4.1.2	Growth performance	42
4.1.3	Feed conversion efficiency and feed gain ratio	45
4.2	Body measurements.....	47
4.3	Correlation coefficients	50

T-6463



4.3	Correlation coefficients.....	50
4.3.1	Dietary protein level, DM intake, CP intake and gain in weight...	50
4.4.2	Body weight with body measurements.....	50
4.4	Blood urea nitrogen and blood total protein.....	54
4.5	Metabolism trial of experimental feed.....	56
4.5.1	Intake and digestibility of treatments feed.....	56
4.5.2	Nitrogen balance	59
4.6	Carcass traits.....	61
4.6.1	Slaughter weights and carcass traits	61
4.6.2	Weight of primal cuts in hot carcass.....	64
4.6.3	Proportion of wholesale carcass cuts	66
4.6.4	Offals of slaughtered animals	68
4.6.3	Organoleptic evaluation of mutton	70
4.6	Economics.....	72
5.	SUMMARY AND CONCLUSIONS	75
5.1	Summary	75
5.2	Conclusions.....	81
6.	LITERATURE CITED	82
7.	APPENDICES	94
8.	VITA.....	98

LIST OF TABLES

Table No.	Title	Page No.
1	Material composition of feed ingredients used for treatment feeds	29
2	Chemical composition of treatment feeds fed to lambs	30
3	Dry matter and crude protein intake of experimental lambs	40
4	Growth performance of experimental lambs	43
5	Effect of CP level on feed conversion efficiency and feed to gain ratio	46
6	Body measurements of experimental lambs	48
7	Correlation coefficients of level of protein with DMI, CPI and gain in weight of lambs	51
8	Correlation coefficient of body weight with body measurements	52
9	Blood urea nitrogen and total blood protein of experimental animals	55
10	Intake and digestibility of nutrients of treatment feeds	57
11	Effect of crude protein level on nitrogen balance and nitrogen retention	60
12	Slaughter weight and carcass traits of male lambs	62
13	Weight of primal cuts in hot carcass of male lambs	65
14	Proportion of carcass wholesale cuts of male lambs	67
15	Non-carcass components of slaughtered male lambs	69
16	Organoleptic test of mutton of male lambs	71
17	Economics of feeding of experimental lambs	73

LIST OF FIGURES

Figure No.	Title	In between pages
1	Average daily DM intake of male lambs	40 & 41
2	Average daily DM intake of female lambs	40 & 41
3	Total DM intake of lambs during the experimental period	40 & 41
4	Change in live weight of experimental lambs	44 & 45

LIST OF PLATES

No.	Title	In between pages
1	Experimental lambs in different treatment groups	30 & 31
2	Experimental lambs in different treatment groups	30 & 31
3	Collection of faeces and urine during metabolism trial	58 & 59
4	Dressed carcass of male lambs from different feeding groups	62 & 63
5	Primal cuts of hot carcass	65 & 66
6	Mutton used for sensory evaluation	71 & 72

LIST OF ABBREVIATIONS/SYMBOLS

%	: Per cent
/	: Per
<	: Less than
°C	: Degree of Celsius
ADG	: Average daily gain
BL	: Body length
BWt.	: Body weight
CF	: Crude fibre
CG	: Chest girth
cm	: Centimeter (s)
CP	: Crude protein
CPI	: Crude protein intake
DCF	: Digestible crude fibre
DCP	: Digestible crude protein
dl	: Deciliter
DM	: Dry matter
DMI	: Dry matter intake
DNFE	: Digestible nitrogen free extract
ed.	: Editor
Edn.	: Edition
EE	: Ether extract
<i>et al.</i>	: et alli (and others)
FCE	: Feed conversion efficiency
g	: Gram
HAW	: Height at withers
kg	: Kilogramme (s)
LSD	: Least significant difference
LWt	: Live weight
m	: Meter (s)
mg	: Milligram
ml	: Milliliter (s)
N	: Nitrogen
NFE	: Nitrogen free extract
NS	: Non significant
S.E.	: Standard error
TDN	: Total digestible nutrients
<i>viz.</i>	: Namely
W/V	: Weight by volume

ABSTRACT

EFFECT OF FEEDING DIFFERENT LEVELS OF CRUDE PROTEIN ON GROWTH PERFORMANCE AND CARCASS TRAITS IN DECCANI LAMBS

By

Tetemke Kidane Gebrehiwot

A candidate for

M.Sc. degree in Animal Science

Research Guide : **Dr. A. P. Fernandes**

Department : **Animal Science and Dairy Science**

The present investigation entitled, "Effect of feeding different levels of crude protein on growth performance and carcass traits in Deccani lambs" was conducted at Network Project on Sheep Improvement, Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, for a period of 90 days with the view of identifying the optimum CP level by using the growth performance, feed efficiency, carcass traits and economics of rearing. Thirty two farm born Deccani lambs of 90±5 days age (16 males of 13.88±1.33 kg and 16 females of 13.23 ± 1.55 kg initial weight) were randomly allotted to four treatment groups (T₀, T₁, T₂ and T₃) in factorial randomized block design, each comprising of four males and four females. Four experimental feeds with crude protein levels of 16, 18, 20 and 22 per cent were prepared for T₀, T₁, T₂ and T₃ treatment groups, respectively, with almost similar TDN levels by mixing green lucerne as roughage and prepared feed as concentrate mixtures in 1:1 ratio.

The results revealed that the average daily dry matter intake was significantly (P<0.05) higher in lamb groups fed T₃ feed (788.31 g)

followed by T₂ (681.64 g), T₁ (678.03 g) and T₀ (634.90 g) while no difference among T₂, T₁ and T₀. Crude protein intake observed tended to increase ($P < 0.05$) with increasing levels of dietary CP. The DMI and per cent DMI were significantly ($P < 0.05$) higher in male lambs (765.45 g/d and 3.18) compared to females (625.99 g/d and 2.95), respectively, while no difference was noticed in per cent DMI among treatments groups. The total weight gain and average daily gain (ADG) were significantly ($P < 0.05$) higher in lambs offered T₃ feed (11.21 kg and 124.58 g, respectively) compared to the other treatment groups. Male lambs were significantly ($P < 0.05$) higher in ADG and total weight gain (112.01 g/d and 10.08 kg) against (88.96 g/d and 8.01 kg) for female lambs. No significant differences ($P < 0.05$) in feed conversion efficiency and feed gain ratio were found among treatments groups fed various diets and between sexes. Likewise non significant difference was found in the cost of feed per kg weight gain but the total weight gain was highest for lambs fed T₃ feed; hence, T₃ was found the most economical and T₀ being the least economical feed.

Dietary CP level did not significantly influence ($P > 0.05$) height at withers and body length, while chest girth was significantly ($P < 0.05$) different among treatments groups, which might be due to its higher correlation with weight gain. Live body weight with chest girth ($r = 0.94$), live body weight with height at withers ($r = 0.83$) and live body weight with body length ($r = 0.87$) of lambs were positively and significantly ($P < 0.01$) correlated. Similarly, the gain in weight with CP level ($r = 0.83$), gain in weight with DMI ($r = 0.74$) and gain in weight with CPI ($r = 0.49$) were positively and significantly ($P < 0.01$) correlated.

Blood urea nitrogen (BUN) concentrations increased linearly as dietary crude protein increased. The BUN values recorded fall in the normal physiological range (8 to 20 mg/dl) suggested for sheep. Likewise, total blood

protein increased as dietary CP levels increased. The average digestibility (%) of DM, EE, CF, and NFE were not significant ($P < 0.05$) in all the treatment groups, whereas CP digestibility coefficient was significantly ($P < 0.05$) higher for lambs fed higher dietary CP levels. No difference ($P < 0.05$) were found in the TDN percent and TDN intake of the various treatment feeds. Apparent nitrogen balance was significantly ($P < 0.05$) higher in T_3 (8.15 g/d) as compared to T_1 and T_0 , whilst N retention as percent of intake and N retention as percentage of absorbed were not significantly affected by the various treatments.

The pre-slaughter weight, dressed carcass and hot carcass weight of lambs increased ($P < 0.05$) as dietary CP level increased. However, dressing percentage in terms of empty weight was statistically similar for all the treatment groups. The cut proportion loin, rack, neck and shoulder and breast and shank were affected ($P < 0.05$) by dietary CP levels, while leg was similar between treatments. Significant ($P < 0.05$) differences were observed in liver, testicles and pouch (empty) as percentage of empty body weight; however, the other non carcass components were not different. Organoleptic evaluations of lamb revealed that all treatment groups fall in the range of moderately desirable to very desirable. In terms of sensory attributes, T_2 obtained highest score compared to the other treatments. In summary, using the growth performance, feed efficiency, carcass traits and economics of rearing as yardsticks, 22 per cent CP dietary concentration is suggested as optimum requirement for weaned Deccani lambs.



INTRODUCTION

1. INTRODUCTION

Livestock is an integral and crucial component of Indian farming system. There are 185.18 million cattle, 97.92 million buffalo, 61.47 million sheep, 124.36 million goats, 13.52 million pigs, and 489.01 million poultry in India (Anon, 2006). In spite of the large livestock population size their performance and productivity is poor because of poor nutritional and non-nutritional factors.

Sheep and goat meat is consumed by all the segment of the society without religious and social taboos hence serves as main source of red meat in the country. More than 70 per cent of Indian population is non-vegetarian by choice and that the proportion is increasing progressively with improvement of their social/economic status. The average meat availability in India is 10 g/head/day as against world average of 25 g/head/day (Singh and Karim, 2006). Thus, the estimated consumption of meat in India against the world average consumption is very low. It clearly shows that there is a possibility to increase the availability of meat to meet the requirement.

The consumption of animal protein is high in most of the developed countries. However, it is an occasional or ceremonial recipe in the diet of large segment of the population in the tropical and sub-tropical developing countries. This is attributed mainly due to high cost of meat and low purchasing power of the majority population. Nutritionally, meat is an excellent source of essential amino acids, which are deficient in cereals and legumes and furthermore vital to a lesser extent of certain minerals, vitamins, and essential fatty acids. Meat protein has higher biological value than the plant protein. That is why meat is an economically important and nutritionally valuable food commodity.

T-6463



Sheep rearing is the oldest livestock industry in the arid and semi-arid areas. It is the most appropriate livestock species for utilizing sparse vegetation, tree leaves and pods and most of the weeds. Sheep and goats are considered as important tools for the development of rural families which subsist on activities related to sheep and goat rearing and utilizing their produce.

The productivity of sheep in India and other tropical countries is lower than those in agriculturally developed countries. The major factors contributing to the poor off take are low/less available nutrients from natural pasture, lack of adopting scientific practices of feeding and breeding, shrinkage of grazing land due to intensive crop production and degradation of grazing land. As a result of the above constraints of small ruminant production systems, there is a changing scenario in sheep rearing from extensive to semi-intensive system of farming.

Under semi-intensive rearing of small ruminants, nutrition is an important non-genetic factor that influences the production of animals, since genes are even expressed when the nutrient requirement of the animal is fulfilled. Hence, modern systems of rearing animals based on scientific principles of breeding, feeding, management and health care should be judiciously followed and will remain the only viable option to address the high demand for animal protein by promoting rapid growth rate by fulfilling the animal requirements.

Feed costs account for approximately two-third of the total cost of production on most sheep farms. The growth of lambs is controlled by heredity (20-30%) and nutrition (70-80%) (Campbell and Lasley, 1977), it is therefore important that producers consider nutrition management a top priority. Naturally, the faster a lamb grows the less time it takes to reach

slaughter weight, and therefore the greater the saving in the costs of body maintenance.

Post-weaning growth is generally the fattening and finishing period. Hence, supplying the nutrient needs of the animal represents the single, largest expense in the total cost of raising sheep. Because of this, a solid understanding of the nutrients is necessary in order to minimize the annual cost of production yet maintain optimum production levels. Tropical countries, with limited feed resources, have to economize feeding of sheep by avoiding their wasteful feeding. Efficient utilization of nutrients depends on adequate supply of energy and protein, which is of paramount importance in determining the productivity of sheep. Protein is the basic structural material from which all body tissues (e.g. muscles, nerves and blood cells) are formed.

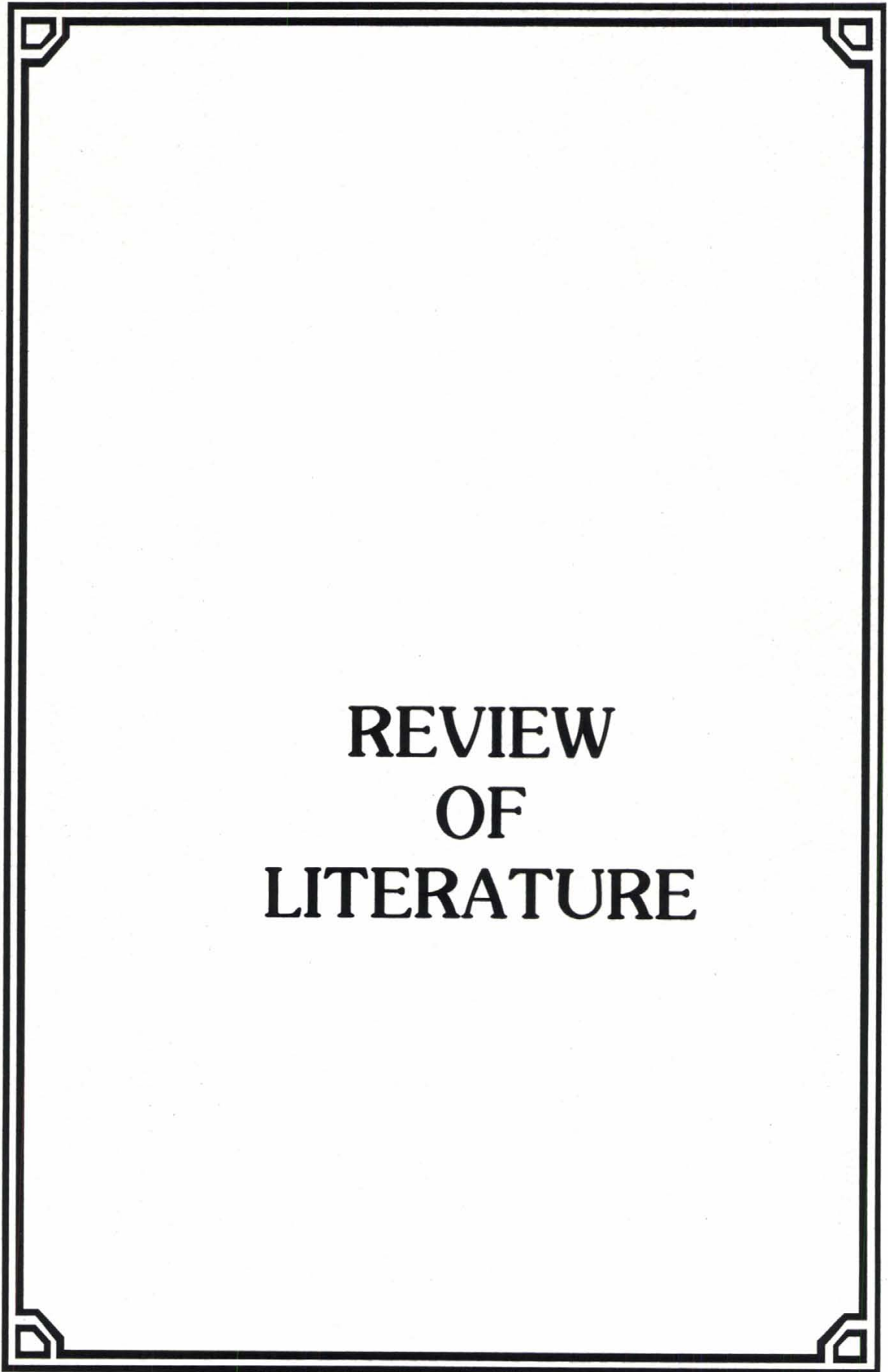
Among the components that make up a ruminant diet, nitrogen expressed as crude protein, either true protein or non-protein nitrogen is noticeably one of the ingredients which receive special attention. Its supplementation at adequate rates is highly relevant, especially in high concentrate diets. Protein requirements suggested by ARC (1980) are smaller than those published by NRC (1985), indicating that additional investigations are necessary on lamb protein requirement, particularly for animals during periods of accelerated growth. Moreover, there is a paucity of data concerning the nutrient requirements of tropical sheep as compared to the immense literature on this subject for the temperate breeds.

Excessive protein impairs performance, as energy is required for removal and loss of nitrogen, especially ammonia, nowadays is getting an environmental concern. Meeting the crude protein (CP) requirements in

modern sheep operations may be more than that just ensuring an abundant supply of crude protein, or diet nitrogen.

Up on the light of these facts, studying the crude protein requirement by assessing the growth performance and carcass traits in response of different levels of CP will have paramount importance for sheep under intensive and semi-intensive production to benefit from the sector. Therefore, the present study was undertaken with the following objectives:

1. To study the effect of feeding different levels of CP on the growth performance of Deccani lambs
2. To study the feed conversion efficiency and carcass traits in Deccani lambs
3. To find out optimum requirement of CP for normal growth of lambs



**REVIEW
OF
LITERATURE**

2. REVIEW OF LITERATURE

In the past years research on sheep management and nutrition, especially the nutrient requirements aspects was not given much attention. Thus, very limited reports are available on the nutritional requirement of sheep in the tropics and subtropics of the world. But to date the improvement of sheep and goats production is attracting researchers, as small ruminant production in the arid and semi arid area of the world is the sustainable livestock production systems due to their wider range of feeding and drought tolerance. Hence, farmers in the dry areas are forced to rear small livestock especially sheep and goat and there also a need for commercialization of the sector. In the foregoing page, an attempt has been made to review some of the works related to growth performance, intake and feed conversion, nutrient utilization, body measurements, carcass traits etc in traditional grazing systems and improved sheep management practices hereunder.

2.1 Dry matter intake

Level of feed intake can greatly affect bottom-line costs in livestock production. Although, lowered amounts of daily intake relate to corresponding decreases in costs of feeding, they also affect ADG and days on feed required to reach a target endpoint.

Ranjhan (1980) while describing the nutritional requirements for the different species in the tropics indicated that dry matter requirement for growing lambs is about 3 – 4 per cent of their live weight.

Wahed and Owen (1986) while comparing the roughage intake of sheep and goat under stall feeding found that when lucerne hay was

offered sheep consumed 28.39g DM/Kg body weight as against 33.2g in goats. When ammonia treated barely straw was offered sheep ate 16.4 g DM as against 21.6g per Kg body weight in the goats.

Tajane *et al.* (1992) stated that the average dry matter intake and dry matter intake per 100Kg body weight during the experimental period of two weeks to be 1.01 ± 0.03 , 1.03 ± 0.03 in the first week and 3.69 ± 0.11 , 3.70 ± 0.12 in the 2nd week in Patanwadi and its half breeds with Rambouillet and Merino.

Aziz *et al.* (1995) reported the daily intake of DM 827 and 1053 g/day during the 0-40 and 41-80 days post weaning periods in Awassi lambs.

Soman (1997) reported that the total dry matter intake in lambs per day averaged 351 to 576 g in stall feeding system, from weaning to six months.

Tripathi (2006) reported effects of free choice tree leaves feeding with restricted or *ad libitum* concentrate supplementation (1.5 per cent and 2.5 per cent body weight and *ad libitum*) on intake of weaner lambs. Lambs concentrate supplemented with 1.5 per cent body weight and *ad libitum* group consumed similar amount of dry matter ($4.2 \text{ kg } 100 \text{ kg}^{-1}$ BW) but 2.5 per cent lambs had significantly higher ($P < 0.01$) dry matter intake ($4.9 \text{ kg } 100 \text{ kg}^{-1}$ BW).

Rokomatu and Aregheore (2006) studied effects of supplementation on voluntary dry matter intake of the Fiji Fantastic sheep on a basal diet of Guinea grass. Treatments were designated as A: Guinea grass (*Panicum maximum*); B: Guinea grass + concentrate mixture; and C: Guinea grass + crushed wheat grain. The results revealed that total DM intake of sheep on forage + concentrate mixture were significantly higher ($P < 0.001$) than those on forage + crushed wheat grain and forage alone.

2.2 Growth performance

Bhatia *et al.* (1980) reported that male and female lambs of 90 days age and managed as (a) grazed for 8 hrs daily on *Cenchrus ciliaris* dominant pasture; (b) grazed as in group 1 plus high energy high protein supplemented *ad lib* and (c) grazed as group 1 plus a low energy low protein supplement *ad lib*. The daily gain in the three groups (males and females) averaged 56.22, 122.28 & 91.86 g, respectively.

Killedar *et al.* (1987) reported the mean for daily weight gain of 0.11 to 0.23 Kg between birth and 3 months of age in Deccani & its half-bred with Merino and Dorset.

Silva and Portugal (1991) evaluated the effects of two diets with different roughage to concentrate ratios (diet 1 - 60 per cent concentrate + 40 per cent roughage; diet 2 - 40 per cent concentrate + 60 per cent roughage) on carcass characteristics, chemical composition of muscle and fat and histological traits of muscle of Merino Precoce lambs. Diet 1 allowed a higher growth rate and a lower feed conversion.

Aziz *et al.* (1995) observed the average daily gain of 160 ± 7.7 & 145 ± 7 g/day during 0 – 40 & 41 – 80 days post weaning periods in Awassi lambs.

Hossain *et al.* (2003) studied the effect of dietary energy supplementation (low and high energy: 10.02 and 11.98 MJ ME/kg DM) to grazing on feed intake, growth and reproductive performance of female sheep. Results showed that, feeding of sheep with increased levels of dietary energy supplementation did not have significant ($P>0.05$) differences for daily average dry matter and crude protein intake.

Patel *et al.* (2004) studied comparative growth performance of weaner lambs on conventional and non- conventional based ration under feedlot system of Marwari and Patanwadi breed, and reported that the lambs grew at the rate of 63.38 and 48.80 g/d to attain 21.35 and 18.51 kg body weight at 11 months of age under conventional and non- conventional treatment groups, respectively.

