

**EFFECT OF FEEDING VARYING DIETARY CALCIUM AND
PHOSPHORUS LEVELS ON THE GROWTH PERFORMANCE AND
SKELETAL HEALTH OF TURKEY POULTS**

Thesis

**Submitted to the
DEEMED UNIVERSITY
Indian Veterinary Research Institute
Izatnagar - 243 122 (U.P.), India**



**Dr. Vikash Bhardwaj
Roll No. 6244**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE DEGREE OF**

**Master of Veterinary Science
(Poultry Science)**

2023

Jai Peepal wali Maiya ki



Dedicated to....

My Beloved Family
&
Respected Guide



भा.कृ.अनु.प.-केन्द्रीय पक्षी अनुसंधान संस्थान
इज्जतनगर -243122, (उ.प्र.), भारत



DIVISION OF AVIAN NUTRITION AND FEED TECHNOLOGY
ICAR-CENTRAL AVIAN RESEARCH INSTITUTE
IZATNAGAR - 243 122, U.P., INDIA

Dr. Chandra Deo
Ph.D.
Principal Scientist

Dated: 14/12/2022

Certificate

Certified that the research work embodied in this thesis entitled "Effect of feeding varying dietary calcium and phosphorus levels on the growth performance and skeletal health of Turkey poults" submitted by Dr. Vikash Bhardwaj, Roll No. M-6244, for the award of Master of Veterinary Science degree in Poultry Science at ICAR-Indian Veterinary Research Institute, Izatnagar, is the original work carried out by the candidate himself under my supervision and guidance.

It is further certified that Dr. Vikash Bhardwaj, Roll No. M-6244 has worked for more than 21 months in this Institute and has put in more than 150 days attendance under me from the date of registration for the degree of Master of Veterinary Science of the Deemed University, ICAR-Indian Veterinary Research Institute as required under the relevant ordinance.


(Chandra Deo)

Chairman
Advisory Committee


Dr. CHANDRA DEO
Principal Scientist & Head
Nutrition & Feed Technology Div.
Central Avian Research Institute
Izatnagar-243 122 (U.P.)


Certificate

We the undersigned members of Advisory Committee of Dr. Vikash Bhardwaj, Roll No. M-6244, a candidate for the degree of Master of Veterinary Science with the major discipline in Poultry Science, agree that the thesis entitled "Effect of feeding varying dietary calcium and phosphorus levels on the growth performance and skeletal health of Turkey poult" may be submitted in partial fulfillment of the requirement for the degree.

We have gone through the contents of the thesis and are fully satisfied with the work carried out by the candidate, which is being presented for the award of Master of Veterinary Science degree of this Institute.

It is further certified that the candidate has completed all the prescribed requirements governing the award of Master of Veterinary Science degree of the Deemed University, ICAR-Indian Veterinary Research Institute, Izatnagar.

Signature 
Name **DR. A. K. SHRIVASTAV**
External Examiner


(Chandra Deo)
Chairman
Advisory Committee

Date : 20.01.2023

Date : 20/01/2023

MEMBERS OF STUDENT'S ADVISORY COMMITTEE

Dr. Subrat Kumar Bhanja, Principal Scientist
Division of Poultry Science, ICAR-CARI, Izatnagar



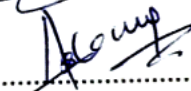
Dr. Avishek Biswas, Principal Scientist & Head
Division of Post Graduate Education and Training, ICAR-CARI, Izatnagar



Dr. Sunil Eknath Jadhav, Principal Scientist
Division of Animal Nutrition, ICAR-IVRI, Izatnagar



Dr. Asok Kumar, Scientist (Sr. Scale)
Division of Pathology, ICAR-IVRI, Izatnagar



ACKNOWLEDGEMENTS

First and foremost, I would like to express my sincere thanks to Almighty for allowing me to be a part of this prestigious institute and my love to **Mrs. Meera** (maa) and **Mr. Vijay** (Papa) for giving me the best of everything, for giving strength to reach for the stars and chase my dreams.

At the outset, I wish to avail this excellent opportunity to express my sincere heartfelt gratitude to my mentor, philosopher and chairperson of the advisory committee, **Dr Chandra Deo**, Head (Principal Scientist), Division of Avian Nutrition and Feed Technology, ICAR-CARI for his scholastic guidance, continuous motivation, constructive criticism, patience, moral support, discipline, simplicity, immense knowledge, meticulous supervision, friendly nature and encouragement throughout the course of my research work. His command over the subject and active persuasion contributed a lot to enrich my growth as a student and researcher. I would always be indebted to him for planning and execution of the work, critical appraisal of the manuscript, completion of thesis work in time and care and affection bestowed on me. I feel fortunate enough to get **Dr Chandra Deo** as my mentor for my M.V.Sc. study.

I extend my grateful acknowledgments and veneration to the members of my advisory committee **Dr. S. K Bhanja**, Principal Scientist, ICAR- CARI, **Dr Avishek Biswas**, Principal Scientist, ICAR-CARI, **Dr. Sunil E. Jadhav**, Principal Scientist, Division of Animal Nutrition and **Dr. Ashok Kumar M**, Scientist, Division of Veterinary Pathology for their valuable suggestions, constant interest and timely help during the course of research work. I am forever thankful to their exceptional guidance.

I also extend my sincere thanks to all my respected teachers from CARI, **Dr. Gautham Kolluri**, Scientist, Division of Avian Physiology and Reproduction, ICAR-CARI, for his valuable suggestions, exceptional guidance throughout my lab analysis, **Dr. Jaydeep Rokade**, Scientist, Division of Post-Harvest Technology, CARI, **Dr. Divya Sharma**, **Dr. J.S. Tyagi**, and **Dr. M. Sirajuddin** for their valuable lessons of professional and personal life during my M.V.Sc. I am falling short of words to express my admiration towards them.

I also take my golden opportunity to thank Director and Joint Director (Academics), IVRI, Director (CARI) for providing the necessary facilities to make this task an accomplishment.

I also extend my sincere thanks to the **Dr. Manish Mehra**, Senior Research Fellow, Division of Poultry Housing and Management, ICAR- CARI, **Tripathi Ji Pradeep Ji** and **Rajpal Ji**, AN&FT for supporting me during my lab analysis. **Vivek Ji**, Senior Research Fellow and **Twinkle** Division of Physiology and Reproduction, ICAR- CARI I wish to thank all the faculty of CARI and IVRI for enlightening me through teaching the subject during these days.

My warmest gratitude to my beloved sister **Dr. Sonam Bhardwaj** who always supported and guided me in all my ups and downs in my whole college journey of UG to PG. She stood by me when I felt that my toughest nerves were being tested through the paths of attaining better knowledge.

I am very glad to have such a kind, cooperative batchmates **Dr. Praveen Kumar**, **Dr. Prasant**, **Dr. Krishna K S**, **Dr. Sruthy Ravi**, **Dr. Shameehand** and **Dr. Hishalo Tsela**. The blissful days during the course of our M.V.Sc. will always hold a special place in my heart.

I would like to thank my divisional seniors **Dr. Jayanti**, **Dr. Azhaguraja**, **Dr. Mukesh**, **Dr. Monika**, **Dr. Abhijeet**, **Dr. Siddarth. M.**, **Dr. Gowthaman**, **Dr. Prashanth**, **Dr. Elamathi**, **Dr. Harshini**, **Dr. Naresh**, **Dr. Stanzin**, **Dr. Zaheeb**, **Dr. Nagesh**, **Dr. Siddarth** and my favourite juniors **Dr. Shriram**, **Dr. Mohit**, **Dr. Manoj**, **Dr. Rajan**, **Dr. Rajawardhan**, **Dr. Basil** and **Dr. Anjana** for helping as and when required during the periods of course work and research.

I owe my deep respect to all CARI People, **Pant Bhaiya**, **Narayan Bhaiya**, **Rakesh Bhaiya**, **Subash Bhaiya**, **Nazir bhaiya** and **Joshi bhaiya** who all stood with me throughout my experiment period.

I express my ineffable gratitude to my batchmate **Dr. Anamika Pandey** for his sincere help and moral support in my two years of M.V.Sc degree program especially during the research work period. I thank my senior **Dr. Ragini Mishra mam**, **Dr. Naveen Verma sir** and junior **Dr. Ayushi Vaidhya** for their support during my days in IVRI.

I thank my beloved classmates **Dr. Manoj Kumar, Dr. Tarun, Dr. Pankaj, Dr. Tapendra, Dr. Gagan and Dr. Theerthesh** for their continuous support, valuable advice and making a home away from situation for me during my M.V.Sc. days.

I am always thankful to my UG friends **Dr. Chandrika, Dr. Prasant Prajapati, Dr. Hemant, Dr. Samarveer** who supported and motivated me to get placement in ICAR-IVRI.

I am at lack of words to express the depth of my emotions and respect to my late grandmother **Mrs. Kamla** who devoted entire her life to the family. Blessings of my late grandfather **Mr. Ram Kumar Bhardwaj** and maternal grand father **Late Mr. Ram Dutt** and maternal grand mother **Mrs. Jaya Devi** my family members **Ashok- Rukmani, Rajesh- Mamta, and Anil- Usha**. I would like to thank my dear sister, **Dr. Sonam, Priya Dii, and Shilpi** for being with me all the time without saying a no for my dreams, your sacrifice and love given me all my achievements. Also, I owe my deep love to my dear brother-in-law **Sandeep** and **Devashish Jijaji** and **Sunil** and brothers **Rahul bhaiya, Mausam Bhaiya, Vinay, Piyush, Shiva** and **Nishtha Bhabhi** for providing me with unfailing support and continuous encouragement throughout my period of study. This accomplishment would not have been possible without all of you.


I thank my mess members and cooks **Maharaj Ji, Umesh** and **Rajpal** for their delicate food preparations.

I would like to acknowledge all my birds used in this study and throughout the history of scientific research, they have paid the ultimate sacrifice in order to advance scientific knowledge and ultimately save lives, for which we, as the human race, should be eternally grateful.

During the course of study, I have received help from many people in one way or the other. It is very difficult to acknowledge all of them individually by name. This shortcoming maybe pardoned and I assure you that I have offered a place in my heart for each of you.

Finally, I would like to extend my thanks to those who have played their part directly or indirectly in my research work. All might not have been mentioned but none is forgotten.

Date: 14/12/2022
Place: ICAR-IVRI, Izatnagar


(Vikash Bhardwaj)

ABBREVIATIONS

%	: Percentage
/	: Per
@	: At the rate
<	: Lesser than
>	: Greater than
%	: Percentage
d ^o	: Less than or equal to
©	: Sum of
°C	: Degree Celsius
µl	: Micro liter
µg	: Micro gram
<i>ad lib</i>	: Ad libitum
25 D	: 25-hydroxicholecalceferol
A/G	: Albumin-Globulin ratio
Abs.	: Absorbance
ALP	: Alkaline phosphatase
ANFT	: Avian Nutrition and Feed Technology
ANOVA	: Analysis Of Variance
Av.P	: Available Phosphorus
B	: Blank
BIS	: Bureau of Indian Standard
BW	: Body Weight
BWG	: Body Weight Gain
C	: Control
Ca	: Calcium
CARI	: Central Avian Research Institute
CMI	: Cell mediated immunity
Conc.	: Concentration
CP	: Crude Protein
D	: Day
DCP	: Dicalcium Phosphate
dl	: Deciliter
DMB	: Dry matter basis
FCR	: Feed conversion ratio
FE	: Feed efficiency
FI	: Feed Intake
Fig.	: Figures

FSPS	:	Feed Storage and Processing Section
FTU	:	Phytase Unit
FWI	:	Foot web index
G ^o %	:	Gram Percent
g	:	Gram
g/b/d	:	Gram per bird per day
g/dl	:	Gram per Decilitre
GDP	:	Gross domestic product
H ₂ SO ₄	:	Sulphuric acid
HNO ₃	:	Nitric acid
Hr	:	Hour
Hrs	:	Hours
HA	:	Hemagglutination
HI	:	Hemagglutination inhibition
IU	:	International Unit
IVRI	:	Indian Veterinary Research Institute
Kcal	:	Kilo calorie
Kg	:	Kilogram
LSP	:	Limestone Powder
Log	:	Logarithm
ME	:	Metabolizable energy
mg	:	Milligram
mg/Kg	:	Milligram/ kilogram
ml	:	Milliliter
Mn	:	Manganese
nm	:	Nanometer
NRC	:	National Research Council
NPP	:	Non-phytate phosphorus
OD	:	Optical Density
P	:	Phosphorus
P<0.01	:	Significant at 1% level
P<0.05	:	Significant at 5% level
RBC	:	Red blood cells
SPSS	:	Statistical Package for Social Sciences
SBM	:	Soybean meal
SRBC	:	Sheep red blood cell
SEM	:	Standard error of mean
TA	:	Total ash
TP	:	Total phosphorus
wk	:	Week
wt	:	Weight

LIST OF TABLES

Table No.	Title	On/After Page No.
Table 3.1:	Ingredients and nutrient composition of growing turkey diet (0-4 wks)	29
Table 3.2:	Ingredients and nutrient composition of growing turkey diet (5-8 wks)	30
Table 4.1:	Biweekly Body weight (g/b) of growing turkeys fed different levels of calcium and available phosphorus	29
Table 4.2	Analysis of variance for biweekly body weight of growing turkeys	30
Table 4.3	Biweekly Body weight gain (g/b) of growing turkeys fed different levels of calcium and available phosphorus	31
Table 4.4	Analysis of variance for biweekly body weight gain of growing turkeys	31
Table 4.5	Cumulative body weight gain (g/b) of growing turkeys fed different levels of calcium and available phosphorus	32
Table 4.6	Analysis of variance for cumulative body weight gain of growing turkeys	33
Table 4.7	Weekly Feed intake (g/b) of growing turkeys fed different levels of calcium and available phosphorus	34
Table 4.8	Analysis of variance for weekly Feed intake of growing turkeys	35
Table 4.9	Cumulative Feed intake (g/b) of growing turkeys fed different levels of calcium and available phosphorus	35
Table 4.10	Analysis of variance for cumulative Feed intake of growing turkeys	36
Table 4.11	Weekly Feed conversion ratio (g feed/ g gain) of growing turkeys fed different levels of calcium and available phosphorus	37
Table 4.12	Analysis of variance for weekly Feed conversion ratio of growing turkeys	37

Table No.	Title	On/After Page No.
Table 4.13	Overall Feed conversion ratio (g food/g gain) of growing turkeys fed different levels of calcium and available phosphorus	39
Table 4.14	Analysis of variance for overall Feed conversion ratio of growing turkeys	39
Table 4.15	Mortality of growing turkeys fed different levels of calcium and available phosphorus	40
Table 4.16	Cellular and humoral immunity of growing turkeys fed different levels of calcium and available phosphorus	41
Table 4.17	Analysis of variance for Cellular and humoral immunity of growing turkeys	42
Table 4.18	Immune organ weight of growing turkeys fed different levels of calcium and available phosphorus	43
Table 4.19	Analysis of variance for immune organs of growing turkeys	43
Table 4.20	Serum biochemical parameters of growing turkeys fed different levels of calcium and available phosphorus	44
Table 4.21	Analysis of variance for serum biochemical parameters of growing turkeys	45
Table 4.22	Serum biochemical parameters of growing turkeys fed different levels of calcium and available phosphorus	45
Table 4.23	Analysis of variance for serum biochemical parameters of growing turkeys	46
Table 4.24	Bone morphometry of growing turkeys fed different levels of calcium and available phosphorus	47
Table 4.25	Analysis of variance for bone morphometry of growing turkeys	48
Table 4.26	Bone mineralization of growing turkeys fed different levels of calcium and available phosphorus	49
Table 4.27	Analysis of variance for bone mineralization weight of growing turkeys	50

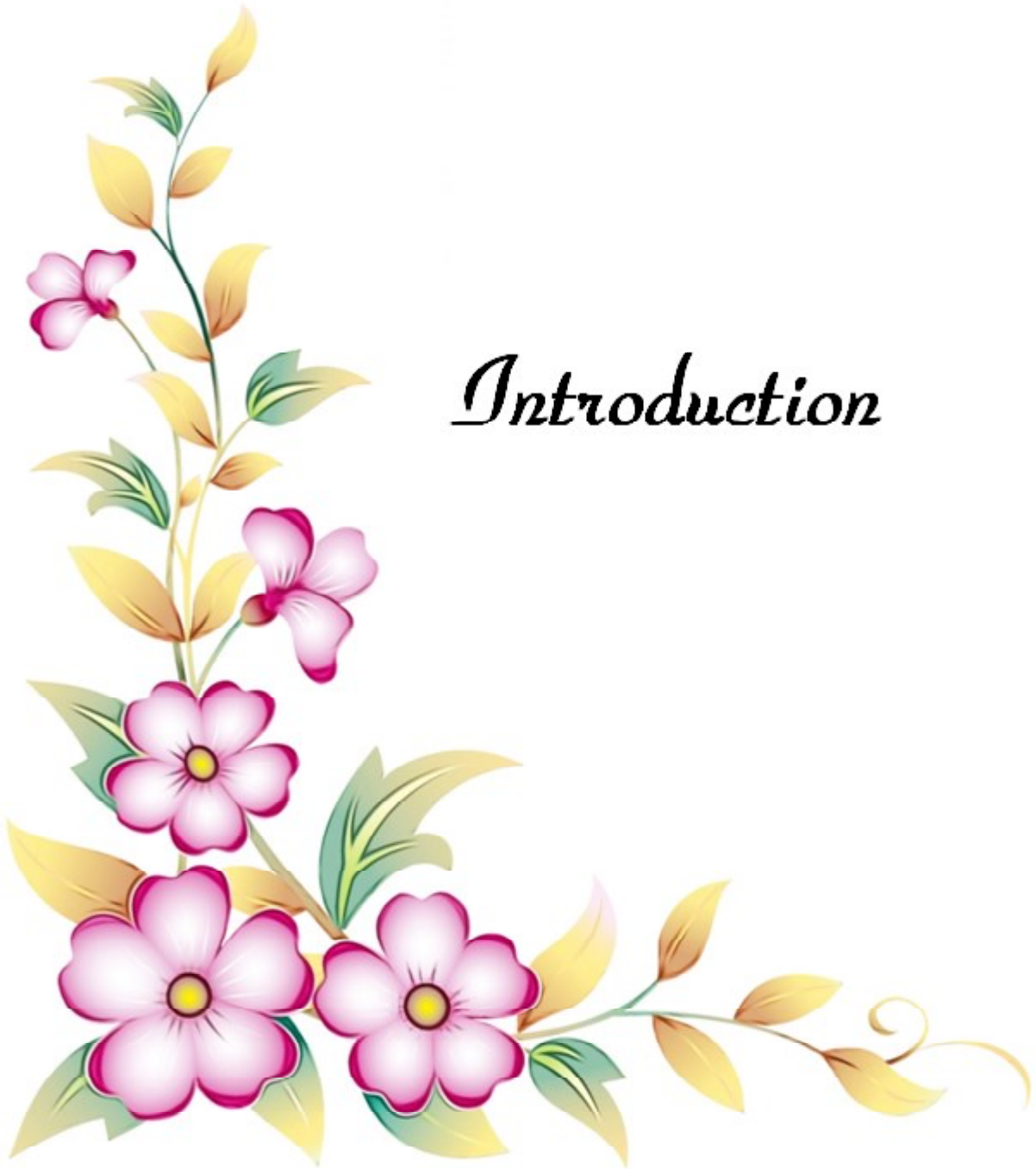
Table No.	Title	On/After Page No.
Table 4.28	Trace minerals in growing turkeys fed diet variable levels of calcium and available phosphorus	52
Table 4.28	Analysis of variance for Trace Minerals in growing turkeys fed diet variable levels of calcium available phosphorus	52
Table 4.30	Ca intake, excreted, retained and percent Ca retention of growing turkeys fed diet variable levels of calcium and available phosphorus	53
Table 4.31	Analysis of variance for Ca intake, excreted, retained and percent P retention of growing turkeys fed diet variable levels of calcium available phosphorus	54
Table 4.32	P intake, excreted, retained and percent P retention of growing turkeys fed diet variable levels of calcium and available phosphorus	55
Table 4.33	Analysis of variance for P intake, excreted, retained and percent P retention of growing turkeys fed diet variable levels of calcium available phosphorus	56

LIST OF FIGURES

Figure No.	Title	On/After Page No.
Fig.1	Biweekly Body weight (g/b) of growing turkeys fed different levels of calcium and available phosphorus	29
Fig.2	Cumulative body weight gain (g/b) of growing turkeys fed different levels of calcium and available phosphorus	33
Fig.3	Cumulative Feed intake (g/b) of growing turkeys fed different levels of calcium and available phosphorus	35
Fig.4	Overall Feed conversion ratio (g food/g gain) of growing turkeys fed different levels of calcium and available phosphorus	39
Fig. 5-6	Cellular and humoral immunity of growing turkeys fed different levels of calcium and available phosphorus	41
Fig. 7	Immune organ weight of growing turkeys fed different levels of calcium and available phosphorus	43
Fig. 8-9	Bone morphometry of growing turkeys fed different levels of calcium and available phosphorus	47
Fig. 10	Bone mineralization of growing turkeys fed different levels of calcium and available phosphorus	49
Fig. 11-12	Trace minerals in growing turkeys fed diet variable levels of calcium and available phosphorus	51

CONTENTS

Sl. No.	CHAPTER	PAGE NO.
1.	INTRODUCTION	01-03
2.	REVIEW OF LITERATURE	04-12
3.	MATERIALS AND METHODS	13-27
4.	RESULTS	28-56
5.	DISCUSSION	57-67
6.	SUMMARY AND CONCLUSIONS	68-73
7.	MINI ABSTRACT	74
8.	HINDI ABSTRACT	75
9.	REFERENCES	76-82



Introduction

Poultry production, in India, has gain all through the previous six decades consequently it has taken a shape of industry. The poultry industry has emerged as the most dynamic and fast expanding segment with a growth rate of 8.51% in egg and 7.52% in broiler production, (BAHS,2019) compared to 2.9% for agriculture crops (Economic survey-2019-20). According to the All India Poultry Breeders Association, poultry adds USD 17.31 billion to India's total gross value and tends to give income and employment to a large group of individuals approx. 50 million people. The high growth has placed India at third position, after china and USA with a production of 103.3 billion eggs and fourth after USA, China and Brazil with a production of 4.1 million tons of broiler meat (BAHS, 2019). The increase in consumer demand for chicken, which is driven by both income and consumption, is one of several important drivers supporting the recent expansion of the Indian poultry market. Changes in the price of chicken meat in comparison to other items. Production costs, marketing margins, and consumer poultry meat pricing have all decreased as a result of vertical poultry production integration and suitable marketing methodology. Poultry feed holds an important place in the global meat industry as it is an essential contributor to the overall growth of poultry. According to the Alltech feed study, commercial feed output in the nation reached approximately 39 million metric tonnes in 2019, with poultry feed accounting for nearly 24.9 million metric tonnes having the highest shares and Ruminants came in second with 11.6 million metric tonnes and 2.5 million metric tonnes share includes aquaculture, swine and others. Feed account over 65- 70 % of the total cost of poultry production and the major means of manipulating poultry profitable. Because feeding costs are the most significant limitation in the chicken industry,

every effort is made to preserve feed quality, keep feed costs as low as possible, and convert every last bit of feed into food for people.

Turkey (*Meleagris gallopavo*) occupies an important position after Chicken, Duck, Guinea fowl, and quail contribute the fastest-growing industry, which helps to improve the nutritional and economic status of a diverse population. Turkey farming is quite suitable for economic and social up-liftment of small and marginal farmers as the birds can be easily reared in free range or intensive system with minimal investment for housing, equipment and management. In India, turkey farming is a viable alternative to the production of chickens. And nowadays gaining popularity in India which is suitable for commercial meat production and it can be also raised for egg production and as a pets. Meat of turkey well-known for its leanness, delicacy among the domestic poultry species. There are some limiting factors like non availability of high yielding germplasm for rural people, availability of low cost feedstuffs and lack of knowledge to prepared least cost feed formulae. Turkey meat productivity can be measured not only by live body weight, growth performance, and feed conversion, but also by slaughter features such as slaughter yield and weight of edible components. (Oblakova, 2004).

Because of improved performance, variations in nutrient availability, interactions of different nutrients at sites of absorption and metabolism, and generating specialized designer products, maximizing and updating poultry nutrient requirements is a continuous struggle.

Calcium (Ca) is a major element found in the body in largest quantity. About 99% of body calcium is present in bones as structural component of skeleton system, while remaining 1% calcium is present in soft tissues and body fluids. Calcium is involve in various physiological functions like helps in coagulation of blood and liberation of insulin, regulate acid-base balance, excitability of nerves, permeability of cell membrane, heart beat and muscle tone and activates digestive enzymes. It is essential component of eggshell in laying hens. A dietary deficiency of calcium causes growth retardation, reduced feed intake, increased BMR, rickets or osteoporosis, abnormal posture and gait, decreased activity and sensitivity, susceptibility to internal hemorrhages, reduced life span, increased urine volume, tetany, decreased egg production and reduced shell thickness which may bring to huge economic losses in the turkey production.

Similarly, phosphorus (P) is a critical and highly expensive mineral in poultry diet which is extremely important in several bio-functions such as acid-base balance, cell-oxidative phosphorylation, egg shell formation, energy transfer mechanism, skeletal development etc. A dietary deficiency of phosphorus causes loss of appetite, weakness, growth failure and rickets as in calcium or vitamin D deficiency.

