Effect of protein and mineral mixture supplementation on growth performance of Black Bengal goats

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BHUBANESWAR-751003

2020

Sabat GP, M.V.Sc. (Livestock Production and Management) Thesis, 2020.

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A THESIS SUBMITTED TO
THE ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE DEGREE OF

MASTER OF VETERINARY SCIENCE

IN

LIVESTOCK PRODUCTION AND MANAGEMENT

By

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Bhubaneswar
Date: 01.09.2020

CERTIFICATE-I

This is to certify that the thesis entitled **"Effect of protein and mineral mixture supplementation on growth performance of Black Bengal goats"** submitted in partial fulfilment of the requirements for the award of the degree of **Master of Veterinary Science (Livestock Production and Management)** to the Odisha University of Agriculture and Technology is a faithful record of bonafide and original research work carried out by **Girija Prasanna Sabat**under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

It is further certified that the assistance and help received by him from various sources during the course of investigation has been duly acknowledged.

CHAIRMAN

ADVISORY COMMITTEE

CERTIFICATE-II

This is to certify that the thesis entitled **"Effect of protein and mineral mixture supplementation on growth performance of Black Bengal goats"** submitted by **Girija Prasanna Sabat** to the Odisha University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of **Master of Veterinary Science** (**Livestock Production and Management)** has been approved/disapproved by the student's advisory committee and the external examiner.

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ACKNOWLEDGEMENT

I would like to extend my heartfelt regards and gratitude towards all those who always stand by me through the ups and downs of this itinerary and whose help is indispensible for the completion of this manuscript.

I wish to avail this golden opportunity in life to express my heartfelt and sincere gratitude from the core of my heart to the chairman of my advisory committee **Dr. B. Panigrahi,** Professor, Department of Livestock Production and Management for his adroit supervision, pertinent suggestions, and erudite guidance throughout this research. Above all and most needed, he provided me unflinching encouragement, blend of affection, moral support and support in various ways.

I am greatly beholden words to express my deep sense of obligation and gratefulness to respected **Dr. L.K. Babu**, Professor and Head, Department of Livestock Production and Management for his keen interest, skilful guidance, enlighten views, inspiring attitude, and valuable suggestions. It is a matter of great pride to work under dynamic guidance of an able and affectionate academician of his calibre.

I express my sincere gratification and indebtedness to **Dr. B. Sahoo**, Principal Scientist, CIWA, Bhubaneswar and member of advisory committee for his valued guidance, suggestions, encouragement, indispensable help and selfless support during the entire course of my work. His moral support at the time of need, the depth of knowledge, authority over the subject as well the affection poured on to his students made a tremendous difference in the pursuit of this venture. No words can convey my gratitude to him, for the enormous effort for my research work and during the compilation of the thesis.

I am especially thankful to **Dr. N. Panda**, Professor, Department of Animal Nutrition for his valuable guidance and encouragement during the study.

I feel eminent in expressing my gratitude and obligation to **Dr. A.P. Acharya**, Assistant. Professor Dept. of Veterinary pathology for his proper guidance, constructive criticism, inspiration in each and every step of my research work.

No words can pay my respect and deep sense of gratitude to **Dr. G.P. Mohanthy**, **Dr. Kumaresh Behera, Dr. S. Kanungo** and **Dr. (Mrs) Jessy Bagh,** Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology Bhubaneswar, for their whole hearted support, valuable suggestions and blessings during this study period.

I extend sincere thanks to **Dr. K. Sethy**, Assistant Professor, Department of Animal Nutrition for their benevolent guidance, valuable advice, wholehearted encouragement, valuable suggestions, providing necessary facilities and timely help during the entire course of investigation.

I am thankful to **Dr. A.K. Panda**, Principal Scientist, CIWA, Bhubaneswar for his benevolent guidance, valuable advice, wholehearted encouragement, valuable suggestions, providing necessary facilities and timely help during the entire course of investigation.

I extend sincere thanks to **Dr. Anil Kumar,** Principal Scientist, CIWA, Bhubaneswar for his benevolent guidance, valuable advice, wholehearted encouragement, valuable suggestions, providing necessary facilities and timely help during the entire course of investigation.

My heartfelt thanks to **Ms. Usha Rani Maradama, Mr. Manoranjan Prusty and Mr. Debendranaath Sarangi** for their active cooperation and timely help during my study.

I am thankful to the **Director,** ICAR-Central Institute for Women in Agriculture (CIWA), Bhubaneswar for providing the necessary facilities to carry out biological trials of my experiment at the renowned institute.

I also pay deep regards to the **Dean,** C.V.Sc. and A.H. for his generous attitude in providing necessary facilities to carry out the research work.

I sincerely express my heartfelt thanks to my batchmates and seniors **Guru, Pravanjan, Prateek, Jaya, Rosalin, Gayatri Didi, Sarbajit Bhai, Bhagwan Bhai, Subham Bhai, Pankaj Bhai, Sagar Bhai** and juniors **Babita, Sukanya** and **Harika** who have with me through all the ups and downs during my stay here. It is not

possible to take everyone name if someone is forgotten, I am highly thankful to them either they help me directly or indirectly.

I am also thankful to all the staffs of Department of Livestock Production and Management, **Sri J.N. Rout, Sri K. Sethi, and Sri N. Gochhayat** for their active cooperation during my study.

My heartfelt thanks to **Kulu Bhai** for his sleepless effort in completion of my thesis work in time.

The present endeavour could not have glanced on the canvass of reality without the blessings, love and deep affection of my Parents **Mr. Ramesh Chandra Sabat** and **Mrs. Padmini Das** whose sustained encouragement and love has always given me a new impetus to move forward & would like to hold this opportunity to express my profound feeling of reverence and love for my family & owe a lot to them.

Above all, I am also thankful to almighty GOD for being most beneficent and merciful during entire period of my M.V.Sc.

Place: Bhubaneswar

Date: 01.09.2020 **(Dr. Girija Prasanna Sabat)**

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LIST OF ABBREVIATIONS

ADF	:	Acid Detergent Fiber
ADG	:	Average daily gain
AIA	:	Acid insoluble ash
ALP	:	Alkaline phosphatase
ALT	:	Alanine aminotransferase
ANSA	:	Amino napthol sulphonic acid
AOAC	:	Association of Official Agricultural Chemists
ASMM	:	Area specific mineral mixture
AST	:	Aspartate aminotransferase
BCG	:	Bromocresol green
BG	:	Barley Grain
BGMS	:	Barley grain plus mineral mixture and salt
BUN	:	Blood urea nitrogen
Ca	:	Calcium
CF	:	Crude fibre
CHE	:	Cholesterol esterase
CHO	:	Cholesterol oxidase
CHOD	:	Cholesterol Oxidase
CK	:	Creatine kinase
CM	:	Concentrate Mixture
Co	:	Cobalt
CP	:	Crude protein
CPF	:	Concentrate pellet feed
CSM	:	Cotton seed meal
Cu	:	Copper
CuSO4	:	Copper sulphate
DC	:	Digestibility coefficient
DCP	:	Digestible Crude fibre
DE	:	Digestible energy
dl	:	Decilitre
DM	:	Dry matter
DMI	:	Dry matter intake

EE	:	Ether extract
FAO	:	Food and Agriculture Organisation
FCE	:	Feed conversion efficiency
Fe	:	Iron
fl	:	Femtoliter
g	:	Gram
GGT	:	Gamma glutamyl transferase
GOD	:	Glucose oxidase
GOI	:	Government of India
H_2SO_4	:	Sulphuric acid
Hb	:	Haemoglobin
HCl	:	Hydrogen chloride
$HClO_4$	:	Perchloric acid
HDL	:	High density lipoprotein
HNO_3	:	Nitric acid
i.e.	:	That is
ICAR	:	Indian Council of Agricultural Research
ICP-OES	:	Inductive coupled plasma emission spectrometry
kcal	:	Kilocalorie
kg	:	Kilogram
KH_2PO_4	:	Potassium dihydrogen phosphate
$KMnO_4$	:	Potassium permanganate
L	:	Litre
LDH	:	Lactate Dehydrogenase
LDL	:	Low Density Lipoprotein
LW	:	Live weight
Mcal	:	Megacalorie
MCH	:	Mean corpuscular haemoglobin
MCHC	:	Mean corpuscular haemoglobin concentration
MCV	:	Mean corpuscular volume
mg	:	Milligram
Mn	:	Manganese
MOC	:	Mustard oil cake
N	:	Normality
$Na_2S_2O_3$	:	Sodium thiosulphate

NaOH	:	Sodium hydroxide
NDF	:	Neutral detergent fibre
NDF	:	Neutral detergent fiber
NFE	:	Nitrogen free extract
nm	:	Nanometer
NRC	:	National Research Council
OCPC	:	O-Cresolphthalein complex
OD	:	Optical density
OM	:	Organic matter
P	:	Phosphorus
PAP	:	Peroxidase aminophena-zone
PBS	:	Phosphate buffer solution
PCV	:	Pack cell volume
pg	:	Picogram
POD	:	Peroxide
POD	:	Peroxidase
ppm	:	Parts per million
RCL	:	Regressed corpus luteum
RDP	:	Rumen degradable protein
Rs	:	Rupees
SBM	:	Soybean Meal
Se	:	Selenium
TA	:	Total ash
TDN	:	Total digestible nutrient
TEC	:	Total erythrocyte count
TLC	:	Total leucocyte count
TP	:	Total Protein
UDP	:	Undegradable dietary protein
Viz.	:	That is to say
WBMS	:	Wheat bran plus mineral mixture and salt
Wt.	:	Weight
Zn	:	Zinc
Zn-Met	:	Zinc methionine
ZnO	:	Zinc oxide
ZnSO4	:	Zinc sulphate

ABSTRACT

An *in vivo* study was conducted to assess the effects of proteinaceous diet along with mineral mixture on nutrient utilization, mineral bioavailability, haemato biochemical profile and growth performance of Black Bengal goats under intensive system of rearing. Eighteen female Black Bengal goats (body weight: 7.20 ± 0.12 kg) of average 5 months old were randomly divided into three groups. Animals were fed T_1: low protein and low mineral diet as per farmers' practice; T_2: high protein and low mineral; T_3: high protein and high mineral (@3% of concentrate mixture). Green fodder (hybrid napier) was provided to animals and concentrate and roughage ratio was maintained at about 40:60 level. The total DM intake was higher ($P<0.05$) in T_3 (488) than T_1 (445) but at par with T_2 (471). DM digestibility (%) in T_3 (61.50) was higher ($P<0.05$) than T_1 (54.75) and T_2 (57.75). Similarly, OM, CP, EE, NDF, ADF and TCHO digestibilities were higher in T_3 thanT_1 but at par with T_2. Daily nutrient intake (CP, DCP, TDN) were higher ($P<0.05$) in T_3 than T_1 but at par with T_2. Similar trend was also followed in nutritive value of the diet in terms of CP%, DCP% and TDN% of diet. The intake and bioavailability of minerals (Ca, P, Fe, Cu, Zn, Mn) were found to be higher ($P<0.05$) in T_3 than T_1 but at par with T_2. The haematological indices of goats especially Hb, TEC and PCV level were higher ($P<0.05$) in T_3 than T_1 and at par with T_2 irrespective of the periods. Similarly, serum biochemical indices i.e. glucose, protein and albumin level were higher in T_3 than T_1 and T_2 being at par irrespective of the period. Serum mineral (Ca, P, Cu, Fe, Zn, Mn) level was also higher ($P<0.05$) in T_3 than T_1 and T_2 which were at par. Total body weight gain (kg) for whole experimental period of 90 days was significantly higher ($P<0.05$) in T_3 (5.37) than in T_1 (3.31) and T_2 (4.39). Similarly, average daily gain (ADG; g/day) was also higher ($P<0.05$) in T_3 (63.94) than T_1 (39.40) and T_2 (52.32). The voluntary feed intake (g/day) of concentrate was higher ($P<0.05$) in T_3 (172.8) than T_1 (158.1) and T_2 (166.5). Feed gain ratio (DMI/unit body weight gain) was comparatively better ($P<0.05$) in T_3 (6.63) than T_1 (9.96) and T_2 (7.89) which were showing synergistic effect of minerals with protein diet for augmenting productive performance of goats. The feed efficiency and economics of production of goats revealed that feeding of protein rich concentrate mixture with mineral mixture t is comparatively better as the net profit (Rs.) was higher in T_3 (1308.40) than in T_1 (670.22) and T_2 (1030.13). It was inferred that feeding goats with high protein diet through increasing the level of ground nut oil cake improved the nutrient utilization, growth rate and feed efficiency. Further supplementation of mineral mixture @ 3% of concentrate mixture with proteinaceous diet improved growth performance and feed efficiency with better cost efficacy in goats.

CHAPTER-I

INTRODUCTION

Goat serves as the basis of livelihood support and financial security to major part of society, particularly for the poor farmers. Goat has incredible capacity to be used for the development of rural and urban society. In past few years, goat production in India has developed in the form of a profitable farming. Although our country ranks first in goat population with 148.88 million goats and 10.14% growth rate (DADF, 2019), the demand for chevon is increasing progressively. In India there is shortage of chevon and the demand is supposed to rise from 0.6 million tons in 2011 to 1.275 million tons in 2030 (FAO, 2012). Indian small ruminant sector contributes remarkably in the form of chevon production which is approximately 15% of the world and small holding farmers play an important role in this aspect. Goat meat contributes around 37% of the total meat produced from the livestock sector in India which comes from the 42% of goat population annually (GOI, 2019). In addition, the goat husbandry generates about 4% rural employment. Goat acts as a livelihood support for about 20 million small and marginal farmers (FAO, 2008).

Goat husbandry is dynamic socio-economic component for rural areas. Black Bengal goat (*Capra hircus*), is mostly found in the Eastern and North-Eastern region of India, is a dwarf meat type highly prolific breed of goat. The goat is renowned for its superior chevon quality, early sexual maturity, low kidding intervals, good adaptability, low capital intensity, no religious taboo against consumption, and steady income shows its importance among all goat breeds (Dixit and Shukla, 1995). Goat farming is a common activity in weaker section of the society especially the women in tribal community of Odisha. The number of small ruminants per household is 8.8 out of which 70.3% are goats and more than 80% of these animals are raised by farm women in small holder production system meant for production of meat (GOI, 2019). Goat farming plays an important role in employment generation, improving household nutrition and livelihood security of 80% of small and marginal farm women (GOI, 2019). However, these animals are usually on low plane of nutrition in extensive rearing system. The productivity of goats under prevailing traditional system is very low as goats are maintained in extensive system on natural vegetation and farmers are unaware about improved feeding system.

The production and reproduction performance in farm animals is primarily regulated by nutrition (Maurya *et al*., 2010). Unavailability of sufficient feed resources has a greater contribution towards lower animal production (Salem, 2010; Kawas *et al*., 2010). As the goat farming is now being taken as an industry, the trend of keeping goats under stall-feeding is being noticed day by day in which proper attention towards nutrient supply is required (Rastogi *et al.,* 2003). Since grazing alone might not improve the weight gain and productivity of goats, manipulation of the diet through feeding proteinaceous concentrate can be done (Ferdous *et al*., 2011). Minerals and vitamins possess a crucial role in the growth and reproductive of performance of animals (El-Shahat and Abdel Monem, 2011). Dietary deficiencies of critical minerals especially iron, copper, selenium and zinc are usually observed in ruminants (Monem and El-Shahat, 2011). Concentrate mixture imbibed with all type of nutrients especially protein, energy and mineral vitamin premix is indeed essential to fulfill the nutrient requirements of (Ferdous *et al.,* 2011).