Tripathi (2006) reported on effects of free choice tree leaves feeding with restricted or *ad libitum* concentrate supplementation (1.5 per cent and 2.5 per cent body weight and *ad libitum*) on growth performance of weaner lambs. The mean average daily gain (ADG) during 0- 90 days feeding increased linearly with higher concentrate feeding but was not statistically different between 1.5 per cent BW (81 g/ day) and 2.5 per cent BW (106 g /day) supplemented animals but *ad libitum* animals had significantly ($P<0.01$) higher (170 g / day) ADG.

Rokomatu and Aregheore (2006) studied effects of supplementation on voluntary dry matter intake of the Fiji Fantastic sheep on a basal diet of Guinea grass. Treatments were designated as A: Guinea grass (*Panicum maximum*); B: Guinea grass + concentrate mixture; and C: Guinea grass + crushed wheat grain. Average daily gains (ADG) were 30, 75 and 42 g/day for forage, forage + concentrate mixture and forage + crushed wheat grain, respectively

Karunanithi *et al.* (2007) reported on growth rate and economics of rearing Mecheri sheep with 250g (group A) and 150g (group B) of concentrate feeding from 3 1/2 to 12 months of age under intensive system of management. The report revealed that the weight gain and average daily weight gain pooled over sexes in group A and B were 10.44 ± 0.56 kg

and 41.12 ± 11.48 g/day and 7.60 ± 0.46 kg and 29.92 ± 9.66 g/day respectively and they were highly significantly different between groups.

2.2.1 Effect of level of protein on DM intake and growth

Andrews & Orskov (1970), testing diets containing cereals ranging in protein concentration from 10 to 20 per cent for Suffolk crosses weighing 20 kg, verified a quadratic response for weight gain, and no weight gain increases were obtained consistently with the increase in protein content above 17.5 per cent.

McGregor and McLaughlin (1980) studied effect of five protein concentrations (9-21 per cent CP) and two digestible energy concentrations, (12.4 and 14.2 MJ DE kg⁻¹ DM) in Merino weaners. The live weight gain and wool growth linearly increased as dietary crude protein concentration increased, and higher energy concentrations reduced live weight gain, and increased wool growth. The authors recommended for high levels of production with Merino weaners, rations should contain at least 18 per cent CP.

Lu and Potchoiba (1990) studied the influence of dietary energy and protein levels on daily DM intake and nutrient utilization of growing Alpine and Nubian goats offered *ad libitum* access to complete mixed diets containing either 2.46, 2.77 or 3.05 Mcal/kg ME plus 11.2, 12.7 or 15.1 per cent CP for 16 week. Average daily gain was 115, 113 and 99 g/d for goats fed diets containing 2.46, 2.77 and 3.05 Mcal/kg ME, respectively. Average daily gain was 104, 106 and 117 g/d for goats fed diets with 11.2, 12.7 and 15.1 per cent CP, respectively. The same authors also reported dry matter intake decreased curvilinearly as dietary ME density increased ($P < .001$) and increased linearly ($P < .05$) as dietary CP level increased.

Manso *et al.* (1998), evaluating three protein sources with levels of 16.5; 22 and 23.7 per cent CP in diet dry matter (DM) for Merino lambs, observed that diets of higher CP contents were better taken in, presented higher average daily gain and better feed conversion. The authors attributed the increased intake to greater ruminal activity and passage rate, and suggested that, since the better results were obtained with diets containing 22 and 23.7 per cent CP, diets containing 16 per cent CP may be insufficient for the adequate growth of the lambs.

Haddad *et al.* (2001) studied CP requirements of finishing Awassi lambs fed five high concentrate isocaloric diets that contained 10, 12, 14, 16, and 18 per cent CP in a totally mixed diets. They found that Lambs fed diets that contained 10, 12, and 14 per cent CP gained less weight than those fed the 16 and 18 per cent CP diets ($P < 0.05$) and suggested that the optimum CP concentration is 16 per cent, any increase above this level will not result in any improvement in production.

Kabir *et al.* (2004) reported the effect of protein supplementation on growth performance in female sheep. Animals were allocated to two feeding regimes [low protein (LP), 168g and high protein (HP), 208g per kg DM] and sheep received the HP diet significantly ($P < 0.05$, $P < 0.01$) improved live weight gain (36.6 vs. 10.7 g/d) compared to those given the LP diet. The authors concluded that supplementary feeding of high protein diet (208g CP per kg DM) significantly increased growth performance of sheep under grazing condition.

Dabiri and Thonney (2004) studied effect of crude protein levels (13, 15, or 17 % CP) in Finnsheep x Dorset lambs and reported that the apparent biological values of nitrogen and average daily gain were lower for lambs fed the diet with 13 per cent crude protein and no significant

difference in gain in weight between lambs fed the diets with 15 or 17 per cent CP.

Kabir (2004) reported the effect of protein supplementation on growth performance in female sheep by allocating in to two feeding regimes [low protein (LP), 168g and high protein (HP), 208g per kg DM] and sheep received the HP diet significantly ($P < 0.05$) improved DM intake (509.0 vs. 425.9 g/d).

Rocha *et al.* (2004) observed the influence of crude protein (CP) levels in ram lambs raised in drylot on a high-concentrate diet (80 per cent concentrate and 20 per cent sugarcane bagasse), there were no differences in average dry matter intake: values of 1.03; 1.02; 1.08 and 1.10 kg per day were obtained for diets containing 14, 16, 18 and 20 per cent CP, respectively.

Soeparn and Davies (2006) reported lambs fed high protein/high energy diet (HP/HE) (20.7 per cent crude protein) grew significantly faster than those lambs fed on a low protein/high energy diet (LP/HE) (10.3 % CP).

2.2.2 Effect of sex on intake and growth performance

Amble *et al.* (1968) reported the average weekly gain in body weight from birth to weaning for male and female Deccani lambs were 0.76 & 0.65 Kg respectively.

Hasmat (1968) reported the growth rate of Nellore and Mandya sheep, males were heavier than females. He further reported that breed and sex of lambs affected the body weights at different periods of life.

Mittal *et al.* (1989) found that female lambs grew significantly faster on moderate concentrate mixture with grazing throughout the day,

whereas the male lambs grew faster on moderate grazing with adequate concentrate mixture. He also stated the growth rates of male lambs were higher than the female lambs under all treatment combination of concentrate and grazing periods.

Kirton (1995) found male Suffolk-cross and Southdown-cross lambs weighed 1.8 kg more than the females at weaning and gained 0.7 kg more between weaning and slaughter. Hammell and Laforest (2000) also observed the effect of sex on growth and intake in Hampshire and Suffolk lambs, males ate more per day, had better gain and were younger at slaughter than females.

2.2.3 Feed conversion efficiency and feed gain ratio

Aziz *et al.* (1995) reported the feed conversion efficiency as 5.48 ± 0.2 and 8.83 ± 0.39 Kg feed intake /Kg live weight gain in Awassi lambs during 0 – 40 and 41 – 80 days post weaning periods respectively.

Haddad *et al.* (2001) studied CP requirements of finishing Awassi lambs fed five high concentrate isocaloric diets that contained 10, 12, 14, 16, and 18 per cent CP in a totally mixed diets. No difference ($P > 0.10$) was observed in feed-to-gain ratio between diets except for the diet that contained 10 per cent CP ($P < 0.05$) which had a lower ratio.

Rocha *et al.* (2004) found the influence of crude protein (CP) levels in ram lambs raised in drylot on a high-concentrate diet (80 per cent concentrate and 20 per cent sugarcane bagasse), there were no statistically differences in feed conversion. Values; 4.19; 4.28; 4.35 and 4.44 kg DM kg⁻¹ gain for diets with 14, 16, 18 and 20 per cent CP, respectively.

Patel *et al.* (2004) reported that the feed conversion efficiency in terms of DM, DCP and TDN per kg gain was significantly influenced by

dietary treatment in Patanwadi breed. Whereas FCE in terms of DM, DCP and TDN kg per kg dressed weight significantly ($P < 0.01$) affect by breed groups.

Dabiri and Thonney (2004) studied effect of dietary levels (13, 15, or 17 per cent CP) in Finnsheep x Dorset lambs and reported feed efficiency was lower for lambs fed diet with 13 per cent crude protein and little difference in feed efficiency between lambs fed the diets with 15 or 17 per cent CP, suggesting that a crude protein level near 15 per cent based on supplemental soybean meal would be optimal for 25 to 40 kg growing lambs.

Soeparn and Davies (2006) reported lambs fed high protein/high energy diet (HP/HE) (20.7 % CP), animals given the HP/HE diets showed significantly superior feed conversion ratio than animals given the LP/HE diets.

Tripathi (2006) reported on effects of free choice tree leaves feeding with restricted or *ad libitum* concentrate supplementation (1.5 per cent and 2.5 per cent body weight and *ad libitum*) on feed conversion ratio (FCR) of weaner lambs. The FCR was higher ($P < 0.01$) in *ad libitum*, while 1.5 per cent and 2.5 per cent BW had similar FCR.

Karunanithi *et al.* (2007) reported on growth rate and economics of rearing Mecheri sheep with 250g (group A) and 150g (group B) of concentrate feeding from 3 1/2 to 12 months of age under intensive system of management. He reported no difference in feed conversion efficiency (dry matter intake/kg live weight gain), the values were 8.78 and 8.72 in group A and B, respectively.

2.3 Digestibility of feed nutrients

Bunting *et al.* (1987) studied the effect of dietary protein level on nitrogen metabolism in lambs using high protein intake (HP; 21 g N/d) or a low protein intake (LP; 12 g N/d). Total tract digestibilities of DM and N were lower ($P < 0.05$) for the LP than the HP treatment.

Willms *et al.* (1991) reported lambs fed diets based on alkaline hydrogen peroxide-treated wheat straw of five dietary CP levels (8.5, 11, 13.5, 16, and 18.5 % CP). Protein level had no effect on extent of dietary CP degradation in the rumen (69 ± 3.2 %) and true ruminal organic matter digestibility increased ($P < 0.01$) linearly and ruminal fluid $\text{NH}_3\text{-N}$ concentration increased ($P < 0.01$) quadratically with increasing CP level.

Haddad *et al.* (2001) studied CP requirements of finishing Awassi lambs fed five high concentrate isocaloric diets that contained 10, 12, 14, 16, and 18 per cent CP in a totally mixed diets. Organic matter and CP digestibility were lowest in lambs fed the 10 per cent CP diet.

Hossain *et al.* (2003) observed the effect of dietary energy supplementation (low and high energy: 10.02 and 11.98 MJ ME/kg DM) to grazing on feed intake, growth and reproductive performance of female sheep. The digestibility of dry matter (DM), organic matter (OM) and crude fibre (CF) significantly ($P < 0.05$) increased as the level energy supplementation was increased. However, the digestibility of crude protein (CP), nitrogen free extract (NFE) and ether extract (EE) was similar ($P > 0.05$) for all dietary energy regimes.

Soeparn and Davies (2006) reported lambs offered varying level of dietary crude protein had little effect upon the apparent digestibility of organic matter (OM) and neutral detergent fibre in the whole tract, the

proportion of NDF digested in the stomach, the total volatile fatty acid concentration (VFA) in the rumen and the proportions of individual VFA.

2.4 Protein utilization by sheep

Protein is an essential dietary element that is necessary for proper soft tissue development in growing lambs. Ruminal microbes possess the ability to digest feeds and synthesize proteins. These microorganisms can either use protein or non-protein nitrogen to synthesize microbial protein (NRC, 1985). Microbial protein so produced, coupled with other dietary proteins that escape ruminal degradation pass through the digestive tract to be absorbed in the small intestine.

Davenport *et al.* (1995) reported abomasal flows of total nitrogen and bacterial nitrogen in growing lambs that increased linearly when the CP levels increased from 9 per cent CP to 12 per cent CP to 15 per cent CP. They also reported an increase in flows of essential and nonessential AA.

Hoffman *et al.* (2001) performed a growth study in which post pubertal heifers were fed diets containing 8, 11, 13 or 16 per cent CP. These researchers observed linear increases in absorbed N as levels of CP increased.

Wand (2003) stated that sheep are capable of recycling dietary and metabolic nitrogen. This recycling is accomplished, by drawing urea from the blood and secreting it during rumination in the saliva. This sparing trait appears to be slightly better developed in sheep than in cattle, so presumably sheep can tolerate low nitrogen rations better than cattle.

2.5 Nitrogen balance

McGregor and McLaughlin (1980) studied effect of five protein concentrations (9-21 per cent CP) and two digestible energy concentrations, (12.4 and 14.2 MJ DE kg⁻¹ DM) in Merino weaners. The total body nitrogen retention increased linearly as dietary crude protein concentration increased.

Bunting *et al.* (1987) studied the effect of dietary protein level on nitrogen metabolism in lambs using high protein intake (HP; 21 g N/d) or a low protein intake (LP; 12 g N/d). Lambs fed HP excreted more ($P < 0.01$) urinary N, yet retained a greater ($P < 0.01$) amount of N than lambs fed LP (6.2 vs 1.8 and 9.7 vs 4.1 g N/d, respectively).

Reddy *et al.* (1989) compared effect of supplementation of protein and energy to forage based ration in Nellore weaner lambs and he found that as the protein source of the concentrate supplement increased the nitrogen balance increased significantly ($P < 0.05$).

Willms *et al.* (1991) reported lambs fed diets based on alkaline hydrogen peroxide-treated wheat straw of six CP levels (6, 8, 10, 12, 14, and 16 per cent of DM), N retention increased quadratically ($P < 0.01$) with increasing CP level. Nitrogen retention, expressed as a percentage of N intake, was greatest for lambs fed 12 per cent CP (20.7 per cent) but was greatest for lambs fed 14 per cent CP when expressed as grams per day (4.0 g/d).

Reddy *et al.* (2002) reported for Deccani lambs fed five complete diets (T_1 = ground cake, T_2 = Raw rapeseed meal (RSM), T_3 = CuSO₄ (0.5 per cent) treated RSM, T_4 = pressure cooked RSM, and T_5 = CuSO₄ (0.5 per cent) + pressure cooked RSM) and showed positive and

significant ($P < 0.05$) nitrogen balance among treatment except T3 and T₅ were at par.

Murthy and Prasad (2002) Nellore male lambs of 3-month age fed isonitrogenous complete rations of different legume proportions combined with concentrate showed significantly different in the range of 6.4 – 12.5 g/d nitrogen balance and non significant nitrogen retention as per cent of absorbed (in the range of 68.4 to 79.3 per cent).

Dabiri and Thonney (2004) reported plasma urea nitrogen values were higher in lambs fed diets with 15 or 17 per cent crude protein; and the apparent biological values of nitrogen, average daily gain, and feed efficiency were lower for lambs fed the diet with 13 per cent crude protein.

Tripathi (2006) reported on effects of free choice tree leaves feeding with restricted or *ad libitum* concentrate supplementation (1.5 per cent and 2.5 per cent body weight and *ad libitum*) on nitrogen balance of weaner lambs. Lambs under all the three feeding regimen had positive N-balance, which was significantly different ($P < 0.01$) among the three groups. The N balance was 3.7, 7.7 and 12.2 g / day respectively in 1.5 per cent, 2.5 per cent BW concentrate supplemented and *ad libitum* offered lambs.

2.6 Correlation of body weight with body measurements

Bhadula *et al.* (1980) reported the phenotypic correlations of weight and linear body measurement in Muzaffanagari sheep from birth to 9 months age and found that correlations were positively and highly significant ($P < 0.05$).

Bhat *et al.* (1980) found the partial regression coefficient of weight on body length and heart girth were highly significant; while, it was

non significant on body height in pre-weaning body measurements in Muzaffanagari and crossbred sheep.

El-Feel *et al.* (1990) described body measurements are considered as qualitative growth indicators which reflect the conformational changes occurring during the life span of animals

Mayaka *et al.* (1995) stated body weight can be reasonably estimated from some linear body measurements in the absence of weighing scales, particularly in rural areas.

Chaturvedi *et al.* (2003) assessed the body weight gain, body confirmation changes to develop the equation to predict the weight based body measurement in lambs fed high concentrate roughage ratio (75:25) diets in Malpura lambs and found that ($R^2 = 86$ per cent) the body height, length, heart girth and paunch girth together can be used in predicting the body weight of intensively fed lambs with 86 per cent confidence.

Fasae *et al.* (2005) studied the linear body measurements of Yankasa ewes kept under the semi-intensive system of management and found high correlation between the body morphometric variables ($r = 0.80-0.97$). Out of which heart girth is observed the best parameter for predicting the live body weight of the animal.

Salako (2006) reported the correlation among the body measurements (live weight, wither height, body length and heart girth) of Yankasa sheep and WAD sheep highly significant ($r = 0.78 - 0.85$). He suggested that out of the body measurements, heart girth ($r = 0.85$) is the best morphometric parameter to estimate the live weight of both the sheep breeds.

Khan *et al.* (2006) observed the relationship of body weight with linear body measurement of different age groups and they found that height at withers has relatively higher correlation values with body weight.

2.7 Blood urea nitrogen and total blood protein

The blood urea nitrogen (BUN) test is a measure of the amount of nitrogen in the blood that comes from urea. Urea is a substance secreted by the liver, and removed from the blood by the kidneys.

Preston *et al.* (1964) reported that when the experimental lambs fed 6.2, 8, 11.7, and 13.5 per cent CP the BUN concentration increased linearly and suggested that the protein status of the lamb can be at least partially assessed by the concentration of the blood constituent. In terms of protein adequacy, a BUN in excess of 10 mg/100 ml would indicate adequate protein intake with the type of rations fed in the experiment.

McIntyre (1970) studied effect of increasing amounts of nitrogen (6.8, 16.8, 23.5, 37.3, and 46.3 g/day) on Plasma urea nitrogen and rumen ammonia levels both increased linearly to about 30 mg/100 ml. At these levels of intake both plasma urea nitrogen and rumen ammonia levels were no longer related to urine nitrogen excretion rates.

Bunting *et al.* (1987) studied the effect of dietary protein level on nitrogen metabolism in lambs using high protein intake (HP; 21 g N/d) or a low protein intake (LP; 12 g N/d). Pool size and production rate for both ruminal NH₃-N and blood urea-N were greater ($P < 0.05$) for the HP than LP treatment. Lambs consuming HP degraded more ($P < 0.05$) blood urea-N in the gastro-intestinal tract (13.4 vs 6.9 g N/d); however, lambs fed LP degraded a greater ($P < 0.05$) percentage of synthesized body urea-N (88.7 vs 71.8 per cent). Ruminal NH₃-N absorption was greater ($P < 0.01$) for the HP

than LP treatment (3.1 vs .5 g N/d). Lambs fed LP incorporated a greater ($P < 0.10$) amount of blood urea-N into bacterial N than lambs fed HP (5.5 vs 2.6 g N/d).

Sahlu *et al.* (1992) studied the effects of dietary CP level (12 and 19 per cent CP) and degradability on mohair fiber production and they found that ruminal ammonia N ($P < 0.05$), Plasma urea N ($P < 0.001$) and total protein ($P < 0.01$) concentration increased as dietary CP level increased.

Phillips *et al.* (2002) reported there is an elevated blood urea nitrogen concentration while studying the digestibility of alfalfa and kenaf pellets fed to lambs and blood urea N levels reflect increased N intakes, and have been used as an indicator of excessive protein intake.

Rocha *et al.* (2004) studied the influence of crude protein (CP) levels in ram lambs raised in drylot on a high-concentrate diet (80 per cent concentrate and 20 per cent sugarcane bagasse) containing 14, 16, 18 and 20 per cent CP, Plasma urea nitrogen concentrations increased linearly as diets contained more CP.

Rokomatu and Aregheore (2006) studied effects of supplementation on voluntary dry matter intake of the Fiji Fantastic sheep on a basal diet of Guinea grass. Treatments were designated as A: Guinea grass (*Panicum maximum*); B: Guinea grass + concentrate mixture; and C: Guinea grass + crushed wheat grain. The authors results revealed that daily protein intakes and BUN concentration were 3.59, 10.39 and 5.60 g/kg^{0.75}/day; and 6.0, 9.7 and 6.0 mmol/l for sheep on forage alone, forage + concentrate mixture and forage + crushed wheat grain, respectively. BUN and glucose concentrations at the post-experimental period are found significantly ($P < 0.001$) higher in sheep on forage + concentrate mixture.

2.8 Carcass traits

Bhatia *et al.* (1981) reported that the dietary protein and energy level has significant effect on the carcass traits.

Nicastro *et al.* (1985) reported the qualitative and quantitative characters of lamb carcass are not affected the source and level of protein.

Silva and Portugal (1991) evaluated the effects of two diets with different roughage to concentrate ratios on carcass characteristics, chemical composition of muscle and fat and histological traits of muscle of Merino Precoce lambs. Diets had no significant effects on carcass characteristics or chemical composition of muscle and fat.

Rocha *et al.* (2004) studied the influence of crude protein (CP) levels in ram lambs raised in drylot on a high-concentrate diet (80 per cent concentrate and 20 per cent sugarcane bagasse) containing 14, 16, 18 and 20 per cent CP, there were no statistically differences in carcass traits.

Patel *et al.* (2004) reported while investigating the growth performance and carcass traits of weaner lambs on non conventional based ration under intensive production system, there was no significant difference between the two treatments in the dressing per cent, weight of primal cuts, edible and non edible offal indicated non significant effects of the dietary treatments on all the parameters.

Pena *et al.* (2005) observed the effects of sex, slaughter weight and carcass weight on carcass characteristics and meat quality traits using Segurena lambs. Carcass weight had a significant influence on “non-carcass” components, dressing percentage, fat deposits, carcass fatness, bone and most carcass measurements. Moreover, the authors reported that sex had a significant effect on age at slaughter, “non-carcass” components, rib

measurements, dressing percentage, fat deposits, and neck and shoulder percentage. As the weight increased, the carcass measurements also increased.