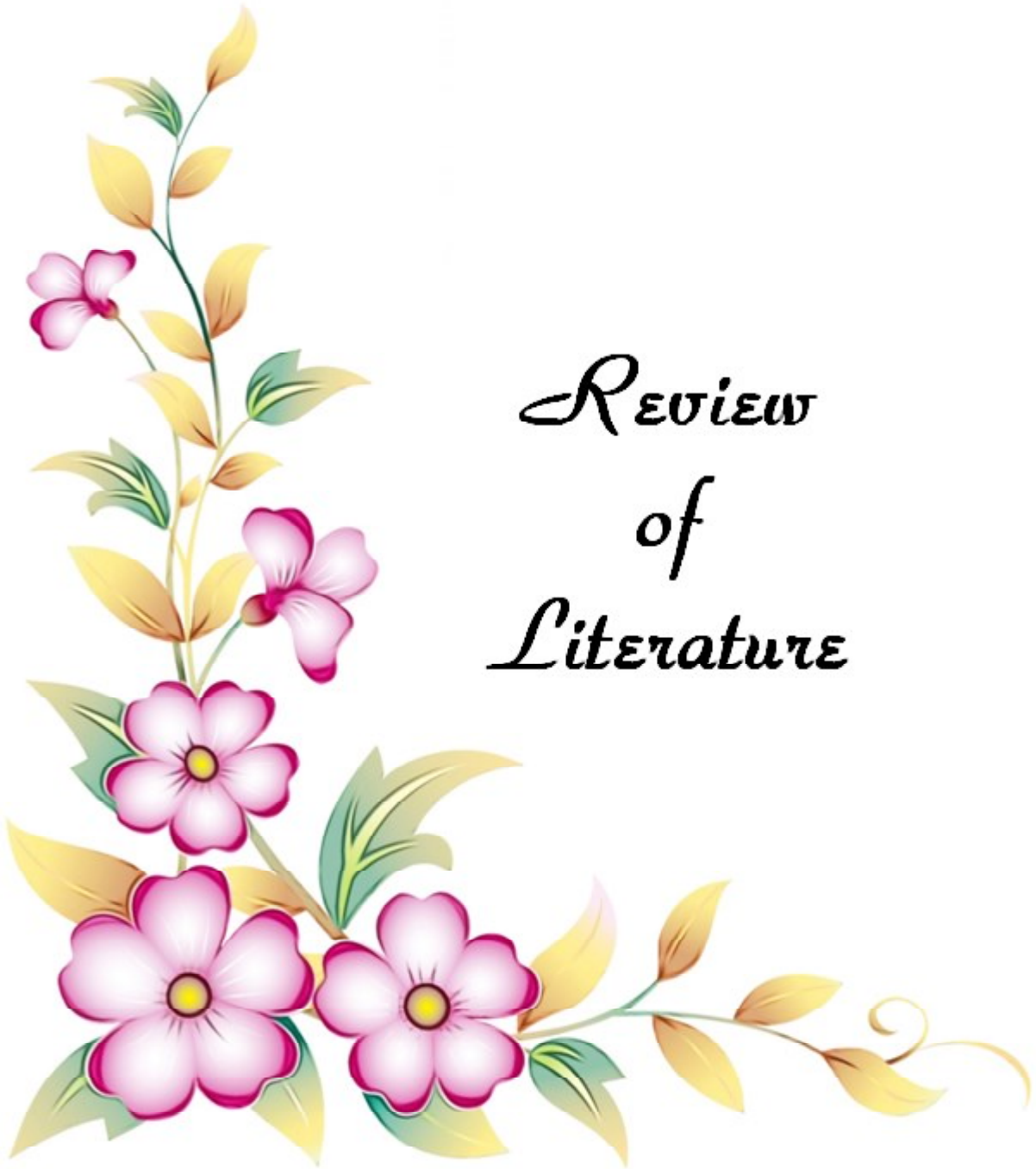
With change in genetic make-up and the managerial practices for the fast growing and high yielding turkey, it is possible that the requirement of calcium and phosphorus for modern rapidly growing genotypes are higher than in the past. Efforts have been made by several researchers to define the calcium and phosphorus requirement for growing turkey but with variable results. Calcium and phosphorus requirement-related studies have been concerned with birds maintained under temperate conditions and it is quite possible that these results may not be applicable to the birds reared in tropical environments .

It is therefore, considered worth-while to undertake the present work on effect of feeding varying dietary levels of calcium and phosphorus on growth performance and skeletal health of CARIVIRAT growing turkey with following objectives.

- **To optimizing dietary calcium(Ca) and phosphorus (P) requirements of CARIVIRAT growing turkey considering growth and skeletal health.**
- **To study the blood biochemical characteristic variables or parameters as influenced by different dietary calcium and phosphorus concentration in growing turkey.**



*Review
of
Literature*



When nutritionists consider the need for mineral supplementation, they must consider a number of factors, each of which may need modifications in the birds' requirements. Breed, sex, Managemental practices, developmental growth of the birds, stress, and diseases are some of these elements. Nutrients, energy levels, manufacturing, storage and mineral sources are all aspects that affect the feed. Only a few studies have been conducted to estimate the ideal levels of calcium and phosphorus for growing turkeys, compared to other nutrients, and there is a wide difference in their requirements. Most of the levels recommended by the NRC (1994) were based on previous studies that were conducted under controlled conditions and used the minimal levels to avoid deficiency signs, rather than evaluating the optimal performance under field challenge situations. Furthermore, current breeds have faster growth and production rates, as well as higher dietary needs, in order to fully express their genetic potential. Other parameters, including as immunity, animal welfare, carcass features, and so on, are currently being evaluated to establish calcium requirements. Several investigations have been undertaken on the requirement of Ca & P in diet of growing turkey particularly for birds reared in temperate zone of the world but such reports seems to be relatively meager for growing turkey under tropical climate. Amassing of the scattered literature into one string has been tried and presented briefly here under.

2.1. Requirements

Diet formulating to meet the minimum requirement of calcium and phosphorus for growing turkey is a complex task, which needs a large number of interacting factors to be

considered, otherwise any one of which can influence the bird's calcium and phosphorus requirements.

NRC (1994) has stated that 1.2 and 1.0% calcium and 0.6 and 0.5 % phosphorus required in the diet of growing turkey during 0-4 and 5-8 weeks, respectively, for optimum growth performance. Similarly, ICAR (2013) stated that 1.2 and 1.0% calcium and 0.55 and 0.50% phosphorus required in the diet of growing turkey during 0-6 and 7-12 weeks of age, respectively for optimum growth performance. Motzok and Slinger (1948) reported that considering growth and bone ash in growing turkey during 0-5 weeks of age, the best results were obtained when the ration contained approximately 2.0% calcium and 1.0% phosphorus. Nelson *et al.* (1960) reported that diet fed containing 0.8% Ca and 0.8% P were found sufficient for maximum growth performance of female turkey during 8-24 weeks of age. Formica *et al.* (1961) reported that when fed a diet containing 0.81 percent calcium and 0.65 percent phosphorus, day old broad breasted bronze turkey poult grew normally to 8 weeks of age and had normally calcified bones. From 8 weeks to market age, broad breasted bronze turkeys developed normally on a ration containing 0.83 percent calcium and 0.56 percent phosphorus. Authors also suggested that addition of minerals to the growing ration did not improve performance. Sanders *et al.* (1992) conducted two experiment to determine Ca and phosphorus requirements of very young turkey by response surface analysis and reported that Ca of 12.5 g/kg was determined to be optimal for growth. and phosphorus requirements were estimated 10.0 g/kg feed , during 0-16 d growth periods. Authors also reported that for maximum bone ash in the regression analysis indicates 13.0 g Ca/kg and 10.2 g total phosphorus were required for 0-16d growth periods. Atia *et al.* (2000) reported that growing turkey during 4-16 weeks of age required 1.0 % calcium with 0.37% available phosphorus and 500 FTU/kg phytase enzyme for optimum growth performance. Hocking *et al.* (2002) reported that maximum body weight of growing turkey was obtained with a dietary calcium concentration of 10 g/kg and an available phosphorus concentration of 3 g/kg from 4 – 13 wks of age. Tatara *et al.* (2011) suggested that dietary calcium needs of growing turkey is 1.02 and 0.85 % during 0-4 and 5-8 weeks respectively for optimum growth performance. Similarly, for maximum bone ash dietary calcium required 1.26 and 1.05% during 0-4 and 5-8 weeks respectively.

2.2. Effect on growth performance

The impact of dietary Ca and P on the growth performance of developing turkeys has been investigated by many workers. Motzok and Slinger (1948) conducted three experiments on calcium and phosphorus requirement in the diet of growing turkey from 0-5 weeks of age and fed variable dietary calcium and phosphorus levels in the diet in (Expt-1 constant Ca level (1.6%) with variable P (0.7 to 1.7%), Expt.2 variable Ca (0.9 to 2.3%) and constant P level (0.7%) and Expt.3 variable Ca (1.2 to 2.0%) and constant P level (1.0%). Based on the results of 3 experiments authors suggested that considering growth and bone ash in growing turkey during 0-5 weeks of age, the best results were obtained when the ration contained approximately 2.0% calcium and 1.0% phosphorus. Sullivan *et al.* (1959) reported that the optimum growth performance were obtained when diet fed 1.55 % calcium with 0.70 to 0.80% and 0.75 to 0.85 % total phosphorus to female and male growing turkey, respectively. Nelson *et al.* (1960) reported that diet fed containing 0.8% Ca and 0.8% phosphorus were found sufficient for optimum growth performance of female turkey during 8-24 weeks of age. Formica *et al.* (1961) reported that turkey poults of day old broad breasted bronze grow normally up to 8 wks of age with diet fed containing 0.81% Ca and 0.65% phosphorus and from 8 wks to market age, turkey broad breasted bronze developed normally with diet containing 0.83 % Ca and 0.56% phosphorus. Sanders *et al.* (1992) reported that the requisites for optimal development in the very young turkey are Ca 12.5 g/kg and total P 10.0 g/kg diet, respectively. Atia *et al.* (2000) reported that growing turkey during 4-16 weeks of age required 1.0 % calcium with 0.37% available phosphorus and 500 FTU/kg phytase enzyme for optimum growth performance. Hocking *et al.* (2002) reported that maximum body weight of growing turkey was obtained with a dietary calcium concentration of 10 g/kg and an available phosphorus concentration of 3 g/kg from 4-13 weeks of age. Tatara *et al.* (2011) suggested that dietary calcium needs of growing turkey is 1.02 and 0.85 % during 0-4 and 5-8 weeks respectively for optimum growth performance.

2.2.1 Weight gain, feed efficiency and survivability:

Pensack and Stockstad (1960) stated 0.6 -0.8 % Ca and 0.6% P, good development and appropriate chick calcification could be achieved. Sanders *et al.* (1992) reported that

feeding variable levels of dietary Ca (0.8,10.0,12.0 and 14.0 g/kg) and TP (7.0,9.0,11.0 and 13.0g/kg) to very young growing turkey had little effect on body weight and efficiency of feed utilization and concluded that 12.4 Ca g/kg with 10.2 TP g/kg are adequate for optimum growth performance from 0 to 16 days of age. Hocking *et al.* (2002) reported that diet fed with variable levels of Ca (6,10,14 and 18g/kg) and Av P (3, 5, 7 and 9 g/kg) to large white male turkey from 4-13 weeks of age had no influence on feed intake and efficiency of feed utilization and authors concluded that the maximum body weight at 7, 10 & 13 Wks of age was obtained with 1.0 % Ca and 0.3% available phosphorus. Tatara *et al.* (2011) reported that no significant effect on body weight was observed when diet fed 0.99-1.33 and 0.85-1.10 % calcium and 0.79- 1.06 and 0.71-0.93% total P during 0-4 weeks and 5-8 weeks of age, respectively. Skinner *et al.* (1992) conducted a trial by feeding of maize-soybean diets supplemented with 0.12% non-phytate P and 0.06, 0.12, 0.24, 0.36, 0.48 and 0.60% Ca or 0.2% non-phytate P with 0.16, 0.24, 0.36, 0.48 and 0.60% Ca to male broilers (42-56 d) and reported that in terms of mortality, there were no changes between broilers fed supplemented and control diets (0.35% non-phytate P and 0.8% Ca). Scheideler *et al.* (1995) indicated that dietary interventions had no effect on total mortality in Trial 1 (100 and 140% NRC Ca and P for 0-7 wk; 140% NRC Ca and P for 0-3 wk followed by 100% NRC Ca and P for 4-7 wk) and Trial 2 (85, 100 and 140% NRC Ca and P for 0-7 wk), but In Trial 3, there was a substantial increase, where Ca was provided at greater amounts in the diet. (85% NRC Calcium and Phosphorus for 0-9 wk; 100% NRC Cal and 85% NRC P for 0-9 wk). They further mentioned that the sudden death syndrome (SDS) mortality was significantly increased by higher dietary Ca and P in Trial 1 and 3. Average SDS mortality was 2.61, 2.39 and 2.52% for Trial 1, 2 and 3, respectively.

2.2.2 Leg abnormality

The nutritional abnormalities resulting in avian rickets are usually related to alteration in dietary levels of Ca, P or vitamin D₃ and errors in feed formulation or mixing (Wise, 1975). Sanders *et al.* (1992) there was little tibial dyschondroplasia (TD) in young poults, despite considerable variations in dietary Ca and P concentrations, and the researchers concluded that there was no link between dietary Ca, total P, and TD. Hocking *et al.* (2002) reported

that there is no evidence that dietary changes have a major impact of Ca or available P on culling or walking ability when diet fed variable levels of Ca (6, 10, 14 and 18g/kg) and available P (3,5,7 and 9 g/kg). Hocking *et al.* (2002) Variable dietary Ca (6, 10, 14, and 18 g/kg) and Av P (3, 5, 7, and 9 g/kg) had no impact on the prevalence of the lesion, except in turkeys fed a diet containing 6 g Ca/kg, where body weight and tibial dyschondroplasia incidence were low. As per authors low dietary Ca was also linked to lower tibial plateau angles at 10 - 13 wks of age,

2.3. Immune response

Kidd (2004) reported that sub nutrition impaired the bird's ability to mount an effective response in natural and acquired immunity. Emami *et al.* (2013) noticed that broiler fed diets low in NPP supplemented with phytase @ 500 unit/kg and 0.2% commercial organic acid, significantly improved immune response to SRBC as compared to non-supplemented phytase and organic acid. Hofmann *et al.* (2021) reported that dietary calcium is correlated with changes in several immune parameters irrespective of strain, hens fed the Ca diets had lower numbers of immune cells, especially T cells and -subsets, in blood and cecal tonsils. Authors also suggested that higher P availability was associated with enhanced immune function. Makola *et al.* (2021) reported that nano-dicalcium phosphate substitution in broiler diet at levels of 40% and 50% could broiler chicken immunological response and intestinal morphology will be improved.

2.4. Blood biochemical parameters

Many factors, including genetics, nutrition, minerals, and vitamins, climate, rearing technique, age and other physiological factors can all play a role in altering the blood constituents. Hocking *et al.* (2002) conducted an experiment involving large white male turkey from heavy commercial male line were fed sixteen diets, containing four concentration of Ca (6,10,14 and 18 g/kg) and available P (3,5, 7 and 9g/kg) in a factorial experiment. Dietary calcium was favourably related with blood Ca and Ca ion concentrations, but had no influence on blood phosphorus, according to the findings. Available phosphorus was linked to higher blood phosphorus levels and lower calcium ion concentrations, but showed no effect on total calcium

levels. High quantities of dietary calcium with low available phosphorus resulted in low alkaline phosphatase activity, whereas low calcium and high available phosphorus diets resulted in higher activity. McMurtry *et al.* (1983) reported that Plasma ionised calcium was 35% of total calcium in poults, and it was affected by a food withholding and feeding regimen. The link between ionised and total calcium, according to the author, would be the ideal index for relating calcium homeostasis and physiological state. Fernandes *et al.* (1999) reported an increased plasma alkaline phosphatase (ALP) 6674 vs 8693 units/litre by addition of incremental dietary AP (0.8 vs 0.16 % from different sources in control diet containing 0.23% AP. They further, suggested that supplementing diet with agriculture and feed grade phosphates caused elevation of 9617 and 6136 unit/lit ALP activity, respectively. Deo *et al.* (2006) reported that serum ALP and calcium (Ca) significantly increased as decreasing dietary AP levels and serum phosphorus concentration were increased as increasing dietary AP levels. Edward (1993) reported that the addition of graded level inorganic P (0, 0.10, 0.20 and 0.30 %) to the basal diet containing 0.40 %TP resulted in lower plasma calcium and higher plasma dialyzable phosphorus concentration. Author also suggested that the addition of either phytase or 1, 25-dihydrocholecalciferol alone had no effect on either plasma Ca or dialyzable P. Rama Rao *et al.* (2007) reported that the concentrations of Calcium & Phosphorus in serum influenced significantly by feeding different levels of Ca, AP and vitamin D₃ in broiler diets. Nakagi *et al.* (2013) reported that with increased phosphorus levels from 0.21 to 0.45 %NPP in broiler diets there will be serum tartrate-resistant acid (ACP) and ALP activity decreased. Author's also suggested that phytase supplementation significantly decreased ALP values in lower phosphorus levels indicating inorganic P depletion induces a significant increase in alkaline phosphatase synthesis, suggesting that the function of this enzyme is down regulated by phosphorus.

2.5. Bone morphometry

Despite years of research, the bone disorders leading to leg weakness or lameness remain significant contributor to concern in turkey production. Among them the rickets and tibial dyschondroplasia (TD) are the most commonly encountered skeletal deformities, of Ca and P deficiency. Skinner *et al.* (1992) opined that the diet with 0.56 % Ca and 0.12 % NPP

content affected length of tibia adversely on comparing to those fed with control diet containing 0.80 % Ca and 0.35 % NPP. Similarly, Deo *et al.* (1996) were unable to observed any significant influence of the Ca ,p and vitamin D₃ contents on the length of tarsometatarsal bone of broiler chicks. On the other hand, length of tibia was reduced as a result of low P content in diet of broiler chicks (Moran and Todd, 1994). Mohamed (1998) reported that the length of tibia was not affected by reducing levels of 0.4% NPP in starter and 0.2 % NPP in finisher diet in broiler chicks.

Lalpanmawia *et al.* (2014) reported that tibia bone length and proximal epiphysis was significantly higher when diet fed low in NPP with phytase supplementation and normal NPP diet to the broiler chicks. Rama Rao *et al.* (2007) reported that enhanced levels of either Ca or NPP significantly increased bone length in broilers given the lowest dose of vitamin D₃ (200 IU/kg diet). Similarly, Broilers given a feed with greater amounts of vitamin D₃ had non-linear increases in bone length at the various combinations of tested Ca (0.5 and 0.6 %) and NPP (0.25 and 0.30 %) in the diets. Deo *et al.* (2001) reported that significant increase in width at long axis of tibia bone was noticed with an increment in dietary P levels (0.2 , 0.25, 0.30 ,0.35 ,0.40 ,0.4 0.50 and 0.55 % AP), whereas no such effect could be noticed on bone length and width at short axis. Tatara *et al.* (2011) reported that Boosted calcium supply in the diet increased skeletal system features, which were increased and created the most desirable traits such as bone weight, length, and volume in turkey consuming 95, 105, and 115 percent of the NRC calcium requirement. Hocking *et al.* (2002) reported that increasing dietary calcium consumption tibial radiodensity, cortical density, and cortex and proximal tibiotarsus widths have all risen.

2.6. Bone mineralization

The bone ash has been the principal criterion of evaluating dietary Ca and/or P contents for poultry in numerous studies (Fritz *et al.*, 1969; Shrivastava *et al.*, 1996a). Waldroup *et al.* (1963) stated that the bone ash values were more responsive to Ca and/or P levels than body weights. Increasing the Ca content above 0.5% in broiler diet reduced the tibia ash percentage (Halley *et al.*, 1987). Shafey *et al.* (1990b) observed 41.2, 40.4 and 38.9% tibia ash in 17-

d old chickens fed diets with 1.2, 2.2 and 3.2% Ca levels respectively and reported that the tibia ash content reduced as the dietary Ca level was increased. Similar depression in bone ash values was seen by Scheideler (1991) in chickens fed the diet containing 1.8% against 1.0% Ca. Tataro *et al.* (2011) reported that In turkey receiving 95, 105, and 115 percent of the NRC calcium requirement, increased calcium supply in the diet boosted skeletal system features, which were increased and created the most desirable traits such as volumetric bone mineral density and cortical bone mineral density. Authors also suggested that the biggest beneficial impact was found in the group that received 105 percent of recommended dietary calcium. Hocking *et al.* (2002) conducted an experiment on turkey involving 16 diet in a factorial manner containing 4 levels of Ca (6,10,14 and 14g/kg) and 4 levels of AP (3,5,7 and 9g/kg). Results suggested that the proportion of ash, calcium, and phosphorus in the bones declines with age, especially between 10 and 13 weeks, although the proportion of bone calcium to phosphorus was unaffected by dietary therapy or age.

Bones trace minerals

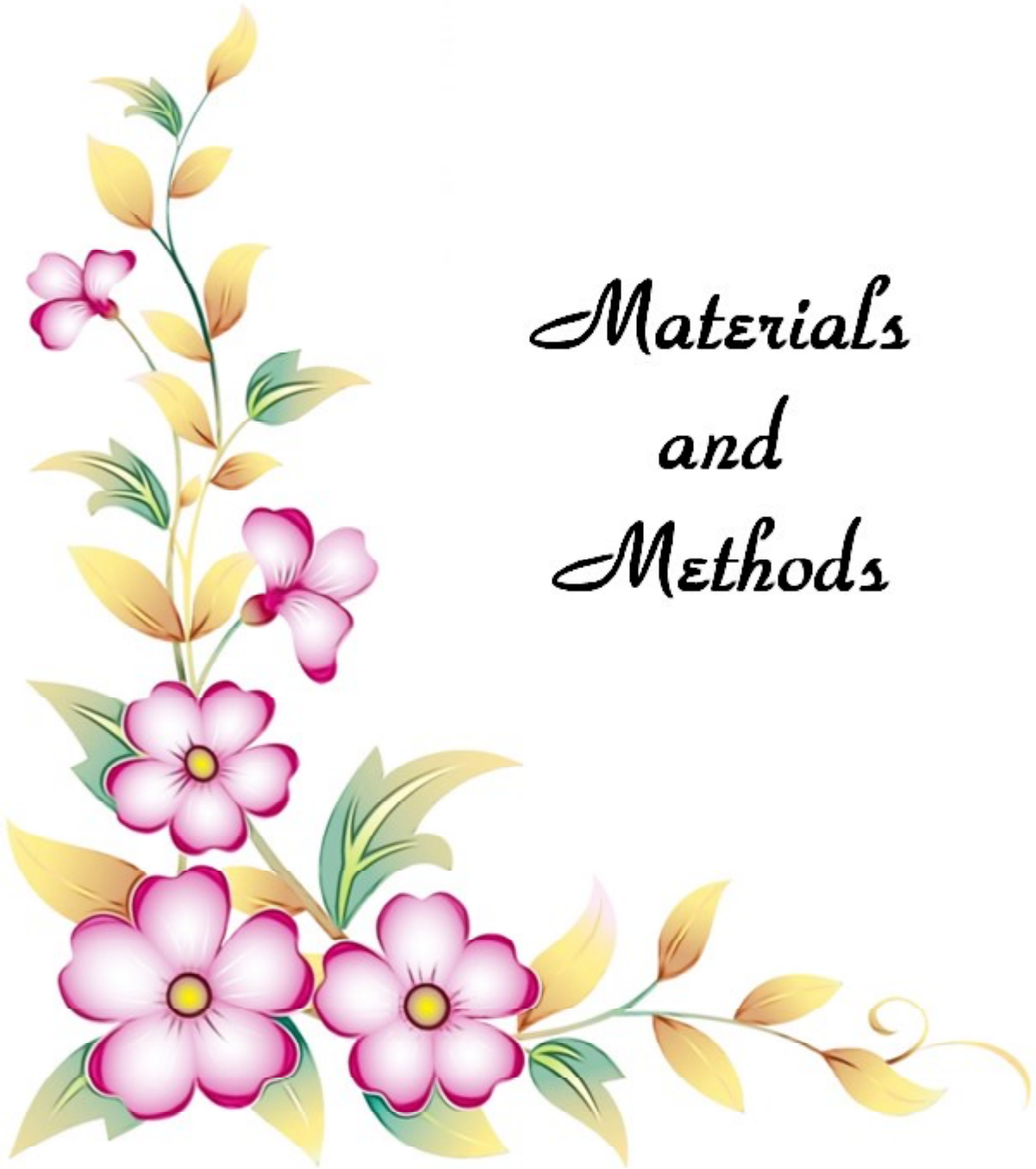
Rao *et al.* (2003) found that decreased concentrations of zinc, manganese and iron in liver with increased calcium and phosphorus in diet suggesting reduced availability of these minerals at disproportionate or higher levels of Ca and available phosphorus in the diet. Tibia Copper and manganese concentration were increased with increasing dietary Ca levels in the diets. Whereas, tibia iron concentration was significantly reduced with increasing dietary concentration of Av.P.

Mineral retention and excretion

The supplementation of com-soybean meal diets deficient in P with vitamin D, increases the retention of phytate P (Roberson, 1994). The addition of 5 ug/kg of vitamin D, or 600 units of phytase /kg of feed replaces approximately 0.1% inorganic P in young broiler chicks (Mitchell and Edwards, 1996b). Lalpanmawia *et al.* (2014) reported that supplementation of commercial phytase @ 500 FTU/kg in low P diets (0.32% during 0-21d and 0.28% during 22-42d), significantly improved Ca and P utilization in broiler chicks as compared to those birds fed diet with low P without phytase supplementation. The phytase supplementation can reduced p

excretion up to 50% which will not only reduced environmental pollution but also save inorganic P (Vohra *et al.*, 2006). Mitchell and Edwards (1996b) suggested that phytase and 1,25-(OH)₂D₃ are equipotent in increasing the utilization of phytate P. They also indicate that there may be a synergistic effect of these supplements when used in combination. Rao *et al.* (2003) reported that increasing the dietary levels of Ca and P, significantly increased Ca and P excretion because the excess quantity of Ca and P consumed beyond the absolute requirement might have been excreted. Increased utilization of minerals by supplementing the metabolites of cholecalciferol in broiler diet was reported by (Biehl and Baker, 1997), which in turn might have resulted in reduced excretion of Ca and P. Sebastian (1996) who suggested that the low P diet reduced the Ca retention at 17-d of age of birds. Similarly, Shafey (1993) who also observed that increasing dietary levels of P reduced Ca availability in the intestinal lumen and this stimulated PTH secretion which increased bone resorption consequently reducing the bone ash.