Protein and minerals have a great impact on animals' productive performance. Most of the roughages, green fodder and concentrate contain less protein and even deficient in very essential trace mineral elements, which is often neglected in correcting the imbalances (Kumar *et al.*, 2011). Health and production of animals is thus greatly influenced by optimal level of essential and trace minerals in animals' diet (Sharma *et al.*, 2009). Goats are usually fed imbalanced diet and improper feeding of goats under this conventional feeding system lead to low productive performance. In some findings it was observed that grazing alone might not be adequate for optimum growth performance of goats (Kochapakdee *et al*., 1994). If foraging goats can be supplemented with required amount of concentrate rich in protein and minerals, an increased production level can be achieved at a minimum cost. Due to rare practice of supplementing concentrate and mineral mixture, animals don't attain desirable weight at their marketable age which leads to huge loss to the farmer. Supplementation of proteinaceous feed through oil cakes and mineral mixture is intended to increase dietary energy, protein, mineral and vitamins which may improve nutrient utilization and growth performance of goats. Strategic nutritional intervention with protein rich feed stuffs and catalytic supplementation of micro nutrients through mineral mixture during peak phase of growth especially six months old till marketable age may be helpful in augmenting growth performance and

enhance the income generation of rural farm women. Nutritional maneuvering by concentrate feeding may help to increase the (Pathasarathy, 1986). Optimum growth rate of kids may be attained by increasing protein level of the diet fortified with trace minerals. However, reports on the nutritional requirements are few and less information is available on the influence of dietary protein and minerals on growth performance, physiological and biochemical profile of Black Bengal goats. Therefore, the current research was undertaken to investigate the effects of proteinaceous di*et al*ong with mineral mixture on nutrient utilization, mineral bioavailability and growth performance of Black Bengal goats under stall feeding condition. Considering the above facts, the current study is envisaged with the following objectives:

1. To study the effect of supplementation of protein (oil cakes) and mineral mixture on growth performance of Black Bengal goats
2. To assess the nutrient utilization in goats fed protein and mineral mixture in the diet.

CHAPTER-II

REVIEW OF LITERATURE

The study relating to the "Effect of supplementation of protein rich concentrate along with mineral mixture on nutrient utilization and growth performance of Black Bengal goats" under intensive rearing system have been presented under this chapter.

Nutrition is generally regarded as a significant regulator for optimum production. The cost of rearing goats in India is low and the animals are often reared through grazing on wasteland, range grasses and browses and agricultural by-products, at times on garden and kitchen wastes and rarely receive any supplements (Singh and Kumar, 2007). The post weaning ration should be a high concentrate ration with a minimum of 16-18% CP, 0.6% Ca and 0.3% P for optimum growth of goats (Sahoo *et al*., 2015). During last trimester of pregnancy, post grazing stall feeding of concentrate at 200-300 g/goat/day is also required to fulfil the heavy nutritional demand of animals (Sahoo *et al*., 2015). Majority of the goat population in the world is reared under the small holding farming system where nutritional management is not optimum (Sibanda *et al*., 1999). Flocks are maintained on community grazing land by the farmers by employing family labour with negligible purchased inputs and marginal output (Chauhan and Moorti, 1999). The productive performance of goats can be improved by feeding concentrate (Madibela and Segwagwe, 2008) and by giving high quality forage (Muri and Jordao, 1991). Concentrate feeding has a recognizable effect on growth and productivity of goats (Kochapakdee *et al.*, 1994). However, the feeding of concentrate mixture which is often devoid of mineral mixture and imbalanced in nature is rarely practiced in goats in rural goat farming system resulting lower growth performance. There is scarce of report on contribution of dietary protein and minerals on nutrient utilization, mineral bioavailability and its effect on productive performance of Black Bengal goats. The study has been reviewed on effect of protein with or without minerals on growth performance of goats as follows.

2.1 Body weight and average daily gain in goats

2.1.1 Effect of protein

Kayongo *et al*. (1984) studied the effect of concentrate supplementation on the productive performance of East African goats maintained on range land grazing during periparturient period and found no significant difference between the treatment and control groups that are maintained with or without concentrate feed during prepartum period on performance of adults or of their kids. The weight gain of adults was not affected by the amount of concentrate given during lactation but kids fed concentrate showed faster weight gain than the kids of control group during first four weeks.

In a study conducted on six females of ten months age of each goat and sheep (average weight 12.6 and 11.7 kg, respectively) for the supplementary effect of concentrate on growth and reproduction under grazing condition, Kabir *et al*. (2002a) reported that the concentrate supplemented animals showed significant change in weight gain as compared to non-supplemented group (26.19 *vs.* 20.24 g/day) irrespective of the animal species.

Pailan *et al.* (2007), experimented on ewes and does by practising 7 hrs. of grazing on daily basis for 3 months along with concentrate feeding @ 0% (Group 1), 0.5%, 1% of body weight in Group 1, 2 and 3 respectively. They concluded that supplementation of concentrate mixture to both sheep and goat @ 1.0% of bodyweight is essential for optimum productivity.

Solomon *et al*. (2008) conducted an experiment on yearling male Sidama goats to study the effect of different parts of cottonseed meal on BW gain, feed intake, digestibility and carcass traits of goats. The animals in the control group (T_1) were fed *ad libitum* hay and animals in the treatment group were supplemented with CSM @ 200 g, 300g and 400g in T_2, T_3 and T_4 respectively on dry matter basis along with diet of T_1. The study revealed that the non-supplemented goats had lower body weight change ($P<0.01$) and final body weight ($P<0.05$) than the goats supplemented with CSM @ 300 g DM/ head/ day.

Ullah *et al.* (2009) conducted on male Black Bengal goats (8 - 10 months of age, average live weight 9.16 kg) and reported that improvement in growth performance of goats can be achieved by supplementing the goats a concentrate mixture containing low protein (16%) supplementation (mustard cake or soybean meal) under intensive rearing system and is beneficial for profitable goat rearing.

Sultana *et al*. (2012) conducted experiment on Black Bengal does (10 months age, 11.5 kg live weight) by dividing the animals into four homogenous groups having four animals in each. Animals in different groups were fed concentrate mixture @ 150, 200, 250 and 300 g and *ad libitum* green grasses, respectively. They observed that daily weight gain of kids was non-significant among the groups.

In an experiment conducted on male Black Bengal goats (12.97kg, 12-13 months age), Ferdous *et al.* (2011) examined the effect of concentrate levels on growth performance and digestibility. They took five groups: A (Dal grass) and B, C, D, E were given 15%, 20%, 25% and 30% concentrate respectively along with Dal grass for rest parts of the dry matter. Live weight gain was the lowest in group A. Significant difference ($P<0.01$) was also observed among the groups B, C, D and E. Increase in concentrate gradually increased live weight from B to E. They concluded that feeding concentrate mixture having 15.60% CP @ 30% of total DM requirement was helpful for optimum growth of goats under stall feeding.

Rahman *et al.* (2013) examined the effects of concentrate diet (formulated by 35% maize, 30% rice bran, 32% palm kernel cake, 2% vitamin mineral mix. and 1% salt) on nutrient intake, digestibility and live weight gain of female goats (average live weight 12.4 kg) and observed that feeding of Napier grass with concentrate mixture improved the ADG (59.0 *vs.* 72.1 g/day).

Kato *et al*. (2013) conducted an experiment on twenty-four yearling of Mubende indigenous meat goats (average body weight 15 kg) to know the supplementary effect of protein source on the performance of goats and concluded that Cassava leaf meal supported better live weight gain (77.1 g/day) as compared with Lablab (41.8 g/day) hay, sweet potato vines (56.8 g/day) and sunflower seed meal as a protein source for indigenous meat goats maintained on a low quality Guinea grass hay.

In a study conducted on 30 male Barbari kids, Chaudhary *et al.* (2015) assessed the effect of supplementing concentrate mixture on performance and economics of kids with grazing based production system. Male Barbari kids (30) were divided randomly in 5 equal groups. Kids were allowed 8 h daily grazing and offered Arhar straw (*Cajanus cajan*) *ad libitum* after grazing for 128 days. Kids of control group were not provided any concentrate supplement, while other kid groups received either concentrate pellet feed (CPF), barley grains (BG), wheat bran plus mineral mixture and salt (WBMS) or barley grain plus mineral mixture and salt (BGMS) at 1% of live weight after grazing. The final live weights were the highest in CPF (27.6 kg) supplemented kids, whereas other groups of kids had lower final live weights. Total live weight gains were higher in CPF (12.33 kg), BG (10.20 kg) and BGMS (10.03 kg) supplemented kids in comparison of control (7.18 kg) and WBMS (9.05 kg) group of kids. Average daily gain (ADG) ranged between 51.6 and 88.7 g, which is higher in the kids of CPF group. It was concluded that additional supplementation of 1.0% concentrate provided higher growth performance over the kids managed on grazing alone, and the feeding of concentrate pellet provided maximum net returns.

In a study conducted on 45 pregnant Ganjam does to assess the effect of different levels of concentrate on peripartum growth performance of goats by dividing them in to three groups with 15 does in each group, Sahu *et al.* (2013) found that the body weight of does in T_1 (sole grazing) increased from 34.59kg (initially) to 38.29 kg (post 60 days), does in T_2 (grazing + 200 g concentrate/goat/day) increased from 33.91kg to 38.71 kg and for T_3 (grazing + 200g concentrate/ goat/day) ranged from 34.05 to 39.55 kg which indicated that supplementation of concentrate mixture helped in significant improvement in peripartum body condition of goats.

Mohsan *et al*. (2019) performed an experiment to know the effect of levels of dietary protein in the feed, on the fattening of twenty seven male Beetal goats (initial bodyweight 35 ± 0.5 kg, 12 to 16 months of age) by randomly assigning them into three treatments, which were fed an isocaloric supplement with 5 kg sorghum, varied in level of CP, viz. 1) 18% (LP) 2) 25.5% (MP) 3) 31.6% (HP) and observed that supplementing higher levels of CP gradually increased the growth in terms of body weight gain (111, 125, 145 g/day).

2.1.2 Effect of mineral

Alfaro *et al.* (1987) observed that higher Ca intake or Ca: P ratio in the feed might not affect the ADG, feed intake, feed efficiency of calves.

Higher feed intake was observed in animals as a result of mineral mixture supplementation in the diet @ 40 g/day which improved palatability of the diet and higher DM intake which increased body weight gain in the experimental period (Kumar *et al.*, 2002). Mineral mixture supplementation @ 50 g/day containing Ca, P, Zn, Mg, and Cu helps in maintaining the growth, reproduction and health status of the animals which play important role in various physiological phenomenon (Boland and Lonergan, 2003).

Maan and Sihag (2014) experimented with eighteen goat kids (22.84 kg and 8 to 9 months age) by taking three groups to study the effect of zinc supplementation on growth performance where kids of control group (T_1) were maintained on concentrate mixture, gram straw, mineral mixture without Zn and salt. The concentrate mixtures in group T_2 and T_3 were fortified with 45 mg/kg of ZnO and $ZnSO_4$, respectively. The DM intake, DM, OM and CF digestibility and DCP and TDN of the ration were comparable in three groups. ADG and feed efficiency were higher ($P<0.05$) in T_2 and T_3 in comparison with T_1. It was concluded that addition of ZnO or $ZnSO_4$ in the diet improved the growth performance of kids.

In an experiment conducted on fifteen local male goat (7-8 months of age, 9.38 kg body weight), Tiwari *et al.* (2014) randomly distributed the animals in three homogenous groups viz. T_1, T_2 and T_3. All were provided *ad libitum* basal diet. Animals in T_2 and T_3 were supplemented with 10 and 15 g mineral mixture per goat per day respectively for a period of 120 days. were recorded in T_3 showed the higher body weight (kg) and ADG (g) (4.9 kg and 41.0g) followed by T_2 (4.8 kg and 39.7g) and T_1 (4.3 kg and 35.5 g). The results of study indicated that adding @ 15 g /goat/day with basal diet helped in higher body weight gain in male goats.

Godara *et al.* (2016) conducted an experiment on female Black Bengal goats (n = 24) and divided into four groups (I, II, III & IV) which were supplemented with 0, 1, 2% trace minerals and 2% commercial mineral mixture for three months, respectively. The results revealed that final body weight and ADG was higher in mineral supplemented groups than control group.

2.1.3 Effect of protein with mineral:

Yadav *et al.* (2010) conducted an experiment on sixty growing goats of about 6-8 months of age kept on sole grazing (group-I), fed 150 g concentrate mixture (group-II), fed 150 g concentrate mixture + 10 g mineral mixture (group-III) along with grazing and found that total body weight gain was higher ($P<0.05$) in group-III in relation to other groups of animal and concluded that feeding of concentrate and mineral mixture along with grazing was beneficial for body weight gain in goats.

Niaz *et al.* (2017) conducted an experiment (3months) on twenty male Ganjam kids (2-3 months, 6.22 kg body weight) by dividing them into four groups. Animals in the group I were maintained as per farmer practice, while animals in treatment groups i.e. group II and III were additionally supplemented with 100 g CM and 5 g of area specific mineral mixture respectively. Kids in group IV were supplemented with both 100 g CM and 5 g of area specific mineral mixture. Results showed significant ($P<0.05$) increase in ADG in treatment groups than the control. It was concluded that supplementation of 100 g of concentrate along with 5 g of area specific mineral mixture improved the growth performance of Ganjam goats.

2.2 Feed intake and feed conversion ratio

2.2.1 Effect of protein

In a study conducted on six females of 15 months age of each goats and sheep (average weight 12.6 and 11.7 kg, respectively) to know the supplemental effect of protein on growth and reproductive performance under extensive system, Kabir *et al*. (2002b) reported that there was significantly higher ($P<0.01$) dry matter intake in supplemented group (concentrate along with grazing) as compared to control group (sole grazing) irrespective of animal species showed higher dry matter intake as compared to non - supplemented group (506.9 *vs.* 186.6 g/d). It was concluded that supplementing protein diet would be benefited for improving the feed intake of goats and sheep.

Solomon *et al*. (2008) conducted an experiment on yearling male Sidama goats with an average body weight 16.8 kg. The animals in the control group (T_1) were fed *ad libitum* hay and animals in the treatment group were supplemented with

CSM @ 200 g, 300g and 400g in T_2, T_3 and T_4 respectively on dry matter basis along with diet of T_1. It was found that the non-supplemented animals had lower final body weight ($P>0.05$) and higher FCR ($P<0.01$) than the goats supplemented with CSM @ 300 g DM/head/day.

In an experiment conducted on male Black Bengal goats (8 to 10 months of age and 9.16 kg average weight), Ullah *et al.* (2009) reported that a concentrate mixture containing low protein (16%) supplementation (mustard cake or soybean meal) can be used for improving feed conversion efficiency of goats under intensive management system and concentrate diet prepared with soyabean meal or mustard oil cake having 16% protein could be implemented for economic goat production.

In an experiment conducted by Ferdous *et al.* (2011) on male goats (12.97 kg; 12-13 months age) animals were supplemented @ 158 g DM/kg $W^{0.75}$/day. Five groups were taken: A (Dal grass) and B, C, D, E were given 15%, 20%, 25% and 30% concentrate respectively along with Dal grass for rest parts of the dry matter. Feed conversion efficiency of group E higher than D, C, B and A (0.09, 0.08, 0.08, 0.07, 0.04). It was concluded that supplementation of CM having 15.60% crude protein @ 30% of total DM requirement per 100 kg body weight was helpful for optimum feed conversion efficiency in goats.

In a study conducted on female Black Bengal goats by dividing the animals into four homogenous groups and by feeding the animals of group A, B, C, D @150, 200, 250 and 300g concentrate mixture and *ad libitum* green grasses respectively, Sultana *et al*. (2012) observed that total DM intake (333.6, 374.7, 416.3 and 456.5g/day in A, B, C and D, respectively) was affected by the concentrate level in the diet. CP intake (45.2, 57.0, 66.4 and 75.7g/day) was higher ($P<0.01$) in group D than the other groups and concluded that daily concentrate supplementation @ 250g to goats enhanced the feed intake.

Rahman *et al.* (2013) examined the effects of concentrate diet (formulated by 35% maize, 30% rice bran, 32% palm kernel cake, 2% vitamin mineral mix and 1% salt) on nutrient intake, digestibility and live weight gain of female goats and observed that feeding of Napier grass with concentrate mixture didn't improve the FCR (10.4 *vs.* 9.6).

Kato *et al*. (2013) conducted an experiment on twenty-four yearling of Mubende indigenous meat goats (average body weight, 15.4 kg) to know the supplementary effect of protein source on the performance of goats and concluded that Cassava leaf meal supported better feed conversion and dry matter intake as compared with Lablab hay, sweet potato vines and sunflower seed meal as a protein source for indigenous meat goats maintained on a low quality Guinea grass hay.