Rohilla *et al.* (2007) reported on Marwari lambs reared under different feeding systems (T1= 8hrs on traditional grazing, T2= *ad libitum* feeding on local crop by-product/ grains + grazing, and T3= *ad libitum* standard animal feed of 20 per cent CP and 70 per cent TDN) showed that the total weight of non-offal cuts (leg, loin, Rack, neck and shoulder, and breast and fore shank) obtained from lambs reared under T2 and T3 was significantly ($P < 0.05$) more by 43.85 and 55.38 per cent, respectively

There were significant differences among the lamb groups for the weight of the head, skin, feet, lung, liver, kidney, internal fat, gastrointestinal tract and testes ($P < 0.05$). The lean, bone and fat weight, backfat thickness and *musculus longissimus dorsi* area in the carcass increased with increasing slaughter weight.

2.8.1 Effect of intensive feeding on dressing percentage

Lloyd *et al.* (1980) reported that the heavy lamb has higher carcass weight, carcass fat and dressing percentage and less bone: meat ratio as compared to the light weight lambs.

Karim and Verma (2001) finisher lambs under intensive feeding (complete feed containing 50:50 ground pala (*Zizyphus nummularia*) leaf and concentrate) and free grazing + 300g/head/day, the dressing percentage in terms of pre-slaughter weight was similar in the two groups while the dressing yield in terms of empty live weight was higher ($P < 0.01$) in the intensively fed lambs as compared to the second group.

2.8.2 per cent of Carcass cuts

Mehrez *et al.* (1977) reported feed intake could be reduced if the rumen ammonia concentration is limiting the rate of fermentation in the rumen.

Lee (1986) reported no significant effect of nutrition on the weight of Omental, kidney plus channel or mesenteric fat depots.

Burrin *et al.* (1990) have reported that there exists a relationship between nutrition level and visceral organ size and metabolic activity whereby the level of feed intake changes the relative proportion of visceral organs to body mass.

Taylor and Murray (1991), Black (1983) and Butler-Hogg (1984) reported nutrition is known to have influence on fat deposition in all parts of the body and at all stages of weight gain.

Karim and Verma (2001) reported in finisher lambs under intensive feeding had higher ($P < 0.01$) depot fat than that of supplemented group. They also found that cut proportion leg, loin, rack was similar in the two groups while the proportion of neck and shoulder was higher in confined lambs and breast and fore shank was higher in the supplemented group.

Karim *et al.* (2007) reported that six-month-old finisher lambs of the Kheri breed raised under extensive range management (G1), grazing with *ad libitum* concentrate supplementation (G2) or intensive feeding (G3) showed higher pre slaughter weight (PSW), empty live weight (ELW), hot carcass weight and hot carcass weight with edible offal ($P < 0.01$) in G2 and G3 fed on a high plane of nutrition than G1 raised under extensive range management. The cut proportions pooled for the three groups averaged 33.2

, 12.3, 13.3, 24.9 and 16.3 per cent of half carcass for leg, loin, rack, neck and shoulder and breast and fore shank, respectively.

2.9 Organoleptic evaluation of mutton

The major factors that determine the quality of meat are: flavour, colour, juiciness, tenderness and overall acceptability.

2.9.1 Flavor

Kemp *et al.* (1980) compared pasture only, pasture plus creep (13 % CP), or dry lot plus creep at two protein levels (13 % or 16 % CP) for effects on lamb flavor intensity. Lamb from animals which solely grazed pasture rated the highest, intense for flavor; whereas, lamb from animals grazing pasture plus creep had the lowest, most desirable flavor ratings.

Rousset-Akrin *et al.* (1997) reported higher, more intense sheep meat flavors for ram lambs finished on pasture with a slow rate of growth compared to those finished on concentrates (42 % corn and wheat diet) or on pasture with a high rate of growth. The same authors observed that the basic flavour of meat is related to water soluble compounds in the muscle, such as sugars, amino acids and nucleotides, which are common to different breed, sex, system of management, nutrition, and post slaughter treatments of the carcass, can all affect carcass fat and hence the flavour of the meat.

Borton *et al.* (1999) reported more off-odors and off-flavors in loin chops from lambs finished on ryegrass compared to concentrates.

Duckett and Kuber (2001) reported that lamb from fine-wool breeds have more intense flavor than coarse-wool breeds. The same authors reported that lamb fat has a very unique aroma and flavor and several compounds (branched chain fatty acids, carbonyl compounds, sulfur-

containing compounds, lipid oxidation products, phenols, and basic compounds) impact lamb flavor.

Borton *et al.* (2005) reported higher incidence of off odor and off flavour in cooked muscle from forage against concentrate fed lambs.

2.9.2 Juiciness

The juiciness of meat is perceived in two ways, first the sensation of moisture in the first moments of mastication produced by the rapid release of juices, followed by the slow release of serum and the stimulating effect of fat on the secretion of saliva.

Borton *et al.* (2005) reported juiciness is related to water holding capacity and marbling. In conjunction with tenderness, it accounts for the over all eating quality. In meat research, Juiciness is usually determined by sensory evaluation or inferred from the measures of water in meat, such as water holding capacity and cooking losses. Cooked meat from concentrate fed lambs received higher over all acceptability scores.

2.9.3 Texture

Meat texture is perceived as a combination of tactile sensations resulting from the interaction of the senses with physical and chemical properties, such as toughness, moisture and elasticity. Toughness can be defined as the ease with which meat can be cut and masticated, and is principally related to the muscle proteins. It is, however, also affected by intramuscular fat, the structure of the connective tissue, the size of the muscle bundles, rigidity and water retention capacity.

Kemp *et al.* (1980) found that high planes of nutrition increase the tenderness of lamb meat through an increase in intermuscular fat and a relative decrease in muscle collagen



T-6463

2.9.4 Colour

Ledward (1992) reported meat colour, one of the most important criteria in initial selection by the consumer, is related to the concentration of pigments (iron), mainly myoglobin. Myoglobin is the basic pigment in fresh meat and its content varies with production factors such as feeding system, species, animal age, sex, exercise and type of muscle and muscular activity

**MATERIAL
AND
METHODS**

3. MATERIAL AND METHODS

The present investigation entitled “Effect of feeding different levels of CP on growth performance and carcass traits in Deccani lambs” was conducted at Network Project on Sheep Improvement under the Department of Animal Science and Dairy Science, MPKV, Rahuri.

3.1 Experimental Location and Climate

The area is located 160 Km northeast of Pune city and categorized under the scarcity zone of Maharashtra state. It is situated at an elevation of 495 to 589 meters above sea level on 19°47' to 19°57' North latitude and 79°19' East longitude. The mean annual precipitation approximates to about 475 mm with an average maximum temperature recorded is 39⁰C in the month of May and the average minimum temperature recorded is 10.8⁰C in the month of December. The minimum and maximum relative humidity of the area are 39.55% (March) and 73.99% (August), respectively (see appendix IV). The area has three distinct seasons such as, Rainy (June to October), winter (November to February) and summer (March to May).

3.2 Description of experimental animals used

Deccani (Sangamneri strain) is one of the promising breed of sheep in Maharashtra state, India. It is hardy with great capacity to walk for long distance and thin tailed sheep. The name “Deccani” is derived from “Deccan plateau” of the central India (74 ° to 78 ° longitude and 14 ° to 22 ° latitude) where this breed is usually found. The All India Co-ordinated

Research Project (AICRP) on Deccani sheep breeding for mutton was initiated at MPKV, Rahuri in the year 1977.

Cross breeding of Deccani sheep with exotic breeds like Dorset and Soviet Merino was carried out for improvement in mutton and wool production. However, it was observed that the survivability of these crossbreds in comparison with Deccani sheep was poor under field conditions. Under these circumstances, the Indian Council of Agricultural Research (ICAR) converted to AICRP on sheep breeding to Network Project on Deccani Sheep Improvement from 1992 with a mandate to carry out survey and genetic improvement of Deccani sheep through selection. Sangamneri strain of Deccani sheep is found to be superior over the other strain in regard to its body conformation, growth and reproductive performance.

3.3 Preparation of experimental diets

Four different concentrate mixtures varying in CP and keeping almost similar TDN levels were prepared on the farm. The different ingredients used in the concentrate mixtures were maize grain, wheat bran, groundnut cake, soybean (roasted), mineral mixture and common salt. Nutrient composition was calculated as per Banerjee (2005). The chemical composition of feed ingredients used for preparing treatment feeds are presented in Appendix III. The details of material composition of the concentrate mixtures prepared on the farm are presented in Table 1.

Four different experimental complete feeds were prepared by mixing the farm prepared concentrate mixtures and roughage (*Medicago sativa*) to contain 16,18, 20 and 22% CP in the ratio of 1:1 (concentrate : Roughage) used for T₀, T₁, T₂ and T₃, respectively. The actual analyzed

crude protein composition of the treatment diets were 16.25, 18.10, 20.00, and 22.05 % CP for T₀, T₁, T₂ and T₃, respectively. Fresh lucerne about 50% flowered were harvested from the farm plots and kept exposed to sunlight for about two hours before feeding to the experimental lambs to reduce the moisture content. Chemically determined nutrient composition on dry matter basis of the experimental treatments is presented in Table 2.

Table 1. Material composition of feed ingredients used for treatment feeds
(Per 100 kg feed on DM basis)

Ingredient (kg)	T ₀	T ₁	T ₂	T ₃
Maize	27.00	22.00	21.00	18.00
Wheat bran	17.00	18.00	13.00	12.00
Soybean (roasted)	1.50	4.50	8.00	8.00
Groundnut cake	1.50	2.50	5.00	9.00
Mineral mixture	2.00	2.00	2.00	2.00
Common salt	1.00	1.00	1.00	1.00
Lucerne	50.00	50.00	50.00	50.00
Total	100	100	100	100

Table 2. Chemical composition of treatment feeds fed to lambs
(% on DM basis)

Treatments	CP	EE	CF	TA	NFE
T ₀	16.25	3.61	15.56	9.17	55.43
T ₁	18.10	4.25	16.73	9.78	51.14
T ₂	20.00	4.50	16.44	9.10	50.00
T ₃	22.05	4.81	16.63	8.87	48.84

Note:

- Each value is mean of six observations

3.4 Animals and their management

3.4.1 Experimental animals and their randomization

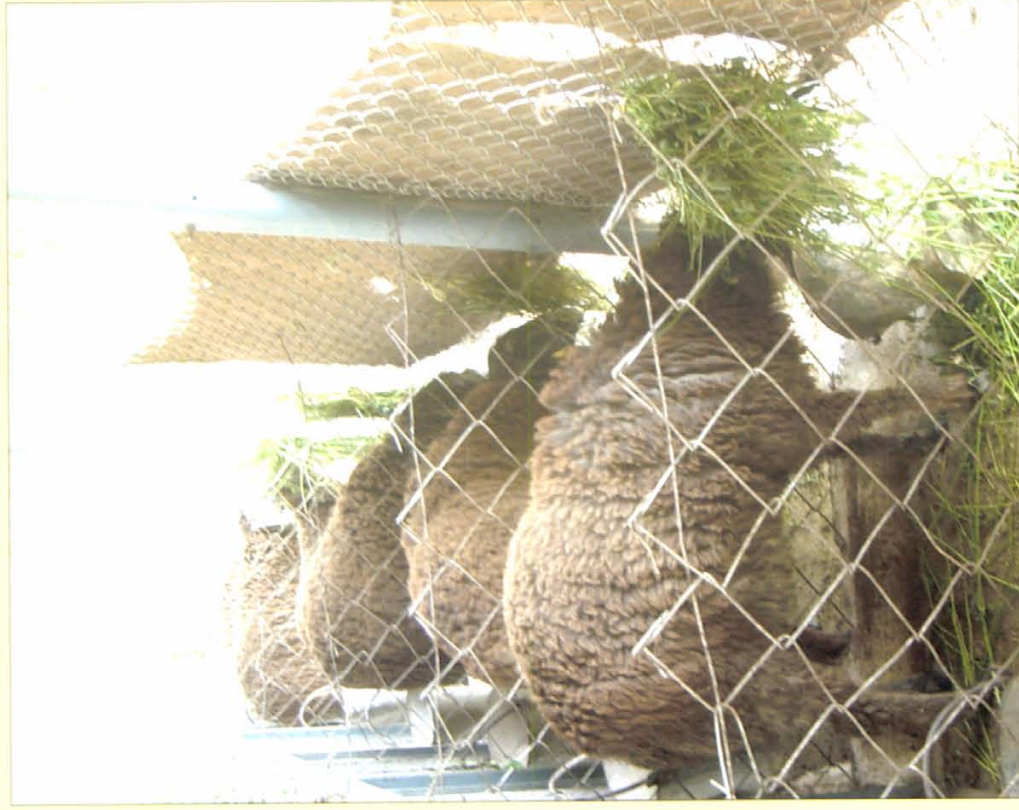
Thirty two farm born Deccani lambs of 90±5 days age (16 males of 13.88±1.33 kg and 16 females of 13.23 ± 1.55 kg) were selected and weighed before the commencement of the experiment. Based on their initial (weaning) body weight, animals were blocked in to four groups. Lambs were randomly allocated to four treatments (T₀, T₁, T₂ & T₃) in a factorial randomized block design (FRBD). Each group comprising four lambs from both sexes and individual animal was considered as replication.

3.4.2 Feeding and housing of lambs

The experimental animals were dewormed for internal parasites before the beginning of the experiment. The lambs were adapted to the experimental feed and facilities for two weeks before taking experimental measurements. The amount of concentrate and lucerne provided and refused was measured during the pre-experimental period.



Treatment - T_0



Treatment - T_1

Plate 1 . Experimental lambs in different feeding groups



Treatment - T₂



Treatment - T₃

Plate 2 . Experimental lambs in different feeding groups

Lambs were fed individually as per the Indian feeding standards i.e. 4 kg dry matter per 100kg body weight. After the commencement of the experimental observation, the concentrate feed and lucerne requirement of lambs were calculated fortnightly by considering preceding body weights. The animals were given their required quota of concentrate mixture at 8.00 A.M and half of the green lucerne at 9:00 A.M and the remaining in the afternoon at 3:00 P.M. Fresh and clean drinking water was made available free of choice to all the lambs.

Each of the experimental lambs was kept in individual compartment, having approximately 12 sq.ft. floor space. The compartments were disinfected before starting of the experiment and were daily cleaned thoroughly for hygienic conditions.

3.5 Methods adopted for recording of observations

3.5.1 Feed intake and growth performance

To calculate daily feed intake, amounts of concentrate and roughage offered to and refused by each individual animal were recorded daily. The left over feed were collected and measured next day in the morning. To study the growth performance of the experimental animals, weekly body weight of lambs were recorded using a 0.1 kg precision scale in the morning before offering their daily ration.

3.5.2 Feed conversion efficiency (FCE) and Feed gain ratio (FGR)

The feed conversion efficiency (FCE) of each experimental animal was worked out for the different treatment groups using the following formulae:

$$\text{FCE} = \frac{\text{Body weight gain (kg)}}{\text{Dry matter consumed (kg)}} \times 100$$

The feed gain ratio was calculated as the ratio of feed consumption to total weight gain during the experimental period.

$$\text{FGR} = \frac{\text{Dry matter consumed (kg)}}{\text{Total live weight gain (kg)}}$$

3.5.3 Digestibility trial

At the end of three months experimental period, a digestion trial of 7 days duration was conducted as per the method suggested by Crompton and Harris (1969) and compiled by Krishna and Ranjahan (1991). To calculate the digestibility of nutrients, the lambs were fed daily with required quantity of ration from the treatment feed in the morning and in the afternoon. The feed offered was recorded during feeding time and the leftover was recorded next day in the morning.

3.5.3.1 Sampling of feed and fodder

Samples of concentrate and roughage offered to and refused by each individual animal was collected and taken daily to estimate dry matter. At the end of 7 days collection period all samples were mixed and a representative sample of 500 g was used for proximate analysis as per A.O.A.C. (1990).

3.5.3.2 Sampling of faeces

The faeces voided during 24 hours by the individual lambs were collected daily. For dry matter determination 1/10th part of the total faeces voided was weighed in an enameled tray and dried in hot air oven at

100±5°C for 24 hours and transferred to numbered paper bags. For nitrogen determination, every day an aliquot 1/20th part of total faecal was weighed and preserved with 40 per cent of sulphuric acid (w/v) in plastic bottle as per the procedure described by Krishna and Ranjhan (1991).

3.5.3.3 Sampling of urine

The daily total urine was collected in plastic container over a 50 ml of 25% sulphuric acid solution (V/V) as per Sastry et al. (1999) to prevent ammonia volatilization. Representative sample i.e. 1/10th of the total volume of urine voided was taken for nitrogen determination. At the end of the metabolism trial pooled urine sample for each animal was used for nitrogen estimation.

3.5.4 Laboratory analysis

All the diets, faecal and urine samples collected during the course of the study were analyzed for proximate nutrient contents following standard procedures. The dry matter and total ash contents of samples of offered and refused diets, and faeces were determined as per the described procedure by A.O.A.C. (1990). Ether extract (EE), Crude fibre (CF), nitrogen free extract (NFE) and crude Protein (CP= N x 6.25) of offered and refused diets were determined as per the procedure described by Sastry *et al.* (1999).

3.5.5 Blood biochemical profile

In the last week of the growth trial period, blood samples were collected in the morning before offering feed and water from the jugular vein of experimental animals. Immediately after collection the blood samples were kept in ice box for transportation. The blood samples were analyzed for blood urea nitrogen (BUN) and total protein (TP) by using

VITROS DT60 II chemistry system as per the procedure described by Anon (2001).

3.5.6 Body measurements

Linear body measurements were taken together with body weight measurements. All body measurements were taken with a measuring tape in centimeter and measured to the nearest 0.5 cm. The following linear body measurements were taken:

- I. **Chest girth** : the circumference of the chest posterior to the forelegs at right angles to the body axis
- II. **Height at wither**: the highest point measured as the vertical distance from the top of the shoulder to the ground
- III. **Body length**: the distance between the point of shoulder and the pin bone

3.5.7 Carcass evaluation

3.5.7.1 Procedure followed for slaughtering

At the end of the growth trial (at the age 6 months) male lambs from each treatment viz. T₀, T₁, T₂, and T₃ were slaughtered to assess the carcass characteristics. The lambs were fasted/ kept away from feed for 16 hrs before slaughtering. Pre-slaughter body weight was taken shortly before slaughtering. This weight was taken as the slaughter weight on which the calculation of dressing percentage on live weight basis.

In this slaughtering process, the lambs were slaughtered by traditional Halal method. The throat of the animal was cut right up to the spinal cord with a sharp knife and the cut animal were placed in such a way that there will be easy bleeding. After 10 to 15 minute the blood completely

oozed out from the jugular vein, there after the weight of the lamb was taken to work out the weight of oozed bleed from the lamb.

The carcass was hanged on a clutch hook and the skin was removed at the abdominal viscera and via the legs by putting the folded hands between skin and viscera. Then the head and hooves of fore and hind legs were detached from the hanging carcass and weighed for each animal.

The incision was taken in the middle of abdominal and plucks. The visceral fat was also removed from the viscera and then the different body organs, stomach along with and with out content, intestine with and with out content, testicles, heart, liver, kidneys, lungs and trachea and spleen weight were recorded. The carcass weight referred to hereafter, except where otherwise stated indicates the weight of dressed carcass with out head, feet and pluck.

Loin eye area of longissimus dorsi muscle at 13th rib level was recorded by tracing its out line on a paper. The tracing was placed on a graph paper and all the squares falling with in the tracing were considered. Nevertheless, squares with more than half of their size occurring outside the tracing were rejected for counting. The area was expressed in cm².

I. Primal cuts

After the removal of the edible and non-edible internal parts from the carcass, the cuts were made as per the Indian Standard Institute Brochure specification (Anon, 1963) and were weighed separately. Carcass was divided in two five major cuts viz. leg, loin, rack, breast and foreshank, and neck and shoulder. Each cut weight was recorded and expressed as percentage of carcass weight.

II. Dressing percentage

The dressing percentage was calculated on two bases:

A. Dressing percentage on live weight basis(DPLW)

$$DPLW = \frac{\text{Weight of hot carcass}}{\text{Pre-slaughter weight}} \times 100$$

B. Dressing percentage on empty body weight basis (DPEW)

$$DPEW = \frac{\text{Weight of hot carcass}}{\text{Empty live weight}} \times 100$$

Where;

Empty live weight = Pre-slaughter weight – weight of digestive tract contents

Hot carcass = Dressed carcass – weight of gastro intestinal tract and fluck

Dressed carcass = Weight of slaughter animal after bleeding and removal of skin, head and hooves.

III. Meat: Bone ratio

To find out the proportion of meat to bone, the carcass cuts were deboned by sharp knife. Then the scrapped bone of the different cuts was boiled in 20% Sodium hydroxide solution.

3.5.7.2 Organoleptic evaluation of mutton

The hedonic scale (9 point) suggested by Peryam and Pilgrim (1957) was used to evaluate mutton samples for appearance, tenderness, flavour, colour, juiciness, texture, chewiness and overall acceptability. For the sensory evaluation, 100g of meat was taken from each primal cut, thoroughly mixed after cutting in the form of cubes. One percent salt was added to each sample and cooked in pressure cooker for 15 minutes. After cooking the meat samples were cooled to room temperature. Panels of 12 semi-trained judges were selected for the sensory evaluation. Precautions

were taken to avoid the biasness in judging by using code numbers. The judges were requested to wash their mouth in between the use of two different samples. The score card used during the present investigation is presented in Appendix II.

3.5.8 Economics

The cost of feed incurred during the experimental period was calculated by adding the market price of each ingredient to estimate the cost of feed per kg gain of the experimental animals. The price of each ingredients used for the preparation of concentrate mixture and roughage is presented in Appendix-V.