*Materials
and
Methods*

In order to achieve the objectives detailed earlier, experiment was carried out to study the effect of feeding varying dietary calcium and phosphorus levels on the growth performance and skeletal health of turkey poult in terms of growth, immune response, serum biochemical parameters and skeletal growth. The experimental procedure and analytical techniques employed during the course of study at the division of Avian Nutrition and Feed Technology (AN & FT), Central Avian Research Institute (CARI), Izatnagar, Bareilly- 243122 are briefly discussed as under.

3.1 Experimental design

An eight week biological experiment was conducted in a factorial (3x3) manner. Nine dietary treatments were used in the experiment with three levels of Calcium (1.0/0.8, 1.2/1.0 and 1.4/1.2%) with three levels of available phosphorus (0.5/0.4, 0.6/0.5 and 0.7/0.6%) during 0-4/5-8 weeks of age which were evaluated with quadruplicated group of 8 growing turkey poult, accommodating 32 growing turkey poult per treatments.

3.2 Procurement of dietary ingredients

Sufficient quantities of the required practical feed ingredients and feed supplements for formulation of experimental diets were procured from the feed storage and processing section (FS&PS) of CARI, Izatnagar. The practical feed ingredients included maize, soybean meal (SBM) and guar korma (GK), whereas the supplements included lime stone powder (LSP), dicalcium phosphate (DCP), common salt, DL-methionine, lysine, vitamin premix, trace mineral premix, choline chloride, coccidostat and toxin binder.

Dietary Treatments during 0-4 and 5-8weeks of age

Treatments	0-4 weeks		5-8weeks	
	Calcium %	Av. Phosphorus %	Calcium %	Av.Phosphorus%
T1	1.0	0.5	0.8	0.4
T2	1.0	0.6	0.8	0.5
T3	1.0	0.7	0.8	0.6
T4	1.2	0.5	1.0	0.4
T5	1.2	0.6	1.0	0.5
T6	1.2	0.7	1.0	0.6
T7	1.4	0.5	1.2	0.4
T8	1.4	0.5	1.2	0.5
T9	1.4	0.5	1.2	0.6

3.3 Determination of proximate principles of feed ingredients and diets

The representative samples of practical feed ingredients and test diets used in the study were analyzed for moisture, crude protein (CP), total phosphorus (TP) (AOAC, 1990); calcium (Talpatra *et al.*, 1940).

TP estimation (AOAC, 1990) in feed ingredients and diet was made by spectrophotometer at 400 nm. The P percent in feed ingredients and diet was calculated using formula:

$$\text{TP \% in feed Ingredients/diets} = \frac{\text{O.D. of sample} \times \text{conc. of standard} \times \text{total volume made} \times 100}{\text{O.D of standard} \times \text{aliquot taken} \times \text{wt. of sample} \times 100}$$

3.4 Preparation of experimental diets

Nine experimental diets will be prepared with practical feed ingredients with adequate concentration of crude protein, metabolizable energy, lysine, and methionine with variable concentration of calcium and available phosphorus in the diet of growing turkey for two growth phase 0-4 and 5-8wks of age. The feed ingredients and nutrients composition of different experimental diet for 0-4 and 5-8 weeks of age have been presented in Table 3.1 and 3.2, respectively.

Table 3.1: Ingredients and nutrients composition of growing turkey during 0-4weeks of age

	D1	D2	D3	D4	D5	D6	D7	D8	D9
Maize	47.62	47.47	47.32	47.23	47.03	46.88	46.42	46.23	46.08
Soybean meal	41.05	41.05	41.05	41.04	41.04	41.04	41.00	41.00	41.00
GUAR Korma	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Lime stone powder	1.25	0.80	0.40	1.60	1.20	0.80	2.15	1.74	1.34
Di-calcium phosphate	1.80	2.40	2.95	1.80	2.40	2.95	1.80	2.40	2.95
Common salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
L-Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Trace mineral premix ¹	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin Premix ²	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Toxin binder	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
coccidiostate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
fat/oil	1.35	1.35	1.35	1.40	1.40	1.40	1.70	1.70	1.70
Total	100	100	100	100	100	100	100	100	100
Nutrients composition analysed (%DM)									
Crude protein	27.92	27.91	27.89	27.88	27.86	27.85	27.79	27.77	27.76
Calcium	1.09	1.08	1.07	1.21	1.22	1.21	1.41	1.41	1.40
Total phosphorus	0.60	0.71	0.80	0.61	0.70	0.81	0.61	0.70	0.81
Nutrients composition calculated (%)									
Available phosphorus	0.50	0.61	0.71	0.50	0.61	0.71	0.50	0.61	0.71
Lysine	1.61	1.62	1.62	1.61	1.61	1.61	1.61	1.61	1.61
Methionine	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.53
ME (Kcal/kg)	2887	2882	2877	2878	2871	2866	2874	2868	2863

1. Trace mineral mixture provided (mg/kg)/diet

2. Vitamin mixture provided(mg/kg)/diet:

Table 3.2: Ingredients and nutrients composition of growing turkey during 5-8 weeks of age

Ingredients	T1	T2	T3	T4	T5	T6	T7	T8	T9
Maize	54.563	54.435	54.285	53.735	53.685	53.385	53.135	52.935	52.785
Soybean meal	38.000	38.000	38.000	38.000	38.000	38.000	38.000	38.000	38.000
Guar Korma	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200
Lime stone powder	0.750	0.400	0	1.500	1.000	0.750	1.900	1.550	1.150
Di-calcium phosphate	1.300	1.850	2.400	1.300	1.850	2.400	1.300	1.850	2.400
Common salt	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
DL-Methionine	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
L-Lysine	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Trace mineral Premix.1	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Vitamin Primix.2	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Toxin binder	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
coccidiostate	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
fat/oil	0.250	0.250	0.250	0.400	0.400	0.400	0.600	0.600	0.600
Total	100	100	100	100	100	100	100	100	100
Nutrients composition analysed (%DM)									
Crude protein	26.09	26.07	26.06	26.01	26.00	25.98	25.96	25.94	25.93
Calcium	0.80	0.81	0.80	1.06	1.01	1.06	1.20	1.21	12.20
Total phosphorus	0.51	0.60	0.71	0.50	0.61	0.70	0.50	0.61	0.70
Nutrients composition calculated (%)									
Available phosphorus	0.41	0.50	0.60	0.40	0.50	0.60	0.40	0.50	0.60
Lysine	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Methionine	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
ME (Kcal/kg)	2912	2905	2900	2894	2892	2895	2890	2896	2890

1. Trace mineral mixture provided (mg/kg) diet:

2. Vitamin mixture provided(mg/kg) diet:

3.5 Experimental birds

In order to carry out a 8 weeks experimental study, desired number of day old turkey chicks had been hatched out from the fertile eggs collected from the flock of CARIVIRAT maintained at the experimental turkey farm and set in Experimental Hatchery at the CARI. The entire hatch out turkey chicks were transferred to experimental nutrition shed of AN & FT Division. All the turkey chicks were wing banded and weighed individually on the same day and 288 healthy turkey chicks were distributed at random into 32 groups of 8 turkey chicks each depending upon their uniform body weight and discarding the heavier and lighter body weight of turkey chicks.

3.6 Housing and management

The experimental birds were housed group wise in randomly allotted cabins or tiers of electrically heated battery brooders with the provision of wire-mesh floor, feeder and waterer located in a well-ventilated shed with 24 hours light and uniform management.

3.7 Feeding and watering

Weighed amount of each test diet used during the growth phase (0-4wks) and (5-8wks) were offered daily in quadruplicate lot of 8 turkey chicks each to ensure *ad lib* feeding at all the time, but with care to avoid spillage and wastage of feed. The clean and fresh water was always made available in suitable troughs to all the birds during the study period.

3.8 Response criteria

The data in relation to several parameters as affected by different dietary levels of calcium and phosphorus listed below were collected with reference to growth performance, immune response, serum blood biochemical parameters and bone morphometric and mineralization traits.

3.8.1 Growth performance

3.8.1.1 Body weight (BW) and body weight gain (BWG):

Body weight changes were recorded periodically during the experimental period to ascertain the biweekly and overall body weight gain.

3.8.1.2 Feed intake (FI)

A weighed quantity of respective diet was offered *ad-lib* daily to quadruplicate groups of each dietary regimen in the morning and the residue was weighed at biweekly interval in order to arrive at biweekly and overall feed intake.

3.8.1.3 Feed conversion ratio (FCR):

Based on the data pertaining to the FI and BWG, the bi-weekly and period wise FCR of birds was determined by the method described by Fritz et al. (1969) using following equation;

$$\text{FCR} = \frac{\text{Total feed intake (g)}}{\text{Final body weight - initial body weight (g)}}$$

3.8.1.4 Skeletal health

The experimental birds were monitored daily on individual basis for the occurrence of any skeletal defects and the observation if any, were properly recorded.

3.8.1.5 Mortality/ Livability

Daily monitoring and recording on individually basis had been carried out to study the livability/mortality of the experimental birds used in the present investigation.

3.8.2 Immune response

The immune response of growing turkeys fed different supplemental Ca and P levels were analyzed by humoral immune response (haemagglutination- HA titer to Sheep red blood corpuscles-SRBC) and cell mediated immune (CMI) response (foot web index to Phytohaemagglutinin, lectin from *Phaseolus Vulgaris*- PHAP) on completing 5 wk of age. For this 72 poults (8 poult per treatment) were selected.

3.8.2.1 Humoral immune response to sheep red blood cell (HA titre to SRBC)

A) Preparation of reagents

Alsever's solution and phosphate buffer saline (PBS) were prepared as per the composition given bellow:

i) Alsever's solution

Dextrose	2.05 g
Tri sodium citrate dehydrate	0.80 g
Sodium Chloride (NaCl)	0.42 g
Citric acid	0.055 g
Distilled water	100 ml

The pH of the solution was adjusted to 6.5 by addition of citric acid and stored in refrigerator at 4°C.

ii) Phosphate buffer saline

Sodium chloride (NaCl)	8.0 g
Potassium chloride (KCl)	0.20 g
Potassium dihydrogen phosphate (KH ₂ PO ₄)	0.20 g
Disodium hydrogen phosphate (Na ₂ HPO ₄ ·2H ₂ O)	1.44 g
Distilled water	1000 ml

The pH of the solution was adjusted to 7.2

iii) Preparation of sheep red blood cell suspension

Blood from jugular vein of healthy sheep was collected in Alsever's solution. The blood was centrifuged at 2500 rpm for about 10 minutes. The supernatant was discarded and the red blood cells were washed thrice in PBS. Suspension of SRBC (1% v/v) in PBS was prepared and stored in refrigerator at 4°C until its use.

iv) Immunization and Harvesting of immune serum

At 35nd day post-hatch 1.0 ml suspension of SRBC was injected intravenously to eight-birds/treatment to study the primary antibody response to SRBC. At 41th day (5 days post-immunization), 2 ml blood was collected from the jugular vein. The blood was allowed to clot, the serum was collected, and frozen (-20°C) until analyzed for the antibody titers to SRBC.

v) Haemagglutination test (HA test)

The antibody titer was determined by haemagglutination (HA) test methods (Siegal and Gross, 1980 and Vander Zijpp, 1983). Micro titer plates (U bottom) were used.

Procedure

- Step-1 : 50 μ l of PBS was distributed in each well of the microtitre plate.
- Step-2 : 50 μ l of serum was added in the first well.
- Step-3 : Two fold serial dilutions were made up to 11th well, 12th well being the control.
- Step-4 : 50 μ l of 1% SRBC was added in each well and mixed by gentle tapping
- Step-5 : The plates were covered and then kept at 37°C for 1 hr for incubation.
- Step -6 : The plates were read under bright light.
- Step-7 : The reciprocal of the highest dilution showing clear agglutination was the end titer. The titers were expressed as \log_2 .

3.8.2.2 Cell mediated immune response

The CMI response was assessed by cutaneous basophilic hypersensitivity test *in vivo* by using PHA-P as per Corrier and Deloach, 1990). At 28nd day post-hatch, eight birds from each treatment were selected and the toe thickness of both left and right foot at 3rd and 4th inter digital spaces were measured by micrometer. Immediately after measurements 100 mg of PHA-P suspended in 0.1 ml of phosphate buffer saline (PBS) and 0.1 ml of PBS was injected into right and left foot (acted as control), respectively. The web swelling of both the feet was measured 24 hours after injection by micrometer. The *in vivo* response to PHA-P was expressed as web index. Foot web index (FWI) was calculated as follows.

- CMIR = (R2-R1) - (L2-L1) where,
- R2 = Thickness after 24 h of PHA-P injection
- R1 = Thickness before injection of PHA-P
- L2 = Thickness after 24 h of PBS injection
- L1 = Thickness before injection of PBS

3.8.2.3 Weight of immune organs

The development of immune organs was studied at 56 days of age. The following immune organ weight on individual basis of 72 birds (8birds/treatment) was calculated on the % live weight (pre-slaughter) basis as shown below.

$$1. \quad \text{Spleen \%} = \frac{\text{Weight of spleen (g)}}{\text{Pre slaughter live weight (g)}} \times 100$$

$$2. \quad \text{Bursa \%} = \frac{\text{Weight of bursa (g)}}{\text{Pre slaughter live weight (g)}} \times 100$$

$$3. \quad \text{Thymus \%} = \frac{\text{Weight of thymus (g)}}{\text{Pre slaughter live weight (g)}} \times 100$$

3.8.3 Serum biochemical parameters

At the end of feeding trial, blood samples from 8 birds/ treatment (2 birds/ replicate) were randomly collected into sterile glass test tube without addition of anticoagulant. Test tubes containing the blood were kept in slanted position at room temperature for half an hour to facilitate separation of serum. Serum was separated by centrifugation at 3000rpm for 10 minutes and serum was decanted into plastic vials and then stored at -20^oc for estimation of serum alkaline phosphatase (ALP), total protein, albumin, globulin, glucose, Calcium and Phosphorus.

3.8.3.1 Serum ALP

The procedure of Kind and King (1954) was adopted for the estimation of ALP in serum. Span diagnostic kit was used for the estimation of serum ALP. The following protocol was used:

	Blank	Standard	Control	Test
Working Buffered substrate	500 µl	500 µl	500 µl	500 µl
Purified water	1500 µl	1500 µl	1500 µl	1500 µl
Mix well and incubate at 37°C for 3 minutes				
Serum	-	-	-	50 µl
Phenol standard	-	50 µl	-	-
Mix well and incubate at 37°C for 15 minutes				
Chromogen Reagent	1000 µl	1000 µl	1000 µl	1000 µl
Serum	-	-	50 µl	-

The contents were mixed well and O.D of standard (S), control (C) and test (T) were measured against blank (B) on a spectrophotometer at 510 nm. The serum ALP concentration was calculated by using the following formula:

$$\text{Serum ALP (KA units)} = \frac{\text{O.D Test} - \text{O.D Control}}{\text{O.D Standard} - \text{O.D Blank}} \times 10$$

3.8.3.2 Serum Total protein

The total protein was estimated by modified biuret and BCS dye binding method (Vatzidis, 1977). Test tubes were labelled as blank (B), standard (S), test (T). The further steps as follows:

	Blank	Standard	Test
Biuret reagent	1 ml	1ml	1 ml
Protein standard	-	10 µl	-
Serum	-	-	10 µl

The contents were mixed well and immediately placed at 37°C in a water bath for 5 minutes. The absorbance of test (T) and standard (S) were measured against blank (B) on a spectrophotometer at 578nm. The total protein concentration was calculated by using the following formula:

$$\text{Total protein (g/dl)} = \text{Absorbance of test (T)/Absorbance of standard (S)} \times 6.5$$

3.8.3.3 Serum Albumin

The serum albumin was estimated by modified Bromocresol Green method (Guastaffson, 1978). Test tubes were labelled as blank (B), standard (S), test (T) and further steps were as follows:

	Blank	Standard	Test
Albumin reagent	1 ml	1ml	1 ml
Albumin standard	-	10 µl	-
Serum	-	-	10 µl

The contents were mixed well and incubated at room temperature (15-30°C) for 1 minute. The absorbance of test (T) and standard (S) were measured against blank (B) on a spectrophotometer at 630nm. The total albumin and globulin concentrations were calculated by using the following formula:

$$\text{Total albumin (g/dl)} = \text{Absorbance of test (T)} / \text{Absorbance of standard (S)} \times 4$$

$$\text{Globulin (g/dl)} = \text{Total protein} - \text{Total albumin}$$

3.8.3.4 Serum Glucose

The procedure of Tietz (1976) was adopted for the estimation of glucose in serum samples. Span diagnostic kit was used for the estimation of serum glucose. The following protocol was used:

	Blank	Standard	Test
Serum	-	-	10 µl
Glucose standard	-	10 µl	-
Working glucose reagent	1000 µl	1000 µl	1000 µl
Mix well and incubate at 37°C for 10 minutes			
Purified water	1500 µl	1500 µl	1500 µl

The absorbance of test (T) and standard(S), against blank (B) was measured on spectrophotometer with a green filter at 505nm. The serum glucose concentration was calculated by using following formula:

$$\text{Glucose in (mg/dl)} = \text{Absorbance of test (T)} / \text{Absorbance of standard (S)} \times 100$$

3.8.3.5 Calcium

The O-cresolphthalein Complexone method described by Baginski(1973) was followed for estimation of serum calcium (Ca). Accordingly, the Ca in alkaline medium reacts with O-Cresolphthalein complexone to form purple coloured complex whose absorbance is proportional to the Ca concentration. The interference due to magnesium and iron is estimated by using the 8 hydroxy-quinoline. Span diagnostic kit was used for the estimation of calcium. The following protocol was used:

	Blank	Standard	Test
Serum	-	-	20 µl
Calcium standard	-	20 µl	-
Working calcium reagent	1000 µl	1000 µl	1000 µl

The contents were mixed thoroughly and incubate at room temperature (15- 30°C) for 5 minutes. The absorbance of test (T) and standard(S), against blank (B) was measured on spectrophotometer at 578nm. The serum Calcium concentration was calculated by using following formula:

$$\text{Serum Ca (mg/dl)} = \text{Absorbance of test (T)} / \text{Absorbance of standard(S)} \times 10$$

3.8.3.6 Serum Phosphorus

Modified metol method described by Morin and Prox (1973) was used to estimate the serum phosphorus content. The P reacts with the ammonium molybdate under acidic conditions to form the phosphomolybdate complex which is reduced to blue coloured complex by metol. The absorbance of colour developed by is proportional to the inorganic P concentration .The span diagnostics kit was used for the estimation of serum phosphorus. The following protocol was used:

	Blank	Standard	Test
Serum	-	-	10 µl
Phosphorus standard	-	10 µl	-
Molybdate reagent	1000 µl	1000 µl	1000 µl

The content was mixed thoroughly and incubated at 37°C for 5 minutes. The absorbance of test (T) and standard (S), against blank (B) was measured on spectrophotometer at 340nm. The serum phosphorus concentration was calculated by using following formula:

$$\text{Serum inorganic phosphorus (mg/dl)} = \text{Absorbance of test} / \text{Absorbance of standard} \times 5$$

3.8.4 Bone morphometry

At the end of 56 day of experimental period, 72 birds (8 birds /treatment) were sacrificed for evaluation of osteomorphometry. During the slaughter, the left tibia bone of each selected bird was collected. The bone were identified individually for each separate treatment and their adhere muscles together with connective tissues had been thoroughly removed manually by the help of scissors. The bones were dipped in boiling water for 5 minutes to remove remaining pin and soft tissues. For the measurement of bone length and width the method described by Collins and Moran (1999) was followed. Maximum width of the mid shaft and each epiphysis (proximal and distal width), as well as the total length of the tibia bone was measured with vernier calipers.

3.8.5 Bone mineralization

In order to study the bone mineralization, the left tibia bone collected from 72 birds (8 birds/ treatment) used for observation of morphometry were subjected to study of bone mineralization. Each tibia bone was defatted by dipping them for 16 hrs in petroleum spirit (boiling point 60-80 °C) using the Soxhlet apparatus and dried before ashing. The following attributes were measured.

3.8.5.1 Bone weight (Fresh and Dried)

The weight of each tibia bone was recorded before and after drying in hot air oven for overnight and the bone moisture percentage was estimated as per (AOAC, 1990). The dried and defatted bones were used to study bone ash, calcium, phosphorus and trace minerals (Zn, Mn, Cu and Fe).

3.8.5.2 Bone ash

The dried and defatted tibia bone was ash (dry ashing) in muffle furnace at 550°C for 3 hrs and the bone ash percentage was estimated (AOAC, 1990).

3.8.5.3 Bone Calcium

The Calcium content was estimated in each tibia bone sample as per following the method described by Talpatra *et al.* (1940).

3.8.5.4 Bone phosphorus

The bone phosphorus content in each tibia bone sample was determined as per the method AOAC (1990) described earlier in this chapter.

3.8.5.5 Trace minerals (Zn, Mn, Cu and Fe)

The trace minerals (Zn, Mn, Cu and Fe) content in each tibia bone sample was determined as per the method described by AOAC (1990) using AAS (*Varian Spectra AA 220 Model*).

3.8.6 Mineral Retention

A 3-d balance study was conducted from 54-56 days of age during which the net feed consumed by each bird in the respective dietary group was recorded and the dropping voided over the same period were collected quantitatively.

After completing 53-d of age, all the birds were starved for a period of two hrs (ie from 8 to 10 AM), during which the preliminary preparations such as cleaning of feed and faecal trays, provision of fresh drinking water and weighing of required quantity of feed into respective feeders were carried out. Exactly at 10 AM the respective feeder and faecal trays

were introduced into cages housing and weighed quantity of feed was offered to all the birds. The dropping of respective dietary group of all the birds was collected separately once daily and transferred into pre-weighed aluminium dishes, weighed again and placed into the forced draft hot air oven at $60\pm 5^{\circ}\text{C}$ during all the 3-d of collection.

On the last day, the feeders were removed at 10 AM to determine the net feed intake and faecal trays were removed to collect the faeces in aluminium dishes. The droppings collected were dried for 4-5 d in oven at $60\pm 5^{\circ}\text{C}$ till a constant weight was attained which represented the net dried faecal output.

The dried and pooled feed and excreta samples were ground and stored in air tight containers for further analysis for Ca (Talpatra et al., 1940) and P (AOAC, 1990). The excreta moisture, the intake, excreted and retained amount of Ca and P were calculated (g/b/d) basis and % retention of Ca and P were calculated on the basis of total intake.

3.7 Statistical analysis

The data pertaining to various parameters were analyzed statistically by the methods of Snedecor and Cochran (1989). The significant mean differences were tested as per Duncan's multiple range test (DMRT) described by Duncan (1955).





Results

An investigation was undertaken at the Division of Avian Nutrition and Feed Technology, CARI, Izatnagar in order to study the effect of feeding varying dietary levels of calcium and phosphorus on growth performance and skeletal health of CARIVIRAT growing turkey poult. The data obtained on growth performance, immune response, blood biochemical parameters and skeletal status were analyzed statistically, for treatment effects and their results have been presented in this chapter.

4.1 Growth performance :

The data pertaining to growth performance and allied traits as influenced by different levels of calcium and available phosphorus in growing turkey poult are elucidated here under.

4.1.1 Body weight and body weight gain (BW and BWG)

Data pertaining to bi-weekly BW (0 day-8 wks) of age in different dietary groups have been presented in Table 4.1 and its analysis of variance (ANOVA) in Table 4.2. The mean bi-weekly BW (g/b) differed significantly due to interaction between Ca and Av.P levels at second ($P<0.05$), fourth ($P<0.01$), sixth ($P<0.01$) and eight ($P<0.01$) weeks of age. At second week of age significantly ($P<0.05$), higher BW were observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in a dietary combinations of 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.2-1.0% Ca with 0.5-0.4% Av.P and 1.4-1.2 % Ca with 0.5-0.4% Av.P. However, in other dietary combinations, the body weight recorded at second weeks age was found intermediary. At fourth of age significantly ($P<0.01$), higher BW were observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.2-1.0

% Ca with 0.7-0.6% Av.P than those recorded in other dietary combinations. At six and eight weeks of age significantly ($P<0.01$) higher BW were observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. The mean BW at fourth, sixth and eighth weeks of age differed significantly due to different dietary levels of Ca in the diet. At fourth, sixth and eighth weeks of age, significantly ($P<0.01$) higher BW was recorded at 1.0-0.8% Ca than those recorded in other levels of Ca in the diet. The mean BW at fourth week of age was found significantly ($P<0.01$) higher at 0.5-0.4% Av.P than that recorded at 0.6-0.5 % Av.P. However, body weight recorded at 0.7-0.6 % Av.P was found intermediary.