In a study conducted on 30 male Barbari kids, Chaudhary *et al.* (2015) assessed the effect of supplementary feeding of concentrate feeds on performance, and economics of kids with grazing-based production system. Male Barbari kids (30) were divided randomly in 5 equal groups. Kids were allowed 8 h daily grazing and offered Arhar straw (*Cajanus cajan*) *ad lib.* after grazing for 128 days. Kids of control group were not provided any concentrate supplement, while other kid groups received either concentrate pellet feed (CPF), barley grains (BG), wheat bran plus mineral mixture and salt (WBMS) or barley grain plus mineral mixture and salt (BGMS) at 1% of live weight after grazing. The final live weights were the highest in CPF (27.6 kg) supplemented kids, whereas other groups of kids had the lower final live weights. Although the supplementary feeding increased the cost of feeding from 227 to 401 on each kid, however net return on each kid over the control were 467, 712, 755 and 1,287, respectively, in WBMS, BGMB, BG and CPF group of kids. It was observed that supplementary feeding of 1.0% concentrate provided higher economic return over the kids managed on grazing alone, and the feeding of concentrate pellet provided maximum net returns.

Mohsan *et al*. (2019) performed an experiment to know the effects of dietary protein levels on the fattening of twenty seven male Beetal goats (initial body weight 35 kg, 12 to 16 months of age) by randomly assigning them into three treatments, which were fed an isocaloric supplement with 5 kg sorghum, varied in the level of CP, viz. 1) 18% (LP) 2) 25.5% (MP) and 3) 31.6% (HP) and observed that supplementing higher levels of CP gradually increased the growth in terms of body weight gain (111, 125, 145 g/day), feed intake in terms of dry matter (1.28, 1.31, 1.33 kg/day) and feed efficiency(0.08, 0.10, 0.11) of growing Beetal goats.

2.2.2 Effect of mineral

Sethy *et al.* (2016) performed an experiment to know the effect of inorganic Zn (Zinc oxide) and organic Zn (Zinc methionine) supplementation in the diet on growth, haematology, metabolic profile, feed conversion efficiency and immune status on fifteen Black Bengal goat kids (2-3 months of age, 6.13 kg average bw.). Animals were divided in to three homogenous groups and fed a diet comprising concentrate mixture and paddy straw, containing 24.7 ppm and 10.3 ppm of Zn, respectively on DM basis. T_1 served as control (without Zn supplementation). T_2 and T_3 groups were fed with 40 mg/kg DM as zinc oxide and Zn-Met respectively. The experiment continued for 90 days. Results revealed that the effect of Zn supplementation on feed conversion efficiency (DMI/ADG/Day) was non-significant . However, FCE was the highest in T_3 group of animals.

2.3 Haemato-biochemical profile

2.3.1 Effect of protein

Patel *et al.* (1992) studied the hemato biochemical profile in Surti and Marwari goats. They observed that the ALP activity decreased during initial part of gestation but later increased. Total protein, peroxides, calcium and glucose showed non-significant difference, but serum copper and phosphorus concentration were declined with advancement of gestation. They concluded that the changes in these parameters for maintenance of pregnancy only.

Singh and Shinde (1997) took Sirohi lactating does maintained on grazing fed concentrate mixture 0, 150, 300 and 450 g/head/day in four respective groups upto 150^{th} day of lactation and concluded that concentrate supplementation improved blood glucose, total protein, albumin, globulin and BUN level.

2.3.2 Effect of mineral

While reviewing the effect of inorganic copper (copper propionate) and organic copper ($CuSO_4$) to Black Bengal goat kids, it was found that kids supplemented with copper propionate showed higher body weight gain and decrease in plasma cholesterol, than $CuSO_4$ supplemented group. Haemoglobin, PCV, TEC and TLC remain unaffected by source and dose of Cu but dose of Cu played a vital role on

the growth performance, nutrient utilization and plasma cholesterol in goats (Datta *et al.*, 2007).

Ray (2009) studied hemato biochemical parameters in pregnant Ganjam does by feeding concentrate @ 50, 100 and 150 g per day to three groups respectively, and compared them to does maintained on sole grazing in every fort night interval and two months before kidding. He observed that serum glucose level ranged from 37.231 to 49.543 mg/dl, total protein level ranged from 8.14 to 9.84 from beginning until kidding. Serum glucose level didn't show any definite pattern and serum total protein decreased in all the treatment groups.

Singh *et al*. (2010) conducted a trial on ten male kids for two months by dividing the animals into two homogenous groups. Group-I was supplemented with deficient minerals such as Mn, Cu while group-II was taken as control (no supplementation). Eight hours grazing was provided to the animals in both the groups daily with no concentrate supplementation. They observed that the hematological parameters were normal in both the groups before and after the experiment. Supplementation of trace minerals significantly ($P<0.01$) improved the hemoglobin concentration (8.6 *vs.* 10.64 g/dl) and Packed cell Volume (29.6 *vs.* 34.4 %) than that of control group where the haemoglobin (g/dl) concentration was 8.5 *vs.* 8.40 and PCV (%) was (31.0 *vs.* 29.20). Supplemented groups showed higher significance ($P<0.05$).

In a study on Black Bengal goats to assess the supplementary effect of mineral mixture, Godara *et al.* (2015) found that plasma glucose concentration was the highest in group commercial mineral mixture fortified concentrate supplementation and lowest in the control group. Plasma alpha amino nitrogen level was higher in the group supplemented with commercial mineral mixture fortified concentrate followed by the groups 2% and 1% mineral mixture supplementation. There was significant difference in Plasma SGPT and SGOT level and goats supplemented with 1% mineral mixture showed the highest value.

Sethy *et al.* (2016) conducted a study in Black Bengal male goats to examine the outcome of inorganic Zn (zinc oxide) and organic Zn (zinc methionine) Supplementation on growth, haematology, metabolic profile, and immune status.

Fifteen Black Bengal male goat kids were divided in to three homogenous groups and fed a diet comprising concentrate mixture and paddy straw, containing 24.7 ppm and 10.3 ppm of Zn, respectively on DM basis. Zn supplementation was made to T_1 (0), T_2 (40 mg /kg DM as ZnO) and T_3 (40 mg /kg DM as, Zn-Met) for 90 days. Results revealed that the effect of Zn supplementation on final body weight (kg), ADG (g), feed conversion efficiency, haematological parameters, *viz*., Hb and PCV, and metabolic parameters, *viz*., total protein, albumin, globulin, urea, and A:G ratio was non-significant, whereas, serum glucose concentrations (mg/dl) in Zn supplemented groups were significantly ($P \leq 0.05$) higher (55.30 and 57.51) than the T_1 (control) which was 48.05.

2.4 Nutrient utilization

2.4.1 Effect of protein.

Solomon *et al*. (2008) conducted an experiment on yearling male Sidama goats (16.8 kg body wt.). The animals in the control group (T_1) were fed *ad libitum* hay and animals in the treatment group were supplemented with CSM @ 200 g, 300g and 400g in T_2, T_3 and T_4 respectively on dry matter basis along with diet of T_1. They found that increase in the level CSM improved ($P<0.05$) apparent DC of DM and OM in comparison with control group. The DC in terms of CP was higher ($P<0.01$) in treatment groups than control group. It was found that CSM supplementation @ 300 g DM/ head/day improved nutrient utilization in goats.

Ferdous *et al.* (2011) conducted an experiment on male goats (12.97 kg; 12-13 months age) and supplemented them @ 158 g DM/kg $W^{0.75}$/day. Goats were divided into five groups: A- dal grass and B, C, D, E were given 15%, 20%, 25% and 30% concentrate respectively along with Dal grass for rest parts of the dry matter. The DM, CP, CF, EE, NFE and OM digestibility (%) for B, C, D and E diets were higher($P<0.01$) than A. Higher level of protein from SBM improved the digestibility of protein. Hence, it was concluded that supplementation of concentrate mixture containing 15.60% CP @ 30% of total DM requirement might help in augmenting the nutrient utilization of Black Bengal goats.

Rahman *et al.* (2013) examined the effects of concentrate diet (formulated by 35% maize, 30% rice bran, 32% palm kernel cake, 2% vitamin mineral mix. and 1%

salt) on nutrient intake, digestibility and live weight gain of female goats (average live weight 12.4). Animals were assigned to four experimental diets. T_1 was fed *ad libitum* Napier grass (*Pennisetum purpureum*). Animals in the T_2, T_3, T4 were supplemented with concentrate @ 0.5, 1.0, 2.0% of live weight respectively along with the diet fed to T_1 for a period of 82 days with a 7 days digestibility trial. The digestibility of DM, OM and CP were found to be similar among treatments. The NDF digestibility decreased with increase in the levels of concentrate, but difference between T_2 and T_3 diets was non- significant ($P>0.05$).

2.4.2 Effect of mineral

While reviewing the effect of inorganic copper (copper propionate) and organic copper ($CuSO_4$) in Black Bengal goat kids, it was found that Cu-P supplementation improved the digestibility of DM and OM ($P<0.01$) in comparison with $CuSO_4$ supplemented group. A linear and quadratic response in terms of DM and OM ($P<0.05$) digestibility was observed to dose of Cu supplementation (Datta *et al.*, 2007).

2.5 Feed efficiency and economics

2.5.1 Effect of protein

In an experiment conducted on male Black Bengal goats, Ullah *et al.* (2009) reported that a concentrate mixture containing low protein (16%) supplementation (mustard oil cake or soybean meal) might improve growth performance of goats under intensive rearing system and it was concluded that concentrate diet containing soyabean meal or mustard oil cake having 16% protein could be implemented for economic goat production.

In an experiment conducted by Ferdous *et al.* (2011) on male goats (12.97 kg; 12-13 months age) animals were supplemented @ 158 g DM/kg $W^{0.75}$/day. Five treatments were taken: A (Dal grass) and B, C, D, E were given 15%, 20%, 25% and 30% concentrate respectively along with Dal grass for rest parts of the dry matter. Feed conversion efficiency of group E was the higher than D, C, B and A (0.09, 0.08, 0.08, 0.07, 0.04). They found that total feed cost and rearing cost per animal was higher ($P<0.01$) for E than other groups. Group E showed the highest net profit

(+134.25). It was concluded that supplementation of concentrate mixture having 15.6% CP @ 30% of total DM requirement per 100 kg body weight was helpful for optimum feed conversion efficiency and higher profit in goat farming.

2.5.2 Effect of mineral

Maan and Sihag (2014) studied the effect of zinc (Zn) supplementation (ZnO and $ZnSO_4$) on growth performance of goat kids where kids of control group (T_1) were maintained on gram straw, concentrate mixture and mineral mixture without Zn and salt. The concentrate mixtures T_2 and T_3 were fortified with 45 mg of ZnO and $ZnSO_4$ per kg, respectively. ADG and FCE were higher ($P<0.05$) in T_2 and T_3 in comparison with T_1. It was concluded that addition of ZnO or $ZnSO_4$ in concentrate mixture improved the FCE and higher economic return.

In a study conducted on 30 male Barbari kids, Chaudhary *et al.* (2015) assessed the effect of supplementary feeding of concentrate feeds on performance, and economics of kids with grazing-based production system. Male Barbari kids (30) were divided randomly in 5 equal groups. Kids were allowed 8 h daily grazing and offered arhar straw (*Cajanus cajan*) *ad lib.* after grazing for 128 days. Kids of control group were not provided any concentrate supplement, while other kid groups received either concentrate pellet feed (CPF), barley grains (BG), wheat bran plus mineral mixture and salt (WBMS) or barley grain plus mineral mixture and salt (BGMS) at 1% of live weight after grazing. They observed that although the supplementary feeding increased cost of feeding from Rs. 227 to 401 on each kid, however net returns over the control kids were Rs. 467, 712, 755 and 1,287, respectively, on each kid of WBMS, BGMB and CPF group. The supplementary feeding had a remunerative approach of meat kid production over grazing alone, and the supplementation of balanced feed have added benefits over a single cereal grain or grain by product feeding. Supplementary feeding promoted growth by providing adequate nutrients and therefore higher live weight and increased market sale prices, which in turn provided high net returns. Hence, they concluded that supplementation of concentrate at 1% of live weight of growing kids was recommended for higher economic returns and supplementation of concentrate feed pellet exhibited the highest net returns of Rs. 1,287 by each animal.

CHAPTER-III

MATERIALS AND METHODS

3.1 Location of the experiment

The study entitled **"Effect of protein and mineral mixture supplementation on growth performance of Black Bengal goats"** was carried out in the Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, during February to May 2020. The biological trial was conducted at the ICAR-Central Institute for Women in Agriculture (CIWA), Bhubaneswar.

3.2 Animal selection and grouping

Eighteen female Black Bengal goats of similar body weight (7.20 ± 0.12 kg) and age (5 months) were randomly divided into three homogenous groups of six in each following standard statistical design. The trial was conducted for three months starting from month of March to month May 2020.

3.3 Experimental animals and management

Throughout the experimental period of 90 days goats were kept under uniform managemental practices in a well ventilated pucca house. Prior to the biological trial deworming of all the animals was done for ecto and endo parasites and proper health management and sanitation was provided during the course of experimentation.

3.4 Experimental design

Eighteen female Black Bengal goats were randomly divided into three homogenous groups based on age and body weight at experimental farm, CIWA, Bhubaneswar. The growth study was conducted for three months duration and feeding experiment was designed as follows.

- T_1(Control group) - The animals were fed as per conventional/farmers' practice adopted by farmers in rural areas (low protein and low mineral)
- T_2 - Goats were fed protein-based diet (high protein and low mineral)
- T_3 - Goats were fed same diet as T_2 group along with supplemental mineral mixture @3% of concentrate mixture (high protein and high mineral).

The feeding of animals satisfied the nutrient requirement of ICAR standard (2013).

The details of the experimental design are given below:

Table 3.1. Distribution of animals for experiment

Group	No. of animals	Dietary Supplementation
T_1 (Control)	6	Conventional/Farmers' practice (Low protein and low mineral)
T_2	6	Conventional/Farmers' practice + Ground nut cake (High protein+ Low mineral)
T_3	6	Conventional /Farmers' practice + Ground nut cake + Mineral mixture @3% (High protein+ High mineral)

3.5 Preparation of concentrate mixture

The feed was prepared in Central Institute for Women in Agriculture, Bhubaneswar. All the ingredients were taken in the requisite amount to meet the required energy, protein and other requirements of the diet and mixed properly. Then the feeds were kept in a clean and dry container and provided to the animals daily as per requirement. The ingredients composition for the three experimental groups is given below.

Table 3.2. Ingredient composition of concentrate mixture

Ingredients	T_1 (%)	T_2 (%)	T_3 (%)
Maize	30	30	30
Rice bran	39	29	26
Ground nut oil cake	0	15	15
Pulse chuni	30	25	25
Mineral mixture	0	0	03
Salt	01	01	01

Feed was offered to the animals @ 4% of the body weight (on DM basis) on daily basis throughout the experimental period. Level of concentrate and roughage was about 40:60 ratio. In roughage Hybrid napier fodder was offered to the animals under cut and fed system. Half of the required concentrate mixture was given in the morning hours and rest half of the concentrate mixture was given in the afternoon hours. Under A commercial mineral mixture named Growmin Forte was fed @3% of concentrate mixture.

3.6 Chemical composition of feeds

The proximate composition, fiber fraction macro- and micro-mineral content of concentrate mixtures and Hybrid napier offered to goats during digestibility trial is presented in Table 4.1 Incorporation of proteinaceous ingredients increased protein content in CM-II (18.33%) and supplementation of mineral mixture in CM-III lower the organic matter (89.75%) with consequent increase in macro and micro mineral level in CM-III.

Table 3.3. Chemical composition (% DM basis) of feeds and fodders

Attributes	(CM-I)	(CM-II)	(CM-III)	Fodder
Organic matter	91.96	93.34	89.75	91.15
Crude protein	13.38	18.33	17.97	7.5
Ether extract	2.96	3.41	3.55	2.9
Total carbohydrates	75.62	71.6	68.23	80.75
Neutral detergent fiber	49.5	47.5	47.2	72.55
Acid detergent fiber	10.5	9.55	9.4	45.75
Calcium	1.2	1.5	2.3	0.55
Phosphorus	0.66	0.6	1.2	0.35
Copper (ppm)	19.8	25	45	10.5
Iron (ppm)	120	140	225	250
Manganese (ppm)	80	92	130	45
Zinc (ppm)	82	92	175	38

Table 3.4. Ingredient composition of mineral mixture (Growmin Forte)

Attributes	Per kg of mineral mixture	Ingredients	Per kg of mineral mixture
Calcium	212.50 g	Potassium	83.07 mg
Phosphorus	106.25 g	Sodium	5.00 mg
Magnesium	5.00 g	Selenium	8.33 mg
Manganese	1.25 g	Bioactive chromium	65.00 mg
Iron	1.25 g	Vitamin A	5833333 IU
Iodine	270.76 mg	Vitamin D_3	58333 IU
Copper	3.50 g	Vitamin E	207.69 mg
Zinc	8.00 g	Nicotinamide	833.07 mg
Cobalt	125.00 mg	Sulphur	6.00 g

3.7 Methods of analysis

3.7.1 Body weight

Initially body weight of the goat kids was measured and subsequently at weekly intervals in the morning hour prior to feeding consecutively for two days and average weight was taken on 0, 7, 14, 21, 28, 35, 42,49, 56, 63, 70,77 and 84 days of experimental feeding. weighing balance (Dr. Trust™) was used to record body weight. The weight of goats was taken by weighing the person with goat, then the person alone and finally by deducting the persons' weight from the total weight to get the actual weight of the goat.