3.6 Statistical analysis

The experimental data with respect to feed intake, growth performance and body measurements were analysed by Factorial Randomized Block Design (FRBD) and the data with respect to digestion trail, carcass traits and economics were analysed by Randomized complete Block Design (RBD). The analysis was done following statistical procedure outlined by SAS system for windows (1996). Least significant difference (LSD) was used to detect significant differences between means.

FRBD model:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + y_k + (\beta y)_{jk} + e_{ijk}$$

Where, Y_{ijk} = the yield or response from j^{th} unit receiving i^{th} feed

μ = general mean effect

α_i = effect due to i^{th} feed (CP level)

y_k = effect due to sex

β_j = effect due to block (replication)

$(\beta y)_{jk}$ = Effect due to interaction

e_{ijk} = random error

Simple correlation coefficients were also calculated to find out the relationship of body measurements with live weight, protein intake with DMI and gain in weight.



**RESULTS
AND
DISCUSSION**

4. RESULTS AND DISCUSSION

The results of the present investigation with respect to the “Effect of feeding different levels of crude protein on growth performance and carcass traits in Deccani lambs” are presented and discussed below.

4.1 Feed intake, Growth performance and Feed efficiency

4.1.1 Dry matter and crude protein intake

The results pertaining on dry matter and crude protein intakes are presented in Table 3

From the results obtained in Table 3, it is observed that the average daily dry matter intake (DMI) due to effect of feed was significantly ($P<0.05$) higher in T_3 (788.31g) followed by T_2 , T_1 and T_0 (681.64, 678.03 and 634.90g), respectively. The same trend was observed in total DMI; however, the difference among T_2 , T_1 and T_0 treatments were non-significant in average daily DMI and total DMI. Rocha *et al.* (2004) reported no difference in average dry matter intake fed in dry lot which was reported to be (1.03, 1.02, 1.08 and 1.10 kg d⁻¹) for diets containing 14, 16, 18 and 20% CP diet, respectively. Male lambs had significantly ($P<0.05$) higher total DMI and average daily DMI (68.89 kg and 765.45 g, respectively) as compared to females lambs (56.34 kg and 625.99 g, respectively). Similar results have been reported by Can *et al.* (2004) and Latif and Owen (1980). Reddy *et al.* (2002) reported daily DMI in Deccani ram lambs as 709 to 835 g, which is in agreement with the present study. The effect of interaction on total and daily DMI was significantly ($P<0.05$) highest for male lambs fed T_3 ($T_3 \times M$) and lowest in female lambs fed T_0 ($T_0 \times F$) (Table 3).

Table 3: Dry matter and crude protein intake of experimental lambs

Particular		TDMI (Kg)	Average daily DMI (g/d)	DMI (kg/100Kg BWt)	CPI (g/d)
Feed	T ₀	57.15 ^b	634.90 ^b	3.09	107.78 ^c
	T ₁	61.03 ^b	678.03 ^b	3.07	117.75 ^c
	T ₂	61.35 ^b	681.64 ^b	3.02	137.01 ^b
	T ₃	70.95 ^a	788.31 ^a	3.12	172.44 ^a
S.E. ±		2.72	30.22	0.09	5.55
LSD		7.99	88.89	NS	16.32
Sex	M	68.89 ^a	765.45 ^a	3.18 ^a	147.19 ^a
	F	56.34 ^b	625.99 ^b	2.95 ^b	120.30 ^b
S.E. ±		1.359	15.112	0.047	2.774
LSD		5.656	62.854	0.207	11.540
Interaction	T ₀ xM	61.63 ^{ab}	684.74 ^{ab}	3.15	120.49 ^{bc}
	T ₀ xF	52.66 ^b	585.06 ^b	2.96	95.08 ^c
	T ₁ xM	66.74 ^{ab}	741.48 ^{ab}	3.21	124.11 ^{bc}
	T ₁ xF	55.31 ^b	614.58 ^b	2.92	111.39 ^c
	T ₂ xM	68.98 ^{ab}	766.43 ^{ab}	3.17	154.05 ^b
	T ₂ xF	53.72 ^b	596.86 ^b	2.87	119.97 ^{bc}
	T ₃ xM	78.22 ^a	869.15 ^a	3.22	190.13 ^a
	T ₃ xF	63.67 ^{ab}	707.47 ^{ab}	3.03	154.76 ^b
S.E. ±		3.846	42.743	0.141	7.847
LSD		17.310	192.400	NS	35.320

Note:

T₀xF= female lambs fed T₀ feed, T₀xM= male lambs fed T₀ feed,

T₁xF= female lambs fed T₁ feed, T₁xM= male lambs fed T₁ feed

T₂xF= female lambs fed T₂ feed, T₂xM= male lambs fed T₂ feed

T₃xF= female lambs fed T₃ feed, T₃xM= male lambs fed T₃ feed

- Values bearing unlike superscripts within a column differ significantly (P<0.05)

Figure 1: Average daily DM intake of male lambs

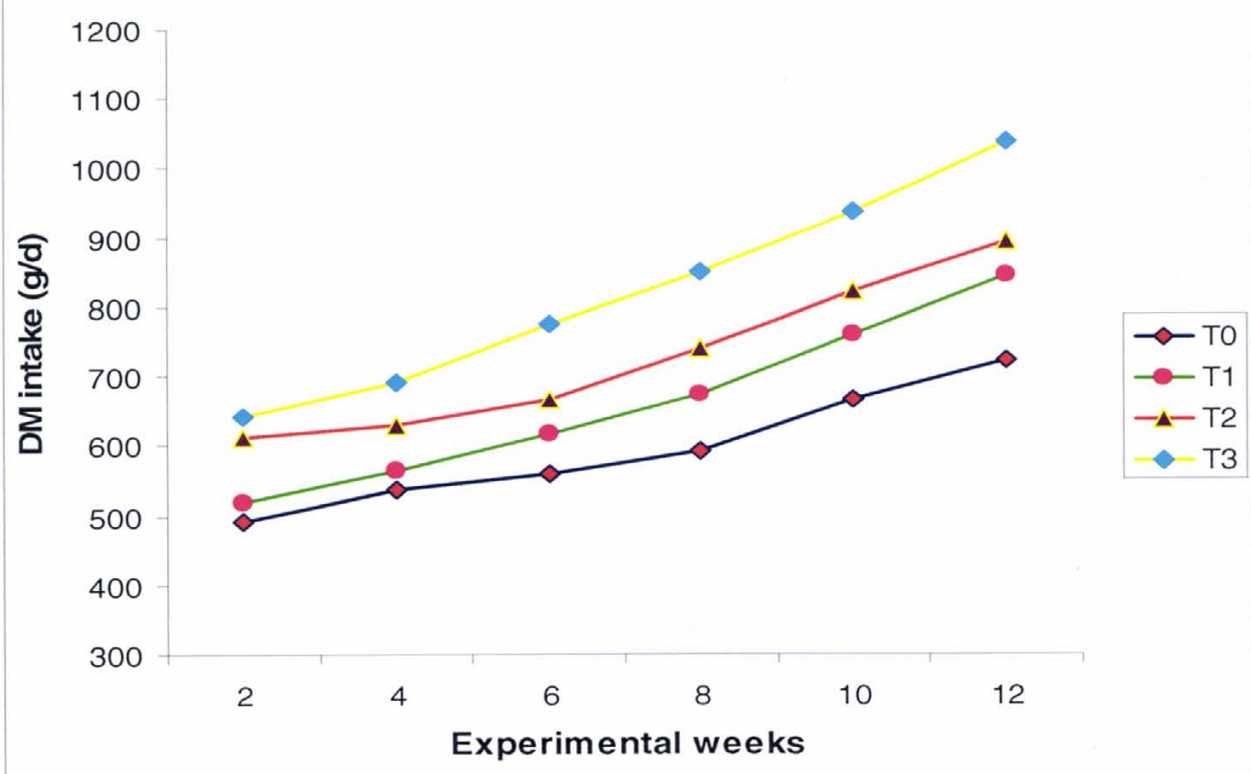


Figure 2: Average daily DM intake of female lambs

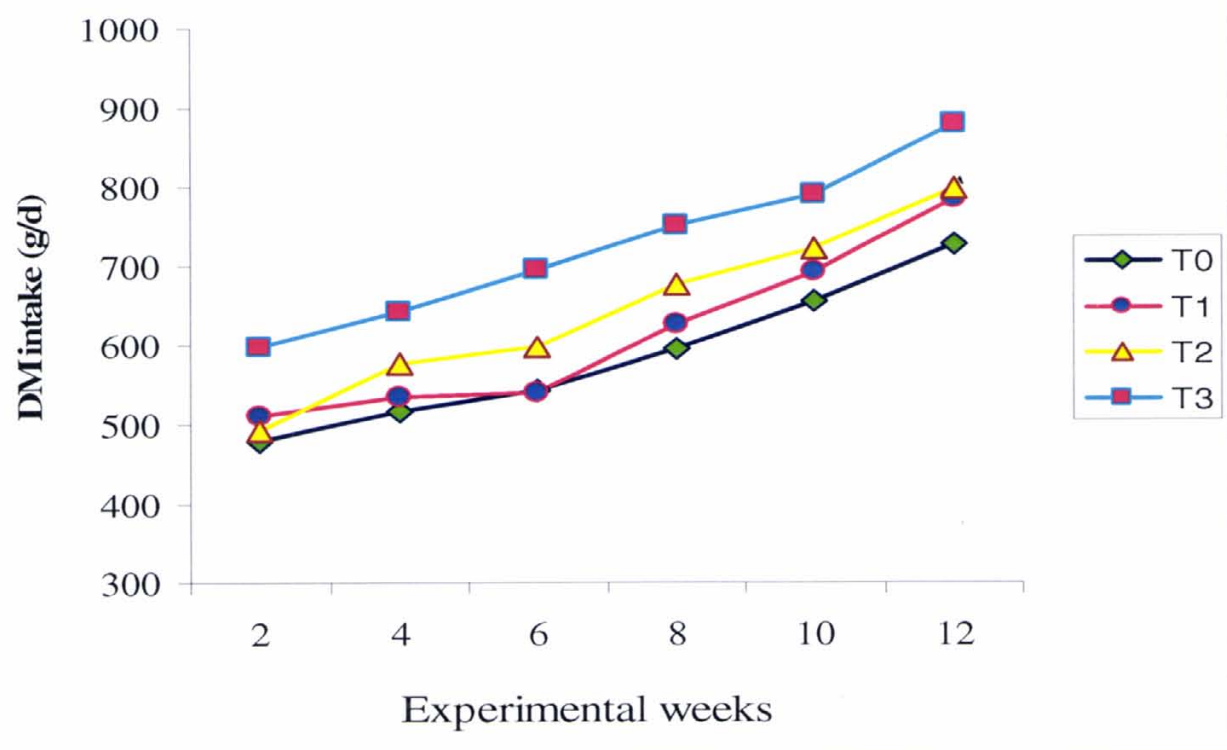
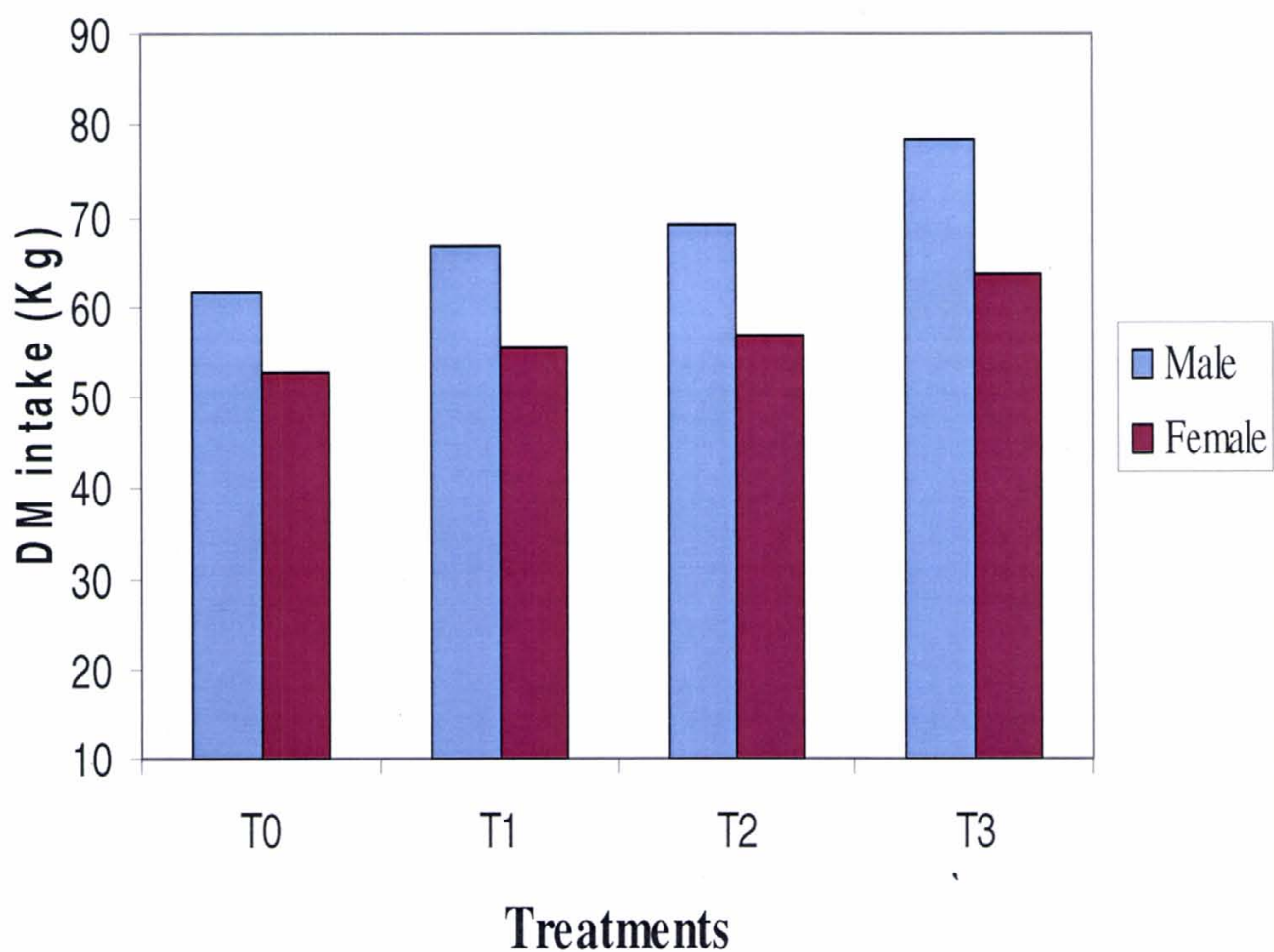


Figure 3: Total dry matter intake of lambs during the experimental period



The average per cent dry matter intake body weight of lambs was slightly higher for lambs fed T₃ (3.12) followed by T₀, T₁ and T₂ (3.09, 3.07 and 3.02, respectively) treatments; however, there was no significant difference among treatment groups. The effect of sex on dry matter intake per cent body weight was significantly ($P < 0.05$) higher in males (3.18%) compared to female lambs (2.95%) whereas there was no effect of interaction on dry matter intake per cent body weight.

The per cent dry matter intake of body weight obtained in the present investigation was lower than observed by Murthy and Prasad (2002) who reported DMI per cent body weight in Nellore male lambs to be 3.3 to 3.8. Similarly, non significant but higher DMI per cent body weight were observed by Tajane *et al.* (1992) who reported as 3.69 and 3.70 for Patanwadi and its half breeds with Rambouillet and Merino, respectively. Tripathi (2006) reported non significant difference in weaner lambs in dry matter intake per cent body weight (4.2 kg 100 kg⁻¹ BW). The variation in per cent DMI might be due to breed difference, kind and physical form of the feed offered to the animals.

The average daily CP intake was significantly ($P < 0.05$) higher in T₃ (172.44 g) followed by T₂ (137.01 g), T₁ (117.75 g) and T₀ (107.78 g). Similarly, highest CP intake was observed in male lambs fed T₃ (T₃xM) and lowest in female lambs fed T₀ (T₀xF) (Table 3). As expected, crude protein intake increased as diet protein level was increased. However, the average crude protein intake of males (147.19 g/d) was significantly ($P < 0.05$) higher than the female lambs (120.30 g/d). This proves that the higher the crude protein in the feed, higher will be the DM intake.

Paul *et al.* (2003) reported the requirement of CP for a 20 kg lamb and gaining 100 g d⁻¹ was reported to be 112 g d⁻¹. In comparison to

the reported findings by the authors, the results of the present study indicated that the CP requirement is fulfilled in all treatments groups. On the other hand, Murthy and Prasad (2002) observed average daily CP intake as 110g in Nellore male lambs which was lower than the results observed in the present study.

4.1.2 Growth performance

The results pertaining to growth studies from weaning to six months of age of lambs in the feedlot trial are presented in Table 4.

The data on the initial body weights revealed that there was no significant ($P<0.05$) difference in body weights of experimental lambs at start of experiment. The initial weight of male lambs was slightly higher as compared to female lambs.

The final live weight of the experimental lambs were significantly ($P<0.05$) different in treatment groups and in both sexes. The final body weight was significantly ($P<0.05$) higher for lambs fed T_3 (25.10kg) followed by T_2 (22.47 kg), T_1 (21.93 kg) and T_0 (20.90 kg), while T_0 , T_1 and T_2 were at par. It was further seen that the average final body weight of male lambs was significantly ($P<0.05$) higher (24.27 kg) compared to female lambs (21.24 kg). Highest final weight was observed in male lambs fed T_3 ($T_3 \times M$) (26.85 kg) and lowest in female lambs fed T_0 ($T_0 \times F$) (19.80 kg). No significant differences were found among the final body weight of $T_2 \times F$, $T_0 \times F$, $T_1 \times F$ and $T_0 \times M$ groups. The above results indicated that there was a linear increase in the final weight as the level of CP per cent increase in the dietary treatments.

Table 4: Growth performance of experimental lambs

Particular		Initial weight (kg)	Final weight (kg)	Total weight gain (kg)	Average daily gain (g/d)
Feed	T ₀	13.16	20.90 ^b	7.75 ^b	86.11 ^b
	T ₁	13.50	21.93 ^b	8.41 ^b	93.49 ^b
	T ₂	13.67	22.47 ^b	8.80 ^b	97.77 ^b
	T ₃	13.88	25.10 ^a	11.21 ^a	124.58 ^a
S.E. ±		0.375	0.743	0.556	6.13
LSD		NS	2.345	1.62	18.03
Sex	M	13.88	24.27 ^a	10.08 ^a	112.01 ^a
	F	13.23	21.24 ^b	8.01 ^b	88.96 ^b
S.E. ±		0.187	0.405	0.276	3.066
LSD		NS	1.682	1.148	12.753
Interaction	T ₀ xM	13.50	22.00 ^b	8.50 ^b	94.44 ^b
	T ₀ xF	13.00	19.80 ^b	7.00 ^b	77.78 ^b
	T ₁ xM	13.53	22.90 ^{ab}	9.37 ^{ab}	104.20 ^{ab}
	T ₁ xF	13.50	20.95 ^b	7.45 ^b	82.78 ^b
	T ₂ xM	14.25	24.10 ^{ab}	9.85 ^{ab}	109.40 ^{ab}
	T ₂ xF	13.10	20.85 ^b	7.75 ^b	86.11 ^b
	T ₃ xM	14.25	26.85 ^a	12.60 ^a	140.00 ^a
	T ₃ xF	13.52	23.35 ^{ab}	9.83 ^{ab}	109.17 ^{ab}
S.E. ±		0.531	1.051	0.786	8.736
LSD		NS	4.730	3.539	39.320

Note:

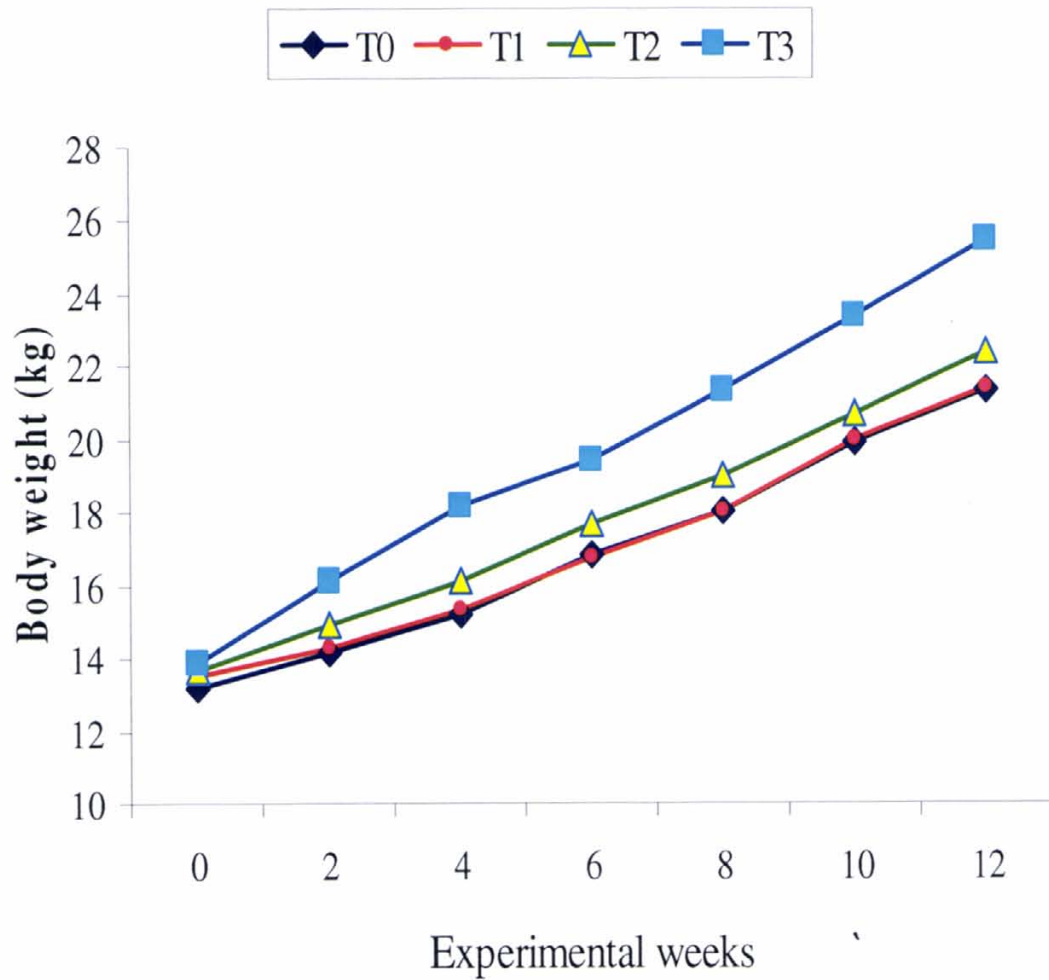
T₀xF= female lambs fed T₀ feed, T₀xM= male lambs fed T₀ feed,
T₁xF= female lambs fed T₁ feed, T₁xM= male lambs fed T₁ feed
T₂xF= female lambs fed T₂ feed, T₂xM= male lambs fed T₂ feed
T₃xF= female lambs fed T₃ feed, T₃xM= male lambs fed T₃ feed

- Values bearing unlike superscripts within a column differ significantly (P<0.05)

The average daily gain (ADG) and total body weight gain were significantly ($P < 0.05$) highest in lambs offered treatment T_3 (11.21 kg and 124.58 g d⁻¹, respectively) and lowest in T_0 (7.75 kg and 86.11g d⁻¹, respectively). However, treatment differences in ADG and total body weight gain in T_0 , T_1 , and T_2 were non significant (Table 4). The effect of sex on ADG was significantly higher in males (112.01 g/d) compared to females (88.96 g/d); similarly, the total gain in weight was higher in male lambs compared to female lambs (10.08 vs. 8.01 kg). The superior growth performance of male lambs may be due to early expression of growth hormones and pubertal stage. This finding agrees with the results reported by Patel (1985) in Dorset x Deccani lambs. Moreover, (Amble *et al.*, 1968; Killedar *et al.*, 1987 and Jagtap and Naikare, 1989) reported higher gain for male lambs compared to female lambs.