Table 4.1: Biweekly body weight (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Biweekly Body Weight (g/b)				
		0 day	2 nd wk	4 th wk	6 th wk	8 th wk
Interaction effect (Ca x AP)						
1.0-0.8	0.5-0.4	49.73	124.12 ^c	267.43 ^d	546.47 ^d	909.62 ^d
	0.6-0.5	48.12	113.01 ^{ab}	233.39 ^{abc}	461.75 ^{bc}	789.08 ^{bc}
	0.7-0.6	49.17	120.25 ^{bc}	237.86 ^{bc}	462.03 ^{bc}	818.31 ^c
1.2-1.0	0.5-0.4	48.34	109.66 ^a	217.00 ^a	396.41 ^a	681.97 ^a
	0.6-0.5	50.30	117.53 ^{abc}	231.78 ^{abc}	419.41 ^{ab}	713.02 ^{ab}
	0.7-0.6	48.50	118.09 ^{abc}	249.78 ^{cd}	470.75 ^c	777.41 ^{bc}
1.4-1.2	0.5-0.4	50.44	115.67 ^{abc}	239.23 ^{bc}	458.44 ^{bc}	780.48 ^{bc}
	0.6-0.5	48.37	112.19 ^{ab}	222.67 ^{ab}	451.73 ^{bc}	790.03 ^{bc}
	0.7-0.6	48.97	116.25 ^{abc}	229.05 ^{ab}	435.87 ^{abc}	781.11 ^{bc}
Pooled SEM		0.26	0.94	2.308	5.72	9.58
Main effect						
Calcium levels	1.0-0.8	49.01	119.129	246.23 ⁿ	490.08 ⁿ	839.00 ^o
	1.2-1.0	49.05	115.094	232.85 ^m	428.85 ^m	724.13 ^m
	1.4-1.2	49.26	114.703	230.32 ^m	448.68 ^m	783.87 ⁿ
AP levels	0.5-0.4	49.50	116.48	241.22 ^q	467.10	790.69
	0.6-0.5	48.93	114.24	229.28 ^p	444.29	764.04
	0.7-0.6	48.88	118.20	238.89 ^q	456.22	792.28
Probabilities						
	Interaction	NS	P<0.05	P<0.01	P<0.01	P<0.01
	Calcium	NS	NS	P<0.01	P<0.01	P<0.01
	AP	NS	NS	P<0.05	NS	NS

abc(Interaction), mno (Ca), pqr (AP), Value bearing different superscripts within a column differ significantly ($P<0.05$), ($P<0.01$), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

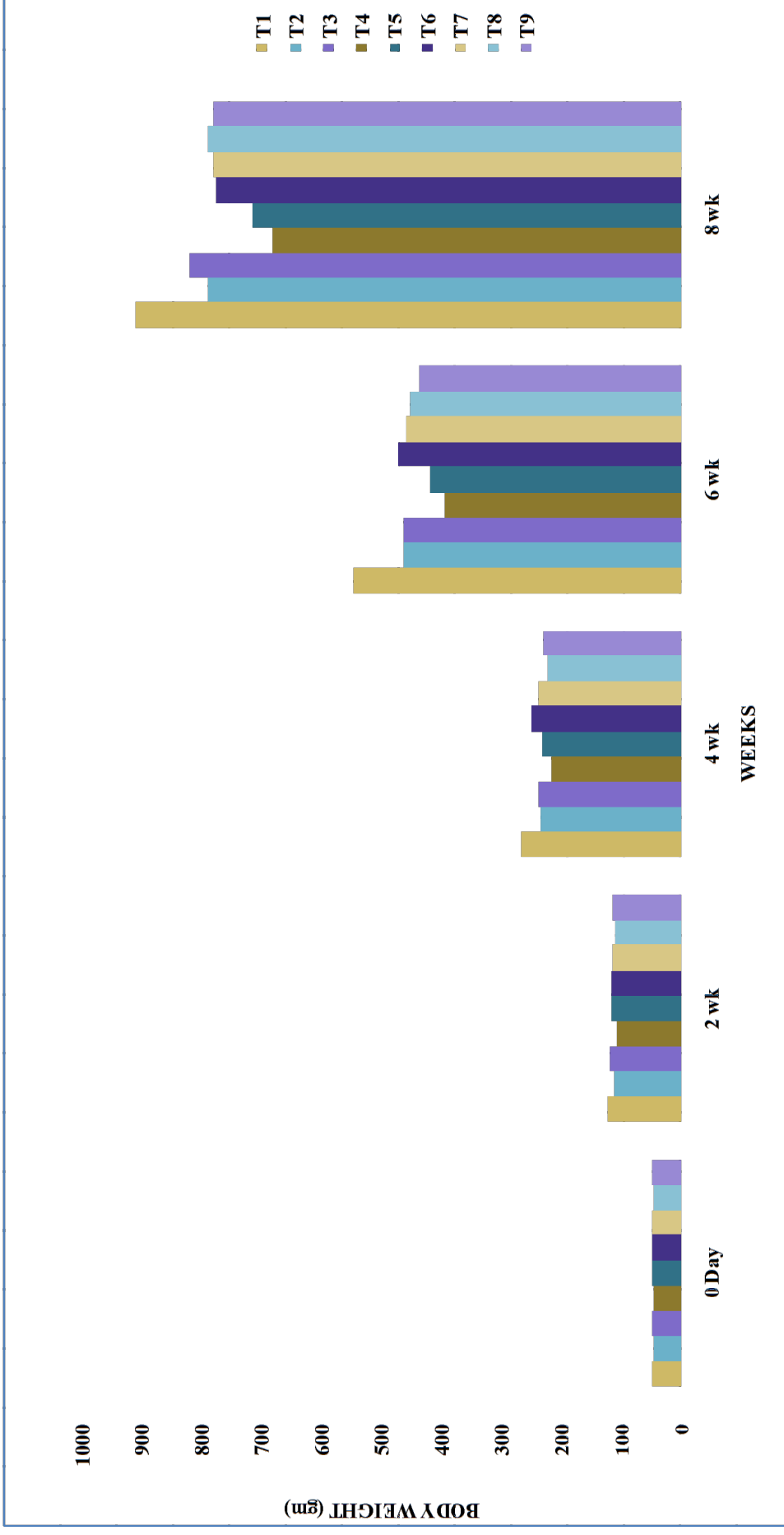


Fig. 1: Biweekly body weight (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Table 4.2: Analysis of variance for biweekly body weight of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares				
		0 day	2 nd wk	4 th wk	6 th wk	8 th wk
Calcium levels	2	1.76 ^{NS}	576.43 ^{NS}	7015.98 ^{**}	93702.98 ^{**}	316880.73 ^{**}
AP levels	2	11.50 ^{NS}	377.47 ^{NS}	3847.82 [*]	12498.52 ^{NS}	24159.44 ^{NS}
Ca X AP	4	41.76 ^{NS}	752.63 [*]	8982.40 ^{**}	57229.25 ^{**}	89556.76 ^{**}
Error	279	20.00	246.62	1371.54	8124.74	23461.60

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

Data pertaining to bi-weekly body weight gain (BWG) from 0-8wks of age in different dietary groups have been presented in Table 4.3 and Fig. 1 its analysis of variance (ANOVA) in Table 4.4. The mean bi-weekly BWG (g/b) differed significantly due to interaction between Ca and Av.P levels at second (P<0.05), fourth (P<0.01) and sixth (P<0.01) and weeks of age. At second week of age significantly (P<0.05), higher BWG were observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in a dietary combinations of 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.2-1.0% Ca with 0.5-0.4% Av.P, 1.4-1.2 % Ca with 0.5-0.4 % Av.P and 1.4-1.2 % Ca with 0.6-0.4% Av.P. However, in other dietary combinations, the body weight gain recorded at second weeks of age was found intermediary. At fourth week of age, significantly (P<0.01) higher BWG was observed in dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.2-1.0% Ca with 0.7-0.6% Av.P than those recorded in other dietary combinations. At sixth week of age, significantly (P<0.01) higher BWG was observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. The BWG did not differed significantly due to interaction of Ca and Av.P in the diet. The mean BWG at second (P<0.01), fourth (P<0.01), sixth (P<0.01) and eighth (P<0.01) weeks of age differed significantly due to different dietary levels of Ca in the diet. Significantly higher BWG was recorded at 1.0-0.8 % Ca than those recorded in other levels of Ca in the diet during second, fourth and sixth weeks of age. At eighth week of age, significantly (P<0.01) higher BWG was recorded at 1.0-0.8 and 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca. At fourth week of age significantly (P<0.01) higher BWG was observed at 0.5-0.4% Av.P than those recorded in other levels of Av.P in the diet. Non-significant differences was recorded on BWG due to different Av.P levels in the diet during second, sixth and eighth weeks of age.

Table 4.3: Biweekly body weight gain (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Biweekly Body Weight (g/b)			
		2 nd wk	4 th wk	6 th wk	8 th wk
Interaction effect (Ca x AP)					
1.0-0.8	0.5-0.4	74.39 ^c	143.31 ^d	279.03 ^d	363.15
	0.6-0.5	64.89 ^{ab}	120.38 ^{abc}	228.36 ^c	327.32
	0.7-0.6	71.08 ^{bc}	117.61 ^{abc}	224.17 ^c	356.28
1.2-1.0	0.5-0.4	61.31 ^a	107.34 ^a	179.41 ^a	285.56
	0.6-0.5	67.23 ^{abc}	114.25 ^{ab}	187.62 ^{ab}	293.61
	0.7-0.6	69.59 ^{bc}	131.69 ^{cd}	220.96 ^c	306.66
1.4-1.2	0.5-0.4	65.23 ^{ab}	123.56 ^{bc}	219.20 ^{bc}	322.05
	0.6-0.5	63.81 ^{ab}	110.58 ^{ab}	229.05 ^c	338.31
	0.7-0.6	67.28 ^{abc}	112.80 ^{ab}	206.82 ^{abc}	345.23
Pooled SEM		0.85	1.671	3.88	4.892
Main effect					
Calcium levels	1.0-0.8	70.12 ⁿ	127.10 ⁿ	243.85 ^o	348.92 ⁿ
	1.2-1.0	66.04 ^m	117.76 ^m	196.00 ^m	295.28 ^m
	1.4-1.2	65.44 ^m	115.61 ^m	218.35 ⁿ	335.20 ⁿ
AP levels	0.5-0.4	66.98	124.74 ^r	225.88	323.59
	0.6-0.5	65.31	115.04 ^p	215.01	319.75
	0.7-0.6	69.32	120.70 ^q	217.32	336.06
Probabilities					
	Interaction	P<0.05	P<0.01	P<0.01	NS
	Calcium	P<0.05	P<0.01	P<0.01	P<0.01
	AP	NS	P<0.05	NS	NS

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.4 : Analysis of variance for biweekly body weight gain of growing turkeys fed diet variable levels of calcium available phosphorus

Source of variation	df	Mean Sum of Squares			
		2 nd wk	4 th wk	6 th wk	8 th wk
Calcium levels	2	621.32*	3579.95**	55039.16**	74559.66**
AP levels	2	388.77 ^{NS}	2280.09*	3147.64 ^{NS}	6978.11 ^{NS}
Ca X AP	4	518.04*	5342.53**	23080.14**	6375.65 ^{NS}
Error	279	200.05	708.25	3716.70	6415.26

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

Data on cumulative body weight gain (BWG) from (0-4wks), (5-8wks) and (0-8wks) of age in different dietary groups have been presented in Table 4.5 and Fig. 2 its analysis of variance (ANOVA) in Table 4.6. The mean BWG (g/b) during (0-4), (5-8) and (0-8) weeks of age differed significantly due to interaction between Ca and Av.P levels in the diets. Significantly ($P<0.01$) higher BWG was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.2-1.0 % Ca with 0.7-0.6%Av.P than those observed in other dietary combinations during 0-4wks of age. During 5-8wks of age, significantly ($P<0.05$) higher body weight gain was recorded in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.0-0.8% Ca with 0.7-0.6% Av.P than those observed in other dietary combinations. During 0-8wks of age, significantly ($P<0.01$) higher body weight gain was recorded in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P

Table 4.5 : Overall gain in body weight (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Biweekly Body Weight (g/b)		
		0-4 wks	5-8 wks	0-8wks
Interaction effect (Ca xAP)				
1.0-0.8	0.5-0.4	217.71 ^d	642.19 ^d	859.89 ^d
	0.6-0.5	185.27 ^{abc}	555.69 ^c	740.59 ^{bc}
	0.7-0.6	188.69 ^{bc}	580.45 ^{cd}	769.14 ^c
1.2-1.0	0.5-0.4	168.66 ^a	464.97 ^a	633.62 ^a
	0.6-0.5	181.48 ^{ab}	481.23 ^{ab}	662.72 ^{ab}
	0.7-0.6	201.28 ^{cd}	527.62 ^{abc}	728.91 ^{bc}
1.4-1.2	0.5-0.4	188.80 ^{bc}	541.25 ^{bc}	730.05 ^{bc}
	0.6-0.5	174.30 ^{ab}	567.36 ^c	741.66 ^{bc}
	0.7-0.6	180.08 ^{ab}	552.06 ^c	732.14 ^{bc}
Pooled SEM		2.21	7.96	9.52
Main effect				
Calcium levels	1.0-0.8	197.22 ⁿ	592.78 ^o	789.99 ^o
	1.2-1.0	183.80 ^m	491.28 ^m	675.08 ^m
	1.4-1,2	181.05 ^m	553.56 ⁿ	734.61 ⁿ
AP levels	0.5-0.4	191.72	549.47	741.19
	0.6-0.5	180.35	534.76	715.11
	0.7-0.6	190.02	553.38	743.40
Probabilities				
	Interaction	$P<0.01$	$P<0.05$	$P<0.01$
	Calcium	$P<0.01$	$P<0.01$	$P<0.01$
	AP	NS	NS	NS

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly ($P<0.05$), ($P<0.01$), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.6: Analysis of variance for cumulative weight gain of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares		
		0-4 wk	5-8 wk	0-8 wk
Calcium levels	2	7179.14**	251509.03**	317056.10**
AP levels	2	3610.40 ^{NS}	9253.30 ^{NS}	23762.06 ^{NS}
Ca X AP	4	8453.00**	46791.46*	88687.65**
Error	279	1252.36	16242.28	23138.10

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

than those observed in other dietary combinations. Significant differences were observed in mean cumulative BWG due to different levels of Ca in the diets. Significantly (P<0.01) higher BWG was observed at 1.0-0.8% Ca than those recorded in other levels of Ca in the diets during 0-4, 5-8 and 0-8wks of age. No-significant differences were noticed on BWG due to different levels of Av.P in the diets.

4.1.2 Feed intake (FI)

Data on bi-weekly FI (first to eighth wks) of age of growing turkey poults in different dietary groups have been set out in Table 4.7 and its analysis of variance (ANOVA) in table 4.8. The mean bi-weekly FI (g/b) during 0-2 wks (P<0.05), 3-4 wks (P<0.01) and 5-6 wks (P<0.01) of age differed significantly due to interaction between Ca and Av.P levels in the diets. However, during 7-8 wks of age FI did not differ significantly due to interaction between Ca and Av.P levels in the diets. During 0-2 wks of age significantly lower FI was recorded in a dietary combination of 1.2-1.0% Ca with 0.5-0.4% Av.P than those recorded in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P, 1.2-1.0% Ca with 0.6-0.5% Av.P, 1.4-1.2% Ca with 0.5-0.4% Av.P and 1.4-1.2% Ca with 0.7-0.6 % Av.P. However FI observed in other dietary combinations were found intermediary. During 3-4wks of age, significantly lower FI was recorded in dietary combinations of 1.0-0.8% Ca with 0.6-0.5 and 0.7-0.6% Av.P than those recorded in other dietary combinations. During 5-6 wks of age, significantly higher FI was observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. FI was differed significantly due to different levels of Ca in the diets during 3-4 and 5-6 wks of age. Significantly (P<0.01) lower

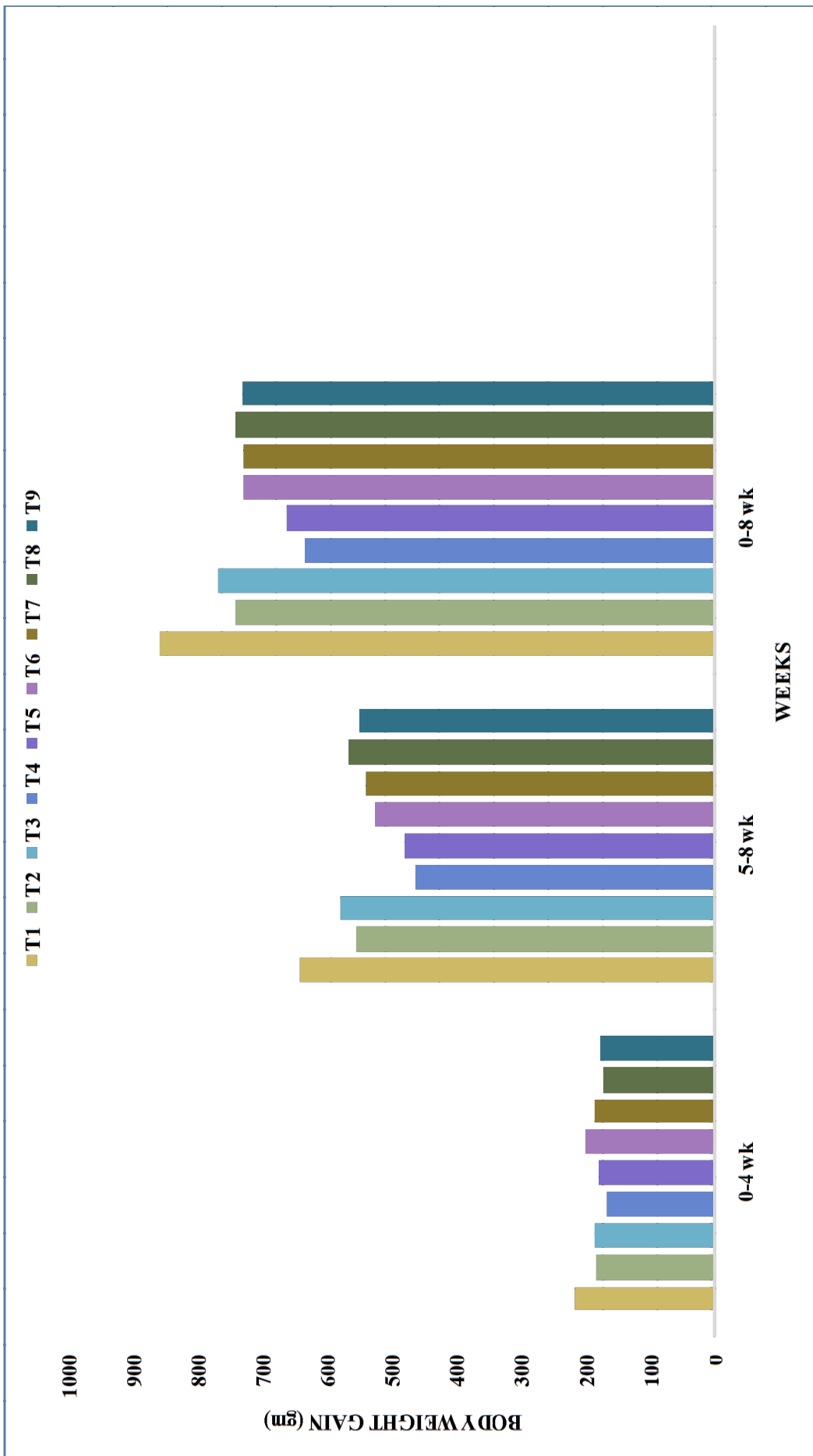


Fig. 2: Overall gain in body weight (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

FI was recorded at 1.0-0.8% Ca than those recorded in other levels of Ca in the diets during 3-4wks of age. Significantly ($P<0.01$) lower feed intake was recorded at 1.2-1.0% and 1.4-1.2% Ca than that recorded at 1.0-0.8% Ca in the diet during 5-6wks of age. Significantly ($P<0.05$) higher FI was recorded at 0.5-0.4% Av.P than those recorded at other Av.P levels in the diets during 3-4wks of age. During 5-6 wks of age, significantly ($P<0.05$) higher FI was recorded at 0.5-0.4% Av.P than that recorded at 0.7-0.6% Av.P. However, FI recorded at 0.6-0.5% Av.P was found intermediary.

Table 4.7: Biweekly feed intake (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Biweekly Body Weight (g/b)			
		0-2 wk	3-4 wk	5-6 wk	7-8 wk
Interaction effect (Ca x AP)					
1.0-0.8	0.5-0.4	136.000 ^b	307.857 ^{bc}	566.765 ^c	992.200
	0.6-0.5	127.717 ^{ab}	256.720 ^a	489.897 ^d	913.472
	0.7-0.6	131.407 ^{ab}	259.925 ^a	469.910 ^{bcd}	898.807
1.2-1.0	0.5-0.4	123.062 ^a	291.812 ^b	409.720 ^{abc}	882.470
	0.6-0.5	136.547 ^b	311.245 ^e	405.562 ^{ab}	895.005
	0.7-0.6	131.782 ^{ab}	296.867 ^{bc}	464.212 ^{bcd}	933.725
1.4-1.2	0.5-0.4	134.765 ^b	294.140 ^b	477.972 ^{cd}	946.207
	0.6-0.5	128.440 ^{ab}	298.620 ^{bc}	450.187 ^{bcd}	908.175
	0.7-0.6	134.970 ^b	302.785 ^{bc}	374.310 ^a	941.695
Pooled SEM		1.216	3.467	11.049	10.165
Main Effect					
Calcium levels	1.0-0.8	131.708	274.834 ^m	508.857 ⁿ	934.827
	1.2-1.0	130.464	299.975 ⁿ	426.498 ^m	903.733
	1.4-1.2	132.725	298,515 ⁿ	434.157 ^m	932.026
AP levels	0.5-0.4	131.276	297.937	484.819 ^q	940.292
	0.6-0.5	130.902	288.862	448.549 ^{pq}	905.550
	0.7-0.6	132.720	286.526	436.144 ^p	924.742
Probabilities					
	Interaction	$P<0.05$	$P<0.01$	$P<0.01$	NS
	Calcium	NS	$P<0.01$	$P<0.01$	NS
	AP	NS	$P<0.05$	$P<0.05$	NS

abc(Interaction),mno (Ca),pqr (AP),Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age
Value bearing different superscripts within a column differ significantly ($P<0.05$), ($P<0.01$), NS-Non-significant

Table 4.8: Analysis of variance for biweekly feed intake (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares			
		0-2 wk	3-4 wk	5-6 wk	7-8 wk
Calcium levels	2	15.386 ^{NS}	2389.950 ^{**}	24843.794 ^{**}	3550.211 ^{NS}
AP levels	2	11.064 ^{NS}	436.038 [*]	7677.30 [*]	3634.212 ^{NS}
Ca X AP	4	149.996 [*]	1663.608 ^{**}	9291.634 ^{**}	5519.262 ^{NS}
Error	27	44.867	105.260	1911.189	3472.611

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

Data on cumulative feed intake (FI) during (0-4wks), (5-8wks) and (0-8wks) of age in different dietary groups have been presented in Table 4.9 and Fig. 3 its analysis of variance

Table 4.9: Cumulative feed intake (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Biweekly Body Weight (g/b)		
		0-4 wks	5-8 wks	0-8wks
Interaction effect (Ca x AP)				
1.0-0.8	0.5-0.4	443.855 ^c	1558.962 ^b	2002.822 ^b
	0.6-0.5	384.437 ^a	1403.370 ^a	1787.802 ^a
	0.7-0.60.5-0.4	391.327 ^a	1368.717 ^a	1760.047 ^a
1.2-1.0	0.6-0.5	414.877 ^b	1292.190 ^a	1707.065 ^a
	0.7-0.6	447.792 ^c	1300.567 ^a	1748.355 ^a
1.4-1.2	0.5-0.4	428.650 ^{bc}	1397.937 ^a	1826.585 ^a
	0.6-0.5	428.907 ^{bc}	1424.172 ^a	1853.080 ^a
	0.7-0.6	427.055 ^{bc}	1358.362 ^a	1785.417 ^a
Pooled SEM		4.101	18.473	19.596
Main effect				
Calcium levels				
	1.0-0.8	406.540 ^m	1443.683 ⁿ	1850.224 ⁿ
	1.2-1.0	430.440 ⁿ	1330.231 ^m	1760.668 ^m
	1.4-1.2	431.283 ⁿ	1366.179 ^m	1797.417 ^{mn}
AP levels				
	0.5-0.4	429.213	1425.108	1854.322
	0.6-0.5	419.761	1354.100	1773.858
	0.7-0.6	419.243	1360.886	1780.129
Probabilities				
	Interaction	P<0.01	P<0.05	P<0.05
	Calcium	P<0.01	P<0.05	P<0.05
	AP	NS	NS	NS

abc(Interaction),mno (Ca),pqr (AP),Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age
Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

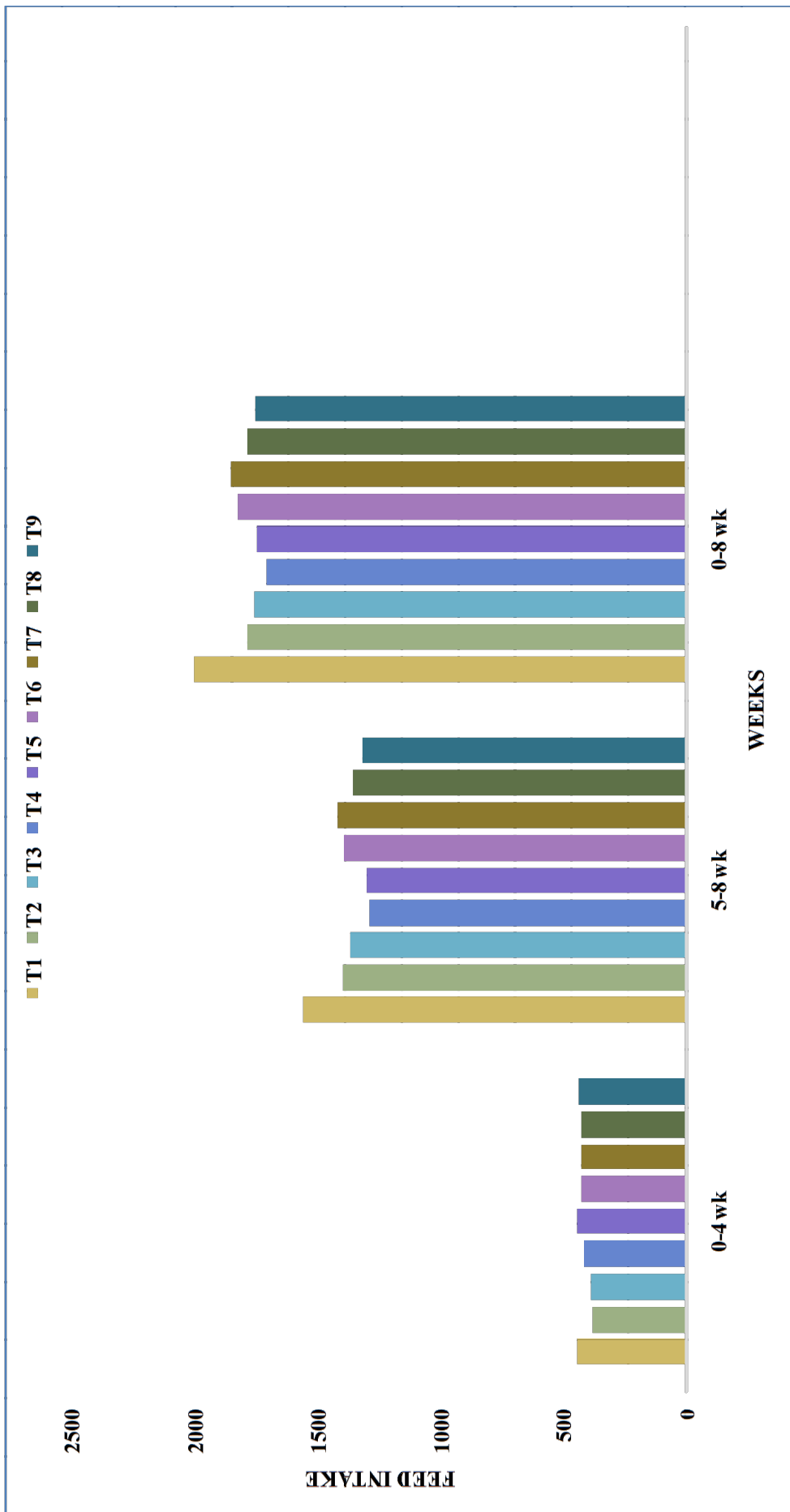


Fig. 3: Cumulative feed intake (g/b) of growing turkeys fed diet variable levels of calcium and available phosphorus

Table 4.10: Analysis of variance for cumulative feed intake fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares		
		0-4 wk	5-8 wk	0-8 wk
Calcium levels	2	2363.710**	40340.799*	24318.585*
AP levels	2	378.007 ^{NS}	18425.521 ^{NS}	24036.912 ^{NS}
Ca X AP	4	2535.219**	24174.803*	35814.761*
Error	27	206.111	7991.318	9032.986

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

(ANOVA) in Table 4.10. The mean cumulative FI (g/b) during (0-4), (5-8) and (0-8) weeks of age differed significantly due to interaction between Ca and Av.P levels in the diets. Significantly (P<0.01) higher FI was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.2-1.0 % Ca with 0.6-0.5% Av.P than those observed in other dietary combinations during 0-4 wks of age. During 5-8 and 0-8wks of age, significantly (P<0.05) higher FI was recorded in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those observed in other dietary combinations. Significant differences were observed in mean cumulative FI due to different levels of Ca in the diets during 0-4, 5-8 and 0-8 wks of age. Significantly (P<0.01) higher FI was observed at 1.2-1.0% and 1.4-1.2% Ca than that recorded at 1.0-0.8% Ca in the diet during 0-4 wks of age. During 5-8 wks of age, the cumulative FI was significantly (P<0.05) higher at 1.0-0.8 % Ca than those recorded at other levels of Ca in the diets. Significantly (P<0.05) higher FI was recorded at 1.0-0.8% Ca than 1.2-1.0% Ca in the diet during 0-8wks of age. However cumulative FI observed at 1.4-1.2% Ca during 0-8 wks of age found intermediary. No-significant differences were noticed on cumulative FI due to different levels of Av.P in the diets during 0-4, 5-8 and 0-8wks of age.