3.7.2 Feed intake

In early morning, at the time of concentrate feeding, the animals were separated as per their treatments and then provided with the concentrate feed. Individual feeding was practiced by offering weighed quantity of feed in plastic container as per experimental schedule. The residual feed was collected every morning. Subtracting the residual feed from the daily feed offered, gave the amount of feed consumed, two days in every week to calculate the feed intake. The feed samples and residues were collected and sampled for DM estimation to assess DM intake in animals during the whole feeding trial of 90 days at weekly intervals.

3.8. Analysis of proximate principles

Feed and faecal samples were analyzed as per the procedures given by Association of Official Analytical Chemist (AOAC, 2000) for dry matter, total ash, organic matter, nitrogen, crude protein, ether extract, total carbohydrate, total digestible nutrient, fiber fractions such as acid detergent fibre, neutral detergent fibre, calcium and phosphorus.

3.9. Haematological parameters

Blood from all the animals was collected at 30,60, and 90 days of experimental period to estimate the haematological, biochemical, enzymatic profile, and mineral profile of the animals

3.9.1 Estimation of haemoglobin

Haemoglobin was estimate by using Sahli's acid hematin method.

3.9.2 Packed cell volume (PCV %)

It was estimated by micro-haematocrit method.

3.9.3 Total erythrocyte count (TEC)

TEC was estimated by using hemocytometer.

3.9.4 Mean cell volume (MCV)

MCV was derived by the following formula

$MCV = (PCV \div RBC) \times 10$

3.9.5 Mean corpuscular haemoglobin (MCH)

MCV was derived by the following formula

$MCH = (haemoglobin \times 10) / RBC$

3.9.6 Mean corpuscular haemoglobin concentration (MCHC)

MCV was derived by the following formula

$MCHC = Hb \times 10/PCV$

3.10 Serum biochemical parameters

The serum biochemical parameters such as glucose, total protein, albumin, globulin, urea, triglyceride, total cholesterol, AST, ALT, calcium, phosphorus were estimated by adopting the procedures described in the respective reagent kits of Crest Biosystems, a division of Coral Clinical Systems, Goa, India by using Biochemistry autoanalyzer.

Serum micro minerals such as copper, iron, zinc and manganese were analyzed by ICP-OES (Optical Emission Spectrometer (PERKIN ELMER, Avio 200, USA).

3.11 Digestibility trial

In order to assess the nutrients digestibility and bioavailability of nutrients, a 6 days digestibility trial preceded by a 3 days adaptation period was conducted for all the animals in the metabolism cages, after 70 days of post feeding along with collection of faecal pellets for 6 days at 24hrs interval.

Body weight was measured before and after the digestibility trial. During the 6 days trial period, collection of the representative samples of feed offered, residues and faecal pellets were done for subsequent analysis and to know the digestibility of nutrients, nitrogen and mineral absorption of Ca, P, Cu, Fe, Mn, and Zn.

3.11.1 Sampling of feed and residues

Everyday representative samples from each experimental feed and leftover residues of previous day's feeding were precisely weighed and subjected to DM estimation daily throughout the metabolism trial. The cumulative samples of individual animals were pooled at the end of collection period and ground to pass through 2 mm screen and preserved in airtight plastic containers until analyzed.

3.11.2 Collection and aliquoting of faecal pellets

Faecal pellets voided by individual animal during the preceding period of 24 hours was collected periodically at 9.00 A.M. Grounded faecal pellets of each animal was thoroughly mixed and a representative sample was taken for further analysis in the laboratory.

A proportionate aliquot of wet faeces was dried at 100 ± 2 °C in hot air oven for DM estimation daily. Dried faecal samples were pooled and kept in air tight polythene bags for further analysis after grinding. Aliquot of wet faeces were preserved daily with 1-2 ml of 20% sulphuric acid in a pre-weighed airtight stoppered bottle for 6 days for nitrogen estimation.

3.12. Statistical analysis

The data collected in the above research were analyzed using SPSS, 2009 (Version 17.0) computer package.

Fig. 3.1. Preparation of feed

Fig. 3.2. Mixing of feed

Fig. 3.3. Feeding of concentrate

Fig. 3.4. Feeding of roughage

Fig. 3.5. Watering of animal

Fig. 3.6. Recording of body weight

Fig. 3.7. Collection of blood from jugular vein

Fig. 3.8. Estimation of serum biochemical parameters

Fig. 3.9. Digestibility trial of animals

CHAPTER-IV

RESULTS

The current experiment was undertaken to know "The effect of protein and mineral mixture supplementation on growth performance, nutrient utilization and haemato-biochemical profile of goats". The data generated have been statistically analyzed and given here.

4.1 Live weight changes and animal performance

Initial live weight (kg) of T_1, T_2, T_3 were 7.20, 7.19 and 7.20, respectively and final live weights (kg) were 10.51, 11.59, 12.57 which differed significantly ($P<0.05$) among the treatments showing better efficacy of proteinaceous feed supplemented with mineral mixture (Table 4.1. and Fig. 4.1.). DM intake/ 100 kg body weight was lower in T_3 than T_1 and T_2 since 7^{th} week to 12^{th} week during the 90 days experimental period showing the efficacy of mineral mixture supplementation with protein diet on growth performance of goats (Table 4.2 and Fig. 4.2.).

Table 4.1. Weekly body weights of goats (kg)

Weeks	T_1	T_2	T_3	SEM	P value
Initial body wt.	7.20	7.19	7.20	0.09	0.89
1^{st}	7.37	7.41	7.42	0.06	0.95
2^{nd}	7.56	7.66	7.70	0.06	0.71
3^{rd}	7.78	7.94	8.02	0.07	0.43
4^{th}	8.03^{a}	8.25^{ab}	8.52^{b}	0.08	0.05
5^{th}	8.30^{a}	8.57^{ab}	9.00^{b}	0.09	0.03
6^{th}	8.58^{a}	8.91^{ab}	9.50^{b}	0.11	0.04
7^{th}	8.88^{a}	9.28^{b}	9.99^{c}	0.13	0.03
8^{th}	9.20^{a}	9.67^{b}	10.49^{c}	0.14	0.03
9^{th}	9.53^{a}	10.10^{b}	11.01^{c}	0.16	0.03
10^{th}	9.86^{a}	10.28^{b}	11.53^{c}	0.18	0.04
11^{th}	10.18^{a}	11.09^{b}	12.06^{c}	0.19	0.02
12^{th}	10.51^{a}	11.59^{b}	12.57^{c}	0.21	0.03

$^{a, b, c}$ Means with different superscripts in a row differ significantly ($P<0.05$).

Table 4.2. Weekly DM Intake (kg/day/100 kg body weight) of goats

Weeks	T_1	T_2	T_3	SEM	P value
1st	4.29	4.41	4.38	0.02	0.17
2nd	4.38	4.40	4.41	0.02	0.88
3rd	4.38	4.46	4.55	0.04	0.27
4th	4.43	4.47	4.54	0.04	0.63
5th	4.47	4.61	4.52	0.02	0.03
6th	4.52	4.62	4.50	0.02	0.04
7th	4.53[b]	4.47[b]	4.37[a]	0.01	0.04
8th	4.54[b]	4.46[b]	4.31[a]	0.02	0.03
9th	4.53[b]	4.45[b]	4.25[a]	0.03	0.04
10th	4.51[b]	4.44[b]	4.33[a]	0.03	0.03
11th	4.43[b]	4.38[b]	4.11[a]	0.04	0.03
12th	4.37[b]	4.37[b]	4.27[a]	0.03	0.03

[a, b] Means with different superscripts in a row differ significantly (P<0.05).

4.1.1 Growth rate and voluntary feed intake

Total body weight gain (kg) for whole experimental period of 90days was significantly higher (P<0.05) in T_3 (5.37) in comparison with T_1 (3.31) and T_2 (4.39). Similarly, ADG (g/day) was also higher (P<0.05) in T_3 (63.94) than T_1 (39.40) and T_2 (52.32). The voluntary feed intake (g/day) of concentrate was higher (P<0.05) in T_3 (172.8) in comparison with T_1 (158.1) and T_2 but T_2 showed the similar value (166.5) as T_3. The voluntary feed intake (g/day) of roughage and total dry matter was higher in T_3 as compared to T_1 but at par with T_2. Feed gain ratio was relatively better (P<0.05) in T_3 (6.63) in comparison with T_1 (9.96) and T_2 (7.89). The concentrate: roughage during the whole experimental period was 37:63, 40:60 and 41: 59 in T_1, T_2 and T_3, respectively (Table 4.3. and Fig. 4.3.).

Table 4.3. Growth rate and voluntary feed intake of goats

Attributes	T_1	T_2	T_3	SEM	P value
Growth rate					
Body weight (kg)					
Initial	7.20	7.19	7.20	0.64	1.10
Final	10.50^{a}	11.58^{b}	12.57^{c}	0.21	0.04
Total gain (kg)	3.31^{a}	4.39^{b}	5.37^{c}	0.20	0.03
Growth rate (g d^{-1})	39.40^{a}	52.32^{b}	63.94^{c}	2.45	0.03
Voluntary feed intake					
Concentrate (g d^{-1})	158.1^{a}	166.5^{b}	172.8^{b}	1.75	0.02
Roughage (g d^{-1})	234.4^{a}	246.5^{b}	251.2^{b}	2.20	0.03
Total DMI (g d^{-1})	392.7^{a}	413.0^{b}	424.2^{b}	3.92	0.03
Feed gain ratio	9.96^{c}	7.89^{b}	6.63^{a}	0.75	0.02
Concentrate: roughage	37:63	40:60	41:59	-	-

[a, b, c] Means with different superscripts in a row differ significantly (P<0.05).

4.2 Digestibility trial

4.2.1 Feed intake and digestibility

The DM intake (g/day) through concentrate was higher (P<0.05) in T_3 (198) than T_1 (178), but at par with T_2 (193). Similarly, DM intake (g/day) through roughage (hybrid napier) was higher (P<0.05) in T_3 (290) in comparison with T_1 (267) but at par with T_2 (278). Total DM intake was higher (P<0.05) in T_3 (488) than T_1 (445) but at par with T_2 (471). Similar trend was also followed in organic matter intake. However, DM intake and organic matter intake (as percent of body weight) was found to be better in T_3 group than T_1 and T_2 which were similar, showing efficacy of mineral mixture supplementation with protein diet in goats. The concentrate: roughage was 40:60, 41:59 and 41:59 in T_1, T_2 and T_3, respectively (Table 4.4.).

Table 4.4. Feed intake of goats during digestibility trial

Attributes	T_1	T_2	T_3	SEM	P value
Concentrate					
g d^{-1}	178[a]	193[b]	198[b]	2.72	0.03
% body weight	1.84[b]	1.86[b]	1.76[a]	0.01	0.03
Roughage					
g d^{-1}	267[a]	278[b]	290[b]	3.36	0.02
% body weight	2.75[b]	2.69[b]	2.57[a]	0.02	0.02
Dry matter					
g d^{-1}	445[a]	471[b]	488[b]	5.85	0.03
% body weight	4.59[b]	4.55[b]	4.33[a]	0.03	0.04
Organic matter					
g d^{-1}	410[a]	430[b]	440[b]	5.35	0.03
% body weight	4.20[b]	4.19[b]	3.93[a]	0.03	0.03
Concentrate: Roughage	40:60	41:59	41:59	-	-

[a, b] Means bearing different superscripts in a row differ significantly (P<0.05).

Dry matter digestibility (%) in T_3 (61.50) was higher (P<0.05) than T_1 (54.75) and T_2 (57.75). The organic matter and crude protein digestibility in T_3, was higher thanT_1 but at par with T_2 (Table 4.5.).

Table 4.5. Digestibility coefficient (%) of nutrients

Attributes	T_1	T_2	T_3	SEM	P value
Dry matter	54.75[a]	57.82[b]	61.50[c]	0.82	0.03
Organic matter	55.54[a]	60.02[b]	60.64[b]	0.73	0.04
Crude protein	61.75[a]	65.82[b]	67.88[b]	0.74	0.02
Ether extract	52.35[a]	56.29[b]	60.88[c]	1.03	0.03
Neutral detergent fibre	43.12[a]	47.04[b]	50.91[c]	0.99	0.03
Acid detergent fibre	33.58[a]	37.02[b]	39.64[b]	1.12	0.03
Total carbohydrates	53.45[a]	56.48[b]	58.28[b]	0.82	0.04

[a, b, c] Means with different superscripts in a row differ significantly (P<0.05).

Ether extract digestibility (%) and neutral detergent fiber digestibility (%) in T_3 was higher ($P<0.05$) than T_1 and T_2. ADF digestibility in T_3 was higher ($P<0.05$) than T_1 and at par with and T_2. Total carbohydrates digestibility in T_1 was lower ($P<0.05$) than$T_2$and T_3 and no significant difference was found between $T_2$and T_3.

4.2.2 Nutritive value of diet and plane of nutrition in different dietary groups

Average body weight (kg) of goats during digestibility trial were higher ($P<0.05$) in T_3 (11.27) than T_1 (9.69) and T_2 (10.34). Daily nutrient intake (g/day) in terms of CP, DCP were higher ($P<0.01$) in T_3 than T_1 but at par with T_2. However, nutrient intake (g/day) in terms of DOM and TDN were higher ($P<0.05$) in T_3 than T_1 but at par with T_2. Similar trend was also followed in nutritive value of the diet in terms of CP%, DCP% and TDN% of diet fed to different groups of goats during the digestibility trial (Table 4.6.).

Table 4.6. Nutritive value and plane of nutrition during digestibility trial

Attributes	T_1	T_2	T_3	SEM	P value
Body weight (kg)	9.69^a	10.34^b	11.27^c	0.17	0.03
Nutrient intake (g/day)					
DOM	226.32^a	260.08^b	268.39^b	5.73	0.03
CP	43.85^a	56.15^b	57.39^b	1.54	0.01
DCP	27.10^a	36.97^b	38.70^b	1.31	0.01
TDN	229.5^a	261.78^b	277.14^b	6.09	0.03
Nutritive values (%)					
CP	9.85^a	11.93^b	11.75^b	0.22	0.03
DCP	6.08^a	7.85^b	7.97^b	0.21	0.03
TDN	51.54^a	55.61^b	56.72^b	0.72	0.04

$^{a, b}$ Means bearing different superscripts in a row differ significantly ($P<0.05$, $P<0.01$).

4.2.3 Comparative plane of nutrition as compared to standard requirement

The nutritional adequacy in different treatment groups was compared with the standard as prescribed by ICAR (2013) for goats and is depicted in Table 4.7. The deficit or excess of any nutrient was compared on the basis of intake (g/day) for uniformity in comparison. In case of DCP requirement there was deficit (%) of 24.72 in T_1 and excess (%) of 2.69, 3.4 in T_2 and T_3 respectively. In case of energy there was deficit (%) of 8.40 in T_1 and excess (%) of 4.71, 10.85 in T_2 and T_3 respectively.

Table 4.7. Comparative plane of nutrition with ICAR (2013) feeding standards of goats

Attributes	T_1	T_2	T_3
Body weight (kg)	9.69	10.34	11.27
DCP			
Requirement (g d^{-1})	36	36	36
Intake (g d^{-1})	27.10	36.97	38.70
Deviation (%)	- 24.72	+ 2.69	+ 7.50
TDN			
Requirement (g d^{-1})	250	250	250
Intake (g d^{-1})	229.50	261.78	277.14
Deviation (%)	- 8.40	+ 4.71	+10.85

4.2.4 Intake and bioavailability of macro and micro minerals in goats

Intake and bioavailability of different minerals are given in Table 4.8.