The average daily gain and total body weight gain of male lambs fed T_3 ($T_3 \times M$) were significantly ($P < 0.05$) higher (12.60 kg and 140.00 g d⁻¹, respectively) and lowest in female lambs fed T_0 ($T_0 \times F$) (7kg and 77.78 g d⁻¹, respectively), whereas $T_2 \times F$, $T_1 \times F$, $T_0 \times F$ and $T_0 \times M$ groups were similar. When lambs intensively fed with complete ration similar body weight gain (8.10 kg) and ADG (95g d⁻¹) have been reported by Karim and Verma (2001). Kabir (2004) also reported similar trends of growth performance of female lambs fed diets containing 20.8% CP to be significantly higher in live weight gain than 16.8% CP diet. Haddad *et al* (2001) reported 10, 12, and 14% CP fed lambs were gained less weight than those fed 16 and 18% CP diets. The average daily gain of both sexes increased as the levels of the CP increased. Similar results have also been reported by McGregor and McLaughlin (1980) live weight gain linearly increased as dietary crude protein concentration increased and suggested

Figure 4: Change in live weight of experimental lambs



rations should contain at least 18% CP for Merino weaners. Low protein diet influenced the body weight and weight gain of growing lambs (Polkowska *et al.*, 2003) and the magnitude of increase in the live weight might be attributed by the source of the protein that influences the bio-availability or digestibility of the nutrients in the diet. Likewise, growth rate affected by breed and sex at different period of life (Hammell and Laforest, 2000; Kirton, 1995; Mittal *et al.*, 1989; and Hasmat, 1968)

4.1.3 Feed efficiency and feed gain ratio

The results on feed conversion efficiency (FCE) and feed gain ratio (FGR) in different treatments groups are presented in Table 5.

The feed conversion efficiency (kg of weight gain per 100 kg of DM) was relatively higher for lambs fed T₃ (16.09) followed by T₂, T₁ and T₀ (14.53, 13.70 and 13.56), respectively. Likewise the FCE of male and female lambs were 14.64 and 14.22 per cent, respectively. However, there were no differences in FCE in the different treatment groups and in both sexes. No effect of interaction was observed in feed conversion efficiency.

The results revealed that the DM required per kg gain in weight was less (6.40 kg) in T₃ followed by T₂, T₁ and T₀ (6.98, 7.36 and 7.55 kg), respectively. Male lambs had less DM required per kg gain (6.85) compared to female lambs (7.05). However, there were non-significant differences in feed gain ratio among lamb groups and between both sexes. Better but non-significant difference in feed gain ratio were observed by Rocha *et al.* (2004) who reported FGR values of 4.19, 4.28, 4.35 and 4.44 kg DM kg⁻¹ gain for diets containing 14, 16, 18 and 20 per cent CP, respectively, for Santa Ines lambs. Murthy and Prasad (2002) reported feed conversion efficiency of

Table 5: Effect of CP level on feed conversion efficiency and feed to gain ratio

Particular		TDMI (Kg)	Total weight gain (kg)	Feed conversion efficiency (%)	Feed gain ratio
Feed	T ₀	57.15 ^b	7.75 ^b	13.56	7.55
	T ₁	61.03 ^b	8.41 ^b	13.70	7.36
	T ₂	61.35 ^b	8.80 ^b	14.53	6.98
	T ₃	70.95 ^a	11.21 ^a	16.09	6.40
S.E. ±		2.72	0.556	1.18	0.21
LSD		7.99	1.62	NS	NS
Sex	M	68.89 ^a	10.08 ^a	14.64	6.85
	F	56.34 ^b	8.01 ^b	14.22	7.05
S.E. ±		1.359	0.276	0.411	0.207
LSD		5.656	1.148	NS	NS
Interaction	T ₀ xM	61.63 ^{ab}	8.50 ^b	13.79	7.59
	T ₀ xF	52.66 ^b	7.00 ^b	13.35	7.51
	T ₁ xM	66.74 ^{ab}	9.37 ^{ab}	14.04	7.14
	T ₁ xF	55.31 ^b	7.45 ^b	13.49	7.57
	T ₂ xM	68.98 ^{ab}	9.85 ^{ab}	14.51	7.05
	T ₂ xF	53.72 ^b	7.75 ^b	14.56	6.91
	T ₃ xM	78.22 ^a	12.60 ^a	16.53	6.21
	T ₃ xF	63.67 ^{ab}	9.83 ^{ab}	15.66	6.60
S.E. ±		3.846	0.786	1.189	0.586
LSD		17.310	3.539	NS	NS

Note:

T₀xF= female lambs fed T₀ feed, T₀xM= male lambs fed T₀ feed,

T₁xF= female lambs fed T₁ feed, T₁xM= male lambs fed T₁ feed

T₂xF= female lambs fed T₂ feed, T₂xM= male lambs fed T₂ feed

T₃xF= female lambs fed T₃ feed, T₃xM= male lambs fed T₃ feed

- Values bearing unlike superscripts within a column differ significantly (P<0.05)

different complete rations for Nellore male lambs in the range of 7.3 - 10 per cent, which is lower than the values obtained in the presents study. These findings are in line with the findings of Karunanithi *et al.* (2007) who reported no effect on FGR (mean value; 8.75 kg DM kg⁻¹ gain) of lambs fed diets with different protein levels. Similar values (5.48 – 8.83 kg DMI/ kg gain) were reported by Aziz *et al.* (1995). Likewise, Haddad *et al.* (2001) reported no effect of dietary crude protein level on feed conversion of lambs. On the other hand, significantly superior feed conversion efficiency was reported for lambs fed higher dietary crude protein levels (Soeparn and Davies, 2006; Chaturvedi *et al.*, 2003 and Can *et al.*, 2004). The variation in the feed conversion efficiency reported may be attributed to breed of experimental animals (Patel *et al.*, 2004). Moreover, the rate and efficiency of nutrient use for growth may be affected by the digestibility or availability of essential nutrients (protein, energy, Vitamins and minerals).

4.2 Body measurements of lambs

The results related to body measurements of female and male lambs in different treatment groups are presented in Table 6. The results obtained for initial body measurements viz. body length, height at withers and chest girth were non significant ($P < 0.05$) among treatment groups, whereas initial body length was significantly higher in male lambs (52.44 cm) compared to female lambs (50.50 cm). Except body length between sexes at the beginning of the experiment animals were similar in height at withers and chest girth, hence there was no effect of initial measurement on final values. The final body length and height at withers were found non significant ($P < 0.05$) among treatment groups while significant between sexes. Male lambs were longer and taller at the end of the experiment.

Table 6: Body measurements of experimental lambs

Particulars		Body length (cm)		Height at withers (cm)		Chest girth (cm)	
		Initial	Final	Initial	Final	Initial	Final
Feed	T ₀	50.37	61.12	54.12	61.75	54.87	62.25 ^b
	T ₁	51.62	60.62	56.25	63.12	54.75	63.25 ^{ab}
	T ₂	51.25	61.12	55.25	62.25	54.50	63.12 ^{ab}
	T ₃	52.62	63.00	56.23	63.25	56.12	65.75 ^a
S.E. ±		0.859	0.855	0.732	0.643	0.714	0.685
LSD		NS	NS	NS	NS	NS	3.084
Sex	M	52.44 ^a	62.88 ^a	56.06	63.75 ^a	55.75	64.81 ^a
	F	50.50 ^b	60.06 ^b	55.25	61.94 ^b	54.88	62.37 ^b
S.E. ±		0.429	0.182	0.366	0.321	0.357	0.117
LSD		1.786	1.777	NS	1.336	NS	1.425
Interaction	T ₀ xM	52.75	63.50	54.00	63.25	56.25	63.75 ^{ab}
	T ₀ xF	49.00	58.75	53.50	60.25	53.50	60.75 ^b
	T ₁ xM	51.25	61.25	56.75	64.15	55.25	64.00 ^{ab}
	T ₁ xF	52.00	60.00	55.75	61.75	54.25	62.50 ^b
	T ₂ xM	52.00	62.75	56.50	63.00	55.00	64.50 ^{ab}
	T ₂ xF	50.50	59.50	54.00	61.50	54.00	61.75 ^b
	T ₃ xM	53.75	64.00	56.25	64.25	56.50	67.00 ^a
	T ₃ xF	51.50	62.00	57.75	63.25	57.73	64.50 ^{ab}
S.E. ±		1.215	1.208	1.035	0.909	1.010	0.969
LSD		NS	NS	NS	NS	NS	4.362

Note:

T₀xF= female lambs fed T₀ feed, T₀xM= male lambs fed T₀ feed,
T₁xF= female lambs fed T₁ feed, T₁xM= male lambs fed T₁ feed
T₂xF= female lambs fed T₂ feed, T₂xM= male lambs fed T₂ feed
T₃xF= female lambs fed T₃ feed, T₃xM= male lambs fed T₃ feed

- Values bearing unlike superscripts within a column differ significantly (P<0.05)

Final Chest girth (CG) was significantly ($P < 0.05$) higher for lambs offered T_3 (65.75 cm) followed by T_2 (64.12 cm), T_1 (63.25 cm) and T_0 (63.25 cm) whereas no difference was observed among treatments T_2 , T_1 and T_0 . The significant difference in CG might be due to its higher association with gain in weight. These results are in agreement with the findings of Patel *et al.* (2004) and Chaturvedi *et al.* (2003), who reported the body length and height at wither did not differ significantly due to treatment, while the Chest girths of Malpura male weaner lambs to be significantly different among lambs subjected to different treatment diets.

The results obtained for body length and height at wither at 3 months (initial) and 6 months (final) are in agreement with Chaturvedi *et al.* (2003) who reported for intensively fed Malpura lambs. The values of chest girth are higher than reported by Patel *et al.* (2004). The difference might be attributed to variation in the breed of animals. The higher Chest girth under present study in lambs fed T_3 may be the reflection of accretion of body tissues as the experimental animals subjected to this treatment attained higher body weight compared to the other three treatments. The increased chest girth might be associated with higher weight gain, as body length and height at withers are the measure of bone growth (Pomeroy, 1955; as cited in Jagatheesan *et al.*, 2003). Further, he reported that chest girth is a measure of development of muscle, bone and fat and it has close relationship with live weight. Accordingly, the results from this study extend support to previous studies by showing that Chest girth of Deccani sheep breed can be used to predict body weights especially in rural areas where there is absence of weighing apparatus.

4.3 Correlation coefficients

4.3.1 Dietary crude protein level, DM intake, CP intake and gain in weight

The results of correlation coefficients among crude protein level (CPL), dry matter intake (DMI), crude protein intake (CPI) and weight gain (WtG) are given in Table 7.

From the results obtained it is seen that there was significantly high correlation between CPL and CPI, CPL and weight gain, while non-significant correlations between CPL and DMI ($r=0.30$) was observed.

The results also indicated that there is a positive and high correlation among the protein levels with dietary protein intake and weight gain of lambs in both sexes. Stronger association was observed between CPI and WtG as compared to the association of DMI and WtG. This implicates higher response of gain in weight by increasing the dietary CP within the range of the present dietary protein levels. The present findings are in line with the reports of Nguyen (1998).

4.3.2 Body weight with body measurements

The results of correlation coefficients between live weight (LWt) and body measurements are presented in Table 8.

Body weight showed positive and highly significant correlation with Chest girth ($r = 0.88, 0.96$ and 0.94) in male, female and pooled over sexes, respectively. Similarly, the correlation coefficients between body weight and body length was high ($r = 0.87, 0.83$ and 0.87) in male, female and pooled over sexes, respectively. High and positive correlation was observed between body weight and height at withers ($r = 0.73, 0.87$ and



T-6463

Table 7: Correlation coefficients of level of protein with DMI, CPI and gain in weight of lambs

Parameters	CP level	DM intake	CP intake	Weight gain
CP level	1	0.30 ^{ns}	0.65 ^{**}	0.49 ^{**}
DM intake	-	1	0.91 ^{**}	0.74 ^{**}
CP intake	-	-	1	0.83 ^{**}
Weight gain				1

Note: ns = Non significant

** = Level of significance (P<0.01)

Table 8: Correlation coefficient of body weight with body measurements

Sex	Parameters	Girth	Height	Length	weight
Male	Girth	1	0.70**	0.81**	0.88**
	Height	-	1	0.84**	0.73**
	Length	-	-	1	0.87**
Female	Girth	1	0.86**	0.77**	0.96**
	Height	-	1	0.81**	0.87**
	Length	-	-	1	0.83**
Pooled (M and F)	Girth	1	0.81**	0.82**	0.94**
	Height	-	1	0.85**	0.83**
	Length	-	-	1	0.87**

Note:

** = level of significance ($P < 0.01$)

0.83) in male, female and pooled over sexes, respectively. These results indicated that there is a high correlation ($p < 0.01$) of live weight (LWt) with Chest girth, body length (BL) and height at withers (HAW). CG with LWt had the highest correlation ($r = 0.94$) and HAW with LWt ($r = 0.83$) being the least in the pooled over sexes (Table 8). Further more, the correlation between LWt and CG was much stronger in female than male lambs ($r = 0.96$ vs. 0.88). Comparatively lower correlation ($r = 0.73$) between LWt and HAW was observed in male lambs, which might be because of the increasing height with the development of the limb. The increase in height is probably not in consonance with gain in general body weight.

The present findings are in agreement with the work of Fasae *et al.* (2005) that reported live weight of Yankasa ewes (under semi-intensive management) found to be highly correlated ($p < 0.01$) with Chest girth ($r = 0.97$) and height at withers ($r = 0.82$). Similar results have been reported by Salako (2006) for West African Dwarf (WAD) and Yankasa sheep, and he suggested that out of the body measurements, Chest girth ($r = 0.85$) is the best morphometric parameter to estimate the live weight. The lower values in correlation of the above report may be attributed to nutritional management, environmental condition and breed difference. Chaturvedi *et al.* (2003) observed in Malpura lambs fed high concentrate roughage ratio (75:25) diets and reported that body height, length, Chest girth and paunch girth together can be used in predicting the body weight of intensively fed lambs with 86 per cent confidence. It can be inferred that since the body measurements had high correlation with the body weight, this may be used as measuring criteria; especially CG could best be used to predict the live weight of sheep.

4.4 Blood urea nitrogen and total blood protein

The results related to blood biochemical profiling (blood urea nitrogen and total blood protein) of the experimental lambs have been presented in Table 9.

Dietary treatments of higher CP contents resulted in higher blood urea nitrogen (BUN) concentrations (Table 9). Highest ($P < 0.05$) BUN was observed in T_3 (20.00 mg/dl) followed by T_2 (17.00 mg/dl), T_1 (13.67 mg/dl) and T_0 (12.00 mg/dl); whereas T_1 and T_0 were at par. The dietary CP levels showed a linear effect of BUN concentrations. The BUN values of the present investigation fall within the normal physiological range of 8 to 20 mg/dl suggested for sheep by Sastry *et al.* (1999).

The total blood protein was found to be significantly ($P < 0.05$) higher in T_3 (8.10 g/dl) followed by T_2 (6.93 g/dl), T_1 (5.93 g/dl) and T_0 (5.83 g/dl), whereas T_1 and T_0 were at par. Similar trend has been reported by Sahlu *et al.* (1992), who found that increasing dietary CP level (12 to 19% CP) ruminal ammonia N, Plasma urea N and total protein ($P < 0.01$) concentration increased as dietary CP level increased.

The increase in BUN concentration possibly comes from increasing dietary protein concentration due to an increase in rumen ammonia absorption, resulting in greater amounts of ammonia being used in the liver to synthesize urea. Therefore, urea concentration in blood reflects the ingestion of dietary protein (Thomas *et al.*, 1988) and Rocha *et al.* (2004) found that increasing CP proportion (14 to 20%), plasma urea nitrogen concentrations increased linearly as diets contained more CP. Bunting *et al.* (1987) verified that plasma urea N percentage derived from rumen ammonia absorption was greater for lambs fed diets containing 15.4

Table 9: Blood urea nitrogen and total blood protein of experimental animals

Treatment	Blood urea nitrogen (mg/dl)	Total blood protein (g/dl)
T ₀	12.00 ^c	5.83 ^b
T ₁	13.67 ^c	5.93 ^b
T ₂	17.00 ^b	6.93 ^{ab}
T ₃	20.00 ^a	8.10 ^a
S.E. ±	0.67	0.37
LSD	2.28	1.29

Note :

- Each value is mean of eight observations
- Values bearing unlike superscripts within a column differ significantly (P<0.05)

per cent CP, as compared to lambs fed 8.7 per cent CP (16.5 and 6.1%, respectively). Therefore, elevated BUN and total blood protein levels reflect increased N intakes and can be used as an indicator of excessive protein intake. Higher BUN concentrations indicate an imbalance between ruminal degradable and undergradable protein content (Phillips *et al.* 2002).

4.5 Metabolism trial of experimental feed

4.5.1 Intake and digestibility of treatment feed

The digestibility coefficients of proximate nutrients and digestible nutrients of experimental feed combinations are presented in Table 10:

The total dry matter intake (DMI) observed were 713.94, 673.26, 685.23, and 693.77 (g/d) for lambs fed T₃, T₂, T₁ and T₀ treatments, respectively. Similarly, the dry matter digestibility coefficients were 71.67, 69.69, 69.18, and 68.68 (%) for T₃, T₂, T₁ and T₀, respectively. No difference in DMI and dry matter digestibility coefficient was found for all the treatment diets. These findings are comparable with the reports of Murthy and Prasad (2002) who reported the digestibility values in the range of 70 to 73.9 per cent for complete rations prepared from legume hay and concentrate mixtures. The total digestible DMI was significantly ($P < 0.05$) higher in T₃ (511.48 g/d) as compared to T₂ (469.27 g/d); while treatments T₃, T₁ and T₀ were similar (Table 10). Even though the DMI was not significant among the four treatment groups, T₃ treatment groups showed relatively higher DMI followed by T₀, T₁ and T₂, which may be attributed to variation in nutrient concentrations.