4.1.3 Feed conversion ratio (FCR)

Data on bi-weekly FCR of growing turkey poults as influenced by feeding different dietary levels of Ca and Av.P from first week to eighth week of age have been mentioned in Table 4.11 and its analysis of variance (ANOVA) in Table 4.12. The results revealed that there was a significant difference was observed on mean bi-weekly FCR during 3-4wks of age due to interaction between Ca and Av.P levels in the diets. Significantly (P<0.05) lower and better

Table 4.11: Biweekly feed conversion ratio (g feed/ g gain) of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Biweekly Body Weight (g/b)			
		0-2 wk	3-4 wk	5-6 wk	7-8 wk
Interaction effect (Ca x AP)					
1.0-0.8	0.5-0.4	1.832	2.152 ^a	2.030	2.735
	0.6-0.5	1.981	2.136 ^a	2.151	2.829
	0.7-0.6	1.852	2.217 ^a	2.110	2.519
1.2-1.0	0.5-0.4	2.011	2.739 ^b	2.300	3.098
	0.6-0.5	2.031	2.738 ^b	2.163	3.053
	0.7-0.6	1.899	2.276 ^a	2.106	3.067
1.4-1.2	0.5-0.4	2.071	2.384 ^a	2.177	2.945
	0.6-0.5	2.019	2.720 ^b	1.977	2.703
	0.7-0.6	2.029	2.702 ^b	1.821	2.762
Pooled SEM		0.025	0.052	0.033	0.050
Main Effect					
Calcium levels	1.0-0.8	1.888 ^m	2.168 ^m	2.097 ^{mm}	2.695 ^m
	1.2-1.0	1.980 ^m	2.585 ⁿ	2.190 ⁿ	3.073 ⁿ
	1.4-1.2	2.039 ⁿ	2.602 ⁿ	1.991 ^m	2.803 ^m
AP levels	0.5-0.4	1.972	2.425	2.169	2.926
	0.6-0.5	2.010	2.531	2.097	2.862
	0.7-0.6	1.926	2.398	2.012	2.783
Probabilities					
	Interaction	NS	P<0.05	NS	NS
	Calcium	P<0.05	P<0.01	P<0.05	P<0.01
	AP	NS	NS	NS	NS

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.12: Analysis of variance for biweekly feed conversion ratio of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares			
		0-2 wk	3-4 wk	5-6 wk	7-8 wk
Calcium levels	2	0.069*	0.724**	0.118*	0.455**
AP levels	2	0.021	0.060	0.074	0.062
Ca X AP	4	0.014	0.188*	0.054	0.052
Error	27	0.021	0.043	0.031	0.072

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

FCR was observed in a dietary combination of 1.0-0.8% Ca with 0.6-0.5% Av.P followed by 1.0-0.8% Ca with 0.5-0.4% Av.P, 1.0-0.8% Ca with 0.7-0.6% Av.P, 1.2-1.0% Ca with 0.7-0.6% Av.P and 1.4-1.2% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. However, during 0-2, 5-6 and 7-8 wks of FCR did not differ significantly due to interaction of Ca and Av.P levels in the diets. Bi-weekly FCR during 0-2, 3-4, 5-6 and 7-8 weeks of age was significantly different due to different levels of Ca in the diets. During 0-2 wks of age significantly ($P < 0.05$) better feed conversion efficiency was observed at 1.0-0.8 and 1.2-1.0% Ca than that recorded at 1.4-1.2% Ca in the diets. During 3-4 wks of age significantly ($P < 0.01$) better FCR was noticed at 1.0-0.8% Ca than other two levels of Ca in the diets. Significantly ($P < 0.05$) better FCR was observed at 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca in the diet during 5-6 wks of age. However, FCR recorded at 1.0-0.8% Ca was found intermediary. During 7-8 wks of age significantly ($P < 0.01$) better FCR was recorded at 1.0-0.8 and 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca in the diet. No-significant differences were recorded on FCR due to different levels of dietary Av.P during different growth phases.

Data on cumulative feed conversion ratio (FCR) during (0-4wks), (5-8wks) and (0-8wks) of age in different dietary groups have been presented in Table 4.13 and Fig. 4 its analysis of variance (ANOVA) in Table 4.14. Results revealed that the mean cumulative FCR of turkey poult was significantly different due to interaction between Ca and Av.P levels in the diet during 0-4wks of age. However, during 5-8 and 0-8wks of age, cumulative FCR was not significantly different due to interactions between Ca and Av.P levels in the diets. Significantly ($P < 0.05$) lower and better FCR was observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations during 0-4wks of age. However, cumulative FCR recorded in dietary combinations of 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.0-0.8% Ca with 0.7-0.6% Av.P and 1.2-1.0% Ca with 0.7-0.6% Av.P was found intermediary. Cumulative FCR was significantly different due to different levels of dietary Ca during 0-4, 5-8 and 0-8 wks of age. Significantly ($P < 0.01$) lower and better FCR was observed at 1.0-0.8% Ca than those observed in other levels of Ca in the diets. During 5-8 and 0-8 wks of age, significantly lower and better FCR was recorded at 1.0-0.8 and 1.4-1.2% Ca than that observed at 1.2-1.0% Ca in the diets. No-significant differences were recorded on cumulative FCR due to different levels of dietary Av.P during 0-4, 5-8 and 0-8wks of age.

Table 4.13: Cumulative feed conversion ratio (g feed/ g gain) of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Biweekly Body Weight (g/b)		
		0-4 wks	5-8 wks	0-8wks
Interaction effect (Ca x AP)				
1.0-0.8	0.5-0.4	2.041 ^a	2.427	2.329
	0.6-0.5	2.076 ^{ab}	2.547	2.427
1.2-1.0	0.7-0.60.5-0.4	2.079 ^{ab}	2.359	2.289
		2.464 ^c	2.789	2.700
	0.6-0.5	2.472 ^c	2.705	2.641
1.4-1.2	0.7-0.6	2.137 ^{ab}	2.664	2.516
	0.5-0.4	2.273 ^{bc}	2.632	2.539
	0.6-0.5	2.462 ^c	2.402	2.416
	0.7-0.6	2.448 ^c	2.403	2.411
Pooled SEM		0.036	0.037	0.031
Main effect				
Calcium levels	1.0-0.8	2.065 ^m	2.444 ^m	2.348 ^m
	1.2-1.0	2.358 ⁿ	2.719 ⁿ	2.619 ⁿ
	1.4-1.2	2.359 ⁿ	2.479 ^m	2.455 ^m
AP levels	0.5-0.4	2.260	2.616	2.523
	0.6-0.5	2.337	2.551	2.495
	0.7-0.6	2.221	2.475	2.405
Probabilities				
	Interaction	P<0.05	NS	NS
	Calcium	P<0.01	P<0.01	P<0.01
	AP	NS	NS	NS

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age.

Table 4.14: Analysis of variance for cumulative FCR of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares		
		0-4 wk	5-8 wk	0-8 wk
Calcium levels	2	0.390**	0.268**	0.223**
AP levels	2	0.042 ^{NS}	0.059 ^{NS}	0.045 ^{NS}
Ca X AP	4	0.075*	0.032 ^{NS}	0.016 ^{NS}
Error	27	0.020	0.037	0.025

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

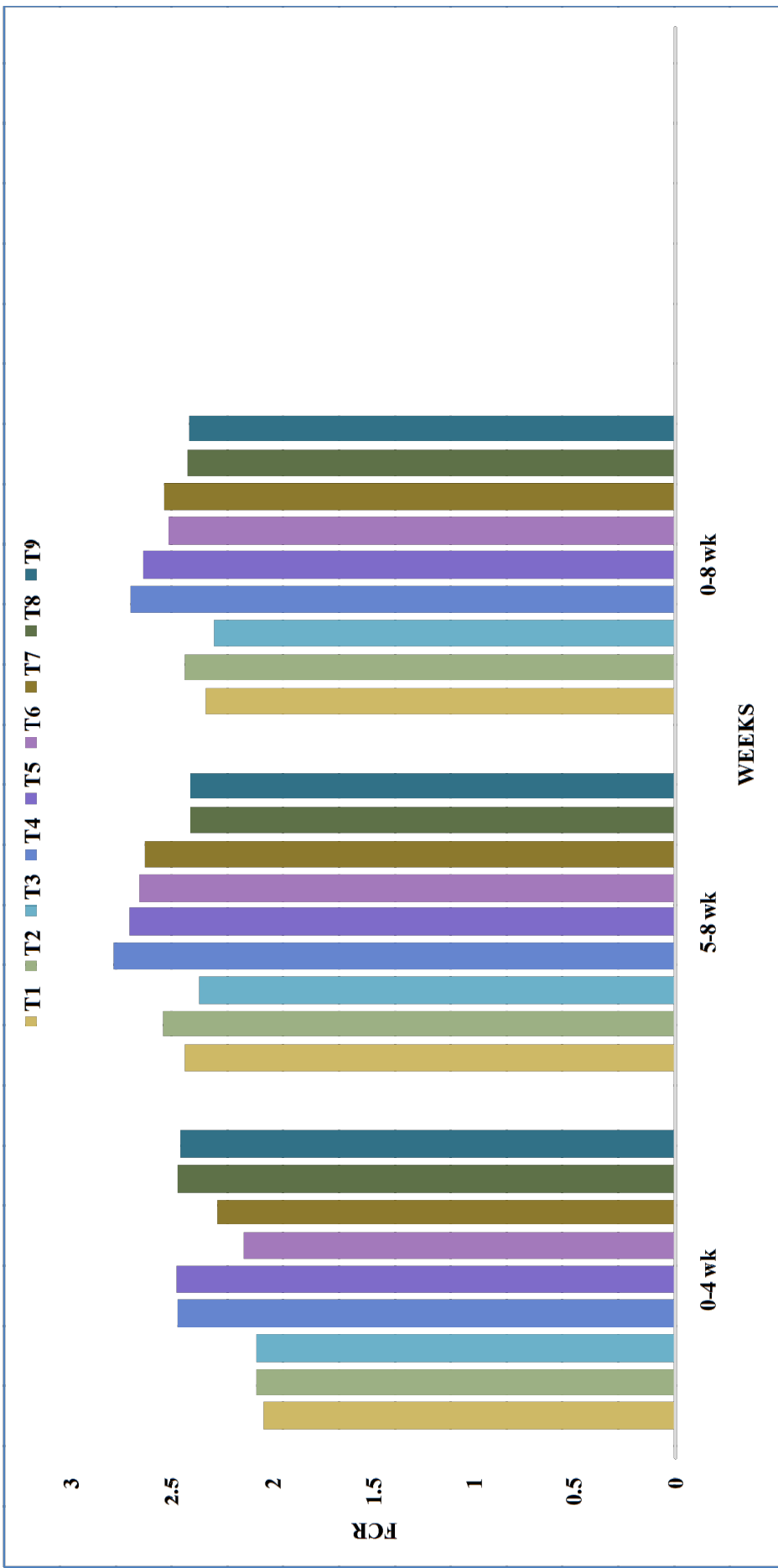


Fig. 4: Cumulative feed conversion ratio (g feed/ g gain) of growing turkeys fed diet variable levels of calcium and available phosphorus

4.1.4. Mortality/Survivability

The data with respect to survivability of growing turkey poulters reared under different dietary regimens from 0-8wks of age have been set out in Table 4.15. The total number of birds at the start of experiment was 288 and each dietary treatment had 32 birds. One bird died from each dietary regimen having 1.0-0.8% Ca with 0.5-0.4 Av.P, 1.0-0.8% Ca with 0.6-0.5 Av.P, 1.4-1.2% Ca with 0.5-0.4 Av.P and 1.4-1.2% Ca with 0.6-0.5 Av.P. Two birds were died from each dietary regimen having 1.0-0.8% Ca with 0.7-0.6% Av.P, 1.2-1.0% Ca with 0.5-0.4% Av.P, 1.2-1.0% Ca with 0.6-0.5% Av.P and 1.4-1.25 Ca with 0.7-0.6% Av.P. Three birds were died in a dietary combination of 1.2-1.0% Ca with 0.7-0.6% Av.P. The overall mortality of the present experiment was observed 5.20 per cent.

Table 4.15: Mortality of growing turkeys fed different levels of calcium and phosphorus

Treatments Calcium (Ca %)	Phosphorus (P %)	No. of poulters died during different phases in the experiment				
		Total No. of birds	No. of birds died (0-4 wks)	No. of birds died (5-8 wks)	No. of birds died (0-8 wks)	Total Mortality (%)
Interaction effect (Ca x AP)						
1.0-0.8	0.5-0.4	32	3	1	4	12.5
	0.6-0.5	32	4	1	5	15.625
	0.7-0.6	32	5	1	6	18.75
1.2-1.0	0.5-0.4	32	1	1	2	6.25
	0.6-0.5	32	3	1	4	12.5
	0.7-0.6	32	2	1	3	9.375
1.4-1.2	0.5-0.4	32	1	0	1	3.125
	0.6-0.5	32	4	0	4	12.5
	0.7-0.6	32	6	1	7	21.875
Total		288	29	7	36	Av. 12.5

4.1.5 Skeletal health

Daily monitoring by physical examination of the individual birds of present experiment reared under different dietary regimens from 0-8 wks period was made to evaluate the overall health of birds. All the experimental birds appeared quit normal and apparently healthy but for variable body growth. No marked clinical sign of illness and skeletal defects were observed in the flock due to feeding different levels of Ca and Av.P. Even the slight extent of lameness, deviated toe, and swollen hock joint and general depression had been unnoticed due to various dietary regimens.

4.2 Cellular and Humoral Immunity and Immune organs weight

The results pertaining to cellular and humoral immune response as affected by feeding different levels of Ca and Av.P have been presented in Table 4.16 and Fig. 5, 6 its analysis of variance (ANOVA) in Table 4.17. The mean cellular immune response (Foot web index) was differed significantly due to interaction between Ca and Av.P levels in the diets. Significantly ($P<0.01$) higher cellular immune response foot web index to PHAP was recorded in a dietary combination of 1.2-1.0% Ca with 0.6-0.5% Av.P than those recorded in other dietary combinations. However, foot web index to PHAP recorded in dietary combinations of 1.0-0.8% Ca with 0.7-0.6% Av.P, 1.2-1.0% Ca with 0.5-0.4% Av.P, 1.2-1.0% Ca with 0.7-0.6% Av.P and 1.4-1.2% Ca with 0.5-0.4% Av.P were found intermediary. Cellular and humoral

Table 4.16: Cellular and humoral immunity of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (P %)	Cellular and humoral immunity	
		Foot web index	HA titer (\log_2)
Interaction effect (Ca x AP)			
1.0-0.8	0.5-0.4	0.583 ^a	2.84
	0.6-0.5	0.961 ^{ab}	3.50
	0.7-0.6	1.607 ^{cd}	3.11
1.2-1.0	0.5-0.4	1.215 ^{bcd}	3.51
	0.6-0.5	1.750 ^d	3.57
	0.7-0.6	1.365 ^{bcd}	3.59
1.4-1.2	0.5-0.4	1.376 ^{bcd}	3.43
	0.6-0.5	1.120 ^{abc}	3.59
	0.7-0.6	0.962 ^{ab}	3.43
Pooled SEM		0.071	0.050
Main effect			
Calcium levels	1.0-0.8	1.050 ^m	3.15 ^m
	1.2-1.0	1.443 ⁿ	3.56 ⁿ
	1.4-1.2	1.153 ^{mn}	3.48 ⁿ
AP levels	0.5-0.4	1.057	3.26 ^p
	0.6-0.5	1.277	3.55 ^q
	0.7-0.6	1.312	3.38 ^{pq}
Probabilities			
	Interaction	$P<0.01$	NS
	Calcium	$P<0.05$	$P<0.01$
	AP	NS	$P<0.05$

abc(Interaction),mno (Ca),pqr (AP)

Value bearing different superscripts within a column differ significantly ($P<0.05$), ($P<0.01$), NS-Non-significant

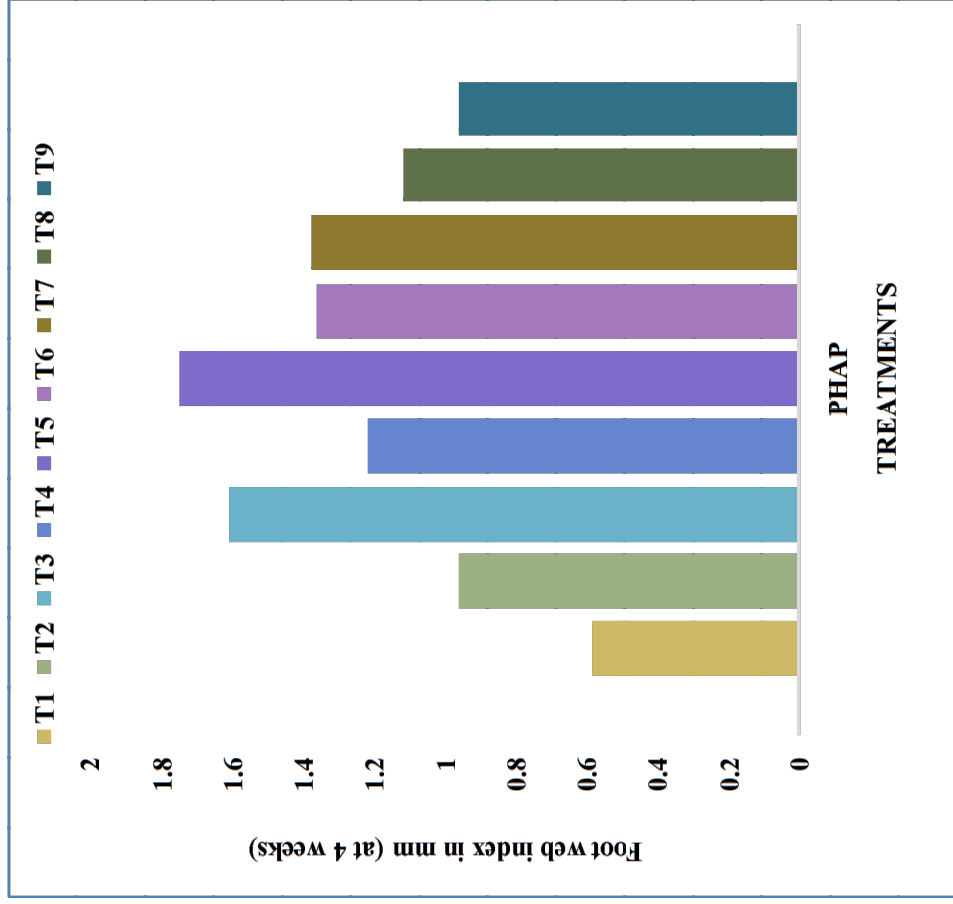


Fig. 5: Cellular immune response of growing turkeys fed diet variable levels of calcium and available phosphorus

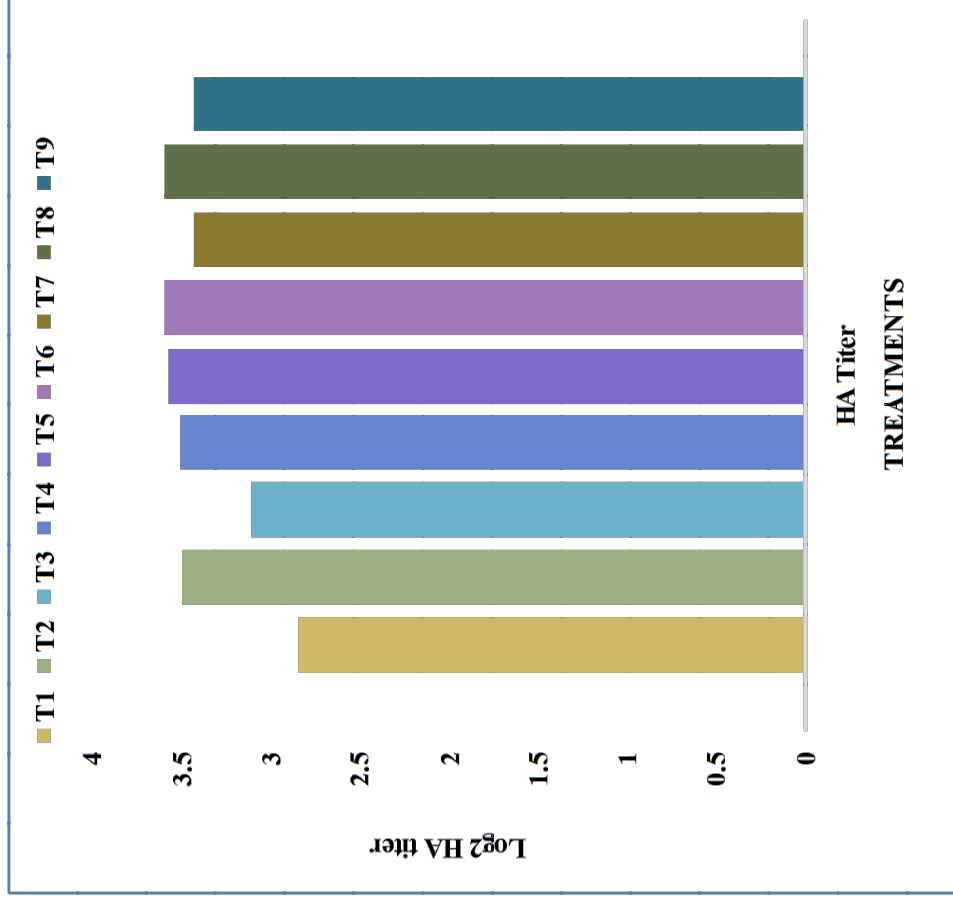


Fig. 6: Humoral immune response of growing turkeys fed diet variable levels of calcium and available phosphorus

Table 4.17: Analysis of variance for cellular and humoral immunity of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df.	Mean Sum of Squares	
		Foot web index	HA titer (log ₂)
Calcium levels	2	0.997*	0.016**
AP levels	2	0.454 ^{NS}	0.007*
Ca X AP	4	0.003**	0.001 ^{NS}
Error	63	0.274	0.139

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

immune response was differed significantly due to different levels of Ca in the diets. Significantly (P<0.05) higher cellular immune response (foot web index to PHAP) was recorded at 1.2-1.0% Ca than 1.0-0.8% Ca in the diet. However, (foot web index to PHAP) recorded at 1.4-1.2% Ca was found intermediary. Humoral immune response (HA titre to SRBC) was recorded significantly (P<0.05) higher at 1.2-1.0 and 1.4-1.2% Ca than that recorded at 1.0-0.8% Ca in the diet. Humoral immune response (HA titre to SRBC) was recorded significantly (P<0.05) higher at 0.6-0.5% Av.P than that recorded at 0.5-0.4% Av.P. However, humoral immune response (HA titre to SRBC) was recorded at 0.7-0.6% Av.P was found intermediary. No-significant differences were recorded on cellular immune response (foot web index to PHAP) due to different levels of Av.P in the diets.