4.2.4.1 Macro mineral bioavailability

The daily Ca intake (g/day) through concentrate differed significantly among the groups being highest in T_3. Similarly, Ca intake through roughage source was higher ($P<0.05$) in T_3 thanT_1 and at par with T_2. The total Ca intake was significantly higher ($P<0.05$) in T_3 thanT_1 and T_2. Calcium absorption was higher ($P<0.05$) in T_3 (39.28) as compared to T_1 (31.46) and T_2 (34.36).

Phosphorus intake (g/day) was significantly higher ($P<0.05$) in T_3 (2.32) than T_1 (2.11), but at par with T_2 (2.24). The absorption (% of intake) of P was higher ($P<0.05$) in T_3 (43.30) than T_1 (36.82) and T_2 (38.95) which were similar.

4.2.4.2 Micro mineral bioavailability

Zinc intake (mg/day) was higher (P<0.05) in T_3 (457.28) as compared to T_1 (247.54) and T_2 (282.83) which was correlated with higher Zn intake through concentrate and roughage in T_3 than T_1 and T_2. The absorption (% of intake) of Zn was higher (P<0.05) in T_3 (36.59) than T_1 (30.66) and T_2 (32.00) which were at par.

Table 4.8. Intake and bioavailability of minerals in goats

Attributes	Treatments			SEM	P value
	T_1	T_2	T_3		
Calcium (g/d)					
Concentrate Ca intake	2.14[a]	2.89[b]	4.56[c]	0.24	0.01
Roughage Ca intake	1.47[a]	1.53[ab]	1.59[b]	0.01	0.04
Total Ca intake	3.60[a]	4.40[b]	6.15[c]	0.26	0.01
Outgo in faeces	2.47[a]	2.90[b]	3.73[c]	0.12	0.02
Absorption	1.13[a]	1.51[b]	2.42[c]	0.13	0.01
Absorption (% intake)	31.46[a]	34.36[b]	39.28[c]	1.28	0.02
Phosphorus (g/d)					
Concentrate P intake	1.17[a]	1.27[b]	1.30[b]	0.05	0.03
Roughage P intake	0.93[a]	0.97[ab]	1.01[b]	0.08	0.02
Total P intake	2.11[a]	2.24[b]	2.32[b]	0.07	0.02
Outgo in faeces	1.33	1.37	1.31	0.09	0.31
Absorption	0.77[a]	0.87[b]	1.03[c]	0.07	0.01
Absorption (% intake)	36.82[a]	38.95[a]	43.30[b]	0.78	0.02
Zinc (mg/d)					
Concentrate Zn intake	146.21[a]	177.25[b]	347.02[c]	21.55	0.01
Roughage Zn intake	101.33[a]	105.58[ab]	110.20[b]	1.27	0.03
Total Zn intake	247.54[a]	282.83[b]	457.28[c]	22.46	0.01
Outgo in faeces	171.55[a]	192.24[b]	289.65[c]	12.98	0.01
Absorption	75.99[a]	90.59[a]	167.63[b]	10.54	0.01
Absorption (% intake)	30.66[a]	32.00[a]	36.59[b]	1.10	0.02

Attributes	Treatments			SEM	P value
	T_1	T_2	T_3		
Copper (mg/d)					
Concentrate Cu intake	35.30[a]	48.16[b]	89.25[c]	5.61	0.01
Roughage Cu intake	28.00	29.17	30.45	0.35	0.09
Total Cu intake	63.30[a]	77.34[b]	119.70[c]	5.87	0.01
Outgo in faeces	35.49[a]	41.16[b]	60.50[c]	2.75	0.01
Absorption	75.99[a]	90.59[b]	167.63[c]	3.29	0.01
Absorption (% intake)	30.66[a]	32.00[ab]	36.59[b]	0.78	0.01
Iron (mg/d)					
Concentrate Fe intake	213.97[a]	269.73[b]	446.25[c]	24.23	0.01
Roughage Fe intake	666.67[a]	694.58[ab]	725.07[b]	8.40	0.03
Total Fe intake	880.63[a]	964.32[b]	1171.25[c]	30.88	0.01
Outgo in faeces	553.66[a]	577.21[a]	629.88[b]	10.19	0.01
Absorption	326.97[a]	387.11[b]	541.37[c]	23.08	0.01
Absorption (% intake)	37.07[a]	40.11[a]	46.24[b]	1.08	0.01
Manganese (mg/d)					
Concentrate Mn intake	142.64[a]	177.25[b]	257.83[c]	11.86	0.01
Roughage Mn intake	120.05	125.02	130.50	1.51	0.09
Total Mn intake	262.64[a]	302.2[b]	388.33[c]	13.04	0.02
Outgo in faeces	179.78[a]	200.64[b]	238.70[c]	6.30	0.02
Absorption	82.86[a]	101.64[b]	149.64[c]	7.36	0.05
Absorption (% intake)	31.50[a]	33.65[a]	38.44[b]	0.95	0.02

[a, b, c] Means with different superscripts in a row differ significantly (P<0.05, P<0.01)

Copper intake (mg/day) differed significantly (P<0.05) among different groups being highest in T_3 (119.70) and lowest in T_1 (63.30). The absorption (% of intake) of Cu was more (P<0.05) in T_3 (36.59) than T_1 (30.66), but at par with T_2 (32.00).

Iron intake (mg/day) differed significantly (P<0.01) among different groups being highest in T_3 (1171.25) and lowest in T_1 (880.63). The absorption (% of intake) of Fe was higher (P<0.05) in T_3 (46.24) than T_1 (37.07) and T_2 (40.11) which were at par.

Manganese intake (mg/day) differed significantly (P<0.05) among different groups being highest in T_3 (388.33) and lowest in T_1 (262.64). The absorption (% of intake) of Mn was higher (P<0.05) in T_3 (38.44) than T_1 (31.50), but T_2 (33.65) which were at par.

4.3 Blood parameters

Blood was collected at 30, 60 and 90 days of experimental period for assessment of hematological, biochemical, enzymatic profile, and mineral profile of the animals.

4.3.1 Haematological indices

Haematological indices in animals are presented in Table 4.9.

Haemoglobin

Mean Hb (g dl^{-1}) under different treatments ranged from 9.90 to 12.1 and the level was higher (P<0.05) in T_3 (11.53) than T_1 (10.53) and at par with T_2 (11.18) irrespective of the periods. Although the mean values among different periods are not significant, but the Hb level gradually increased with the advance in period. The interaction between treatment and period was non-significant (Fig. 4.4.).

Total Erythrocyte Count (TEC)

Mean RBC counts under different treatments ranged from 11.37 to 13.88. The level was higher (P<0.05) in T_3 (13.36) than T_1 (12.15) and at par with T_2 (13.11) irrespective of the periods. The interaction between treatment and period was non-significant (P>0.05).

Packed Cell Volume (PCV)

Mean PCV (%) levels under different treatments ranged from 24.25-31.93. The level was higher (P<0.05) in T_3 (30.08) than T_1 (26.51) and at par with T_2 (28.83) irrespective of the periods. The interaction between treatment and period was non-significant (P>0.05).

Mean Corpuscular Volume (MCV)

Mean MCV (fl) under different treatments ranged from 20.67 to 23.36. The level was higher (P<0.05) in T_3 (22.70) than T_1 (12.15) but at par with T_2 (21.45)

irrespective of the periods. The cumulative period means also showed non-significant variation (P>0.05).

Table 4.9. Haematological indices in different groups of goats

Treatment	Days post experimental feeding			Mean ± SE	P values		
	30	60	90		T	P	T x P
Haemoglobin (g dl^{-1})							
T_1	9.90	10.8	10.9	10.53 ± 0.09^{a}	0.05	0.33	0.98
T_2	10.25	11.6	11.8	11.18 ± 0.18^{b}			
T_3	10.75	11.8	12.1	11.53 ± 0.14^{b}			
Mean ±SE	10.30 ± 0.14	11.38 ± 0.16	11.50 ±0.14				
TEC (10^6/mm^3)							
T_1	11.37	12.29	12.80	12.15 ± 0.58^{a}	0.05	0.50	0.98
T_2	12.34	13.37	13.63	13.11 ± 1.27^{b}			
T_3	12.89	13.30	13.88	13.36 ± 0.47^{b}			
Mean ±SE	12.20 ± 0.71	13.01 ± 0.93	13.44 ± 0.89				
PCV (%)							
T_1	24.25	27.40	27.88	26.51 ± 2.27^{a}	0.05	0.92	0.98
T_2	25.50	30.14	30.86	28.83 ± 2.13^{b}			
T_3	27.29	31.04	31.93	30.08 ± 1.37^{b}			
Mean ±SE	25.68 ± 2.15	29.53 ± 2.08	30.22 ± 1.6				
MCV (fl)							
T_1	21.23	21.34	21.79	21.45 ± 0.96^{a}	0.05	0.15	0.24
T_2	20.67	22.59	22.64	21.97 ± 1.45^{ab}			
T_3	21.20	23.36	23.56	22.70 ± 1.15^{b}			
Mean ±SE	21.03 ±0.76	22.43 ±1.18	22.06 ±1.46				
MCH (pg)							
T_1	7.21	7.50	8.05	7.59 ± 0.12	0.11	0.15	0.29
T_2	7.50	7.90	8.10	7.83 ± 0.13			
T_3	7.85	8.10	8.60	8.18 ± 0.18			
Mean ±SE	7.52 ±0.76	7.83 ±1.18	8.25 ±1.18				
MCHC (g dl^{-1})							
T_1	40.86	39.46	39.18	34.29 ± 0.96	0.11	0.11	0.28
T_2	40.32	38.44	38.09	34.77 ± 1.45			
T_3	39.45	38.03	37.75	35.15 ± 1.15			
Mean ±SE	34.27 ±0.76	34.71±1.18	35.23 ±1.46				

[a, b] Means bearing different superscripts in a column differ significantly (P<0.05).

Mean Corpuscular Haemoglobin (MCH)

MCH (pg) level was non-significant (P>0.05) between treatment and control groups.

Mean Corpuscular Haemoglobin Concentration (MCHC)

MCHC (g dl^{-1}) ranged from 37.75-40.86 which (P>0.05) was observed among the treatment groups. The interaction between treatment and period was non-significant (P>0.05).

4.3.2 Biochemical indices

The serum glucose, serum proteins, albumin, globulin, serum cholesterol, triglyceride, serum urea, serum enzymes (SGOT and SGPT) are given in Table 4.10.

Serum glucose

Glucose level (mg dl^{-1}) under different treatments ranged from 68.51 to 78.60 and the level was significantly higher (P<0.05) in T_3 (74.39) than T_1 (70.32) and T_2 (72.86) being at par irrespective of the period. However, the interaction between treatment and period was non-significant (P>0.05). (Fig.4.5)

Serum protein

The mean values of TP, G, A and A: G ranged from 6.05-8.13, 3.62-4.95, 2.43-3.40, 0.68-0.88, respectively and there was significant difference in protein and albumin level in T_2 and T_3 which were higher (P<0.05) than T_1 among the treatment and control groups (Fig.4.6.).

Cholesterol

Mean cholesterol level (mg dl^{-1}) under different treatments ranged from 59.30 to 63.23 and there was no significant difference (P>0.05) between the treatment and control groups.

Table 4.10. Serum biochemical profile in different groups of goats

Treatments	Days post experimental feeding			Mean ± SE	P values		
	30	60	90		T	P	T x P
Glucose (g dl^{-1})							
T_1	68.51	70.10	72.52	70.32 ± 0.15[a]	0.03	0.35	0.62
T_2	69.52	73.21	75.91	72.86 ± 0.21[b]			
T_3	69.72	74.92	78.60	74.39 ±0.24[b]			
Mean ±SE	69.23±0.20	72.70± 0.24	75.67± 0.21				
Total protein (g dl^{-1})							
T_1	6.05	6.26	6.52	6.27 ± 0.28[a]	0.02	0.35	0.65
T_2	7.38	7.57	8.27	7.74 ± 0.21[b]			
T_3	7.55	7.28	8.13	7.8 3± 0.19[b]			
Mean ±SE	7.00 ± 0.29	7.28 ± 0.18	7.59 ± 0.28				
Albumin (g dl^{-1})							
T_1	2.43	2.83	2.63	2.63 ± 0.08[a]	0.03	0.54	0.65
T_2	3.10	3.47	3.31	3.29 ± 0.08[b]			
T_3	3.20	3.65	3.40	3.42± 0.06[b]			
Mean ±SE	2.95 ± 0.08	3.28 ± 0.08	3.12 ± 0.09				
Globulin (g dl^{-1})							
T_1	3.62	3.42	3.88	3.64± 0.20	0.19	0.53	0.94
T_2	4.28	4.10	4.95	4.44±0.16			
T_3	4.35	4.17	4.73	4.42±0.24			
Mean ±SE	4.04 ± 0.23	4.00 ± 0.22	4.47 ± 0.18				
Albumin: Globulin (A: G) ratio							
T_1	0.68	0.83	0.68	0.73±0.10	0.96	0.89	0.99
T_2	0.73	0.85	0.67	0.75±0.07			
T_3	0.74	0.88	0.72	0.78±0.05			
Mean ±SE	0.72 ± 0.08	0.85 ± 0.08	0.69 ± 0.07				
Cholesterol (mg dl^{-1})							
T_1	59.30	60.57	61.20	60.36±3.11	0.12	0.15	0.39
T_2	59.60	60.61	61.60	60.60±2.15			
T_3	61.33	62.34	63.23	62.30±2.50			
Mean ±SE	60.08 ± 2.75	61.17 ± 2.78	62.01 ± 2.63				

Treatments	Days post experimental feeding			Mean ± SE	P values		
	30	60	90		T	P	T x P
Triglyceride (mg dl^{-1})							
T_1	75.32	77.96	77.17	76.81±1.20	0.67	0.58	0.75
T_2	77.63	78.61	79.46	78.57±0.73			
T_3	79.00	79.30	80.82	79.71±1.15			
Mean ±SE	77.43± 0.22	78.78 ± 0.28	79.04 ± 0.24				
Urea (mg dl^{-1})							
T_1	35.98	38.01	39.02	37.67±0.26^{a}	0.03	0.11	0.22
T_2	38.13	40.15	41.23	39.84±0.33^{b}			
T_3	37.60	39.14	40.53	39.03±0.24^{b}			
Mean ±SE	37.48± 0.21	39.32 ± 0.30	40.06 ± 0.22				
SGPT (IU L^{-1})							
T_1	63.30	65.93	66.93	65.39±0.18	0.29	0.27	0.87
T_2	65.38	66.40	67.40	66.39±0.20			
T_3	64.45	66.48	66.97	65.97 ±0.18			
Mean ±SE	64.49 ± 0.17	66.26 ± 0.19	66.93 ± 0.20				
SGOT (IU L^{-1})							
T_1	73.40	76.07	79.23	76.23 ± 0.07	0.37	0.19	0.91
T_2	80.63	82.73	83.75	82.37 ± 0.07			
T_3	71.78	80.48	81.80	78.02 ± 0.09			
Mean ±SE	75.27 ± 0.06	79.76 ± 0.07	81.59 ± 0.07				

[a, b] Means bearing different superscripts in a column differ significantly (P<0.05).

Triglyceride

Mean triglyceride level (mg dl^{-1}) under different treatments ranged from 75.32 to 80.82 and there was non-significant (P>0.05) between the treatment and control groups.

Urea

Mean urea level (mg dl^{-1}) under different treatments ranged from 35.98 to 41.23 and there was non-significant (P>0.05) between the treatment and control groups.

Serum enzyme profile

The activity of SGPT (IU/L) ranged from 63.30 to 67.40 and there was no significant difference (P>0.05) between the treatment and control groups. The mean activity of SGOT (IU/L) ranged from 71.78 to 83.75 and there is no significant difference (P>0.05) between the treatment and control groups (Table 4.11).

4.3.3 Serum mineral profile

The serum mean concentration of Ca, P, Cu, Fe, Mn and Zn in various groups have been presented in Table 4.11.

The serum Ca level (mg dl^{-1}) ranged from 8.28 to 12.0. The values are higher (P<0.05) in T_3 (10.97) than T_1 (9.10) and T_2 (9.72) and T_1 and T_2 are at par with each other. The cumulative period mean of serum Ca level varied significantly (P<0.05) at 60 and 90 days of post feeding which increased with the advancement of experimental feeding. However, the interaction between treatment and period was non-significant (Fig.4.7).