Daily total crude protein intake (CPI) was significantly ($P < 0.05$) higher in T₃ (157.43 g) followed by T₂ (135.17 g), T₁ (126.06 g)

Table 10: Intake and digestibility of nutrients of treatment feeds

Parameter	Treatments				S.E. ±	LSD
	T0	T1	T2	T3		
Body weight (kg)	21.47	21.13	21.27	23.20	1.19	NS
Metabolic body weight	9.94	9.84	9.89	10.57	0.42	NS
DMI (kg/100KgBWt)	3.34	3.30	3.19	3.08	0.18	NS
DMI g/W ^{0.75} kg	71.14	70.31	68.28	67.53	2.96	NS
Total DMI (g/d)	693.77	685.23	673.26	713.94	14.31	NS
a. Digestibility coefficient	68.68	69.18	69.69	71.67	1.19	NS
b. Total digestible DMI (g/d)	476.45 ^{ab}	473.55 ^{ab}	469.27 ^b	511.48 ^a	11.52	39.87
Total CP intake (g/d)	112.61 ^c	126.06 ^{cb}	135.17 ^b	157.43 ^a	3.94	13.63
a. Digestibility coefficient	76.62 ^b	77.69 ^{ab}	79.45 ^{ab}	79.63 ^a	0.83	2.85
b. Total DCPI (g/d)	86.31 ^c	97.99 ^{cb}	107.74 ^b	125.11 ^a	3.86	13.35
Total EE intake (g/d)	24.64 ^{ab}	22.69 ^b	24.89 ^{ab}	29.55 ^a	1.58	5.46
a. Digestibility coefficient	67.35	71.09	70.53	70.97	1.31	NS
b. Total DEE (g/d)	16.61 ^{ab}	16.14 ^b	17.57 ^{ab}	20.97 ^a	1.27	4.39
Total CF intake (g/d)	119.17	117.85	112.25	121.44	5.46	NS
a. Digestibility coefficient	59.75	58.76	61.23	59.61	1.31	NS
b. Total DCF (g/d)	71.17	69.10	68.73	72.43	2.67	NS
Total NFE intake (g/d)	323.40	339.58	315.74	282.94	23.92	NS
a. Digestibility coefficient	70.97	71.09	70.21	71.90	2.45	NS
b. Total DNFE (g/d)	229.73	242.08	221.14	204.32	20.32	NS
Total TDN intake (g/d)	461.24	455.24	451.35	489.75	13.46	NS
TDN (Kg/100 Kg DM)	66.47	66.54	67.03	68.61	1.49	NS
DCP (Kg/100 Kg DM)	12.45 ^c	14.31 ^{bc}	16.03 ^{ab}	17.52 ^a	0.59	2.04

Note:

- Each value is mean of four observations
- Values bearing unlike superscripts within a row differ significantly (P<0.05)

and T₀ (112.61 g). No difference was observed between T₂ and T₁, and T₂ and T₁ in crude protein intake. Crude protein (CP) digestibility coefficient was significantly ($P<0.05$) higher in T₃ (79.63) followed by T₂ (79.45) and T₁ (77.69) and T₀ (76.62). No difference was found among T₂, T₁ and T₀. Similar results were reported by Haddad *et al.* (2001), who found diets containing 10% CP had lowest CP digestibility compared to diets with 12, 14, 16, and 18% CP on Awassi lambs. Moreover, Willms *et al.* (1991), compared five dietary CP levels (8.5, 11, 13.5, 16, and 18.5% CP), true ruminal organic matter digestibility increased ($P<0.01$) linearly and ruminal fluid NH₃-N concentration increased ($P<0.01$) quadratically with increasing CP level. The total digestible crude protein intake (DCPI) was significantly ($P<0.05$) higher in T₃ (125.11 g/d) followed by T₂ (107.74 g/d), T₁ (97.99 g/d) and T₀ (86.31 g/d). No difference was found between T₂ and T₁, and T₂ and T₁ in DCPI.

There was no difference in digestibility coefficients of ether extract (EE) among treatments (Table 10); while the total digestible EE was significantly ($P<0.05$) higher in T₃ (20.97g/d) as compared to T₁ (16.14 g/d), and T₃, T₁ and T₀ were similar. This may be attributed to the proportion of Soybean and GNC in the treatment diets. No significant ($P<0.05$) differences were observed in both digestible crude fibre intake and digestibility per cent of crude fibre for all treatment diets. Similarly, there was no significant difference in digestibility coefficient (%) and total digestible nitrogen free extract (NFE) intake. Daily TDN intake and TDN % were found to be not significant ($P<0.05$) among treatments. Treatment diets were formulated to have similar TDN and fulfill the recommended requirement of the animals. It may be the reason for no difference observed in TDN.



Plate 3 . Collection of faeces and urine during metabolism trial

4.5.2 Nitrogen balance

The results related to nitrogen intake, outgo and balance obtained from the *in vivo* digestion trial are presented in Table 11.

From the results obtained, among the feed combinations, nitrogen intake (g/d) was higher in T₃ (21.18) followed by T₁ (18.64), T₂ (18.66), and T₀ (17.43). However, treatment difference was not significant in nitrogen (N) intake. The values for nitrogen outgo through faeces in T₃, T₂, T₁ and T₀ were 4.66, 4.33, 4.31 and 4.14 g/d, respectively and there was not significant difference among treatments. The daily nitrogen outgo through urine was significantly ($P < 0.05$) highest in T₃ (8.47 g) compared to other treatments. Non significant difference in nitrogen outgo (g/d) through urine among T₂ (6.83), T₁ (7.09) and T₀ (6.71) was observed. Similar results have been reported by Bunting *et al.* (1987) who verified that lambs fed high protein (21 g N/d) excreted significantly ($P < 0.01$) higher (6.2 g/d) urinary N, yet retained a greater ($P < 0.01$) amount of N (9.7 g/d) than lambs fed 12 g N/d (excreted 1.8 and retained 4.1 g N/d).

The apparent nitrogen balance of the treatment diets fed to lambs were found positive and significantly ($P < 0.05$) higher in T₃ (8.15 g/d) followed by T₂ (7.47 g/d), T₁ (7.25 g/d) and T₀ (6.71 g/d). Treatments T₃ and T₂, and T₂, T₁ and T₀ were at par. This result proves significantly increased ADG of lambs in the feeding trial as the CP level of the diet increased. These findings are comparable with Tripathi (2006), who reported the nitrogen balance of concentrate supplemented weaner lambs in range of 3.7 to 12.2 g/day. Similarly, Murthy and Prasad (2002) reported nitrogen balance of 6.4 to 12.5 g/d for male lambs fed complete rations (legume + concentrate). Further, McGregor and McLaughlin (1980) reported for five

Table 11: Effect of crude protein level on nitrogen balance and nitrogen retention

Treatment	N intake (g/d)	N outgo through (g/d)		N balance (g/d)	N retention as % of intake	N retention as % of absorbed
		Faeces	Urine			
T ₀	17.43	4.14	6.57 ^b	6.71 ^b	38.45	50.47
T ₁	18.66	4.31	7.09 ^b	7.25 ^b	38.71	50.38
T ₂	18.64	4.33	6.83 ^b	7.47 ^{ab}	40.06	52.24
T ₃	21.28	4.66	8.47 ^a	8.15 ^a	38.29	49.03
S.E.±	1.20	0.25	0.37	0.25	0.94	1.28
LSD	NS	NS	1.29	0.87	NS	NS

Note:

- Each value is mean of four observations
- Values bearing unlike superscripts within a column differ significantly (P<0.05)

protein concentrations (9-21% CP); total body nitrogen retention increased linearly as dietary crude protein concentration increased.

The nitrogen retention as a per cent of intake and absorbed was apparently higher in T₂ (40.06 and 52.24 g/d, respectively) and less in T₃ (38.29 and 49.03 g/d, respectively). However, there was no significant (P<0.05) influence of crude protein level in both N retention as a per cent of intake and absorbed. Murthy and Prasad (2002), observed non significant but higher nitrogen retention as a per cent of absorbed (68.4 to 79.3 %). On the other hand Willms *et al.* (1991) reported increased N retention quadratically (P<.01) with increasing CP level. This may be attributed to the type of treatment feeds offered to experimental animals.

4.6 Carcass traits

The least squares means of carcass traits and organoleptic evaluations are presented from Table 12 to 16.

4.6.1 Slaughter weights and carcass traits

The results related to slaughter weights and carcass traits are presented in Table 12. Slaughtered male lambs fed with T₀, T₁, T₂ and T₃ had average pre slaughter weight of 22.09, 23.33, 25.55, and 27.51 kg, respectively, empty live weight of 18.55, 20.50, 22.63, and 24.09 kg, respectively, dressed carcass of 14.65, 15.89, 18.04, and 19.96 kg, respectively, and hot carcass weight of 9.49, 10.96, 12.33, and 13.38 kg, respectively.

Pre-slaughter weight was significantly (P<0.05) higher in T₃ (27.51 kg) followed by T₂ (25.55 kg), T₁ (23.33 kg) and T₀ (22.09 kg), while no difference was observed between T₁ and T₂ in preslaughter weight.

Table 12: Slaughter weight and carcass traits of male lambs

Treatment	Preslaughter Wt. (kg)	Empty slaughter Wt. (kg)	Dressed carcass Wt. (kg)	Hot carcass Wt. (kg)	Dressing %		Meat : Bone ratio	Loin eye area (cm ²)
					Live Wt. basis	Empty Wt. basis		
T ₀	22.09 ^c	18.55 ^d	14.65 ^c	9.49 ^c	43.01 ^b	51.15	4.55 ^b	15.67 ^c
T ₁	23.33 ^c	20.50 ^c	15.89 ^{bc}	10.96 ^b	46.98 ^{ab}	53.46	4.84 ^{ab}	16.33 ^{bc}
T ₂	25.55 ^b	22.63 ^b	18.04 ^{ab}	12.33 ^a	48.26 ^a	54.58	5.33 ^a	18.00 ^{ab}
T ₃	27.51 ^a	24.09 ^a	19.96 ^a	13.38 ^a	48.64 ^a	55.54	5.35 ^a	19.37 ^a
S.E. ±	0.36	0.35	0.68	0.38	1.36	1.37	0.166	0.57
LSD	1.25	1.22	2.36	1.31	4.71	NS	0.577	1.99

Note :

- Each value is mean of four observations
- Values bearing unlike superscripts in the same column differ significantly (P<0.05)



T₀



T₁



T₂



T₃

Plate 4 . Dressed carcass of male lambs from different feeding groups

Similarly, empty slaughter weight was significantly ($P < 0.05$) higher in T_3 (24.09 kg) followed by T_2 (22.63 kg), T_1 (20.50 kg) and T_0 (18.55 kg). The hot carcass weight was found to increased significantly ($P < 0.05$) with increased in crude protein per cent of dietary treatments.

The dressing percentage in terms of live weight basis (DLW) were 43.01, 46.98, 48.26, and 48.64, and on empty weight basis (DEW) were 51.15, 53.46, 54.58, and 55.54 per cent, respectively in T_0 , T_1 , T_2 and T_3 treatments. The perusal of data revealed that there was significant ($P < 0.05$) difference in the dressing percentages on live weight basis, where T_3 was the highest followed by T_2 and T_1 and T_0 ; whereas T_1 and T_0 were similar. There were a slight increase trend in the dressing per cent on empty weight basis as the concentration of dietary crude protein increased; however, variation was not significant ($P < 0.05$). This could be attributed to higher non carcass components and amount of gut fill at slaughter of T_0 groups that could cumulatively increase the dressing percentage on empty weight basis. Similar results were reported by Patel *et al.* (2004) for weaned lambs fed conventional and non-conventional based ration and Rocha *et al.* (2004) in ram lambs fed different CP levels (14 to 20 % CP). Further, Kemp *et al.* (1976) reported non significant dressing percentage (50 – 52.6%) of lambs fed 10, 13, 16 dietary protein. The findings correspond with Rohilla *et al.* (2007), who reported non significant dressing percentage of Marwari lams (53 - 56%) on empty weight basis supplemented with different concentrates. Reddy and Reddy (1999) reported more or less similar dressing percentage on empty weight basis (53.5 to 57.4) in Deccani/Nellore lambs and Shaker *et al.* (2003) findings coincide with the present study results of dressing percentage on empty weight basis. Lloyd *et al.* (1980) reported that the heavier lambs have higher carcass weight and

dressing percentage compared to light weight lambs. On the other hand, Nadeem *et al.* (1999) reported dressing percentage of 36.63 % for Deccani (50%), Bannur (25%) and Southdown (25%) crossbred male lambs, which is very low as compared to the results of the present study.

The meat to bone ratio was significantly ($P<0.05$) higher in T_3 (5.35) followed by T_2 (5.33), T_1 (4.84) and T_0 (4.55), while T_3 , T_2 and T_1 were at par. This finding corresponds with several reports (Rohilla *et al.* 2007; Suliman and Babiker, 2007; Madhavi *et al.*, 2006, and Llody *et al.* 1980). The loin eye area (LEA) was significantly ($P<0.05$) higher in lambs offered T_3 (19.39) followed by T_2 (18.00), T_1 (16.33) and T_0 (15.67), whereas no difference between T_3 and T_2 , T_2 and T_1 , and T_1 and T_0 . The loin eye area is an index of muscle growth and reflected the trends of pre-slaughter weight. Kemp *et al.* (1976) reported similar values but non significant ($P<0.05$) difference in LEA between lambs fed 13 and 16 % CP; however, they found significant variation between lambs of different weights. Increasing slaughter weight increased ($P<0.05$) loin weight more when lambs were on concentrate diet and less when lambs were finished on forage (Borton *et al.*, 2005b). Increased dietary CP levels have generally been shown to increase loin eye area.

4.6.2 Weight of primal cuts in hot carcass

The results of the major cuts in hot carcass are depicted in Table 13. The data revealed that there were significant ($P<0.05$) differences in leg, loin, neck and shoulder, and breast and fore shank cuts of the hot carcass among treatments. The least mean square values were 3.31, 3.60, 4.20 and 4.53 kg of leg for T_0 , T_1 , T_2 and T_3 , respectively.

Table 13: Weight of primal cuts in hot carcass of male lambs

Treatment	Hot carcass Wt. (kg)	Weight of primal cuts (kg)				
		Leg	Loin	Rack	Neck & shoulder	Breast & fore shank
T ₀	9.49 ^c	3.31 ^b	0.90 ^b	1.23	2.30 ^b	1.75 ^b
T ₁	10.96 ^b	3.60 ^b	1.20 ^{ab}	1.23	2.40 ^b	2.00 ^b
T ₂	12.33 ^a	4.20 ^a	1.23 ^{ab}	1.33	3.00 ^a	2.57 ^a
T ₃	13.38 ^a	4.53 ^a	1.50 ^a	1.54	3.20 ^a	2.60 ^a
S.E. ±	0.38	0.14	0.09	0.09	0.12	0.13
LSD	1.31	0.49	0.34	NS	0.43	0.47

Note:

- Each value is mean of four observations
- Values bearing unlike superscripts within a column differ significantly (P<0.05)



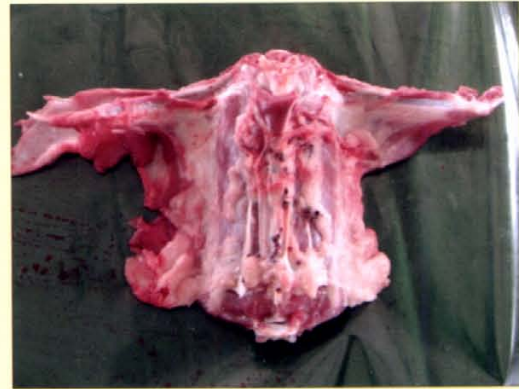
Neck & shoulder



Breast & fore shank



Rack



Loin



Leg

Plate 5 . Primal cuts of hot carcass

The corresponding values for loin were 0.90, 1.20, 1.23 and 1.50 kg; rack were 1.23, 1.23, 1.33 and 1.54 kg; neck and shoulder were 2.30, 2.40, 3.00 and 3.20 kg and breast and fore shank were 1.75, 2.00, 2.57 and 2.60 kg.

Leg cuts were significantly ($P < 0.05$) heavier in T_3 followed by T_2 , T_1 and T_0 ; while no difference was found between T_3 and T_2 , and T_1 and T_0 . The loin carcass cuts were significantly ($P < 0.05$) heavier in T_3 compared to other treatments; while T_0 , T_1 and T_2 were similar. The neck and shoulder, and breast and fore shank weights were significantly ($P < 0.05$) heavier in T_3 followed by T_2 , T_1 and T_0 ; whereas no difference between T_3 and T_2 , and T_1 and T_0 . There was no significant ($P < 0.05$) difference in rack cuts detected among treatments. It can be seen that the carcass cut weights were highly associated with the hot carcass weights. Non significant but higher values of leg, loin and rack were reported by Shaker *et al.* (2003) for Awassi lambs supplemented different concentrates. The higher value may be due to the higher weaning weight (23 kg) and preslaughter weight (40 Kg) of the Awassi lambs (*ibid*).

4.6.3 Proportion of wholesale carcass cuts

The weight and proportions of carcass cuts are of great economic importance for mutton production, especially from export point of view as there is separate pricing scheme for every cut. The loin is the most costly part of the hot carcass of mutton.

The average proportions of carcass wholesale cuts are shown in Table 14. From the total hot carcass weight, higher per cent weight of carcass cut was of leg followed by neck and shoulder, breast and fore shank

Table 14: Proportion of carcass wholesale cuts of male lambs

Treatment	Carcass cuts (%)				
	Leg	Loin	Rack	Neck & shoulder	Breast & fore shank
T ₀	32.66	9.48 ^b	12.96 ^a	24.24 ^a	18.44 ^b
T ₁	32.85	10.95 ^a	11.22 ^{bc}	21.89 ^b	18.25 ^b
T ₂	34.06	9.97 ^{ab}	10.78 ^c	24.33 ^a	20.84 ^a
T ₃	32.14	11.21 ^a	11.51 ^b	24.06 ^{ab}	19.43 ^{ab}
S.E. ±	0.60	0.37	0.18	0.67	0.49
LSD	NS	1.276	0.640	2.311	1.690

Note:

- Each value is mean of four observations
- Values bearing unlike superscripts within a column differ significantly (P<0.05)

while lower loin and rack. The values for T₀, T₁, T₂ and T₃ were 32.66, 32.85, 34.06 and 32.14; 24.24, 21.89 and 24.33; 18.44, 18.25, 20.84 and 19.43; 9.48, 10.95, 9.97 and 11.21 and 12.96, 11.22, 10.78 and 11.51 per cent, respectively.

As can be seen from the results T₂ had higher per cent of leg followed by T₁, T₀ and T₃. However, there were no significant ($P>0.05$) variation among treatment groups for proportion of leg cuts. Even though the trend was not consistent with increase in the dietary CP level, significant ($P>0.05$) differences were observed in the proportion of wholesale cuts of loin, rack, neck and shoulder and breast and fore shank. This finding is in agreement with that of Reddy and Reddy (2001) who reported that proportion of different whole sale cuts of Nellore lambs are 35.2, 16.6, 12.7, 22.5 and 13.0 per cent for leg, loin, rack, shoulder and neck and fore shank and brisket, respectively. similar results have been reported by Madhavi *et al.* (2006) and Karim *et al.* (2007), who observed 33.2%, 12.3%, 13.3%, 24.9% and 16.3% for leg, loin, rack, neck and shoulder and breast and fore shank, respectively in Kheri finisher lambs. In contrast, Kemp *et al.* (1976) reported non significant percentage of wholesale cuts in response of dietary CP levels (10, 13 and 16%); further more, Shaker *et al.* (2003) reported non significant ($P<0.05$) and slightly lower values for leg, loin and rack per cent.

4.6.4 Offals of slaughtered animals

The yield of different edible and non edible offals viz. liver, heart, spleen, kidney, testicles, lungs and trachea, intestine (empty), pouch (empty), caul and mesenteric fat, blood and skin are presented in Table 15.

The perusal of results presented in Table 15 envisaged that there were significant ($P<0.05$) difference in liver, testicles and pouch

Table 15: Non-car cass components of slaughtered male lambs

Treatment	(% on empty body weight basis)									
	Edible offal					Non-edible offal				
	Liver	Heart	Spleen	kidney	Testicles	Intestine (Empty)	Lungs & trachea	Pouch (Empty)	Caul & mesenteric fat	Blood
T ₀	1.97 ^b	0.55	0.70	0.48	0.48 ^b	3.14	2.12	3.78 ^a	4.34	6.55
T ₁	2.48 ^a	0.57	0.70	0.45	0.42 ^b	3.27	1.84	3.59 ^{ab}	4.22	6.63
T ₂	2.07 ^{ab}	0.59	0.66	0.50	1.25 ^a	3.06	1.85	3.07 ^b	5.06	6.20
T ₃	1.95 ^b	0.58	0.51	0.43	1.25 ^a	3.18	2.20	3.18 ^{ab}	4.90	6.63
S.E.±	0.121	0.023	0.060	0.021	0.034	0.142	0.064	0.203	0.380	0.362
LSD	0.417	NS	NS	NS	0.118	NS	NS	0.705	NS	NS

Note:

- Each value is mean of four observations
- Values bearing unlike superscripts within a column differ significantly (P<0.05)

(empty) as percentage of empty body weight of lambs among treatments. However, the weight as per cent of empty body weight of the other non-carcass components (heart, spleen, kidney, lungs and trachea, intestine, caul and mesenteric fat, and blood) were non significant ($P < 0.05$) among treatments.

It was found that the weight of liver as per cent of empty body weight was higher in T_1 (2.48) followed by T_2 (2.07), T_0 (1.97) and T_3 (1.95). The results were in close agreement with Suliman and Babiker (2007) in Sudan desert lambs fed different sources of protein. The weight of testicles as percentage of empty body weight was higher and same in T_3 (1.25) and T_2 (1.25) compared to T_1 (0.42) and T_0 (0.48). The higher weight proportion in testicular development in T_3 and T_2 treatments may be attributed to the higher average daily gain in weight and reaching pubertal stage where the sexual organ undergoes massive change in growth and development.

The weight of pouch (rumen) as percentage of empty body weight was higher in T_1 (3.78) followed by T_2 (3.59), T_3 (3.18) and T_2 (3.07). This might be due to higher absorption of water by the pouch contents. Suliman and Babiker (2007) reported non significant difference in rumen empty but more or less similar values (3.39 – 3.92) in Sudan desert lambs fed different sources of protein. Similar results have been reported by Pena *et al.* (2005).

4.6.5 Organoleptic evaluation of mutton

The organoleptic evaluations of mutton are presented in Table 16. The perusal of results indicated that the color, flavor, tenderness, Juiciness, chewiness and over all acceptability were significantly ($P < 0.05$)

Table 16: Organoleptic test of mutton of male lambs

Treatment	(9 point hedonic scale)									
	Appearance	Color	Flavor	Tenderness	Texture	Juiciness	Chewiness	Over all acceptability		
T ₀	7.12	7.54 ^c	7.37 ^b	7.16 ^b	6.87	7.15 ^b	7.05 ^b	7.06 ^b		
T ₁	7.47	8.06 ^{ab}	7.84 ^{ab}	7.24 ^b	7.03	7.28 ^b	7.39 ^{ab}	7.86 ^{ab}		
T ₂	7.78	8.29 ^a	8.10 ^a	7.86 ^a	7.57	7.13 ^b	7.82 ^a	8.07 ^a		
T ₃	7.68	7.73 ^{bc}	7.58 ^{ab}	7.67 ^{ab}	7.52	7.81 ^a	7.53 ^{ab}	7.51 ^{ab}		
S.E.±	0.26	0.12	0.19	0.16	0.20	0.14	0.19	0.28		
LSD	NS	0.42	0.67	0.58	NS	0.47	0.66	0.97		

Note:

- Each value is mean of four observations
- Values bearing unlike superscripts within a column differ significantly (P<0.05)



Treatment - T_0



Treatment - T_1



Treatment - T_2



Treatment - T_3

Plate 6 . Mutton used for sensory evaluation

influenced by dietary protein level. While, the appearance and texture of meat were not significantly ($P < 0.05$) varied among treatments. Appearance and texture scores were found moderately acceptable and similar for all treatment groups.