Data on immune organ weight in relation to body weight of growing turkey poult as influenced by feeding different level of Ca and Av.P at 56 days of age have been presented in Table 4.17 and Fig. 7 its analysis of variance (ANOVA) in Table 4.18. The mean immune organ weight such as bursa and spleen at 56 days of age did not differed significantly due to the interaction between Ca and Av.P levels in the diets. However, significant difference was observed on thymus weights at 56 days of age due to the interaction between Ca and Av.P levels in the diets. Significantly (P<0.01) higher thymus weight was recorded in a dietary combination of 1.2-1.0% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. Various immune organs weight was also differed significantly due to different levels of Ca in the diets. Significantly (P<0.05) higher bursa weight was recorded at 1.2-1.0% Ca than 1.4-1.2% Ca in the diet. However, bursa weight recorded at 1.0-0.80% Ca was found intermediary. Significantly (P<0.05) higher spleen weight was observed at 1.2-1.0% Ca than 1.0-0.8% Ca

Table 4.18: Immune organ weight at 56d of age of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Organ weight (%body wt.) at 56 days		
		Bursa	Spleen	Thymus
Interaction effect (Ca x AP)				
1.0-0.8	0.5-0.4	0.134	0.143	0.065 ^a
	0.6-0.5	0.176	0.164	0.120 ^{bc}
	0.7-0.6	0.166	0.166	0.092 ^{ab}
1.2-1.0	0.5-0.4	0.200	0.225	0.223 ^d
	0.6-0.5	0.195	0.173	0.153 ^c
	0.7-0.6	0.153	0.205	0.100 ^{ab}
1.4-1.2	0.5-0.4	0.163	0.195	0.080 ^{ab}
	0.6-0.5	0.151	0.175	0.078 ^{ab}
	0.7-0.6	0.118	0.180	0.065 ^a
Pooled SEM		0.006	0.008	0.008
Main effect				
Calcium levels	1.0-0.8	0.158 ^{nm}	0.157 ^m	0.092 ^m
	1.2-1.0	0.183 ⁿ	0.201 ⁿ	0.159 ⁿ
	1.4-1.2	0.144 ^m	0.183 ^{nm}	0.745 ^m
AP levels	0.5-0.4	0.166	0.188	0.123
	0.6-0.5	0.174	0.171	0.117
	0.7-0.6	0.146	0.181	0.108
Probabilities				
	Interaction	NS	NS	P<0.01
	Calcium	P<0.05	P<0.05	P<0.01
	AP	NS	NS	P<0.05

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.19: Analysis of variance for immune organ weight at 56d of age of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares		
		At 56 days		
Calcium levels	2	0.009	0.012	0.047
AP levels	2	0.005	0.002	0.010
Ca X AP	4	0.004	0.003	0.014
Error	63	0.002	0.003	0.002

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

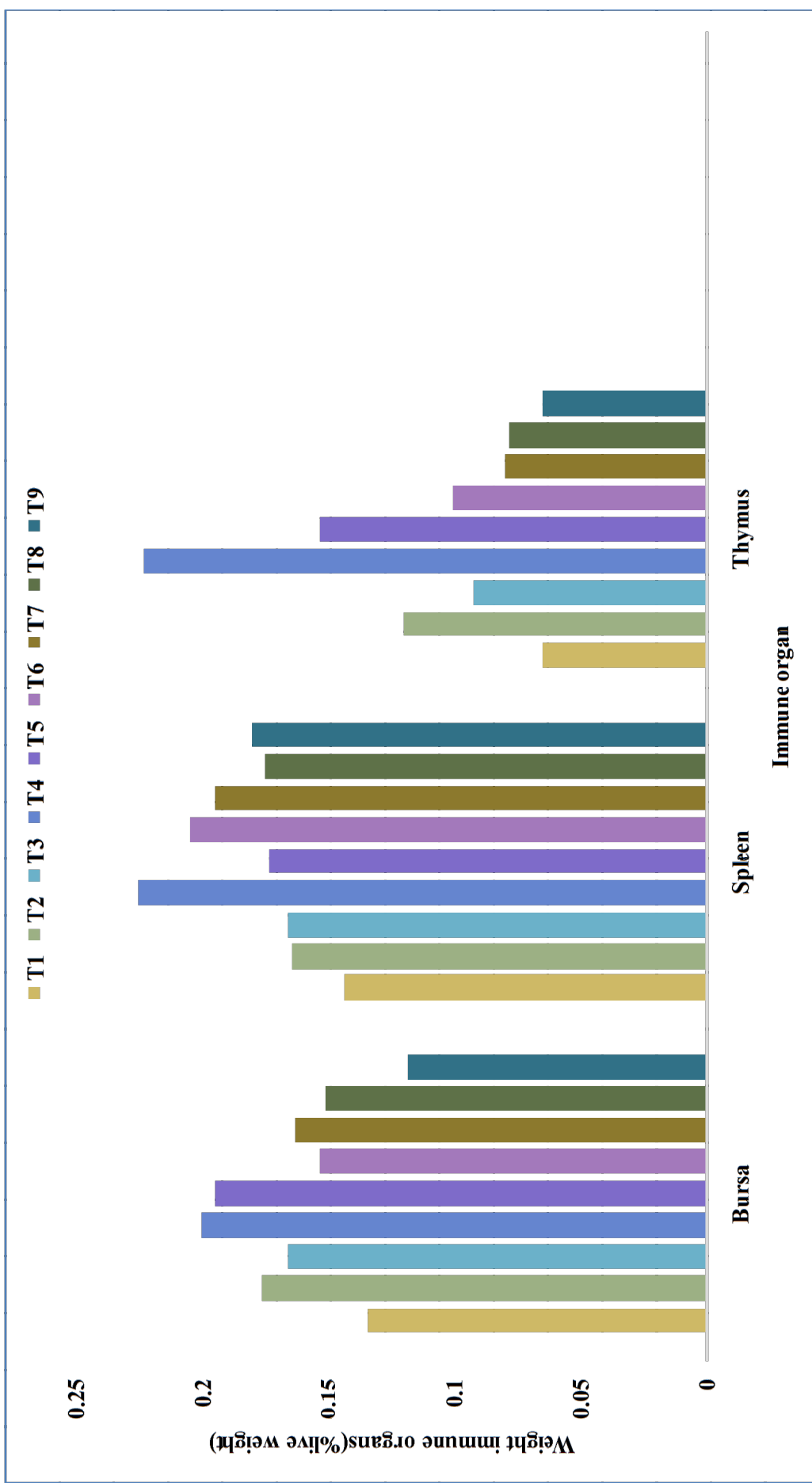


Fig. 7: Response on immune organ weight of growing turkeys fed diet variable levels of calcium and available phosphorus

in the diet. Whereas, spleen weight observed at 1.4-1.2% Ca was found intermediary. Significantly ($P<0.05$) higher thymus weight was observed at 1.2-1.0% Ca than those recorded at other two levels of Ca in the diets. Significantly ($P<0.01$) higher thymus weight was recorded at 0.5-0.4 and 0.6-0.5% Av.P than that observed at 0.7-0.6% Av.P. Bursa and spleen weight did not differ significantly due to different levels of Av.P in the diets.

4.3 Serum biochemical parameters

The results pertaining to various blood biochemical parameters as affected by feeding different levels of Ca and Av.P have been presented in Table 4.20,22 and its analysis of variance

Table 4.20: Serum biochemical parameters of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments	Serum biochemical parameters				
	Calcium (Ca %)	Av.Phosphorus (AP %)	ALP (U/L)	Calcium (mg/dl)	Phosphorus (mg/dl)
Interaction effect (Ca x AP)					
1.0-0.8		0.5-0.4	193.37	10.65	5.59
		0.6-0.5	170.87	10.53	5.86
		0.7-0.6	148.12	10.68	6.06
1.2-1.0		0.5-0.4	179.62	11.04	5.56
		0.6-0.5	161.5	11.21	5.56
		0.7-0.6	138.72	11.57	5.98
1.4-1.2		0.5-0.4	175.87	12.19	5.98
		0.6-0.5	167.25	12.48	5.4
		0.7-0.6	150.25	12.63	5.64
Pooled SEM		2.21	3.82	0.12	
Main effect					
Calcium levels		1.0-0.8	170.79	10.62 ^m	5.84
		1.2-1.0	159.95	11.27 ⁿ	5.70
		1.4-1.2	164.45	12.43 ^o	5.67
AP levels		0.5-0.4	182.95 ^q	11.30	5.71
		0.6-0.5	166.54 ^q	11.41	5.61
		0.7-0.6	145.70 ^p	11.63	5.89
Probabilities					
	Interaction	NS	NS	NS	NS
	Calcium	NS	$P<0.01$	NS	NS
	AP	$P<0.01$	NS	NS	NS

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly ($P<0.05$), ($P<0.01$), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.21: Analysis of variance for serum biochemical parameters of growing turkeys

Source of variation	df	Mean Sum of Squares		
		ALP (U/L)	Calcium (mg/dl)	Phosphorus (mg/dl)
Calcium levels	2	712.12	20.26**	0.19
AP levels	2	8367.25**	0.68	0.50
Ca X AP	4	223.47	0.17	0.55
Error	63	878.68	0.40	0.34

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

Table 4.22: Serum biochemical parameters of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Serum biochemical parameters				
		Total Protein	Albumin (A) (mg/dl)	Globulin (G) (mg/dl)	A/G Ratio	Glucose
Interaction effect (Ca xAP)						
1.0-0.8	0.5-0.4	7.0725	1.7963	5.2725	0.3425	100.0063
	0.6-0.5	7.0488	1.4438	5.6050	0.2638	158.6513
	0.7-0.6	7.1750	1.7213	5.4550	0.3213	115.3150
1.2-1.0	0.5-0.4	7.2375	1.5450	5.6925	0.2763	113.4763
	0.6-0.5	7.1675	1.5788	5.5900	0.2850	189.0975
	0.7-0.6	7.1363	1.5363	5.6000	0.2838	144.3663
1.4-1.2	0.5-0.4	7.2250	1.8713	5.3538	0.3750	133.0975
	0.6-0.5	7.2063	1.7613	5.4425	0.3338	120.6288
	0.7-0.6	7.2888	2.1238	5.1638	0.4313	109.0500
Pooled SEM		0.05660	0.04602	0.07341	0.01317	6.99535
Main effect						
Calcium levels	1.0-0.8	7.0988	1.6538 ^m	5.4442	0.3092 ^m	124.6575
	1.2-1.0	7.1804	1.5533 ^m	5.6275	0.2817 ^m	148.9800
	1.4-1.2	7.2400	1.9188 ⁿ	5.3200	0.3800 ⁿ	120.9221
AP levels	0.5-0.4	7.1783	1.7375	5.4396	0.3313	115.5233 ^p
	0.6-0.5	7.1408	1.5946	5.5458	0.2942	156.1258 ^q
	0.7-0.6	7.2000	1.7938	5.4063	0.3454	122.9104 ^p
Probabilities						
	Interaction	NS	NS	NS	NS	NS
	Calcium	NS	P<0.05	NS	P<0.05	NS
	AP	NS	NS	NS	NS	P<0.05

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.23: Analysis of variance for serum biochemical parameters of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares				
		Total Protein	Albumin (A) (mg/dl)	Globulin (G) (mg/dl)	A/G Ratio	Glucose
Calcium levels	2	0.121 ^{NS}	0.855*	0.574 ^{NS}	0.062*	5571.136 ^{NS}
AP levels	2	0.022 ^{NS}	0.253 ^{NS}	0.128 ^{NS}	0.017 ^{NS}	11225.584*
Ca X AP	4	0.025 ^{NS}	0.152 ^{NS}	0.141 ^{NS}	0.008 ^{NS}	4448.784 ^{NS}
Error	63	0.254	246.62	0.406	0.11	3155.023

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

(ANOVA) in Table 4.21,23. The various blood biochemical parameters namely serum total protein, albumin, globulin, albumin/globulin ratio, glucose, Serum alkaline phosphatase (ALP), serum calcium and phosphorus did not differ significantly due to interaction between Ca and Av.P levels in the diets. The serum albumin and albumin/globulin ratio differed significantly (P<0.01) due to different levels dietary Ca. Significantly higher albumin and albumin/globulin ratio were recorded at 1.4-1.2% Ca than those recorded in other dietary levels of Ca in the diets. Significantly (P<0.01) linear increased in serum Ca as increasing Ca levels from 1.0-0.8 to 1.4-1.2% in the diet. Significantly (P<0.01) higher glucose value was recorded at 0.6-0.5% Av.P than those recorded in other dietary levels of Av.P in the diets. Significantly (P<0.01) higher alkaline phosphatase activity was recorded at 0.5-0.4% Av.P than those recorded in other levels of Av.P in the diets.

4.4 Bone morphometry

Data on tibia bone morphometry of growing turkey fed diet varying in dietary Ca and Av.P, days from 0-56 days of age are presented in Table 4.24 and Fig. 8-9 and its analysis of variance (ANOVA) in Table 4.25. The mean tibia bone morphometry at 56 days of age in term of proximal width (mm), midshaft width(mm) and distal width(mm) of growing turkey did not differed significantly due to interaction between Ca and Av.P in the diets. However, mean tibia bone length was differed significantly due to interaction between Ca and Av.P in the diet. Significantly (P<0.05) higher tibia bone length was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.4-1.2% Ca

with 0.5-0.4% Av.P, 1.0-0.8% Ca with 0.7-0.6% Av.P, 1.2-1.0 % Ca with 0.7-0.6%Av.P than those observed in other dietary combinations. The tibia bone length ($P<0.01$), midshaft width ($P<0.05$) and distal width ($P<0.01$) differed significantly due to different dietary Ca levels in the diets. Significantly ($P<0.01$) higher tibia bone length was recorded at 1.0-0.8% Ca than those recorded at other levels of Ca in the diets. Significantly ($P<0.05$) higher tibia bone mid shaft width was recorded at 1.0-0.8% Ca than that recorded at 1.2-1.0% Ca in the diet. However, tibia bone midshaft width recorded at 1.4-1.2% Ca was found intermediary. Significantly ($P<0.01$) higher tibia distal width was recorded at 1.0-0.8 and 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca in the diets. Non-significant differences were recorded on various bone morphometry parameters due to different levels of dietary available phosphorus in the diets.

Table 4.24: Bone morphometry of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments Calcium (Ca %)	Av.Phosphorus (AP %)	Bone morphometry			
		Length (mm)	Proximal width (mm)	Mid shaft (mm)	Distal width (mm)
Interaction effect (Ca x AP)					
1.0-0.8	0.5-0.4	105.74 ^d	20.40	7.19	16.72
	0.6-0.5	102.00 ^{cd}	19.47	6.77	16.65
	0.7-0.6	100.96 ^{bcd}	19.66	6.81	16.60
1.2-1.0	0.5-0.4	92.56 ^a	19.10	6.27	15.41
	0.6-0.5	96.35 ^{abc}	18.71	6.49	15.86
	0.7-0.6	99.72 ^{bcd}	19.05	6.85	15.29
1.4-1.2	0.5-0.4	101.42 ^{bcd}	20.31	6.82	17.16
	0.6-0.5	96.89 ^{abc}	19.43	6.76	16.40
	0.7-0.6	95.25 ^{ab}	19.60	6.67	16.65
Pooled SEM		0.77	0.19	0.06	0.17
Main effect					
Calcium levels	1.0-0.8	102.90 ⁿ	19.84	6.92 ⁿ	16.66 ⁿ
	1.2-1.0	96.21 ^m	18.95	6.53 ^m	15.52 ^m
	1.4-1.2	97.85 ^m	19.78	6.75 ^{mn}	16.74 ⁿ
AP levels	0.5-0.4	99.91	19.94	6.76	16.43
	0.6-0.5	98.41	19.21	6.67	16.30
	0.7-0.6	98.64	19.44	6.78	16.17
Probabilities					
	Interaction	$P<0.05$	NS	NS	NS
	Calcium	$P<0.01$	NS	$P<0.05$	$P<0.01$
	AP	NS	NS	NS	NS

abc(Interaction),mno (Ca),pqr (AP),Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age Value bearing different superscripts within a column differ significantly ($P<0.05$), ($P<0.01$), NS-Non-significant

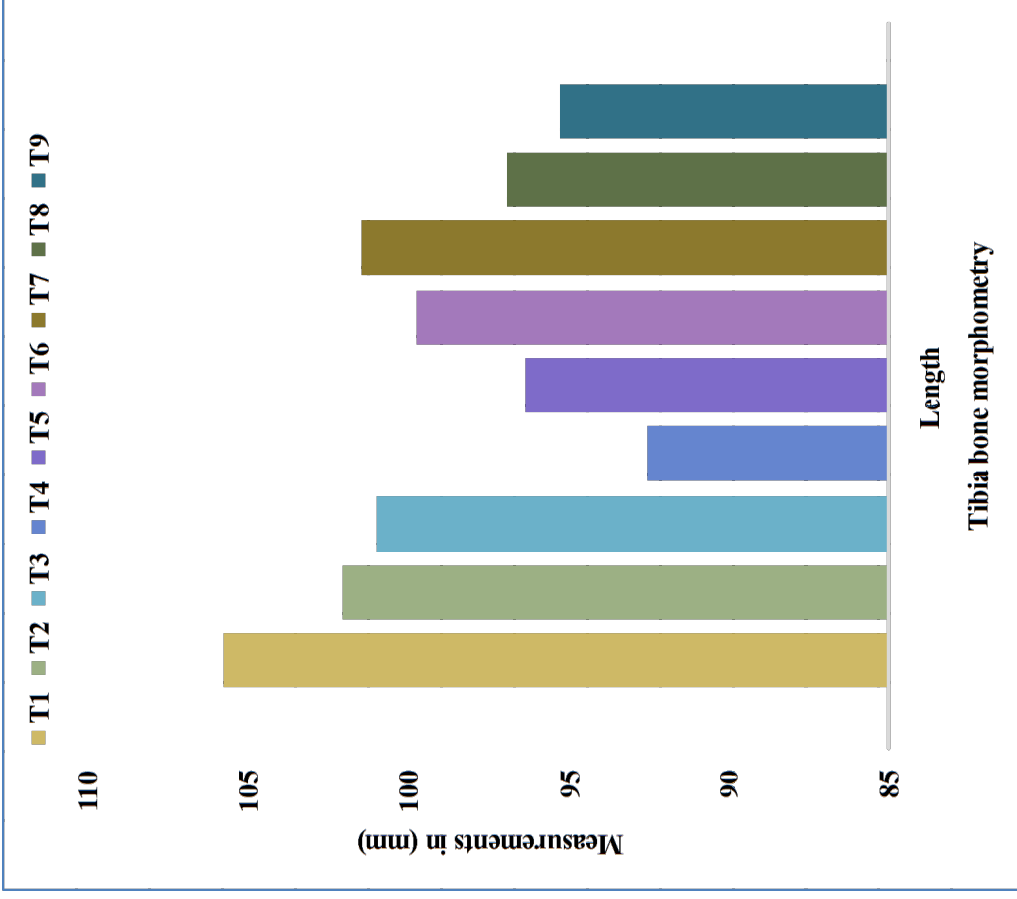


Fig. 8: Tibia bone morphometry of growing turkeys fed diet variable levels of calcium and available phosphorus

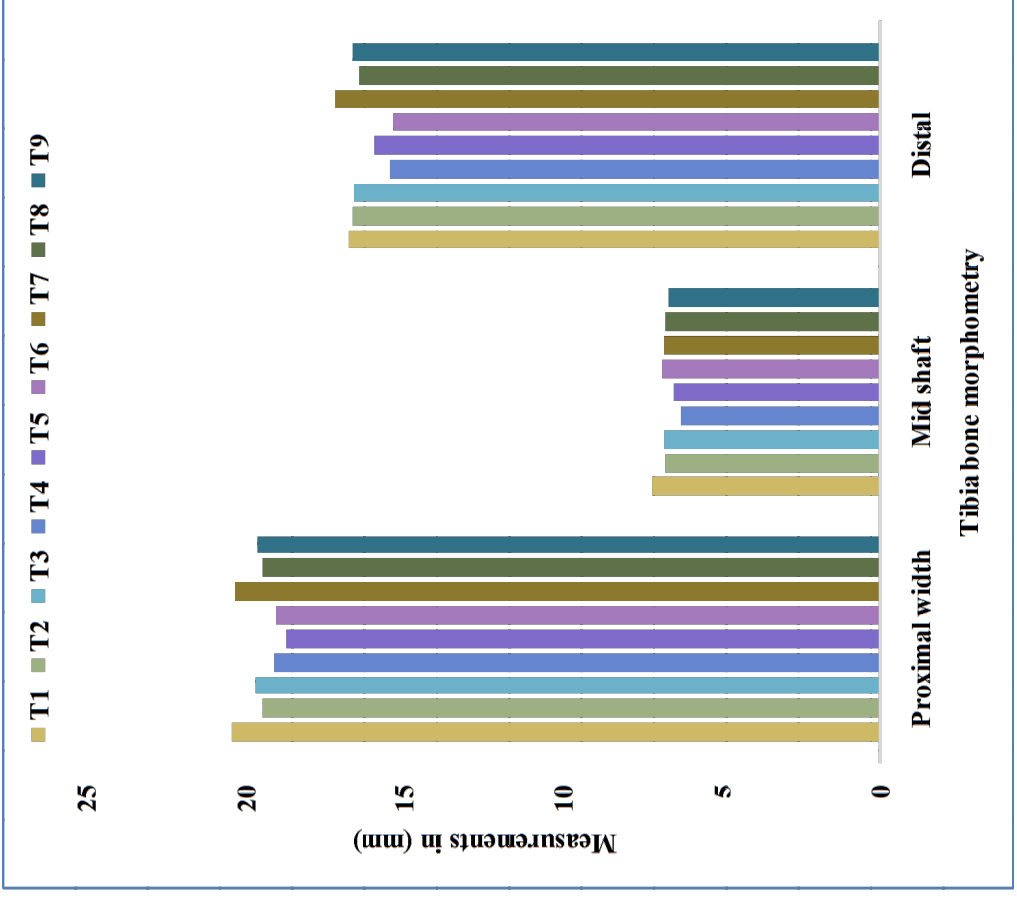


Fig. 9: Tibia bone morphometry of growing turkeys fed diet variable levels of calcium and available phosphorus

Table 4.25: Analysis of variance for bone morphometry of growing turkeys fed diet variable levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares			
		Length (mm)	Proximal width (mm)	Mid shaft (mm)	Distal width (mm)
Calcium levels	2	291.51**	5.94	0.90*	11.12**
AP levels	2	15.54	3.33	0.07	0.39
Ca X P	4	109.75*	0.33	0.53	0.79
Error	63	1.30	2.70	0.26	1.87

*Significant ($P < 0.05$), ** Significant ($P < 0.01$), NS-Non-significant

4.5.1 Bone mineralization

The effect of feeding different levels of dietary Ca and Av.P on tibia bone mineralization of growing turkey was studied in terms of tibia bone weight, moisture percentage, ash weight, ash percentage, calcium (Ca) and phosphorus (P) in tibia bone collected at end of 56 days of age. The tibia bone mineralization parameters are summarized in Table 4.26 and Fig. 10 its analysis of variance (ANOVA) in Table 4.27. Significantly ($P < 0.01$) higher dry tibia bone weight and ash weight were observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. Significantly ($P < 0.01$) higher ash weight was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.4-1.2% Ca with 0.5-0.4% Av.P, 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.2-1.0% Ca with 0.7-0.6% Av.P, 1.4-1.2 Ca with 0.7-0.6% Av.P and 1.4-1.2% Ca with 0.6-0.5% Av.P than those recorded in other dietary combinations. The various traits of tibia bone mineralization such as fresh bone weight, dry bone weight, bone moisture content, bone ash weight and bone Ca content differed significantly due to different levels of Ca in the diet. However, bone ash % and bone phosphorus content in tibia bone did not change significantly due to different levels of Ca in the diets. Fresh bone weight was significantly ($P < 0.05$) higher at 1.0-0.8% Ca than that recorded at 1.2-1.0% Ca in the diet. However, fresh bone weight recorded at 1.4-1.2% Ca was found intermediary. Significantly ($P < 0.05$) higher bone weight and ash weight were recorded at 1.0-0.8 and 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca in the diet. Bone moisture content was significantly ($P < 0.01$) higher at 1.2-1.0% Ca than those recorded at other levels of Ca in the diets. Linear improvement ($P < 0.01$) in tibia bone

Table 4.26: Bone mineralization of growing turkeys fed different levels of calcium and phosphorus

Treatments	Bone mineralization						
	Phosphorus (P%)	Fresh Bone Wt. (%)	Dry Bone Wt. (%)	Bone Moisture (%)	Total Ash Wt. (g)	Total Ash (%)	Phosphorus (P%)
Calcium (Ca%)							Calcium (Ca%)
							Phosphorus (P%)
Interaction effect (Ca x AP)							
1.0-0.8	0.5-0.4	5.1	3.68	27.57	1.83	49.78	14.17
	0.6-0.5	4.68	3.19	31.82	1.68	53.56	13.44
	0.7-0.6	4.47	3.08	31.33	1.48	48.98	12.75
1.2-1.0	0.5-0.4	3.57	2.43	32.79	1.2	49.57	15.66
	0.6-0.5	4.06	2.8	33.72	1.21	45.17	14.83
	0.7-0.6	4.39	3.35	32.49	1.61	47.81	13.88
1.4-1.2	0.5-0.4	4.55	3.59	29.35	1.7	47.53	16.34
	0.6-0.5	4.19	3.18	30.92	1.52	48.16	15.58
	0.7-0.6	4.11	3.27	30.04	1.57	48.03	14.78
Pooled SEM		0.10	0.09	0.39	0.04	0.66	0.16
Main effect							
Calcium levels	1.0-0.8	4.75 ⁿ	3.32 ⁿ	30.24 ^m	1.66 ⁿ	50.77	13.45 ^m
	1.2-1.0	4.01 ^m	2.86 ^m	33.00 ⁿ	1.34 ^m	47.51	14.79 ⁿ
	1.4-1.2	4.28 ^{mm}	3.35 ⁿ	30.10 ^m	1.60 ⁿ	47.91	15.57 ^o
AP levels	0.5-0.4	4.41	3.23	29.90 ^p	1.58	48.96	15.39 ^r
	0.6-0.5	4.31	3.06	32.15 ^r	1.47	48.96	14.62 ^q
	0.7-0.6	4.32	3.23	31.29 ^{pq}	1.55	48.27	13.80 ^p
Probabilities							
	Interaction	NS	P<0.05	NS	P<0.01	NS	NS
	Calcium	P<0.05	P<0.05	P<0.01	P<0.01	NS	P<0.01
	AP	NS	NS	P<0.05	NS	NS	P<0.01

abc(Interaction), mno (Ca), pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