The mean serum phosphorus level (mg dl^{-1}) was ranged from 5.25 and 7.90 mg dl^{-1}. The values were higher (P<0.05) in T_3 (7.29) than T_1 (5.89) and T_2 (6.59) which are at par. The cumulative group mean period and interaction between treatment and period showed non-significant variation (Fig.4.7).

Average serum Cu concentration (mg l^{-1}) in T_1, T_2 and T_3 was 3.37, 4.10 and 4.54, respectively. The values were higher (P<0.05) in T_3 than T_1 and T_2 being at par. The period mean of serum Cu also showed a non-significant (P>0.05) variation. However, the interaction between treatment and period was non-significant (P>0.05).

Similarly, average serum Fe concentration (mg l^{-1}) in T_1, T_2 and T_3 was 38.60, 40.54 and 42.40, respectively and were higher in T_3 than T_1 and T_2 being at par. Cumulative period mean of serum Fe level varied significantly (P<0.05) at 90 days of post feeding which increased with the advancement of experimental feeding. However, the interaction between treatment and period was non-significant (P>0.05).

Table 4.11. Serum mineral profile of goats

Treatments	Days post experimental feeding			Mean ± SE	P values		
	30	60	90		T	P	T x P
Calcium (mg dl^{-1})							
T_1	8.28	9.31	9.71	9.10 ± 0.26^{a}	0.02	0.03	0.22
T_2	8.77	9.81	10.62	9.72 ± 0.33^{a}			
T_3	9.97	11.02	12.02	10.97 ± 0.24^{b}			
Mean ±SE	9.00 ± 0.21^{A}	9.96 ± 0.30^{B}	10.64 ± 0.22^{B}				
Phosphorus (mg dl^{-1})							
T_1	5.25	5.90	6.51	5.89 ± 1.20^{a}	0.05	0.58	0.75
T_2	5.75	6.68	7.33	6.59 ± 0.73^{a}			
T_3	6.50	7.47	7.90	7.29 ± 1.15^{b}			
Mean ±SE	5.83 ± 0.22	6.68 ± 0.28	7.25 ± 0.24				
Copper (mg l^{-1})							
T_1	3.10	3.20	3.80	3.37 ± 0.18^{a}	0.04	0.27	0.87
T_2	3.40	4.10	4.80	4.10 ± 0.20^{a}			
T_3	3.71	4.50	5.40	4.54 ± 0.18^{b}			
Mean ±SE	3.40 ± 0.17	3.93 ± 0.19	4.67 ± 0.20				
Iron (mg l^{-1})							
T_1	37.20	38.20	40.40	38.60 ± 0.07^{a}	0.04	0.05	0.91
T_2	38.50	40.07	43.07	40.54 ± 0.07^{a}			
T_3	40.73	41.73	44.73	42.40 ± 0.09^{b}			
Mean ±SE	38.81 ± 0.06^{A}	40.01 ± 0.07^{A}	42.73 ± 0.07^{B}				
Manganese (mg l^{-1})							
T_1	7.06	7.80	8.01	7.62 ± 0.34^{a}	0.05	0.53	0.33
T_2	8.28	8.61	9.15	8.68 ± 0.34^{a}			
T_3	8.77	9.02	9.52	9.10 ± 0.23^{b}			
Mean ±SE	8.04 ± 0.24	8.48 ± 0.28	8.89 ± 0.41				
Zinc (mg l^{-1})							
T_1	13.05	13.20	13.90	13.38 ± 0.07^{a}	0.05	0.05	0.99
T_2	13.50	14.37	16.37	14.75 ± 0.08^{a}			
T_3	13.70	15.01	17.01	15.24 ± 0.08^{b}			
Mean ±SE	13.42 ± 0.06^{A}	14.19 ± 0.08^{A}	15.76 ± 0.07^{B}				

[a, b] Means bearing different superscripts in a column ($P<0.05$)

[A, B] Means bearing different superscripts in a row differ significantly ($P<0.05$)

Serum Mn concentration (mg l^{-1}) in T_1, T_2 and T_3 was 7.62, 8.68 and 9.10, respectively and the values were higher ($P<0.05$) in T_3 than T_1 and T_2 being at par. The period mean of serum Mn and interaction showed a non-significant ($P>0.05$) variation.

Serum Zn concentration (mg l^{-1}) in T_1, T_2 and T_3 was 13.38, 14.75 and 15.24, respectively and the values were higher ($P<0.05$) in T_3 than T_1 and T_2 which were at par. The cumulative period mean of serum Zn level also differed among different periods of post feeding. The interaction between treatment and period was also non-significant ($P>0.05$).

4.4 Feed efficiency and economics of goat production

Table 4.12 shows the feed efficiency and economics of production of Black Bengal goats fed protein rich concentrate mixture with or without mineral mixture. The total body weight gain, amount of fodder and concentrate ration with mineral mixture fed were taken into account while calculating the economics of production. Similarly, the additional body weight obtained was taken into account while calculating the net profit. The average additional body weight gain was 2.16 kg in T_3 and 1.18 kg in T_2 over the control group. The cost of concentrate mixture per kg was calculated to be Rs. 31.12, 33.26 and 36.29 in T_1, T_2 and T_3 respectively. Fodder prices was estimated to be Rs. 0.50 per kg. The selling price of goats was calculated Rs. 350.00 per kg and accordingly the net profit was calculated as Rs. 670.22, 1030.13 and 1308.40, in T_1, T_2 and T_3, respectively.

Table 4.12. Feed efficiency and economics of goat production

Particulars	T_1	T_2	T_3
Initial body weight (kg)	7.29	7.19	7.20
Final body weight (kg)	10.50	11.58	12.57
Total weight gain (kg)	3.21	4.39	5.37
Cost per kg concentrate (Rs.)	31.12	33.26	36.29
Total concentrate fed (kg)	13.30	13.98	14.57
Cost of concentrate (Rs.)	413.90	464.97	528.74
Total roughage fed (kg)	78.76	82.80	84.72
Cost of roughage (Rs. @ 0.50/ kg)	39.38	41.40	42.36
Total feed cost (Rs.) during 3 months	453.28	506.37	571.10
Cost of live weight gain (Rs. @ 350/kg live weight	1123.50	1536.50	1879.50
Net profit (Rs.) per goat	670.22	1030.13	1308.40