It was found that T₂ scored highest in appearance (7.78), color (8.29), flavor (8.10), tenderness (7.86), texture (7.57), chewiness (7.82) and over all acceptability (8.07), while juiciness score was highest in T₃ (7.81). These findings were in accordance with those reported by Kemp *et al.* (1976). Borton *et al.* (2005a) and Rousset-Akrim *et al.* (1997) reported that odours detected by taste panel in lambs reared on concentrates were significantly lower than those lambs reared at pasture. High planes of nutrition increase the tenderness of lamb meat through an increase in intermuscular fat and a relative decrease in muscle collagen (Kemp *et al.*, 1981).

As it can be seen in all the treatments groups, the sensory results fall in the range of moderately desirable (7) to very desirable (9) scores of hedonic scale. Considering most of the sensory attributes, it might be concluded that lamb groups fed T₂ i.e. 20% CP dietary treatment was superior as compared to the other three (T₀, T₂ and T₃) treatment groups.

4.7 Economics

The ultimate goal of any feeding strategy is to optimize the income by make use of the principles and practices of nutrition from the animals reared. The important criterion that influences the economy of fattening is cost per 1 kg weight gain. The economics of feeding of experimental lambs for the three month feeding trial is presented in Table 17.

Table 17: Economics of feeding of experimental lambs

Treatment	Total Wt. gain(kg)	Total roughage consumed (kg)	Total concentrate consumed (kg)	Total cost of feed (Rs)	Cost of feed/kg gain (Rs)
T ₀	7.75 ^b	116.27	32.81 ^b	340.82 ^c	45.01
T ₁	8.41 ^b	116.88	35.38 ^b	375.90 ^{bc}	44.69
T ₂	8.80 ^b	117.95	36.19 ^{ab}	417.45 ^b	47.76
T ₃	11.21 ^a	128.78	41.15 ^a	495.13 ^a	44.95
S.E. ±	0.55	5.66	1.92	20.18	2.79
LSD	1.62	NS	5.59	58.77	NS

Note:

- Each value is mean of eight observations
- Values bearing unlike superscripts within a column differ significantly (P<0.05)
- 1 USD dollar = 45 Indian rupees

The perusal of results revealed that the cost of feed per kg gain was lower in T₁ (Rs. 44.69) followed by T₃ (Rs. 44.95) and T₀ (Rs. 45.01), and higher in T₂ (Rs. 47.76). However, there were no statistically difference ($P < 0.05$) among treatment feeds in terms of cost per kg gain. It can be seen that the total cost of feed increase as the percentage of dietary CP increased due to the inclusion of costly protein sources (Soybean and GNC) to the dietary treatments to fulfill the targeted CP level. Moreover, lambs fed higher dietary CP had higher DMI that could increase the total cost of feed per kg gain. Nevertheless, the higher cost of production was compensated by superior ADG and total gain in weight. Even though T₃ and T₁ appeared to be lowest and similar in terms of cost per kg gain, T₃ had highest total gain in weight. Therefore, Treatment T₃ (22% CP) was found to be the most economical, while T₀ (16% CP) being the least economical feed.



**SUMMARY
AND
CONCLUSIONS**

5. SUMMARY AND CONCLUSIONS

5.1 Summary

The present investigation entitled, “Effect of feeding different levels of crude protein on growth performance and carcass traits in Deccani lambs” was conducted at Network Project on Sheep Improvement under the department of Animal Science and Dairy Science, Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, for a period of three months.

Thirty two farm born Deccani lambs of 90 ± 5 days age (16 males and 16 females) were randomly allotted to four treatment groups (T_0 , T_1 , T_2 and T_3) in a factorial randomized block design, each comprising of four animals from both sex and each animal was considered as replication. Four experimental feeds varying in crude protein levels (16, 18, 20 and 22 % CP were prepared for T_0 , T_1 , T_2 and T_3 treatments, respectively) with almost similar TDN levels were prepared by mixing Lucerne green as roughage and concentrate mixtures in 1:1 ratio. The salient findings of the investigation are briefly given below:

5.1.1 Feed intake, Growth performance and Feed efficiency

5.1.1.1 Dry matter and crude protein intake

The results revealed that the average daily dry matter intake was significantly ($P < 0.05$) higher for lambs fed T_3 feed (788.31 g) followed by T_2 (681.64 g), T_1 (678.03 g) and T_0 (634.90 g), while lambs fed T_2 , T_1 , and T_0 were at par. Male lambs had higher DMI (765.45 g/d) compared to females (625.99 g/d). Per cent dry matter intake of lambs showed in the range of 3.02 to 3.12 and no difference were found among lamb groups due

to feed, whereas per cent DM intake was significantly higher in males (3.18) than female lambs (2.95).

The average daily crude protein intake (CPI) was significantly ($P<0.05$) higher in lambs offered T_3 feed (172.44 g) followed by T_2 (137.01), T_1 (117.75 g) and T_0 (107.78 g). Male lambs had significantly ($P<0.05$) higher CPI (147.19g/d) as compared to female lambs (120.30 g/d).

5.1.1.2 Growth performance

The total body weight gain and average daily gain (ADG) were significantly ($P<0.05$) higher for lambs fed T_3 feed (11.21 kg and 124.58 g d⁻¹) followed by T_2 (8.80 kg and 97.77 g d⁻¹), T_1 (8.41 kg and 93.49 g d⁻¹) and T_0 (7.75 kg and 86.11 g d⁻¹), respectively. Furthermore, male lambs responded significantly better in ADG and total weight gain (112.01 g/d and 10.08 kg) against (88.96 g/d and 8.01 kg), respectively, for female lambs. This may be attributed to the higher DMI and CPI intake observed for male lambs.

5.1.1.3 Feed efficiency

Feed conversion efficiency (%) and feed gain ratio (dry matter intake/ kg live weight gain) were non significant in the different treatment groups. Likewise there was no effect of sex on feed conversion efficiency and feed gain ratio.

5.1.2 Body measurements of lambs

The data obtained for skeletal growth (body length, height at withers and Chest girth) revealed that there were no significant difference in the initial and final measurements except the final measurement in Chest

girth. The significant difference in Chest girth is attributed to its higher correlation with body weight gain of the animals. Male lambs had significantly ($P < 0.05$) higher in girth, height and length compared to female lambs.

5.1.3 Correlation coefficients

5.1.3.1 Dietary crude protein level, feed intake, CP intake and gain in weight

The mean gain in weight was correlated with DMI ($r = 0.61$ and 0.76) and CPI ($r = 0.71$ and 0.81) for the male and female lambs, respectively. Crude protein intake was also correlated with DMI ($r = 0.90$ and 0.89) for male and female lambs, respectively. The results indicated that there were a positive and high correlation among the dietary protein intake, dry matter intake and gain in weight of the lambs, while positive and non-significant correlations between CPL and DMI ($r = 0.30$) was observed.

5.1.3.2 Body weight and body measurements

It was revealed that body weight was correlated with Chest girth ($r = 0.88$ and 0.96), body length ($r = 0.87$ and 0.83), and height at withers ($r = 0.73$ and 0.87) for male and female lambs, respectively. Highest correlation was observed between live weight and Chest girth.

5.1.4 Blood urea nitrogen and total blood protein

Blood urea nitrogen (BUN) was significantly ($P < 0.05$) higher in lambs fed treatment T_3 (20.00 ml/dl) followed by T_2 (17.00 ml/dl), and T_1 (13.67 ml/dl) and T_0 (12.00 ml/dl). The BUN values of all treatment groups

fall in the normal physiological range of 8 to 20 ml/dl suggested for sheep. The total blood protein was found to be significantly ($P<0.05$) higher in T_3 (8.10 g/dl) followed by T_2 (6.93 g/dl), T_1 (5.93 g/dl) and T_0 (5.83 g/dl).

5.1.5 Metabolism trial of experimental feeds

5.1.5.1 Intake and digestibility of nutrients by lambs

The average digestibility (%) of DM, EE, CF, and NFE were non significant in all the treatment groups, while CP digestibility coefficient was significantly high in T_3 (79.63 %) followed by T_2 (79.45), T_1 (77.69 %), and T_0 (76.62%). The total daily DMI, CFI, NFEI and TDNI was found non significant in all the treatment groups. However, the total CP and EE intake was significantly higher in T_3 (157.43 and 29.55 g/d) followed by T_2 (135.17 and 24.89 g/d), T_1 (126.06 and 22.69 g/d), and T_0 (112.61 and 24.64 g/d), respectively.

5.1.5.2 Nitrogen balance

The results pertaining nitrogen balance showed significantly ($P<0.05$) higher in lambs fed treatment T_3 (8.15 g/d) as compared to the other treatments. The urinary N excretion was also observed higher in lambs fed T_3 (8.47 g/d) but there was no difference in faecal N among treatment groups. However, N retention as per cent of intake and N retention as percentage of absorbed were non significant among treatment groups.

5.1.6 Carcass traits

5.1.6.1 Slaughter weights and carcass traits

Dressing percentage in terms of live weight basis was higher in T_3 (48.64%) followed by T_2 (48.26%), T_1 (46.98 %), while significantly

($P < 0.05$) low in T_0 (43.01%). No significant differences were found in dressing per cent on empty weight basis among the treatments groups. The meat to bone ratio and loin eye area were increased ($P < 0.05$) as dietary CP level increased.

5.1.6.2 Weight of primal cuts in hot carcass

The average weight of the standard cuts (leg, loin, neck and shoulder, and breast and fore shank) except in case of rack, significant variation were observed among the treatment groups with T_3 the heavier followed by T_2 , T_1 and T_0 . Hot carcass was found significantly highest in T_3 (13.38 kg) followed by T_2 (12.33 kg), T_1 (10.96 kg) and lowest in T_0 (9.49 kg).

5.1.6.3 Per cent carcass wholesale cuts

The variations in proportions of carcass wholesale cuts were found significant ($P < 0.05$) except in case of leg cut among treatment groups. The percentage of primal cuts for lambs fed T_0 , T_1 , T_2 and T_3 were, leg 32.66, 32.85, 34.06 and 32.14; loin 9.48, 10.95, 9.97 and 11.21; rack 12.96, 11.22, 10.78 and 11.51; neck and shoulder 24.24, 21.89 and 24.33, and breast and fore shank 18.44, 18.25, 20.84 and 19.43 per cent, respectively.

5.1.6.3 Weight of offals

There were significant ($P < 0.05$) differences in liver, testicles and pouch (empty) as percentage of empty body weight; however, no significant variation were observed in the other non carcass components (heart, spleen, kidney, lungs and trachea, intestine, caul and mesenteric fat, and blood) among treatments.

5.1.6.5 Organoleptic evaluation of mutton

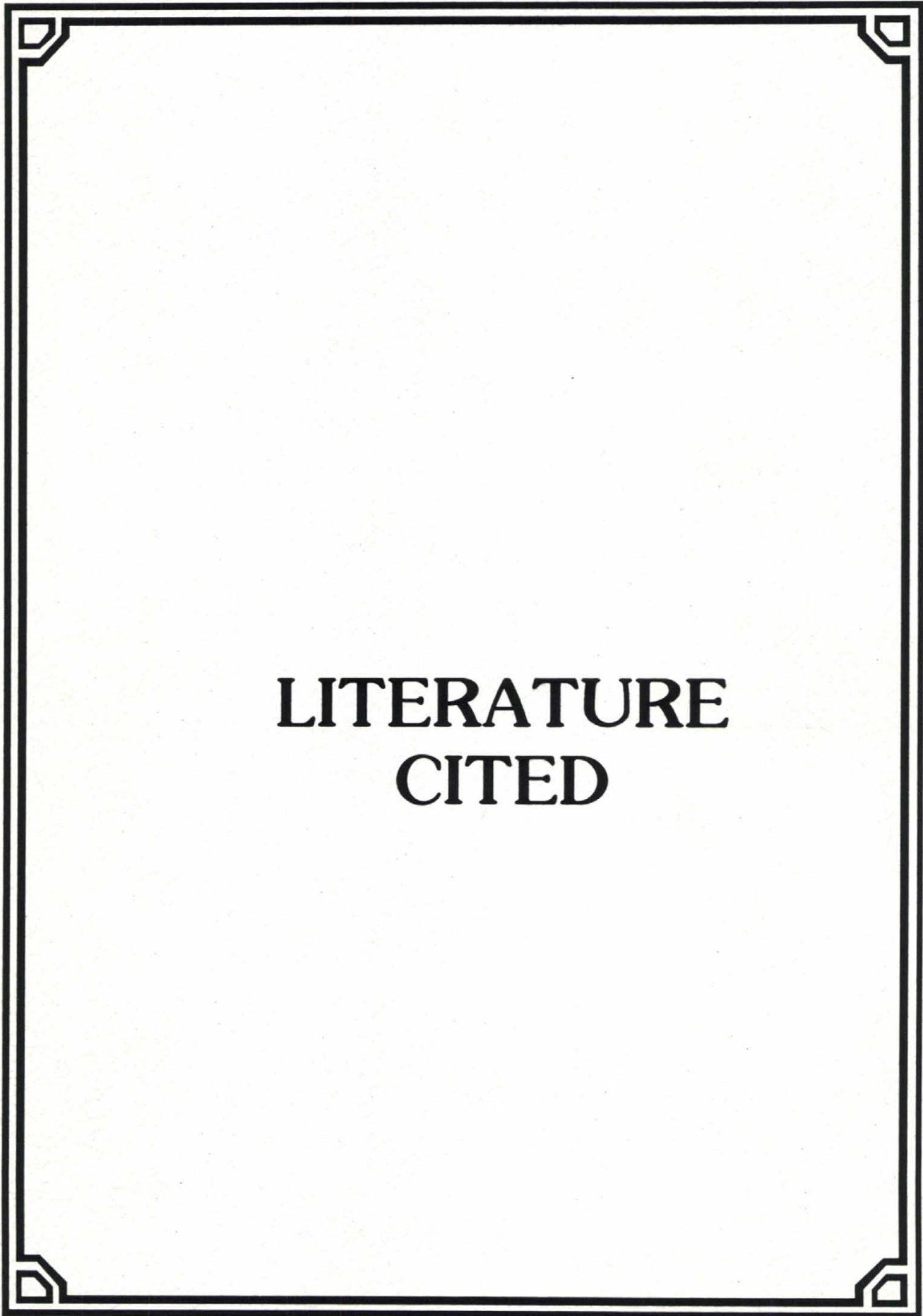
Organoleptic evaluations of lamb revealed that T₂ scored highest in appearance (7.78), color (8.29), flavor (8.10), tenderness (7.86), texture (7.57), and chewiness (7.82) and over all acceptability (8.07), whereas juiciness scored was highest (7.81) in T₃ group.

5.1.7 Economics

The results on economics revealed that the cost of feed per unit gain was lower in T₁ (Rs. 44.69) followed by T₃, T₀ and T₂ (Rs. 44.95, 45.01 and 47.76), respectively. However, there was no difference among lamb groups in cost of feed per kg weight gain. Even though T₃ and T₁ appeared to be lowest and similar in terms of cost per unit gain, T₃ had highest total gain in weight. Therefore, Treatment T₃ (22% CP) was found to be the most economical, while T₀ (16% CP) being the least economical feed.

5.2 Conclusions

- The results of the present study have shown superior growth performance in lambs fed ration containing 22 per cent CP.
- The feed conversion efficiency and feed to gain ratio was found to be better in lambs fed 22 per cent CP ration and the carcass traits improved as the crude protein level in ration increased.
- The results of the present investigation suggest that the optimum CP concentration for weaned Deccani lambs is 22 per cent and this can be used as a guide line for other tropical breeds under similar environmental conditions. However, this work was carried out with varying levels of CP keeping energy constant. It is therefore, recommended that future investigations or attempts be made to combine CP and energy levels in the complete feed for economic rearing of lambs.



**LITERATURE
CITED**

6. LITERATURE CITED

- Agricultural Research Council. 1980. The nutrient requirements of ruminant livestock, London: CAB. pp 351.
- Amble, V. N., Khandekar, N. C. and Garg, J. N. 1968. Statistical studies on breeding data of Deccani and crossbred sheep. *Indian J. Vet. Sci.* 37: 305.
- Andrews, R. P.; Orskov, E. R. 1970. The effect of dietary protein concentration, feeding level and sex on body composition at two live weights. *J. Agri. Sci.*, 75:19-26.
- Anonymous. 2001. VITROS DT II chemistry system operators manual. Ortho-Clinical Diagnostics, Johnson – Johnson Company, USA.
- Anonymous. 1963. Specifications for mutton and goat flesh-fresh, chilled and frozen. ISI (Indian Standard Institute), meat and meat product committee. New Delhi.
- Anonymous. 2006. Basic Animal Husbandry Statistics; Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries. Krishi Bhavan, New Delhi.
- AOAC. 1990. Official Methods of Analysis, Association of Official Analytical Chemist. 15th Edn. Washington, DC. USA.
- Aziz, D. A., Alkass, J. E. and Al-nidawi, K. A. 1995. Factors affecting feed efficiency, feed intake and daily gain of Awssi lambs. *Indian J. Anim. Sci.* 65 (4): 450-454.
- Balci, F. and Karakas, E. 2007. The effect of different slaughter weights on the fattening performance, slaughter and carcass characteristics of male Karayaka lambs. *Turk. J. Vet. Anim. Sci.*, 31(1): 25-31.
- Banerjee, G. C. 2005. A text book of animal husbandary (8th Edn). Oxford and IBH publishing Co. pvt. Ltd, New Delhi. pp 1066.

- Bhadula, S. K., Bhat, P. N., and Garg, R. C. 1980. Note on the estimates of heritability and phenotypic correlation of weight and linear body measurement in Muzaffarnagari sheep. *Indian J. Anim. Sci.* 50(7): 573 – 575.
- Bhat, P. N., Bhat, Pran. P and Garg, R. C. 1980. Note on predicting pre-weaning weights using linear body measurement in sheep. *Indian J. Anim. Sci.* 50 (8): 657 – 659.
- Bhatia, D. R., Singh, N. P., Patnayak, B. C. and Ram, R. 1980. Note on top feed incorporated diets to lamb. *Indian J Anim. Sci.* 50 (9): 779 – 781.
- Bhatia, D. R., Mohan, M., Patnayak, B. C. and Ratan, R. 1981. Note on growth of Malpura lambs with or without supplemental concentrates. *Indian J. Anim. Sci.* 52 (2): 238 – 242.
- Black, J. L. 1983. Growth and development of lambs. In: *Haresign, W. (Ed.). Sheep production. Proc. of 35th Easter School in Agri. Sci., Univ. of Nottingham.* pp: 21-58.
- Borton, R. J., Loerch, S. C., McClure, K. E., and Wulf, D. M. 2005a. Comparison of characteristics of lambs fed concentrate or grazed on ryegrass to traditional or heavy slaughter weights. I. Production, carcass, and organoleptic characteristics. *J. Anim. Sci.*, 83: 679-685.
- Borton, R. J., Loerch, S.C., McClure, K. E. and Wulf, D. M. 2005b. Characteristics of lambs fed concentrate or grazed on ryegrass to traditional or heavy slaughter weights. II. Wholesale cuts and tissue accretion. *J. Anim. Sci.*, 83: 1345 - 1352.
- Borton, R. J., McClure, K. E., and Wulf, D. M. 1999. Sensory evaluation of loin chops from lambs fed concentrate or grazed on ryegrass to traditional or heavy weights. *J. Anim. Sci.* 77 (Suppl. 1):168.
- Bunting, L.D.; Boling, J.A.; Mackown, C.T.; Muntifering, R.B. 1987. Effect of dietary protein level on nitrogen metabolism in lambs: studies using ¹⁵N-Nitrogen. *J. Anim. Sci.*, 64: 855- 867. (Abstr)

- Burrin, D. G., Ferrell, C. L., Britton, R. A. and Bauer Marc. 1990. Level of nutrition and visceral organ size and metabolic activity in sheep. *British Journal of Nutrition*. 64: 439-448.
- Butler-Hogg, B. W. 1984. Growth patterns in sheep: Changes in the chemical composition of the empty body and its constituent parts during weight loss and compensatory growth. *J. Agri. Sci. (Camb.)*, 103: 17-24.
- Campbell, J. R. and Lasley, J. F. 1977. The science of animals that serves mankind TMH ed. Tata McGraw Hill pub. Co. Ltd. New Delhi. pp. 200.
- Can, A., Denek, N. and Tufenk, S. 2004. Effect of escape protein level on finishing performance of Awassi lambs. *Small Rumin. Res.*, 55 (1-3): 215-219. (Abstr)
- Chaturvedi, O.H., Santra, A., Tripathi, M. K., Jayashankar, J. and Karim, S.A. 2003. Weight gain and body conformational changes in weaner lambs fed high concentrate diets containing graded levels of Sodium bicarbonate. *Indian J. Anim. Sci.*, 73 (6): 668-673.
- Crompton, E.W. and Harris, L.E. 1969. Applied animal nutrition, 2nd Edn., W. H. Freeman and Co., San Francisco.
- Dabiri, N. and Thonney, M. L. 2004. Source and level of supplemental protein for growing lambs. *J. Anim. Sci.* 82:3237-3244.
- Dadi, H., Woldu, T. and Lema, T. 2005. Comparison of carcass characteristics of Borana and Arsi-Bale goats under different durations of feedlot management. *Livestock Research for Rural Development*. 17(137). Retrieved April 20, 2007, from <http://www.cipav.org.co/lrrd/lrrd17/12/dadi17137.htm>
- Davenport, G. M., Cummins, K. A., and Mulvaney, D. R. 1995. Abomasal nitrogen flow affects the relationship between dietary nitrogen and insulin-like growth factor-I in growing lambs. *J. Nutr.* 125:842-850.
- Duckett, S. K., and Kuber, P. S. 2001. Genetic and nutritional effects on lamb flavor. *J. Anim. Sci.* 79(E-suppl.): E249-E259.