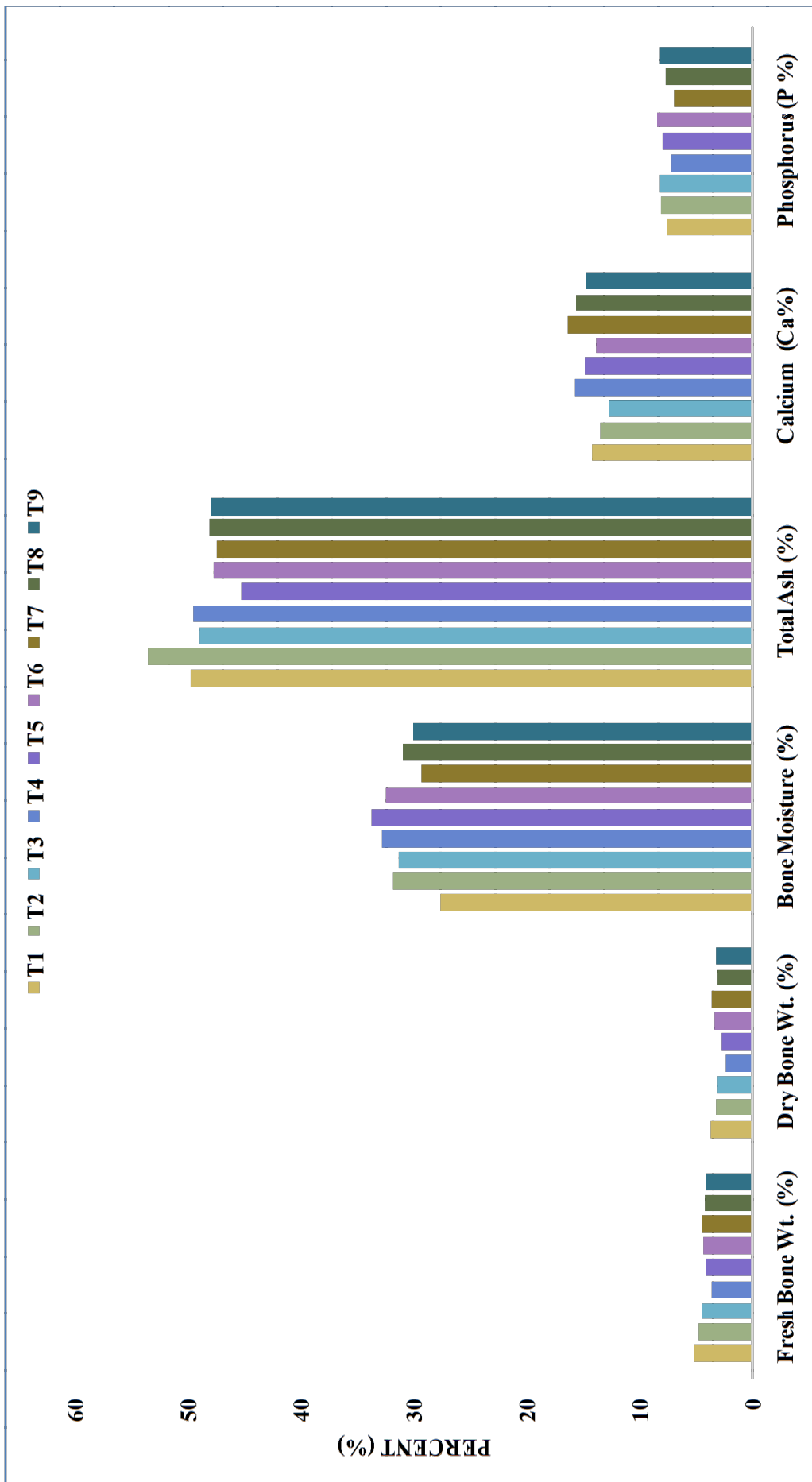


Fig. 10: Tibia bone mineralization of growing turkeys fed diet variable levels of calcium and available phosphorus

Table 4.27: Analysis of variance for bone mineralization of growing turkeys fed different levels of calcium and available phosphorus

Source of variation	df	Mean Sum of Squares						
		Fresh Bone Wt. (%)	Dry Bone Wt. (%)	Bone Moisture (%)	Total Ash Wt. (g)	Total Ash (%)	Calcium (Ca%)	Phosphorus (P%)
Calcium levels	2	3.39	1.77	64.21	0.71	75.73	27.48	0.80
AP levels	2	0.07	0.25	30.94	0.08	3.79	15.12	6.97
Ca X P	4	1.27	1.34	10.33	0.34	42.12	0.07	0.24
Error	63	0.68	0.46	8.65	0.09	30.07	0.51	0.79

*Significant (P<0.05), ** Significant (P<0.01), NS-Non significant

Ca content was observed with increase Ca concentration in the diet from 1.0-0.8 to 1.4-1.2 %. Significant changes were recorded on tibia bone moisture, bone Ca content and phosphorus content in tibia bone due to different levels of dietary available phosphorus in the diets. Significantly ($P<0.05$) higher tibia bone moisture was recorded at 0.6-0.55 Av.P than that recorded at 0.5-0.4% Av.P. However, bone moisture recorded at 0.7-0.6% Av.P was found intermediary. Linear decreased ($P<0.01$) in tibia bone Ca content was observed with increase Av.P concentration in the diet from 0.5-0.4 to 0.7-0.6 %. Significantly ($P<0.01$) higher tibia bone phosphorus was recorded at 0.6-0.5 and 0.7-0.6 % Av.P than that recorded at 0.5-0.4% Av.P in the diet. The other tibia bone mineralization traits did not differed significantly due to different levels of Av.P in the diets.

4.5.2 Bones trace minerals

The effect of trace minerals content in tibia bone of growing turkey fed diet variable in Ca and available phosphorus are summarized in Table 4.28 and Fig. 11-12 its analysis of variance (ANOVA) in Table 4.29. The copper and manganese content in tibia bone differed significantly due to interaction between dietary Ca and Av.P in the diet. Significantly ($P<0.01$) higher copper content in tibia bone was observed in a dietary combinations of 1.4-1.2% Ca with 0.6-0.5% Av.P than those recorded in other dietary combinations. Significantly ($P<0.05$) higher manganese content in tibia bone was recorded in a dietary combination of 1.2-1.0% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. Significantly ($P<0.01$) linear increased in copper content in tibia bone was recorded as increasing dietary Ca concentration from 1.0-0.8% to 1.4-1.2% during 0-4 - 5-8wks of age. Significantly ($P<0.05$) higher tibia manganese content was recorded at 1.2-1.0% Ca than 1.0-0.8% Ca. However, tibia bone manganese content observed at 1.4-1.2% Ca was found intermediary. Significantly ($P<0.01$) higher tibia copper content was noticed at 0.6-0.5% Av.P than those recorded in other levels of dietary Av.P. Significant ($P<0.01$) gradual decreased in tibia iron content as increasing the dietary Av.P in the diet from 0.5-0.4% to 0.7-0.6% Av.P during 0-4 – 5-8wks of age.

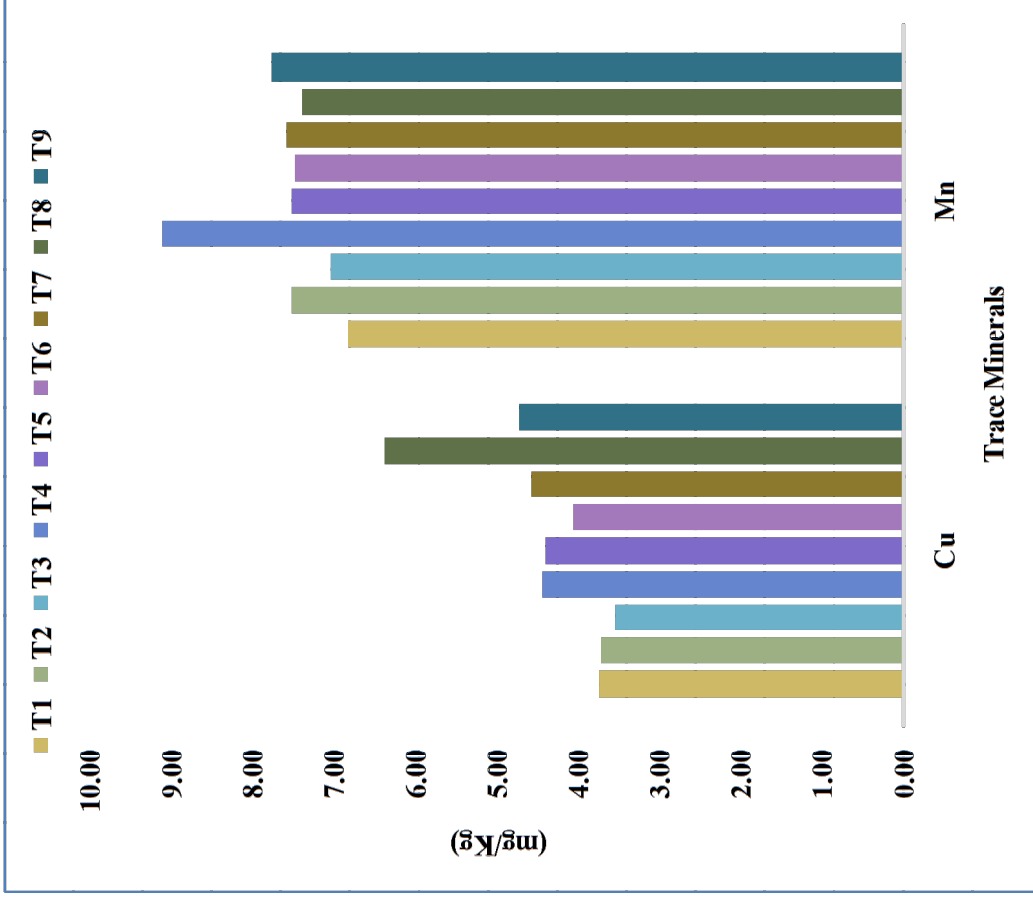


Fig. 11: Trace mineral content in tibia bone of growing turkeys fed diet variable levels of calcium and available phosphorus

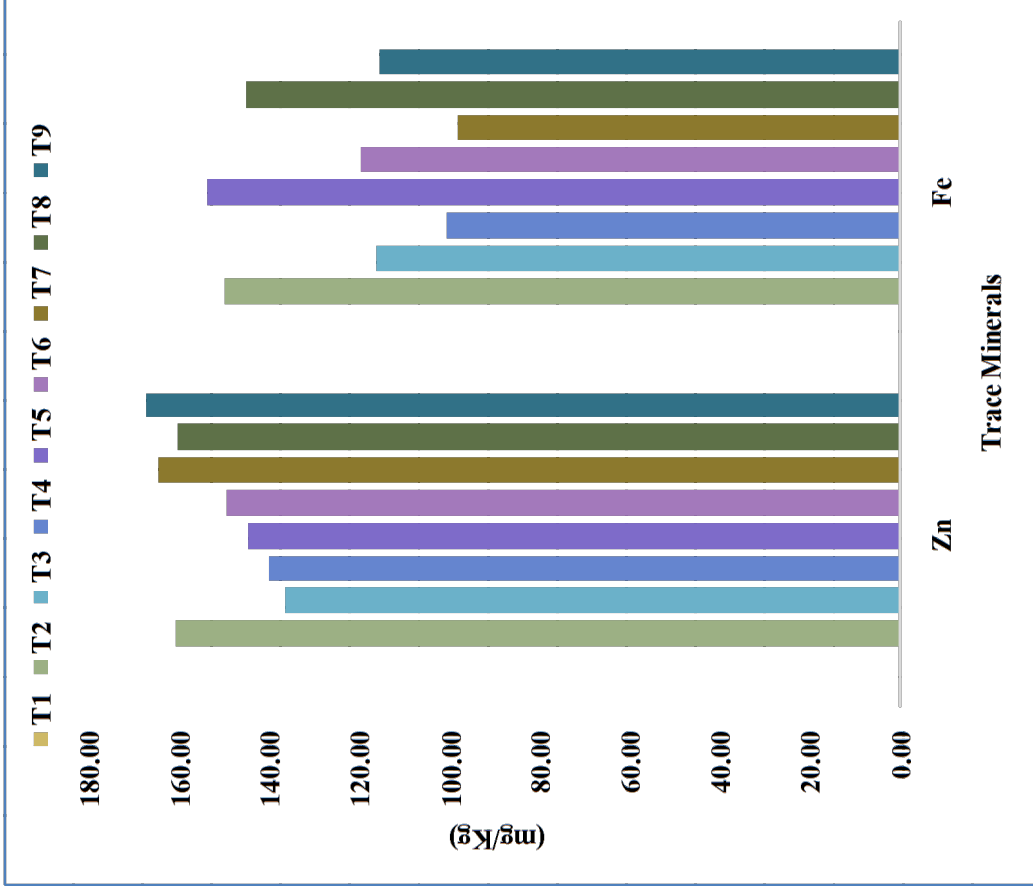


Fig. 12: Trace mineral content in tibia bone of growing turkeys fed diet variable levels of calcium and available phosphorus

Table 4.28: Trace minerals in growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments		Trace Minerals			
Calcium (Ca %)	Av.Phosphorus (AP %)	Cu	Zn	Mn	Fe
Interaction effect (Ca x AP)					
1.0-0.8	0.5-0.4	3.7313 ^a	160.8850	6.8225 ^a	149.4338
	0.6-0.5	3.7175 ^a	136.0975	7.5100 ^a	116.0038
	0.7-0.6	3.5475 ^a	139.9050	7.0250 ^a	100.7313
1.2-1.0	0.5-0.4	4.4400 ^p	144.7150	9.0925 ^{ab}	153.8063
	0.6-0.5	4.4100 ^p	149.1150	7.5050 ^a	119.6950
	0.7-0.6	4.0625 ^{ab}	164.6450	7.4575 ^a	98.6375
1.4-1.2	0.5-0.4	4.5800 ^p	160.3625	7.5650 ^a	145.0675
	0.6-0.5	6.3600 ^c	167.4925	7.3725 ^a	115.4338
	0.7-0.6	4.7200 ^p	145.6800	7.7650 ^a	96.3488
Pooled SEM		0.11542	152.0997	7.5683	121.6842
Main effect					
Calcium levels	1.0-0.8	3.6654 ^m	145.6292	7.1192 ^m	122.0563
	1.2-1.0	4.3042 ⁿ	152.8250	8.0183 ^o	124.0463
	1.4-1.2	5.2200 ^p	157.8450	7.5675 ^{mm}	118.9500
AP levels	0.5-0.4	4.2504 ^q	155.3208	7.8267	149.4358 ^r
	0.6-0.5	4.8292 ^r	150.9017	7.4625	117.0442 ^q
	0.7-0.6	4.1100 ^p	150.0767	7.4158	98.5725 ^p
Probabilities					
	Interaction	P<0.01	NS	P<0.05	NS
	Calcium	P<0.01	NS	P<0.05	NS
	AP	P<0.01	NS	NS	P<0.01

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.29 : Analysis of variance for Trace Minerals in growing turkeys fed diet variable levels of calcium available phosphorus

Source of variation	df	Mean Sum of Squares			
		Cu	Zn	Mn	Fe
Calcium levels	2	29.308**	1809.656 ^{NS}	9.702*	316.645 ^{NS}
AP levels	2	6.975**	381.688 ^{NS}	2.429 ^{NS}	31820.010**
Ca X AP	4	9.571**	6202.369 ^{NS}	14.040*	151.356 ^{NS}
Error	279	22.251	38763.051	85.376	5168.129

*Significant ((P<0.05), ** Significant ((P<0.01), NS-Non-significant

4.6 Calcium retention

The observation on Ca intake, excreted, retained and percent Ca retention by growing turkey in different dietary treatments as influenced by feeding different dietary levels of Ca and Av.P during metabolic trial (54-56 d of age) have been presented in Table 4.30 and its analysis of variance (ANOVA) in table 4.31.

Table 4.30: Calcium intake, excreted, retained and percent Ca retention of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments		Ca Retention			
Calcium (Ca %)	Av.Phosphorus (AP %)	Ca intake (g/b/d)	Ca excreted (g/b/d)	Ca retained (g/b/d)	Ca retention (%)
Interaction effect (Ca xAP)					
1.0-0.8	0.5-0.4	0.89	0.37	0.51	57.81
	0.6-0.5	0.86	0.37	0.5	57.58
	0.7-0.6	0.87	0.38	0.49	56.62
1.2-1.0	0.5-0.4	0.94	0.43	0.51	53.83
	0.6-0.5	0.98	0.46	0.52	53.11
	0.7-0.6	1.01	0.42	0.59	58.2
1.4-1.2	0.5-0.4	1.18	0.53	0.64	54.66
	0.6-0.5	1.14	0.56	0.58	50.62
	0.7-0.6	1.34	0.55	0.79	58.63
Pooled SEM		0.03	0.13	0.02	0.77
Main effect					
Calcium levels	1.0-0.8	0.87m	0.37m	0.50m	57.34
	1.2-1.0	0.98n	0.44n	0.54m	55.04
	1.4-1.2	1.22o	0.55o	0.67n	54.64
AP levels	0.5-0.4	0.59	0.39	0.2	34.28
	0.6-0.5	0.59	0.39	0.19	33.52
	0.7-0.6	0.6	0.4	0.2	34.56
Probabilities					
	Interaction	NS	NS	NS	NS
	Calcium	P<0.01	P<0.01	P<0.01	NS
	AP	NS	NS	NS	NS

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant

Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.31 : Analysis of variance for Ca intake, excreted, retained and percent Ca retention of growing turkeys fed diet variable levels of calcium available phosphorus

Source of variation	df	Mean Sum of Squares			
		Ca intake (g/b/d)	Ca excreted (g/b/d)	Ca retained (g/b/d)	Ca retention (%)
Calcium levels	2	0.379**	0.094**	0.096**	25.430 ^{NS}
AP levels	2	0.001 ^{NS}	0.000 ^{NS}	0.000 ^{NS}	2.031 ^{NS}
Ca X AP	4	0.015 ^{NS}	0.001 ^{NS}	0.015 ^{NS}	23.21 ^{NS}
Error	27	0.006	0.001	0.007	18.785

*Significant (P<0.05), ** Significant ((P<0.01), NS-Non-significant

The mean values of Ca intake (g/b/d), excreted (g/b/d) and retained (g/b/d) and percent Ca retention did not differ significantly due to interaction of Ca and Av.P in the diet. However, mean values of Ca intake (g/b/d), excreted (g/b/d) and retained Ca (g/b/d) differed significantly due to different levels of calcium in the diet. Calcium intake was significantly (P<0.01) linearly increased with increased concentration of Ca in the diet. Similarly, Ca excretion was also significantly (P<0.01) increased linearly as increasing the dietary concentration of Ca in the diet. The absolute retained value of Ca was significantly (P<0.01) higher at 1.4-1.2% Ca than those recorded at its lower levels of Ca in the diet. None-significant differences were recorded on Ca intake, excreted, retained and percent Ca retention due to different concentration of Av.P in the diet.

4.7 Phosphorus retention

The observation on phosphorus (P) intake, excreted, retained and percent P retention by growing turkey in different dietary groups as influenced by feeding different dietary levels of Ca and Av.P have been presented in Table 4.32. The differences among mean values have been analyzed and summarized in Table 4.33. The mean values of P intake (g/b/d), excreted (g/b/d), retained (g/b/d) and percent P retention did not differ significantly due to interaction between Ca and Av.P in the diet. Significant effect was seen on P intake and absolute retained value of P due to different levels of dietary Ca. Significantly (P<0.05) higher P intake was observed at 1.4-1.2% Ca than those recorded at its lower levels of Ca in the diet. Significantly

Table 4.32: Phosphorus intake, excreted, retained and percent P retention of growing turkeys fed diet variable levels of calcium and available phosphorus

Treatments	Av.Phosphorus (AP %)	P Retention			
		P intake (g/b/d)	P excreted (g/b/d)	P retained (g/b/d)	P retention (%)
1.0-0.8	0.5-0.4	0.50	0.30	0.20	40.68
	0.6-0.5	0.59	0.39	0.21	34.63
	0.7-0.6	0.69	0.50	0.19	27.54
1.2-1.0	0.5-0.4	0.49	0.30	0.19	39.29
	0.6-0.5	0.57	0.38	0.19	32.41
	0.7-0.6	0.70	0.49	0.18	28.86
1.4-1.2	0.5-0.4	0.51	0.30	0.20	39.79
	0.6-0.5	0.60	0.39	0.21	34.41
	0.7-0.6	0.70	0.50	0.20	28.27
Pooled SEM		0.01	0.01	0.01	1.11
Main effect					
Calcium levels	1.0-0.8	1.00 ^p	0.45	0.56 ^{mno}	55.43
	1.2-1.0	1.00 ^p	0.46	0.53 ^m	53.77
	1.4-1.2	1.07 ^q	0.45	0.62 ⁿ	57.82
AP levels	0.5-0.4	0.50 ^p	0.30 ^p	0.19	39.92 ^r
	0.6-0.5	0.58 ^q	0.39 ^q	0.19	33.82 ^q
	0.7-0.6	0.69 ^r	0.50 ^r	0.20	28.22 ^p
Probabilities					
	Interaction	NS	NS	NS	NS
	Calcium	P<0.05	NS	P<0.05	NS
	AP	P<0.01	P<0.01	NS	P<0.01

abc(Interaction),mno (Ca),pqr (AP), Value bearing different superscripts within a column differ significantly (P<0.05), (P<0.01), NS-Non-significant Ca levels: 0 to 4-5 to 8 wks age, AP levels: : 0 to 4-5 to 8 wks age

Table 4.33: Analysis of variance for P intake, excreted, retained and percent P retention of growing turkeys fed diet variable levels of calcium available phosphorus

Source of variation	df	Mean Sum of Squares			
		P intake (g/b/d)	P excreted (g/b/d)	P retained (g/b/d)	P retention (%)
Calcium levels	2	0.022*	0.001 ^{NS}	0.027*	49.728 ^{NS}
AP levels	2	0.115**	0.120**	0.005 ^{NS}	6.94**
Ca X AP	4	0.000 ^{NS}	0.458 ^{NS}	0.141 ^{NS}	0.209 ^{NS}
Error	27	0.001	0.000	0.001	26.407

*Significant (P<0.05), ** Significant (P<0.01), NS-Non-significant

($P < 0.05$) higher absolute retained value of P was recorded at 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca. However, absolute retained value of P recorded at 1.0-0.8% Ca was found intermediary. P intake and P excreted were significantly ($P < 0.01$) increased linearly with increasing dietary concentration of Av.P in the diet. Percent phosphorus retention was significantly ($P < 0.01$) decreased linearly with increased dietary concentration of Av.P in the diet. However, absolute retained value of P did not change significantly due to different levels of Av.P in the diet.





Discussion

The discussion of the present experiment conducted at the Division of Avian Nutrition and Feed Technology, CARI, Izatnagar in order to study the effect of feeding varying dietary levels of calcium and available phosphorus on growth performance and skeletal health of CARIVIRAT growing turkey poults have been discussed under this chapter.

5.1. Growth performance

5.1.1 Body weight and body weight gain (BW and BWG)

Diet formulating to meet the minimum requirement of calcium and phosphorus for growing turkey is a complex task, which needs a large number of interacting factors to be considered, otherwise any one of which can influence the bird's calcium and phosphorus requirements. The impact of dietary Ca and P on the growth performance of developing turkeys has been investigated by many workers. NRC (1994) has stated that 1.2 and 1.0% calcium and 0.6 and 0.5 % phosphorus required in the diet of growing turkey during 0-4 and 5-8 weeks, respectively, for optimum growth performance. Similarly, ICAR (2013) stated that 1.2 and 1.0% calcium and 0.55 and 0.50% phosphorus required in the diet of growing turkey during 0-6 and 6-12 weeks of age, respectively for optimum growth performance. In the present finding significantly ($P<0.01$) higher BWG was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.2-1.0 % Ca with 0.7-0.6%Av.P than those observed in other dietary combinations during 0-4wks of age. During 5-8wks of age, significantly ($P<0.05$) higher body weight gain was recorded in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.0-0.8% Ca with 0.7-0.6% Av.P than those

observed in other dietary combinations. During 0-8wks of age, significantly ($P<0.01$) higher body weight gain was recorded in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P than those observed in other dietary combinations. The maximum body weight gain was obtained in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P during 0-4, 5-8 and 0-8wks of age. It seems that dietary level of Ca and Av.P in the diet of growing turkey poult during 0-4, 5-8 and 0-8wks of should be 1.0-0.8% Ca with 0.5-0.4% Av.P. Present results get support from earlier observation reported by Tatara et.al.(2011) suggested that dietary calcium needs of growing turkey is 1.02 and 0.85 % during 0-4 and 5-8 weeks respectively for optimum growth performance. However, slightly higher levels of available phosphorus were suggested by ICAR (2013). In contrary to present finding Sullivan et.al.(1959) reported that the optimum growth performance were obtained when diet fed 1.55 % calcium with 0.70 to 0.80% and 0.75 to 0.85 % total phosphorus to female and male growing turkey, respectively. Similarly, Motzok and Slinger (1948) conducted three experiments on calcium and phosphorus requirement in the diet of growing turkey from 0-5weeks of age and fed variable dietary calcium and phosphorus levels in the diet in (Expt-1 constant Ca level (1.6%) with variable P (0.7 to 1.7%), Expt.2 variable Ca (0.9 to 2.3%) and constant P level (0.7%) and Expt.3 variable Ca (1.2 to 2.0%) and constant P level (1.0%). Based on the results of 3 experiments authors suggested that considering growth and bone ash in growing turkey during 0-5 weeks of age, the best results were obtained when the ration contained approximately 2.0% calcium and 1.0% phosphorus.