Fig. 4.1. Weekly body weight of goats

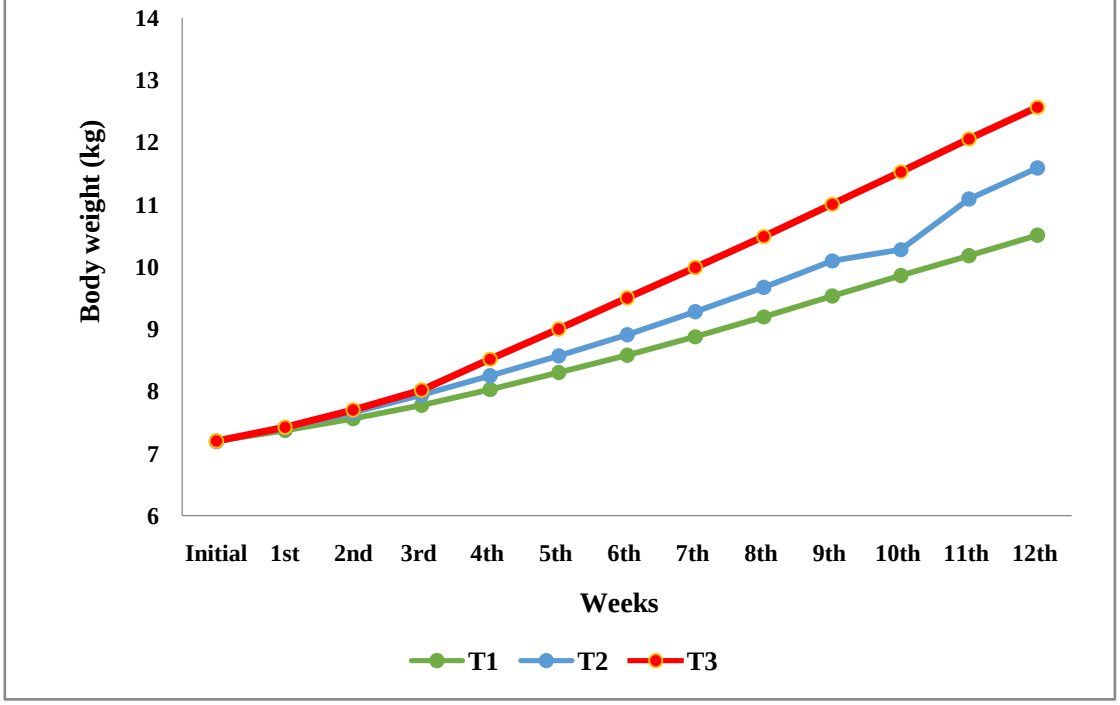


Fig. 4.2. Weekly feed (DM) intake of goats

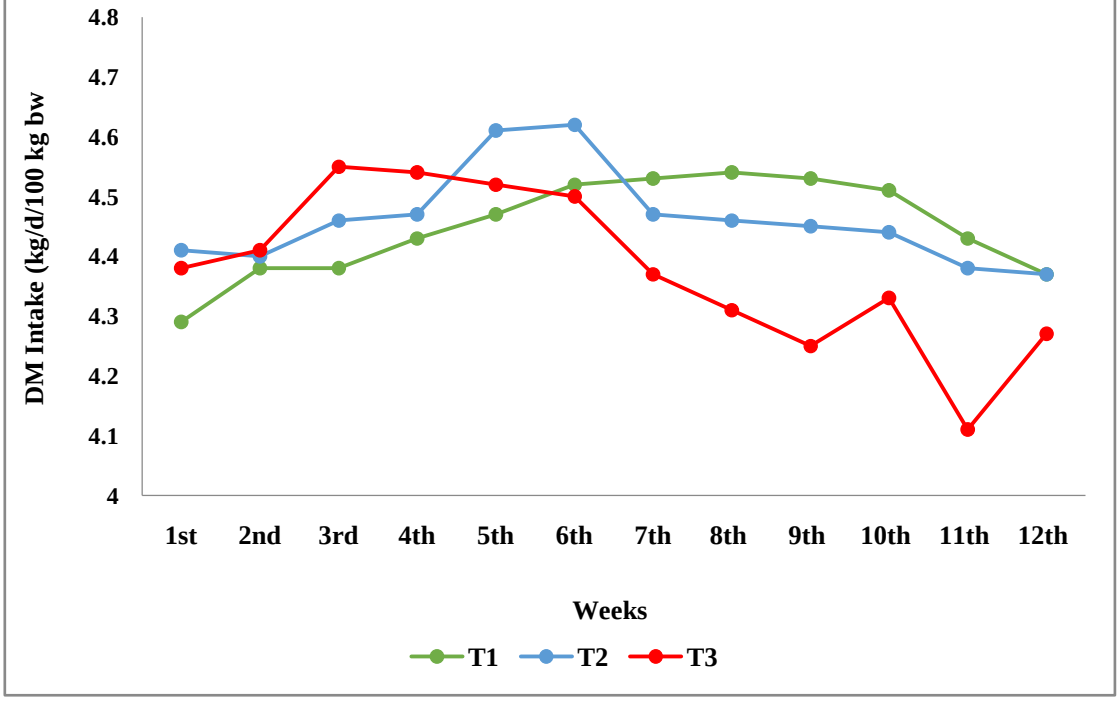


Fig. 4.3. Body weight (kg) and body weight gain (g) in goats

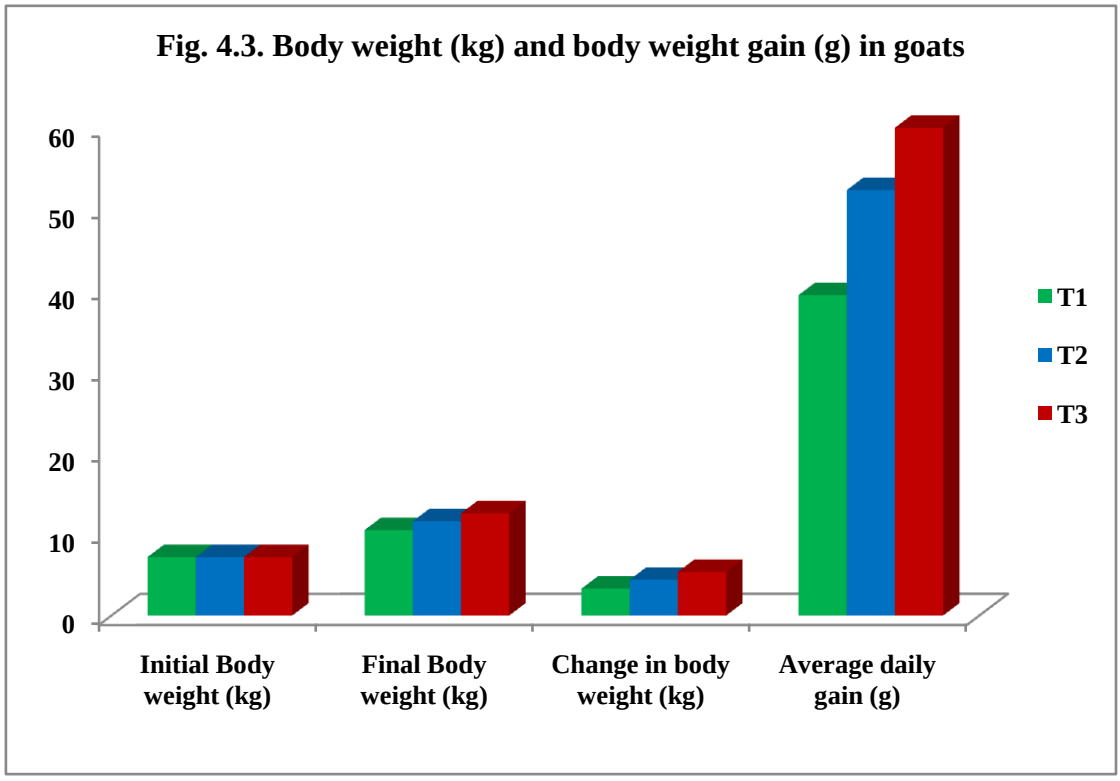


Fig. 4.4. Haemoglobin concentration in goats

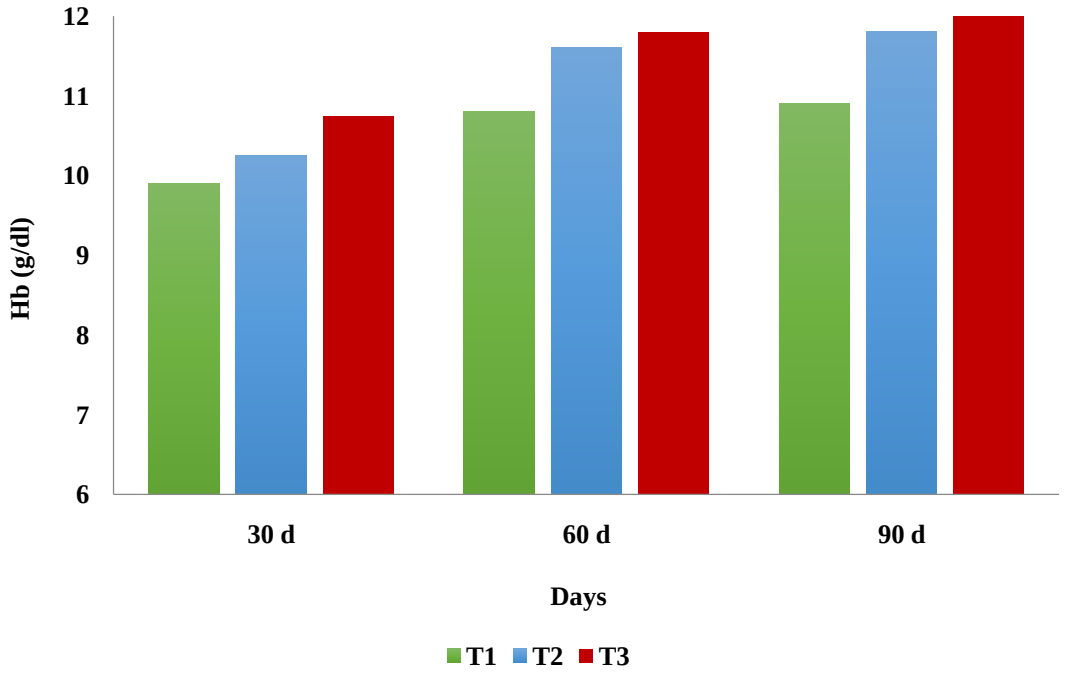


Fig. 4.5. Glucose concentration in goats

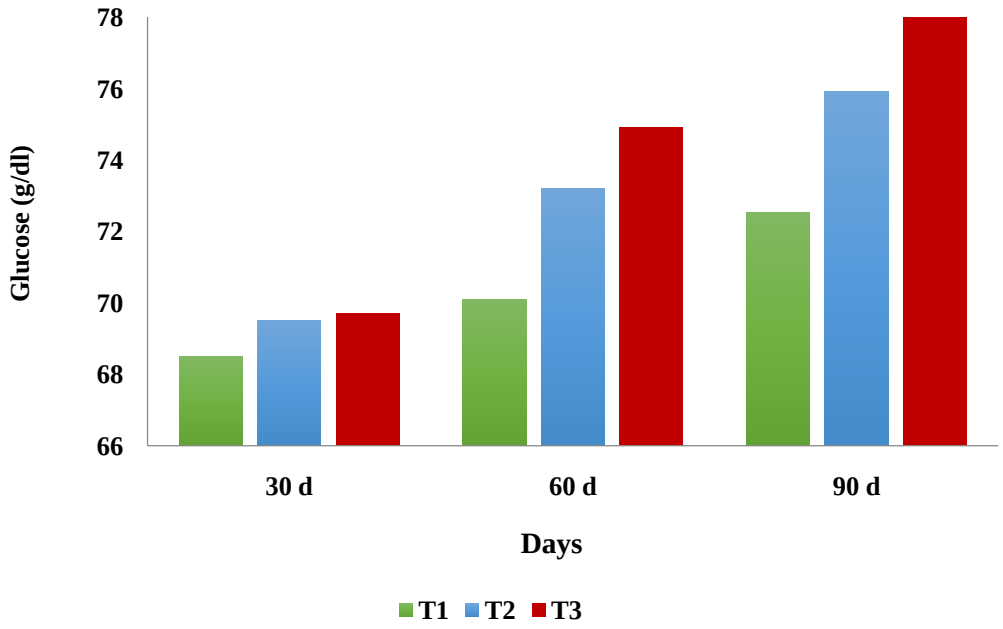


Fig. 4.6. Serum total protein concentration in goats

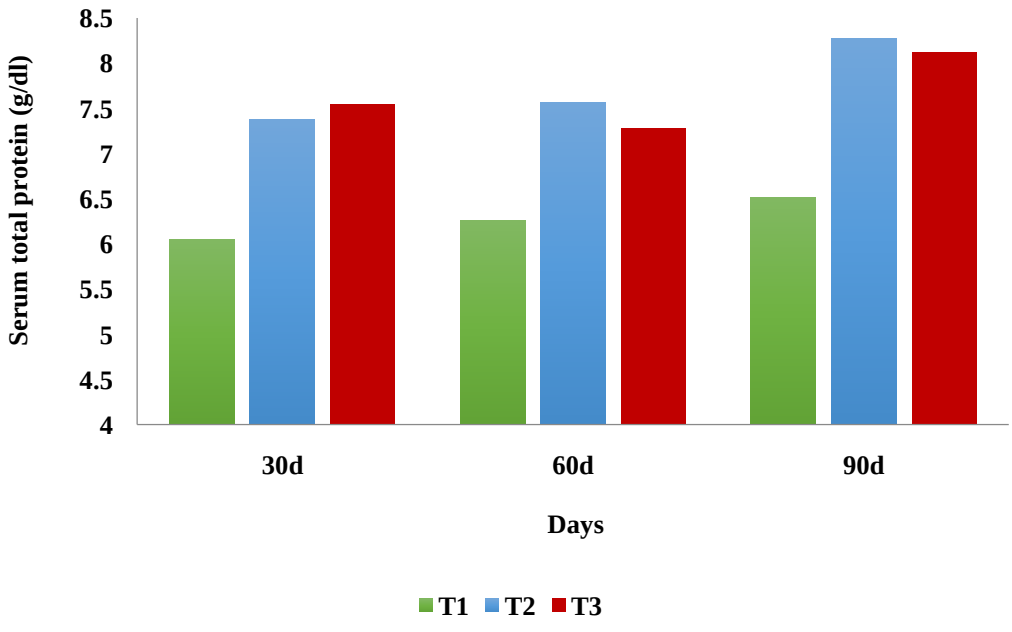
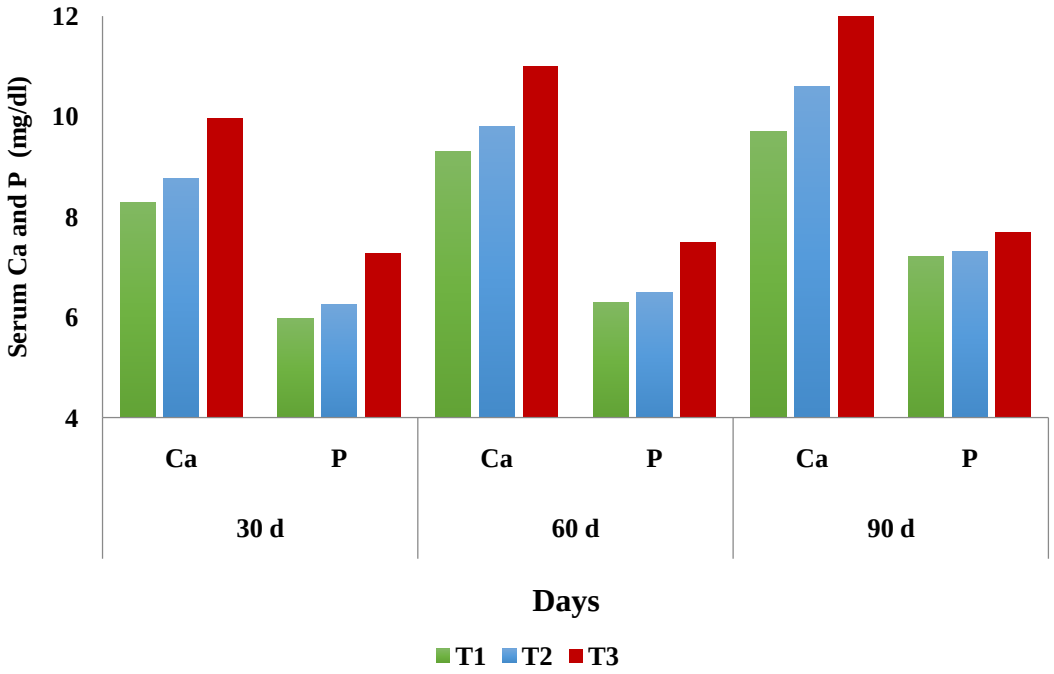


Fig. 4.7. Serum Ca and P concentration in goats



CHAPTER-V

DISCUSSION

5.1 Composition of experimental diets

The chemical composition and fiber fraction of concentrate mixture and fodder offered to goats was within the normal range (Ranjhan, 1998). Incorporation of proteinaceous deoiled ground nut oil cake in CM-II and CM-III by replacing some parts of rice bran and pulse chuni of CM-I increased protein content in CM-II and CM-III. Further, supplementation of mineral mixture @ 3% in concentrate mixture lowered the organic matter (89.75%) content with consequent increase in macro and micro mineral level in CM-III. Similarly, fiber fraction (NDF and ADF) of hybrid napier fodder was more being attributed to high cell wall constituents with consequent decrease in protein content of fodder. The mineral profile of feed and fodder offered to goats were also found to be within normal range (Ranjhan, 1998).

5.2 Growth performance and feed efficiency

The growth rate and voluntary feed intake through concentrate and roughage during the experimental period was higher ($P<0.05$) in high protein diet. Supplemental mineral mixture @ 3% in diet could not further improve voluntary feed intake. However, growth performance was higher ($P<0.05$) in mineral supplemented animals showing synergistic effect of protein with mineral which might be due to better nutrient utilization at tissue level. The perusal of the data revealed that feed gain ratio was comparatively better ($P<0.05$) in T_3 (6.63) than T_1 (9.96) and T_2 (7.89) with T_3 showing efficacy of mineral mixture with protein diet for augmenting productive performance of goats.

5.2.1 Effect of protein

Increasing the level of protein through linear increase in concentrate mixture up to 30% along with Dal grass enhanced ($P<0.01$) feed conversion efficiency which might be due to improvement in digestibility of all nutrients in goats (Ferdous *et al.,* 2011). Similarly, supplementation of high protein cotton seed meal @ 300 g DM per per day exhibited higher ($P<0.05$) body wt. gain and higher FCR ($P<0.01$) in Sidama

goats (Solomon *et al*., 2008) supported the present findings. It was reported that a diet of isocaloric supplement with different levels of protein (i.e. 18% CP, 25.5% CP and 31.6% CP), resulted linearly increased feed intake, growth rate and feed efficiency (111, 125, 145 g/day) in Beetal goats fed higher levels of protein which supports the present findings (Mohsan *et al*., 2019). Bishwas (1997) also supported the findings that high protein diet couldn't improve feed efficiency significantly which might be due to the cause that same quantity of protein was obtainable from high and low protein levels at the small intestine although, CP intakes were higher in high protein than low protein level A large portion of dietary protein in goats fed high protein diets was possibly converted to ammonia in the rumen resulting greater nitrogen losses in urine. Earlier studies on goats that were fed high protein diet (20.9 % CP) showed that 28% of the dietary nitrogen was deceptively lost across the stomach (Ash and Norton, 1987).

5.2.2 Effect of protein with mineral

Yadav *et al.* (2010) found that supplementary feeding of concentrate and mineral mixture with grazing was beneficial in growing goats in terms of body weight gain fed 150g concentrate mixture + 10 g mineral mixture. Niaz *et al.* (2017) also supported that goats fed 100 g concentrate mixture supplemented with 5 g of area specific mineral mixture resulted higher ($P<0.05$) ADG. In corroborate with the present reports, supplementation of ZnO or $ZnSO_4$ through mineral mixture increased ADG and feed conversion efficiency and better economic return ($P<0.05$) in goats (Maan and Sihag, 2014). Supplementation of mineral mixture @15 g /goat/day (Tiwari *et al.*, 2014) and 1-2% mineral mixture (Godara *et al.*, 2016) improved average daily weight gain which might be due to important role played by minerals in efficient nutrient utilization. The higher average daily gain in mineral supplemented groups than control animals was attributed to increased energy and protein supplementation in concentrate supplemented groups and better nutrient utilization in mineral supplemented animals in different breeds of goats (Mahanta *et al.*, 2002; Hossain *et al.*, 2003; Sahu *et al.*, 2013). It was also observed that supplementary feeding of protein fortified with mineral have a remunerative approach of Barbari kid production over grazing alone, and the supplementation of balanced feed promoted growth by providing adequate nutrients and therefore higher live weight and increased market sale prices, which in turn provided high net returns (Chaudhary *et al.*, 2015).

In contrast to the present findings, palm kernel cake as a protein source with 2% vitamin mineral premix in a Napier grass diet did not improve the feed conversion ratio (Rahman *et al.*, 2013).

5.3 Nutrient Intake and digestibility of nutrients

5.3.1 Effect of protein

The dry matter intake in terms of concentrate and roughage, total DM intake and organic matter intake was higher ($P<0.05$) in T_2 than T_1 but similar with T_3. Increasing the level of protein content and fortification of diet with supplemental mineral mixtures improved the feed intake which might be due to enriching the value of diet through improvement in palatability and voluntary feed intake. Kabir *et al*. (2002b) supported the present findings showing higher ($P<0.01$) DM intake in goats and sheep fed on high protein content through concentrate mixture as compared to non-supplemented group (506.90 vs. 186.60 g/d). Similarly, feeding of Black Bengal goats with linear increase in concentrate mixture (150 to 300g) and *ad libitum* green grasses resulted higher ($P<0.01$) DM intake and CP intake by increasing the level of protein through increasing supplemental protein level of concentrate mixture in the feed (Sultana *et al*., 2012). The dry matter intake in experimental goats ranged from 4.11-4.62% in the present study. Several authors supported the present findings that DM intake in goats ranged from 1.5 to 3.7% of live weight (Ranjhan, 1980; Kabir *et al.*, 2002a).

The nutrient digestibility coefficient (%) revealed that increasing the protein level in the diet improved ($P>0.05$) nutrient digestibility. Further, additional supplementation of mineral mixture along with proteinaceous feed in T_3 enhanced the nutrient (DM, EE, NDF) digestibility. The nutrient intake through CP and DCP were higher ($P<0.01$) in T_2 than T_1 but at par with T_3. Similarly, TDN intake was higher ($P<0.01$) in T_2 than T_1, but similar with T_3. Similar trend was also followed in nutritive value of the diet in terms of CP%, DCP% and TDN% of diet fed to different groups of goats during the digestibility trial. Increasing the level of protein through incorporation of ground nut oil cake in T_2 enriched the value of diet through improvement in nutrient utilization in goats which was reflected in better growth performance.

Ullah *et al.* (2009) also supported the present findings that concentrate diet made with SBM and/or mustard oil cake having 16% protein could be implemented for economic Black Bengal goat rearing and digestibility's of DM, CP and OM were significantly higher for soybean meal having high protein than mustard oil cake of low protein. Ferdous *et al.* (2011) supported the findings of the current study that increasing the level of protein through linear increase in concentrate mixture up to 30% along with Dal grass enhanced ($P<0.01$) digestibility of all nutrients in Black Bengal goats under stall feeding. Total DM, CP and TDN intake were significantly higher with increase in the level of protein in the diet Black Bengal goats through concentrate which might be attributed to improved palatability resulting higher voluntary feed intake (Sultana *et al*., 2012).

5.3.2 Effect of protein with mineral

The DM intake in terms of concentrate and roughage and total DM intake and OM intake was found to be higher ($P<0.05$) in T_3 than T_1 but at par with T_2. Additional supplementation of mineral mixture along with protein diet could not further increase the value to the level of significance. However, the digestibility's of DM, EE and NDF were higher ($P<0.05$) in T_3 than T_2 which was attributed to stimulation to microbial ecosystem through different critical nutrients (macro and micro minerals). Of course, supplementation of mineral mixture plays important role in improving the level of feed intake in terms of better palatability and nutrient digestibility and further utilization at tissue level which was reflected in improved growth performance in animals. Daily nutrient (CP, DCP, TDN) intake (g/ day) and nutritive value of the diet in terms of CP%, DCP% and TDN% of diet in mineral supplemented group (T_3) was also similar with high protein fed group (T_2) showing similar plane of nutrition in both the groups.

Supplementation of mineral mixture plays an important role for sustainable growth and health status of the animals which plays crucial role in enzyme systems and different physiological processes (Kumar *et al.,* 2002; Boland and Lonergan, 2003). In corroborate with the present results, supplementation of ZnO or $ZnSO_4$ as source of Zn in concentrate mixture, the DM intake, DM, OM and CF digestibility and nutritive values (DCP% and TDN%) were not influenced (Maan and Sihag, 2014).

5.4 Mineral bioavailability

5.4.1 Effect of protein

The data revealed that intake of macro and micro minerals was higher in protein with or without mineral supplemented group of animals than control group. Similar trend was also followed in mineral excretion in faeces and absorption (% of intake) of respective minerals. Feeding of high protein diet also enhanced the mineral absorption capacity. Higher intake of Ca, P, Zn, Cu, Fe and Mn in group T_2 was correlated with higher DM intake. Similar pattern of fecal excretion of these minerals leads to higher absorption of minerals and mineral bioavailability which was reflected in better growth performance in goats. Further mineral supplementation along with high protein diet resulted synergistic effect of mineral with protein which lead to better growth rate and feed efficiency in goats. It is revealed that the serum mean concentration of different minerals were not influenced by increasing the protein level in the diet irrespective of higher DM intake in high protein diet fed animals. Similar results were observed in dairy cattle by other workers (Samanta *et al.,* 2005; Agrawalla *et al.,* 2017).