- El-Feel, F. M. R., Sallam, M. T., Tawfik, E. S. and Abdel-Ghani, A. A. 1990. Body measurements of Buffalo and cow calves as affected by weaning, calving season and sex and their relation to body weight and carcass traits. *Der Tropenlandwirt*, 91. Jahrgang. Oktober, pp:119-132.
- Fasae, O. A., Chineke, A. C. and Alokun, J. A. 2005. Relationship between some physical parameters of grazing yankasa ewes in the humid zone of Nigeria. *Arch. Zootec.* 54: 639-642.
- Haddad, S. G., Nasr, R. E., Muwalla, M. M. 2001. Optimum dietary crude protein level for finishing Awassi lambs. *Small. Rumin. Res.* 39 (1):41-46. (Abstr)
- Hammell, K. L. and Laforest, J. P. 2000. Evaluation of the growth performance and carcass characteristics of lambs produced in Quebec. *Canadian Journal of Animal Science*, 80:25 - 33. (Abstr)
- Hasmat, M. A. 1968. Growth rate of lambs in different strains of sheep. *Indian Vet. J.*, 45 (2): 135-139.
- Hoffman, P. C., Esser, N. M., Bauman, L. M., Denzine, S. L., Engstrom, M., and Chester- Jones, H.. 2001. Short communication: Effect of dietary protein on growth and nitrogen balance of Holstein heifers. *J. Dairy Sci.*, 84:843-847.
- Hossain, M. E., Shahjalal, M., Khan, M. J. and Bhuiyan, A. A. 2003. Effect of Dietary Energy Supplementation on Feed Intake, Growth and Reproductive Performance of Sheep under Grazing Condition. *Paki. J. Nutri.*, 2 (3): 148-152. Retrieved may 15, 2007, from <http://jas.fass.org/cgi/reprint/70/5/1526>
- Jagatheesan, P. N., Richard, A., Runachalam, S., Sivakumar, T. and Selvaraju, M. 2003. Performance of Mecheri sheep in its breeding tract. *Indian J. Anim. Sci.*, 73 (8): 909-912.

- Jagtap, D. Z. and Naikare, B. D. 1989. Growth rate in Deccani and its halfbreeds with Merino and Dorsets. *Indian J. Anim. Sci.* 14 (12): 3-7.
- Kabir, F., Sultana, M. S., Shahjalal, M., Khan, M. J. and Alam, M. Z. 2004. Effect of protein supplementation on growth performance in female goats and sheep under grazing condition. *Paki. J. Nutri.* 3 (4): 237-239.
- Karim, S. A., Porwal, K., Kumar, S. and Singh, V. K. 2007. Carcass traits of Kheri lambs maintained on different system of feeding management. *Meat Science*, 76 (3):395-401. (Abstr).
- Karim, S. A. and Verma, D.S. 2001. Growth performance and carcass characteristics of finisher lambs maintained on intensive feeding or grazing with supplementation. *Indian J. Anim. Sci.*, 71 (10): 959-961.
- Karunanithi, K., Thiruvankadan, A. K., Senthilvel, K. and Muralidharan, J. 2007. Growth rate and economics of rearing mecheri lambs under different levels of concentrate feeding. *Tamilnadu J. Veterinary and Animal Sciences*, 3(2): 83-88.
- Kemp, J. D., Johnson, A. E., Stewart, D. F., Ely, D. G. and Fox, J. D. 1976. Effect of dietary protein, slaughter weight and sex on carcass composition, organoleptic properties and cooking losses of lamb. *J. Anim. Sci.*; 42(3): 575 – 583.
- Kemp, J. D., Mahyuddin, M., Ely, D. G., Fox, J. D., and Moody, W. G. 1980. Effect of feeding system, slaughter weight and sex on organoleptic properties, and fatty acid composition of lamb. *J. Anim. Sci.* 51:321-330.
- Khan, H., Muhammad, F., Ahmad, R., Nawaz, G., Mullah, R. and Zubair, M. 2006. Relationship of body weight with linear body measurements in goats. *Journal of Agricultural and Biological Science*, 1(3): 51-54.

- Killedar, N. S., Mahesh, K., Naikare, B. D. and Jagtap, D. Z. 1987. Factors influencing lambs growth rate in Deccani and its halfbreeds with Merino and Dorset. *Indian Vet. J.* 64 (2): 1039 – 1042.
- Kirton, A. H., Bennett, G. L., Dobbie, J. L., Mercer, G. J. K., Duganzich, D. M. 1995. Effect of sire breed (Southdown, Suffolk), sex, and growth path on carcass composition of crossbred lambs. *New Zealand J. Agric. Res.*, 38: 105-114. (Abstr)
- Krishna, G. and Ranjhan, S. K. 1991. Special analytical techniques in nutritional biochemistry. Edn. I. Kalyani Publishers, New Delhi/Ludhiana.
- KrishnaMohan, D. V. G. and Charyulu, E. K. 1983. Studies on growth, nutrient utilization and carcass characteristics in lambs fed rations having different proportions of concentrate to roughage. *Indian J. Anim. Sci.*; 53: 1228-1233.
- Latif, M. G. A and Owen, E. 1980. A note on growth performance and carcass composition of Taxel and Suffolk sired lambs in intensive feeding system. *J. Anim. Prod.* 30: 311- 314.
- Ledward, D. A. 1992. Colour of raw and cooked meat. In: D. E. Johnston, M. K. Knight and D. A. Ledward (Eds.).The chemistry of muscle-based foods, The Royal Society of Chemistry, Cambridge, UK. pp 128-144.
- Lee, G. J. 1986. Growth and carcass composition of ram and wether lambs fed at two levels of nutrition. *Aust. J. Exp. Agric.*, 26: 275-278.
- Lloyd, W. R., Slyter, A. L, Costello, W. J. 1980. Effect of breed, sex, final weight on feed to performance , carcass characteristics and meat palatability of lambs. *J. Anim. Sci.* 51: 316-320.
- Lu, C. D. and Potchoiba, M. J. 1990. Feed intake and weight gain of growing goats fed diets of various energy and protein levels. *J. Anim. Sci.*, 68:1751-1759.

- Nicastro, F., Kemp, J. D., Ely, D. G., Fox, J. D. and Aaron, D. K. 1985. Influence of sources of level of protein on quantitative and qualitative characteristics of lamb carcasses. *J. Anim. Sci.* 61: 279. (Abstr. No. 177)
- Madhavi, K., Reddy, T. J., Reddy, Y. R. and Reddy, G. V. N. 2006. Effect of feeding differently processed detoxified neem (*Azadirachta indica*) seed cake based complete diet on growth, nutrient utilization and carcass characteristics in Nellore sheep. *Livestock Research for Rural Development*. 18 (10). Retrieved April 20, 2007, from <http://www.cipav.org.co/lrrd/lrrd17/12/dadi17137.htm>.
- Manso, T.; Mantecon, A. R.; Giraldez, F. J.; Lavin, P.; Castro, T. 1998. Animal performance and chemical body composition of lambs fed diets with different protein supplements. *Small Rumin. Res.*, 29:185-191.
- Mayaka, T. B., Tchoumbone, J., Manjeli, Y. and Tegua, A. 1995. Estimation of live body weight in West African Dwarf goats from heart girth measurements. *Tropical Animal Health and Production*. 28: 126-128.
- McGregor, B. A. and McLaughlin, J. W. 1980. The influence of dietary protein and energy concentration on the growth of Merino weaner sheep. *Aust. J. Exp. Agric. Anim. Husb.*, 20: 308-315.
- McIntyre, K. H. 1970. The effects of increased nitrogen intakes on plasma urea nitrogen and rumen ammonia levels in sheep. *Austr. J. Agri. Res.*, 21(3): 501 - 507. (Abstr)
- Mehrez, A. Z., Ørskov, E. R. and McDonald, I. 1977. Rates of rumen fermentation in relation to ammonia concentration. *British Journal of Nutrition*. 38: 437-443.
- Mittal, G. K., Sharma, K. M., Maheshwari, M. L., and Barsaul, C. S. 1989. Growth performance of cross-bred lambs on different feeding regimes. *Indian J. Anim. Nutri.*, 6 (4): 329- 330.
- Murthy, K. U. G. and Prasad, J. R. 2002. Evaluation of legume hay based complete rations in sheep. *Indian J. Anim. Sci.*, 19 (4): 315-319.

- Nadeem, F. M., Murthy, H. N., Vasundara Davi, M. and Ziauddin, K. S. 1999. Sluagheter and carcass characteristics of U.A.S. breed of sheep. *Indian Vet. J.*; 76: 131 - 133.
- National Research Council. 1985. Nutrient requirements of sheep. (6thEdn.). Washington: National Academy Press, pp 99.
- Nguyen, T. H. N. 1998. Effect of *Sesbania grandiflora*, *Leucaena leucocephala*, *Hibiscus rosa-sinensis* and *Ceiba pentadra* on intake, digestion and rumen environment of growing goats. *Livestock Research for Rural Development*. 10 (3). (Abstr)
- Patel, K. M., Patel, K. S., Wadhvani, K. N., Parnerkar, S., Pandya, P. R. and Patel, A. M. 2004. Comparative growth performance of weaned lambs on non-conventional based ration under intensive production system. *International J. Agric. & Biol.*, 6(5): 860-864.
- Patel, S. C. 1985. Studies on growth performance of Dorset X Deccani lambs fed with varying in DCP levels. M.Sc. thesis submitted to MPKV, Rahuri, Dist. Ahmednagar, India.
- Paul, S. S., Mandal, A. B, Mandal, G. P., Kannan, A. and Pathak, N. N. 2003. Deriving nutrient requirements of growing Indian sheep under tropical conditions using performance and intake data emanated from feeding trials conducted in different research institutes. *Small Rumin. Res.* 50: 97-107.
- Pena, F., Cano, T., Domenech, V., Alcalde, M. J., Martos, J., Garcia-Martinez, A., Herrera, M., and Rodero, E. 2005. Influence of sex, slaughter weight and carcass weight on “non-carcass” and carcass quality in segureña lambs. *Small Rumin. Res.*, 60: 247–254. Retrieved September 19, 2007, from www.elsevier.com/locate/smallrumres
- Peryam, D. R. and Pilgrim, F. J. 1957. Hedonic Scale method of measuring food performance. *Food tech.*, 11 (9): 9-14. In: Sensory evaluation practices by Herbert stone and Sidel, J. L. 1985. Academic press, INC. pp 76.

- Phillips, W. A., Rao, S. C., Fitch, J. Q., and Mayeux, H. S. 2002. Digestibility and dry matter intake of diets containing alfalfa and kenaf. *J. Anim. Sci.*, 80: 2989 - 2995.
- Polkowska, J.; Lerrant, Y.; Wankowska, M.; Wojcik-gładysz, A.; Starzec, A. and Counis, R. 2003. The effect of dietary protein restriction on the secretion of LH and FSH in pre-pubertal female lambs. *Anim. Reprod. Sci.*, 76 (1-2): 53-66.
- Preston, R. L., Schnakenberg, D. D. and Pfander, W. H. 1964. Blood urea nitrogen as affected by protein intake. *The J. Nutri.*, 86: 281- 288. Retrieved on June 21, 2007 from <http://www.jn.nutrition.org>.
- Ranjhan, S. K. 1980. Animal nutrition in the tropics. Vikas Publishing house pvt. Ltd, New Delhi.
- Reddy, G .V. N. and Reddy, M. R. 2001. Meat production and carcass characteristics of native goats and sheep under intensive system of feeding utilizing urea treated sorghum straw based diet. *Indian J. Anim. Nutri.*; 18: 375-377.
- Reddy, G. V. N., Alexander, G. and Reddy, M. S. 2002. Effect of feeding rapeseed meal on growth and nutrient utilization in sheep. *Indian J. Anim. Nutri.*, 19 (4): 306- 310.
- Reddy, M. R. and Reddy, G. V. N. 1999. On-farm performance of sheep and goats under intensive rearing. *Indian J. Anim. Nutri.*, 16 (2): 164-166.
- Reddy, V. P., Prasad, J. R., Krishna, N. and Prasad, D. A. 1989. Effect of supplementation of energy and protein to forage based basal ration in Nellore weaner lambs. *Indian J. Anim. Nutri.*, 6 (4): 301 – 306.
- Rocha, M. H. M., Susin, I., Pires A .V., Fernandes, J. S., Mendes, C. Q. 2004. Performance of Santa ines lambs fed diets of variable crude protein levels. *Sci. Agric. (Piracicaba, Braz.)*. 61(2): 141-145.

- Rohilla, P. P., Chand, K. and Jangid, B. L. 2007. Economic mutton and wool production from marwari sheep. *Indian Vet. J.*; 84: 188-190.
- Rokomatu, I. and Aregheore, E.M. 2006. Effects of supplementation on voluntary dry matter intake, growth and nutrient digestibility of the Fiji Fantastic sheep on a basal diet of Guinea grass (*Panicum maximum*). *Livestock Science*. 100(2-3): 132-141. Retrieved September 10, 2007, from <http://www.sciencedirect.com/science/journal/18711413>
- Rousset-Akrim, S., Young, O. A. and Berdague, J. L. 1997. Diet and growth effects in panel assessment of sheepmeat odour and flavour. *Meat Sci.*, 45: 169-181. (Abstr)
- Sahlu, T., Fernandez, J. M., Lu, C. D. and Manning, R. 1992. Dietary protein level and ruminal degradability for mohair production in Angora goats. *J. Anim. Sci.*, 70 (5): 1526-1533.
- Salako, A. E. 2006. Application of morphological indices in the assessment of type and function in sheep. *Int. J. Morphol.*, 24(1): 13-18.
- SAS . 1996. User's Guide Statistics, Version 6.12th Ed. SAS. Institute Inc., Cary, NC, USA.
- Sastry, V. R. B., Kamra, D. N. and Pathak, N. N. 1999. Laboratory manual of animal nutrition. Centre of Advanced Studies, Division of Animal Nutrition, Indian Veterinary Research Institute, India, pp 266.
- Shaker, M. M, Abdullah, A.Y., Kridli, R. T., Blaha, J., Sada, I. 2003. Influence of the nutrition level on fattening and carcass characteristics of Awassi ram lambs. *Czech J. Anim. Sci.*, 48, (11): 466-474.

- Silva, J. S. and Portugal, A. V. 1991. Contribution to the study of body development in merino precece lambs, subject to two diets. *Livestock Research for Rural Development*. 3 (2): 36-50. Retrieved on September 21, 2007, from: <http://www.cipav.org.co/lrrd/lrrd3/2/portugal.htm>
- Singh, V. K, and Karim, S. A. 2006. Contribution of sheep and goats to Indian meat industry. IMSACON-II and National symposium on “*Prospects and challenges in Indian meat industry*” held on 27 – 29th July, 2006 at Madras Veterinary College, Chennai. Accessed from : <http://imsa.in/images/invited.pdf>
- Soeparn, O. and Davies, H. L., 2006. Studies on the growth and carcass composition in Daldale wether lambs. 2. The effect of dietary protein/energy ratio. *Aust. J. Agri. Res.*, 38 (2): 417 - 426. (Abstr)
- Soman, P. S. 1997. Growth performance of lambs kept with dams under grazing vs. stall-feeding management systems. MSc. (Agri) thesis submitted to MPKV, Rahuri. (Unpublished).
- Suliman, G. M. and Babiker, S. A. 2007. Effect of diet-protein source on lamb fattening. *Res. J. Agric. & Biol. Sci.*, 3(5): 403-408.
- Tajane, K. R., Kulkarni, V. V., Patel, J. S. and Radadia, N. S. 1992. Effect of heat exposure on feed and water intake in sheep. *Indian J. Anim. Prod. Mgmt.* 8 (4): 269 - 272.
- Taylor, St. C. S. and Murray, J. I. 1991. Effect of feeding level, breed and milking potential on body tissues and organs of mature, non-lactating cows. *Animal Production*. 53: 27-38.
- Thomas, V. M.; Mcinerney, M. J.; Kott, R. W. 1988. Influence of body condition and lasalocid during late gestation on blood metabolites, lamb birth weight and colostrum composition and production in Finn-cross ewes. *J. Anim. Sci.*, 66: 783-791.

- Tripathi, M. K., Karim, S. A., Chaturvedi, O. H. and Singh, V. K. 2006. Effect of *ad libitum* tree leaves feeding with varying levels of concentrate on intake, microbial protein yield and growth of lambs. *Livestock Research for Rural Development*. 18 (179). Retrieved October 15, 2007, from <http://www.cipav.org.co/lrrd/lrrd18/12/trip18179.htm>
- Wahed, R. A. and Owen, E. 1986. Comparison of sheep and goats under stall feeding conditions; Roughage intake and selection. *Indian J. Anim. prod.*, 42: 89 - 95.
- Wand, C. 2003. Protein content in modern sheep rations. Fact sheet. Retrieved , October 11, 2007, from <http://www.omaf.gov.on.ca/english/livestock/sheep/facts/03-019.htm>
- Willms, C. L., Berger, L. L., Merchen, N. R., Fahey, G. C., and Fernando, R. L.. 1991. Effects of increasing crude protein level on nitrogen retention and intestinal supply of amino acids in lambs fed diets based on alkaline hydrogen peroxide-treated wheat straw. *J. Anim. Sci.* 69: 4939 - 4950.



APPENDICES

8. Appendices

Appendix – I: Daily crude protein requirements for growth and maintenance of lambs (g/d) (NRC, 1985)

A. Small mature weight lambs

Daily gain (g)	Body weight (kg)			
	10	20	25	30
100	84	112	122	127
150	103	121	137	140
200	123	145	152	154
250	142	162	167	168
300	162	178	182	181

B. Medium mature weight lambs

Daily gain (g)	Body weight (kg)			
	10	20	25	30
100	85	114	125	130
150	106	132	141	145
200	127	150	158	160
250	147	167	174	175
300	168	185	191	191
350	188	203	207	206
400	209	221	224	221

Appendix - IIScore sheet for semi-trained panel

Name of panelist: _____

Date: ___/___/___

Hedonic scale:

Very desirable9

Desirable.....8

Moderately desirable.....7

Slightly desirable.....6

Neither desirable nor undesirable.....5

Slightly undesirable.....4

Moderately undesirable.....3

Undesirable.....2

Very undesirable.....1

ID No.	Appearance	colour	Flavour	Tenderness	Texture	Juiciness	Over all Acceptability	Remark

Signature:

Appendix – III: Chemical composition of feed ingredients used for preparing treatment feeds

(% on DM basis)

Feed ingredients	CP	EE	CF	TA	NFE	TDN	DCP
Maize grain	10.6	3.30	2.2	1.85	82.10	76	5.86
Wheat bran	15.4	3.45	10.76	5.59	64.79	74.93	11.80
Soybean (roasted)	41.60	17.40	6	6.20	28.80	87.8	37.44
Ground nut cake	51.75	8.22	7.39	5.70	26.94	78.92	46.58
Lucerne green	19.90	1.81	29.61	14.10	34.68	57.79	15.92

Source: Banerjee (2005), Text book of animal husbandry (8th Ed.)

Appendix – IV: Meteorological data during experimental period (2007)

Period	Temperature (°C)		Humidity (%)		Rainfall (mm)
	Maximum	Minimum			
January	30.16	11.84	68.20	35.40	--
February	31.35	12.78	64	27	--
March	35.10	16.03	55.75	22.50	--
April	38.30	19.98	51.20	17.60	--
May	38.08	22.10	62.50	29.5	29.45

Appendix – V

A. Cost of feed ingredients used in preparation of concentrate mixtures

S. No.	Items	Price per kg of ingredients on as-fed basis (Indian Rs.)
1	Maize grain	6.25
2	Wheat bran	5.50
3	Soyabean (roasted)	11.90
4	Ground nut cake	12.60
5	Mineral mix	28.60
6	Common salt	2.30
7	Lucerne green	1.10

B. Cost of concentrate mixtures treatment wise per kg on as-fed basis

S. No.	Items	Price per kg on as – fed basis (Indian Rs.)
1	Concentrate mix. 1 (T ₀)	6.49
2	Concentrate mix. 2 (T ₁)	6.99
3	Concentrate mix. 3 (T ₂)	7.95
4	Concentrate mix. 4 (T ₃)	8.59

Note

1 USD dollar = 45 Indian Rupees = 9 Ethiopian birr



VITA

9. VITA

TETEMKE KIDANE GEBREHIWOT

A candidate for the degree
of

Master of Science (Agriculture) in Animal Science



Title of thesis : Effect of feeding different levels of crude protein on growth performance and carcass traits in Deccani lambs

Major Field : Animal Science

Biographical Information:

Personal Data : Born at Enticho, Tigray, Ethiopia on 19th January, 1981. Son of Kidane Gebrehiwot and Akheza Kahsay.

Education : Attended primary education at Enticho Complete Primary School, Tigray; secondary education at Enticho Secondary School, Tigray and Nefas Silk Comprehensive Secondary School, Addis Ababa.
: Received Bachelor of Science in Animal and Range Sciences from Mekelle University, Ethiopia in July 2004.
: Completed requirement of M.Sc. degree course and thesis has been submitted for the Master of Science in Animal Science at Post graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, India in 2008.

Work experience : From September 2004 to February 2006 served as Graduate Assistant at Mekelle University, Ethiopia.



T-6463