5.4.2 Effect of protein with mineral

The serum mineral values in different treatments were within the normal range. A progressive increase in level of all minerals in the study with the advance in experimental feeding showed that animals were earlier deficient in minerals and mineral mixture supplementation overcomes the deficiency. All the goats in experiment showed higher intake and absorption of minerals as percent of intake in mineral supplemented group of animals which was attributed to higher DM intake, improvement in palatability. Data revealed that the serum mean concentration of Ca, Fe, and Zn level differed between groups at 90 days of post feeding only showing its effect at prolong period of feeding. However, serum mineral level was higher ($P<0.05$) in mineral supplemented group (T_3) which might be due to higher DM intake and incorporation of mineral mixture in the diet of animals. The increased serum mineral concentration might be due to additional supplementation of minerals through concentrate and mineral mixture. Similar results were observed in dairy cattle by other workers (Samanta *et al.,* 2005; Agrawalla *et al.,* 2017). However, status of Mn, Cu and Zn in blood was not altered by supplemental mineral mixture. In support

of the current findings, Kumar *et al.* (2003) reported that Zn supplementation increases retention of Zn and Cu whereas retention of Mn and Fe were not affected by Zn supplementation in goats. Mondal *et al*. (2007) found that Cu supplementation increased Cu, Fe and Zn retention percentage in goats. The findings of present study and the reported work revealed that the plasma concentrations of trace minerals under study were improved their level in the plasma showing positive influence on the mineral metabolism due to mineral mixture supplementation (Bis-Wencel, 2003; Kalita *et al.*, 2003).

5.5 Haemato-biochemical profile

5.5.1 Effect of protein

The mean haemoglobin level was higher ($P<0.05$) in protein and mineral supplemented group irrespective of the periods and Hb level gradually increased with the advance in period showing positive impact of mineral with protein. However, TEC, PCV, MCV were found to be higher ($P<0.05$), whereas MCH, MCHC level were not influenced by protein and mineral mixture. In the present study, serum protein, albumin, urea level was found to be higher ($P<0.05$) by protein or protein with mineral mixture feeding whereas globulin, cholesterol, triglyceride, serum enzymes (SGOT and SGPT) were not influenced either by protein or protein with mineral mixture supplementation. In contrast with the present findings, various hemato biochemical parameters in pregnant Ganjam does supplemented with concentrate (50, 100, 150 g) feed with different level of protein did not change in serum total protein, albumin and globulin level except glucose (Ray, 2009). Similarly, a significant increase in blood glucose concentration was reported when supplemented with concentrate in browsing goats and Osmanabadi goats (Singh and Shinde, 1997; More *et al.*, 2008). Sahu *et al*. (2015) supported the present findings that diet containing varied level of protein through concentrate supplementation @ 200 and 300 g/day in Ganjam goat's serum glucose was significantly higher ($P<0.05$) than control with lower ($P<0.05$) level of urea along with nonsignificant difference in haemoglobin, total protein, albumin, globulin and A/G ratio. Higher level of glucose in proteinaceous diet provided to animals might be attributed to concentrate supplementation which resulted in propionic acid production, which is a gluconeogenic substrate, in the rumen fermentation resulting in increased serum

glucose (Thomas *et al*., 1988). The haemato-biochemical profile in goats estimated in the present research were in agreement with the reports by Kumar *et al*. (2008) and Porwal *et al.* (2005), but much lower than the value reported by Bhide *et al*. (2001). These alterations might be due to the breed, environment and nutritional status of the experimental animals in the current study. Further, animals maintain their homeostasis mechanism in different physiological stages resulting no significant changes in different haemato-biochemical parameters in goats.

5.5.2 Effect of protein with mineral

The mean haemoglobin, TEC, PCV and MCV level was higher ($P<0.05$) in mineral supplemented group which might be attributed to better bioavailability of critical minerals especially, Fe, Cu, Zn etc. Optimum nutrition through required protein and minerals supplied to animals showed positive impact on blood glucose, protein, albumin but serum enzymes were not affected showing no adverse effect on vital organs of animals through supplementation of minerals. In corroborate with the present findings, Singh *et al*. (2010) observed that animal's diet supplemented with mineral mixture containing Mn, Cu and Zn which were deficient in their feeds along with grazing eight hours daily, hematological parameters and trace mineral status of blood in animals significantly improved ($P<0.05$) especially Hb , PCV, TEC, MCV, MCH and MCHC concentration than that of control group. Deficiency of critical minerals especially Co and Zn decreased the concentration of Hb, PCV, TEC, MCV, MCH and MCHC in goats (Sandhu and Randhawa, 1999; Al-Habsi *et al.*, 2007).Similarly, lower value of Hb, TEC and MCH in Cu deficient goats was reported (Unny *et al.*, 2001; Draksler *et al.*, 2002; Tola *et al.*, 2003) which are supportive to the present findings. Supplementation of protein with or without mineral mixture could not raise the haematological indices in the present study although the values were on higher side which might be probably due to compensatory growth and homeostasis mechanism of animals. Hb concentration was significantly higher in Cu supplemented goats (Frank *et al.*, 2000; Dey and Sanyal, 2004). Similarly, supplementation of iron and cobalt increased Hb, PCV, TEC, MCH, MCV and MCHC level in the kids (Sharmin *et al*., 2004; Kadus, 2004). As the trace minerals such as Cu and Co are directly associated with the formation of important blood constituents like RBC and Hb, the supplementation is supposed to improve the concentration of these blood constituents.

Plasma glucose level was higher (P<0.05) in Black Bengal goats fed with commercial mineral mixture which supported the present findings (Godara *et al.*, 2015). Increase in blood glucose level in protein with or without mineral supplemented animals was probably due to increased dietary protein and increased availability of nutrients, which might have provided more gluconeogenic precursors. Similarly, it was observed that glucose concentration was increased in crossbred cattle supplemented with area specific mineral mixture (@ 50 g/day), which might be due to alteration of molar proportion of volatile fatty acid in the rumen with an increase in propionate production resulting in increased glucose concentration in the plasma (Sahoo *et al.*, 2016). In agreement with the current study, no significant variation (P>0.05) was observed among treatment groups at 90 days of the experiment indicating that the supplementation of concentrate mixture and area specific mineral mixture had no effect on serum total protein, albumin, globulin, A:G ratio and urea level by Porwal *et al.* (2005) in lambs and Sahu *et al.* (2015) in pregnant goats supplemented with concentrate mixture incorporated with mineral mixture. Several studies also supported the fact that mineral mixture supplementation showed a positive effect on plasma glucose level in goat (Jain *et al.*, 2005; Kiomurasi *et al.*, 2011) and cattle (Sahoo *et al*., 2017). As opposed to this Sharma *et al.* (2011) reported that minerals supplemented group of crossbred heifers had lower glucose level than control group. Area specific mineral mixture might have enhanced the process of gluconeogenesis. Because of this, higher plasma glucose level was observed in mineral supplemented groups than the control.

5.6 Feed efficiency and economics of goat production

The Black Bengal goats fed protein rich concentrate mixture with mineral mixture performed better in terms of growth, feed efficiency and economics of production than other two groups. The average additional body weight gain was 2.16 kg in T_3 and 1.18 kg in T_2 over the control group. The cost of concentrate mixture per kg was calculated to be Rs. 31.12, 33.26 and 36.29 in T_1, T_2 and T_3, respectively. Fodder price was estimated to be Rs. 0.50 per kg. The selling price of goats was calculated Rs. 350.00 per kg and accordingly the net profit was calculated as Rs. 670.22, 1030.13 and 1308.40 in T_1, T_2 and T_3, respectively. Though the cost of feed was more, the ADG and feed efficiency were more in T_3 which was due to the higher live weight gain than control (T_1) and protein supplemented group (T_2) of animals.

The current findings with respect to economics and feed efficiency confirms the reports of Chaudhary *et al.* (2015) on male Barbari kids where they found highest net profit in the groups feed with concentrate feed pellet @ 1% of live weight.

CHAPTER-VI

SUMMARY AND CONCLUSION

The *in vivo* experiment was carried out to assess the effects of proteinaceous diet along with mineral mixture on nutrient utilization, mineral bioavailability, haemato - biochemical profile and growth performance of Black Bengal goats under intensive rearing system. Eighteen female Black Bengal goats were randomly divided into three homogenous groups 6 in each based-on age and body weight at experimental farm, ICAR-Central Institute for Women in Agriculture, Bhubaneswar. Animals in T_1 (Control) were fed as per conventional/farmers' practice adopted by farmers in rural areas (semi intensive condition with low protein and low mineral) and animals in T_2 were fed protein-based diet (high protein and low mineral), whereas animals in T_3 were fed same diet as T_2 group along with supplemental mineral mixture @3% of concentrate mixture (high protein and high mineral).

Initial live weight (kg) of T_1, T_2, T_3 were 7.20, 7.19 and 7.20, respectively and final live weights (kg) were 10.51, 11.59, 12.57 which differed significantly ($P<0.05$) among the treatments showing better efficacy of proteinaceous feed supplemented with mineral mixture. DM intake as percentage of body weight was lower in T_3 than T_1 and T_2 from 7^{th} week to 12^{th} week during the 90 days experimental period showing the efficacy of mineral mixture supplementation with protein diet on growth performance of goats. Total body weight gain (kg) for whole experimental period of 90days was significantly higher ($P<0.05$) in T_3 (5.37) than in T_1 (3.31) and T_2 (4.39). Similarly, ADG (g/day) was also higher ($P<0.05$) in T_3 (63.94) than T_1 (39.40) and T_2 (52.32). The voluntary feed intake (g/day) of concentrate was higher ($P<0.05$) in T_3 (172.8) in comparison with T_1 (158.1) and T_2 (166.5). The voluntary feed intake (g/day) of roughage and total dry matter was higher in T_3 in comparison T_1 but at par with T_2. The concentrate: roughage during the whole experimental period was 37:63, 40:60 and 41:59 in T_1, T_2 and T_3, respectively. Growth performance was higher ($P<0.05$) in mineral supplemented animals showing synergistic effect of protein with mineral due to better nutrient utilization at tissue level. Feed gain ratio was comparatively better ($P<0.05$) in T_3 (6.63) than T_1 (9.96) and T_2 (7.89) which were showing efficacy of mineral mixture with protein diet for augmenting productive performance of goats.

Incorporation of groundnut oil cake increased protein content in CM-II (18.33%) and supplementation of mineral mixture in CM-III lower the organic matter (89.75%). Fiber fraction percent (NDF, 72.55 and ADF, 45.75) of hybrid napier fodder was more being attributed to high cell wall constituents. The DM intake (g/day) through concentrate was higher ($P<0.05$) in T_3 (198) than T_1 (178), but at par with T_2 (193). Similarly, DM intake (g/day) through roughage (hybrid napier) was higher ($P<0.05$) in T_3 (290) than T_1 (267) but at par with T_2 (278). Total DM intake was higher ($P<0.05$) in T_3 (488 g) in comparison T_1 (445 g) but at par with T_2 (471 g). Similar trend was also followed in organic matter intake. However, DM intake and organic matter intake (as percent of body weight) was found to be better in T_3 group than T_1 and but similar to T_2, showing efficacy of mineral mixture supplementation with protein diet in goats. The concentrate: roughage was 40:60, 41:59 and 41:59 in T_1, T_2 and T_3, respectively.

Dry matter digestibility (%) in T_3 (61.50) was higher ($P<0.05$) than T_1 (54.75) and T_2 (57.75). The organic matter and crude protein digestibility in T_3 was higher thanT_1 but at par with T_2. Ether extract digestibility (%) and neutral detergent fiber digestibility (%) in T_3 were higher ($P<0.05$) than T_1 and T_2. The digestibility of acid detergent fibre in T_3 was higher ($P<0.05$) than T_1 and at par with and T_2. Total carbohydrates digestibility in T_1 was lower ($P<0.05$) thanT_2 and T_3 which were similar.

Daily nutrient intake (g/day) in relations to CP, DCP were higher ($P<0.01$) in T_3 than T_1 but at par with T_2. However, nutrient intake (g/day) in terms of DOM and total TDN were higher ($P<0.05$) in T_3 than T_1 but at par with T_2. Similar trend was also followed in nutritive value of the diet in terms of CP%, DCP% and TDN% of diet fed to different groups of goats during the digestibility trial. Increasing the level of protein through incorporation of ground nut oil cake in T_2 and ground nut oil cake with mineral mixture in T_3 enriched the value of diet through improvement in nutrient utilization in goats which was reflected in better growth performance.

The total Ca intake was higher ($P<0.05$) in T_3 thanT_1 and T_2. The absorption (% of intake) of Ca was significantly higher ($P<0.05$) in T_3 (39.28) in comparison with T_1 (31.46) and T_2 (34.36). Phosphorus intake (g/day) was higher ($P<0.05$) in T_3 (2.32) than T_1 (2.11), but at par with T_2 (2.24). The absorption (% of intake) of P was

significantly higher ($P<0.05$) in T_3 (43.30) in comparison with T_1 (36.82) and T_2 (38.95) which were at par. Zinc intake (mg/day) was higher ($P<0.05$) in T_3 (457.28) in comparison with T_1 (247.54) and T_2 (282.83) and the absorption (% of intake) of Zn was higher ($P<0.05$) in T_3 (36.59) than T_1 (30.66) and T_2 (32.00) which were at par. Copper intake (mg/day) differed significantly ($P<0.05$) among different groups being highest in T_3 (119.70) and lowest in T_1 (63.30). The absorption (% of intake) of Cu was higher ($P<0.05$) in T_3 (36.59) than T_1 (30.66), but at par with T_2 (32.00). Iron intake (mg/day) differed significantly ($P<0.01$) among different groups being highest in T_3 (1171.25) and lowest in T_1 (880.63). The absorption (% of intake) of Fe was higher ($P<0.05$) in T_3 (46.24) than T_1 (37.07) and T_2 (40.11) which were at par. Manganese intake (mg/day) differed significantly ($P<0.05$) among different groups being highest in T_3 (388.33) and lowest in T_1 (262.64). The absorption (% of intake) of Mn was higher ($P<0.05$) in T_3 (38.44) than T_1 (31.50), but T_2 (33.65) which were at par.

The haematological indices of experimental goats revealed that mean Hb (g dl^{-1}) level was higher ($P<0.05$) in T_3 (11.53) than T_1 (10.53) and at par with T_2 (11.18) irrespective of the periods. Total erythrocyte count (TEC) (10^6/ mm^3) of experimental animals was higher ($P<0.05$) in T_3 (13.36) than T_1 (12.15) and at par with T_2 (13.11) irrespective of the periods. Packed cell volume (PCV) level was higher ($P<0.05$) in T_3 (30.08) than T_1(26.51) and at par with T_2 (28.83) irrespective of the periods.

The serum biochemical indices revealed that mean glucose level (mg dl^{-1}) was significantly higher ($P<0.05$) in T_3 (74.39) than T_1 (70.32) and T_2 (72.86) being at par irrespective of the period. The serum total protein, and albumin level in T_2 and T_3 were higher ($P<0.05$) than T_1. The activity of SGPT (IU/L) and SGOT (IU/L) level did not differ among treatments.

Serum Ca level (mg dl^{-1}) was higher ($P<0.05$) in T_3 (10.97) than T_1 (9.10) and T_2 (9.72) where as T_1 and T_2 were at par. The mean serum values of phosphorus (mg dl^{-1}) was higher ($P<0.05$) in T_3 (7.29) than T_1 (5.89) and T_2 (6.59) which were at par. Mean serum Cu concentration (mg l^{-1}) were higher ($P<0.05$) in T_3 than T_1 and T_2 being at par. Similarly, average serum Fe concentration (mg l^{-1}) were higher in T_3 than T_1 and T_2 being at par. Serum Mn concentration (mg l^{-1}) was higher ($P<0.05$) in

T_3 than T_1 and T_2 which were similar. Similarly, Serum Zn concentration (mg l^{-1}) was higher ($P<0.05$) in T_3 than T_1 and T_2 which were at par.

The economics of production of Black Bengal goats fed protein rich concentrate mixture with or without mineral mixture revealed that Black Bengal goats fed protein rich concentrate mixture with mineral mixture was comparatively better than other two groups. The income generated from selling price (kg live weight) of goats and net profit was Rs. 670.22, 1030.13 and 1308.40, in T_1, T_2 and T_3, respectively. The ADG and feed efficiency were improved in T_3, which was due to the higher live weight gain than control (T_1) and protein supplemented group (T_2) of animals.

CONCLUSION

The following conclusions can be drawn from the above experiment.

- Feeding goats with high protein diet by increasing the level of groundnut oil cake improved the nutrient utilization, growth rate and feed efficiency.
- Supplementation of mineral mixture along with proteinaceous diet showed a synergistic effect, which further improved growth performance and feed efficiency with better cost efficacy in goats.
- Supplementation of protein with mineral mixture in goats showed better blood biochemical and mineral profile indicating improvement in mineral bioavailability, which was reflected in enhanced productive performance.

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