5.1.2 Feed intake (FI)

In the present results significantly ($P<0.01$) higher FI was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.2-1.0 % Ca with 0.6-0.5%Av.P than those observed in other dietary combinations during 0-4 wks of age. During 5-8 and 0-8wks of age, significantly ($P<0.05$) higher FI was recorded in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those observed in other dietary combinations. It seems that dietary level of 1.0-0.8% Ca with 0.5-0.4% Av.P could satisfy the optimum feed intake and efficiency of feed utilization. Contrary to the present finding Sanders et.al.(1992) reported that feeding variable levels of dietary Ca (0.8,10.0,12.0 and 14.0 g/kg) and TP

(7.0,9.0,11.0 and 13.0g/kg) to very young growing turkey had little effect on body weight and efficiency of feed utilization and concluded that 12.4 Ca g/kg with 10.2 TP g/kg are adequate for optimum growth performance from 0 to 16 days of age. Similarly, Hocking *et al.* (2002) reported that diet fed with variable levels of Ca (6,10,14 and 18g/kg) and Av P (3, 5, 7 and 9 g/kg) to large white male turkey from 4-13 weeks of age had no influence on feed intake and efficiency of feed utilization and authors concluded that the maximum body weight at 7, 10 & 13 wks of age was obtained with 1.0 % Ca and 0.3% available phosphorus.

5.1.3 Feed conversion ratio (FCR)

In the present results significantly ($P < 0.05$) lower and better FCR was observed in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations during 0-4wks of age. However, during 5-8 and 0-8wks of age, cumulative FCR was not differed significantly due to interactions between Ca and Av.P levels in the diets. In the present finding during all growth phases' better efficiency of feed utilization was obtained in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P. It seems that if dietary levels of Ca or available phosphorus increased from above level did not improved efficiency of feed utilization. Sanders *et al.* (1992) reported that feeding variable levels of dietary Ca (0.8,10.0,12.0 and 14.0 g/kg) and TP (7.0,9.0,11.0 and 13.0g/kg) to very young growing turkey had little effect on body weight and efficiency of feed utilization and concluded that 12.4 g/kg Ca with 10.2 g/kg TP are adequate for optimum growth performance from 0 to 16 days of age. Hocking *et al.* (2002) reported that diet fed with variable levels of Ca (6,10,14 and 18g/kg) and Av P (3, 5, 7 and 9 g/kg) to large white male turkey from 4-13 weeks of age had no influence on feed intake and efficiency of feed utilization and authors concluded that the maximum body weight at 7, 10 & 13 Wks of age was obtained with 1.0 % Ca and 0.3% available phosphorus. Tatara *et al.* (2011) reported that no significant effect on body weight was observed when diet fed 0.99-1.33 and 0.85-1.10 % calcium and 0.79- 1.06 and 0.71- 0.93% total P during 0-4 weeks and 5-8 weeks of age, respectively.

5.1.4 Mortality/Survivability

In the present study the overall mortality was observed 5.20 % which is under normal limit (5.0%). This reveals that mortality was not affected due to different dietary treatments.

Finding of present study supported by Skinner *et al.* (1992) conducted a trial by feeding of maize-soybean diets supplemented with 0.12% non-phytate P and 0.06, 0.12, 0.24, 0.36, 0.48 and 0.60% Ca or 0.2% non-phytate P with 0.16, 0.24, 0.36, 0.48 and 0.60% Ca to male broilers (42-56 d) and reported that in terms of mortality, there were no changes between broilers fed supplemented and control diets (0.35% non-phytate P and 0.8% Ca). Scheideler *et al.* (1995) indicated that dietary interventions had no effect on total mortality in Trial 1 (100 and 140% NRC Ca and P for 0-7 wk; 140% NRC Ca and P for 0-3 wk followed by 100% NRC Ca and P for 4-7 wk) and Trial 2 (85, 100 and 140% NRC Ca and P for 0-7 wk), but In Trial 3, there was a substantial increase, where Ca was provided at greater amounts in the diet (85% NRC Calcium and Phosphorus for 0-9 wk; 100% NRC Ca and 85% NRC P for 0-9 wk). They further mentioned that the sudden death syndrome (SDS) mortality was significantly increased by higher dietary Ca and P in Trial 1 and 3. Average SDS mortality was 2.61, 2.39 and 2.52% for Trial 1, 2 and 3, respectively.

5.1.5 Skeletal health

In the present results all the experimental birds appeared quit normal and apparently healthy but for variable body growth. No marked clinical sign of illness and skeletal defects were observed in the flock due to feeding different levels of Ca and Av.P. Even the slight extent of lameness, deviated toe, and swollen hock joint and general depression had been unnoticed due to various dietary regimens. The nutritional abnormalities resulting in avian rickets are usually related to alteration in dietary levels of Ca, P or vitamin D3 and errors in feed formulation or mixing (Wise, 1975). Hocking *et al.*(2002) reported that there is no evidence that dietary changes have a major impact of Ca or available P on culling or walking ability when diet fed variable levels of Ca (6, 10, 14 and 18g/kg) and available P (3,5,7 and 9 g/kg). Hocking *et al.*(2002) Variable dietary Ca (6, 10, 14, and 18 g/kg) and Av P (3, 5, 7, and 9 g/kg) had no impact on the prevalence of the lesion, except in turkeys fed a diet containing 6 g Ca/kg, where body weight and tibial dyschondroplasia incidence were low. As per authors low dietary Ca was also linked to lower tibial plateau angles at 10 - 13 wks of age.

5.2 Cellular and Humoral Immunity and Immune organs weight

In the present finding significantly ($P < 0.01$) higher cellular immune response foot web index to PHAP was recorded in a dietary combination of 1.2-1.0% Ca with 0.6-0.5% Av.P than those recorded in other dietary combinations. Significantly ($P < 0.05$) higher cellular immune response (foot web index to PHAP) was recorded at 1.2-1.0 Ca than 1.0-0.8% Ca in the diet. Humoral immune response (HA titre to SRBC) was recorded significantly ($P < 0.05$) higher at 1.2-1.0 and 1.4-1.2% Ca than that recorded at 1.0-0.8% Ca in the diet. Humoral immune response (HA titre to SRBC) was recorded significantly ($P < 0.05$) higher at 0.6-0.5% Av.P than that recorded at 0.5-0.4% Av.P. From above results it seems that higher level of calcium and available phosphorus is required for improved immune response of the birds. Present results get support from earlier observation reported by Emami *et al.* (2013) noticed that broiler fed diets low in NPP supplemented with phytase @ 500unit/kg and 0.2% commercial organic acid, significantly improved immune response to SRBC as compared to non-supplemented phytase and organic acid. Hofmann *et al.* (2021) reported that dietary calcium is correlated with changes in several immune parameters irrespective of strain, hens fed the Ca diets had lower numbers of immune cells, especially T cells, in blood and cecal tonsils. Authors also suggested that higher P availability was associated with enhanced immune function. Makola *et al.* (2021) reported that nano-dicalcium phosphate substitution in broiler diet at levels of 40% and 50% could improve broiler chicken immunological response and intestinal morphology.

In the present results significantly ($P < 0.01$) higher thymus weight was recorded in a dietary combination of 1.2-1.0% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. The various immune organs were recorded significantly higher at 1.2-1.0% Ca than other two levels of Ca in the diet. Significantly ($P < 0.01$) higher thymus weight was recorded at 0.5-0.4 and 0.6-0.5% Av.P than that observed at 0.7-0.6% Av.P. Bursa and spleen weight did not differed significantly due to different levels of Av.P in the diets. Kidd (2004) reported that sub nutrition impaired the bird's ability to mount an effective response in natural and acquired immunity. At first sight, the results of the present study may appear contradictory to other studies in which higher P availability was associated with enhanced immune function (Nie *et al.*, 2018). Dietary Ca was also shown to be associated with alterations in several immune

parameters in the present study. Ca deficiency leads to an increase in parathyroid hormone which, in turn, promotes the production of 1, 25-dihydroxyvitamin D3 (1, 25-(OH)2D3 (Singh *et al.*, 1986). 1, 25 (OH)2D3 interacts with the vitamin D receptors that have been found in various cells in the body, including immune cells (Veldman *et al.* 2000) indicating immunomodulatory properties (Martens *et al.* 2020).

5.3 Serum bio-chemical parameters

Many factors, including genetics, nutrition, minerals, and vitamins, climate, rearing technique, age and other physiological factors can all play a role in altering the blood constituents. In the present finding significantly higher albumin and albumin/globulin ratio were recorded at 1.4-1.2% Ca than those recorded in other dietary levels of Ca in the diets. Significantly ($P < 0.01$) higher glucose value was recorded at 0.6-0.5% Av.P than those recorded in other dietary levels of Av.P in the diets. The present study may appear contradictory to other studies reported by Attia *et al.* (2020) who that increasing the dietary Ca from 3.5 to 4.5%, significantly decreased albumin/globulin ratio from 1.15 to 0.89 and albumin value did not change significantly due to increasing dietary Ca levels in layer diets. In the present finding significantly ($P < 0.01$) linear increase in serum Ca as increasing Ca levels from 1.0-0.8 to 1.4-1.2% in the diet. Present results get support from earlier observation reported by McMurtry *et al.* (1983) reported that Plasma ionised calcium was 35% of total calcium in poults, and it was affected by a food withholding and feeding regimen. The link between ionised and total calcium, according to the author, would be the ideal index for relating calcium homeostasis and physiological state. Hocking *et al.* (2002) conducted an experiment involving large white male turkey from heavy commercial male line were fed sixteen diets, containing four concentration of Ca (6, 10, 14 and 18 g/kg) and available P (3, 5, 7 and 9 g/kg) in a factorial experiment. Dietary calcium was favourably related with blood Ca and Ca ion concentrations, but had no influence on blood phosphorus. In the present results significantly ($P < 0.01$) higher alkaline phosphatase activity was recorded at 0.5-0.4% Av.P than those recorded in other levels of Av.P in the diets. Contradictory finding were also reported by Fernandes *et al.* (1999) reported an increased plasma alkaline phosphatase (ALP) 6674 vs 8693 units/litre by addition of incremental dietary AP (0.8 vs 0.16 % from different sources in control diet containing 0.23% AP. They further,

suggested that supplementing diet with agriculture and feed grade phosphates caused elevation of 9617 and 6136 unit/lit ALP activity, respectively. Similar to present finding Deo *et al.* (2006) reported that serum ALP and calcium (Ca) significantly increased as decreasing dietary AP levels and serum phosphorus concentration were increased as increasing dietary AP levels.

5.4 Bone morphometry

Despite years of research, the bone disorders leading to leg weakness or lameness remain significant contributor to concern in turkey production. Among them the rickets and tibial dyschondroplasia (TD) are the most commonly encountered skeletal deformities, of Ca and P deficiency. Skinner *et al.* (1992) opined that the diet with 0.56 % Ca and 0.12 % NPP content affected length of tibia adversely on comparing to those fed with control diet containing 0.80 % Ca and 0.35 % NPP. In the present finding significantly ($P < 0.05$) higher tibia bone length was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.4-1.2% Ca with 0.5-0.4% Av.P, 1.0-0.8% Ca with 0.7-0.6% Av.P, 1.2-1.0 % Ca with 0.7-0.6% Av.P than those observed in other dietary combinations. It seems that dietary Ca level (1.0-0.8%) with Av.P (0.5-0.4%) during 0-4 and 5-8wks of age was found adequate for optimum bone development because further increasing dietary Ca and Av.P from 1.2 to 1.4% and 0.6-0.7% respectively during 0-4 wks of age and 1.0 to 1.2% and 0.5 to 0.6% respectively during 5-8wks of age did not improve bone length and width of tibia bone. In contrary to present finding Deo *et al.* (1996) were unable to observed any significant influence of the Ca, P and vitamin D₃ contents on the length of tarsometatarsal bone of broiler chicks. On the other hand, length of tibia was reduced as a result of low P content in diet of broiler chicks (Moran and Todd, 1994). Mohamed (2020) reported that the length of tibia was not affected by reducing levels of 0.4% NPP in starter and 0.2 % NPP in finisher diet in broiler chicks. Tataru *et al.* (2011) reported that Boosted calcium supply in the diet increased skeletal system features, which were increased and created the most desirable traits such as bone weight, length, and volume in turkey consuming 95, 105, and 115 percent of the NRC calcium requirement.

5.5.1 Bone mineralization

Skeletal health could be adversely influenced by diets with an imbalance of the Ca: NPP ratio. The bone ash has been the principal criterion of evaluating dietary Ca and/or P contents for poultry in numerous studies (Fritz *et al.*, 1969). Waldroup *et al.* (1963) stated that the bone ash values were more responsive to Ca and/or P levels than body weights. In the present finding significantly ($P < 0.01$) higher dry tibia bone weight was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.4-1.2% Ca with 0.5-0.4% Av.P, 1.2-1.0% Ca with 0.7-0.6% Av.P, 1.4-1.2% Ca with 0.7-0.6% Av.P, 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.4-1.2% Ca with 0.6-0.5% Av.P and 1.0-0.8% Ca with 0.7-0.6% Av.P than those recorded in other dietary combinations. It seems that dietary Ca 1.0-0.8% with Av.P 0.5-0.4% is sufficient for optimum bone weight as well as ash weight. Present results get support from earlier observation reported by Shafey *et al.* (1990b) observed 41.2, 40.4 and 38.9% tibia ash in 17-d old chickens fed diets with 1.2, 2.2 and 3.2% Ca levels respectively and reported that the tibia ash content reduced as the dietary Ca level was increased. Similar depression in bone ash values was seen by Scheideler (1995) in chickens fed the diet containing 1.8% against 1.0% Ca. The Ca and P levels in serum and bone can reflect the nutritional status of Ca and P in broilers. Insufficient Intake of one or both mineral interferes with homeostasis of second one, resulting in retarded growth and poor bone mineralization (Shafey *et al.*, 1990; Hurwitz *et al.*, 1995). In the present finding % bone ash value indicated insignificant differences due to different dietary Ca and Av.P. Similar finding were also reported by Deo *et al.* (1996) who found that no significant effect on total ash in tarsometatarsal bone, due to due to feeding different levels of Ca, P and vit.D3. However, an increase in P or D3 in diet could elevate the bone ash. In the present finding linear improvement ($P < 0.01$) in tibia bone Ca content was observed with increase Ca concentration in the diet from 1.0-0.8 to 1.4-1.2%. Linear decreased ($P < 0.01$) in tibia bone Ca content was observed with increase Av.P concentration in the diet from 0.5-0.4 to 0.7-0.6%. Significantly ($P < 0.01$) higher tibia bone phosphorus was recorded at 0.6-0.5 and 0.7-0.6% Av.P than that recorded at 0.5-0.4% Av.P in the diet. The other tibia bone mineralization traits did not differed significantly due to different levels of Av.P in the diets. Present results get support from earlier observation reported by Sohail and Roland (1999)

who found that on increasing the AP concentration in broiler diet, there was significant increase in the tibiae Ca and P. Similarly, El Boushy (1979) found that tibiae P increased with increasing P content in broiler diet. In contrary to present finding Deo *et al.* (1996) reported that Ca and P content of tarsometatarsal bone of chicks did not varied due to different levels of Ca P and vit D3.

5.5.2 Bones trace minerals

In the present finding significantly ($P < 0.01$) linear increased in copper content in tibia bone was recorded as increasing dietary Ca concentration from 1.0-0.8% to 1.4-1.2% during 0-4 - 5-8wks of age. Significantly ($P < 0.05$) higher tibia manganese content was recorded at 1.2-1.0% Ca than 1.0-0.8% Ca. However, tibia bone manganese content observed at 1.4-1.2% Ca was found intermediary. Significantly ($P < 0.01$) higher tibia copper content was noticed at 0.6-0.5% Av.P than those recorded in other levels of dietary Av.P. Significant ($P < 0.01$) gradual decreased in tibia iron content as increasing the dietary Av.P in the diet from 0.5-0.4% to 0.7-0.65 Av.P during 0-4 – 5-8wks of age. Present results get support from earlier observation reported by Rao *et al.* (2003) who found that decreased concentrations of zinc, manganese and iron in liver with increased calcium and phosphorus in diet suggesting reduced availability of these minerals at disproportionate or higher levels of Ca and available phosphorus in the diet. Tibia Copper and manganese concentration were increased with increasing dietary Ca levels in the diets. Whereas, tibia iron concentration was significantly reduced with increasing dietary concentration of Av.P.

5.6 Calcium retention

The ability of birds to utilize dietary Ca varies significantly depending on the age, genotype, dietary energy, protein and fibre content, source and levels of calcium, source and levels of phosphorus and vitamin D3 in the diet as reported by Edward (1982), Ballam *et al.* (1984) and Baghel and Pradhan (1990). In the present finding calcium intake was significantly ($P < 0.01$) linear increased with increased concentration of Ca in the diet. Similarly, Ca excretion was also significantly ($P < 0.01$) increased linearly as increasing the dietary concentration of Ca

in the diet. Present results get support from earlier observation reported by Rao *et al.* (1999) reported that increasing the dietary levels of Ca and P, significantly increased Ca and P excretion because the excess quantity of Ca and P consumed beyond the absolute requirement might have been excreted. The absolute retained value of Ca was significantly ($P < 0.01$) higher at 1.4-1.2% Ca than those recorded at its lower levels of Ca in the diet. However, percent Ca retention did not change significantly due to different levels Ca and Av.P in the diet. Rao *et al.* (2003) reported that excretion of Ca and P was significantly lower at lower levels of Ca and NPP tested (6 and 3g/kg diet, respectively) as observed in present finding.

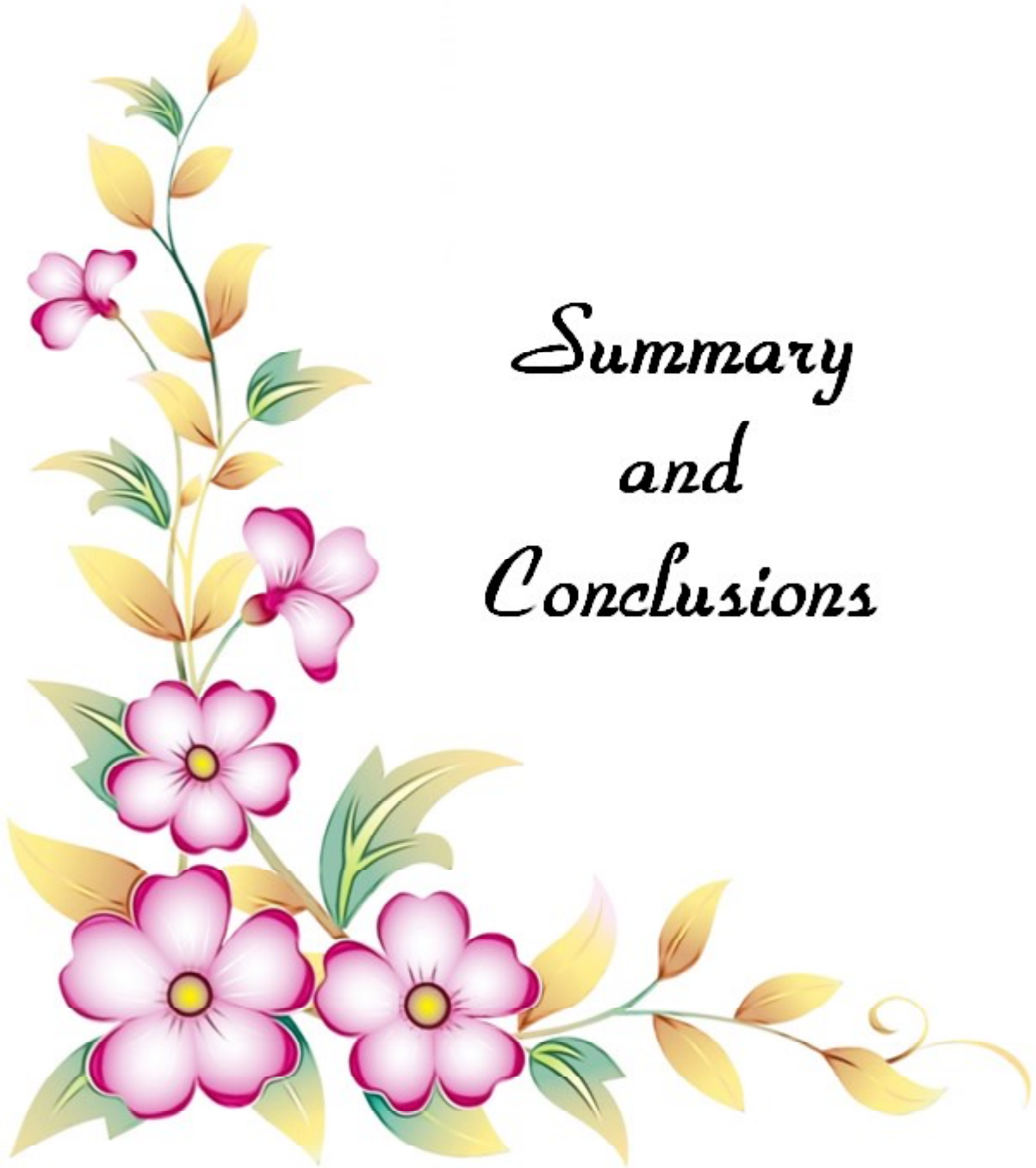
5.7 Phosphorus retention

The ability of birds to utilize dietary P depending on various factors such as age, genotype, dietary energy, protein and fibre content, source and levels of calcium, source and levels of phosphorus and vitamin D₃ in the diet as reported by Edward (1982), Ballam *et al.* (1984) and Baghel and Pradhan (1990). In the present results significantly ($P < 0.05$) higher P intake was observed at 1.4-1.2% Ca than those recorded at its lower levels of Ca in the diet. Present results get support from work reported by Rao *et al.* (1999) reported that increasing the dietary levels of Ca and P, significantly increased Ca and P excretion because the excess quantity of Ca and P consumed beyond the absolute requirement might have been excreted. In the present finding P intake and P excreted were significantly ($P < 0.01$) increased linearly with increasing dietary concentration of Av.P in the diet. Percent phosphorus retention was significantly ($P < 0.01$) decreased linearly with increased dietary concentration of Av.P in the diet. Similar results were also reported by Edwards and Veltmann (1983) and Punna and Roland (1999) opined that phytate P was more efficiently retained when chickens were fed suboptimal levels of NPP. Shafey *et al.* (1990) reported that an increased dietary AP caused reduction in excreta moisture as well as increase in P consumption and excretion. Pernery *et al.* (1993) reported that increasing levels of AP in the diet of broiler chicks increased significantly P intake, P-excretion and numerically P retention. In contrary, Sebastian (1996) suggested that low (0.33%) AP diet did not change relative retention of P, but numerically brought about higher P retention as compared to high AP (0.46%) diet at 10-d age but not in 17-d age.

Ravindran *et al.* (2000) found that the dry matter retention decreased when the NPP concentration was increased by addition of inorganic P supplements. They further reported significantly higher P retention in low AP diet (0.23%) as compared to normal AP diet (0.45%) in birds.



*Summary
and
Conclusions*



Calcium (Ca) is a major element found in the body in largest quantity. About 99% of body calcium is present in bones as structural component of skeleton system, while remaining 1% calcium is present in soft tissues and body fluids. Calcium is involve in various physiological functions like helps in coagulation of blood and liberation of insulin, regulate acid-base balance, excitability of nerves, permeability of cell membrane, heart beat and muscle tone and activates digestive enzymes. It is essential component of eggshell in laying hens. A dietary deficiency of calcium causes growth retardation, reduced feed intake, increased BMR, rickets or osteoporosis, abnormal posture and gait, decreased activity and sensitivity, susceptibility to internal hemorrhages, reduced life span, increased urine volume, tetany, decreased egg production and reduced shell thickness which may bring to huge economic losses in the turkey production. Similarly, Phosphorus (P) is a critical and most expensive mineral in poultry diet, which plays a vital role in energy metabolism, DNA and RNA synthesis and many other bio-functions such as maintenance of acid-base balance, cell-oxidative phosphorylation, egg shell formation, energy transfer mechanism, skeletal development etc. Phosphorus deficiency can hinder growth in birds and cause the onset of rickets or even death, if it is severe. Major quantity (more than 50%) of P contained in feedstuffs of plant origin is phytic acid. The salts of phytic acid are named as phytates. In general, phytate account for about two thirds of the total P present in plants. Non-ruminants such as poultry and pig have virtually no phytase activity of their own. Thus, the availability of P in feedstuffs of plant origin is generally low, ranging from 30 to 40 percent.

With change in genetic make-up and the managerial practices for the fast growing and high yielding turkey, it is possible that the requirement of calcium and phosphorus for modern rapidly growing genotypes are higher than in the past. Efforts have been made by several researchers to define the calcium and phosphorus requirement for growing turkey but with variable results. Calcium and phosphorus requirement-related studies have been concerned with birds maintained under temperate conditions and it is quite possible that these results may not be applicable to the birds reared in tropical environments.

An eight week biological experiment was undertaken with an aim to study the response of growing turkey to different levels of dietary Calcium and available phosphorus with respect to the growth performance, immune response, blood biochemical parameters, skeletal growth and retention of calcium and phosphorus. For the study, 288 straight run day-old CARI Virat turkey chicks developed at Central Avian Research Institute, Izatnagar - 243122 were randomly distributed into 36 groups. Nine dietary treatments with three levels of calcium (1.0/0.8, 1.2/1.0 and 1.4/1.2%) each with three levels of available phosphorus (0.5/0.4, 0.6/0.5 and 0.7/0.6%) during 0-4/5-8 weeks of age were formulated following 3 (Ca) x 3 (Av.P) in a factorial design.

During 0-8wks of age, significantly ($P<0.01$) higher body weight gain was recorded in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P than those observed in other dietary combinations. Significantly ($P<0.01$) higher BWG was observed at 1.0-0.8% Ca than those recorded in other levels of Ca in the diets during 0-4, 5-8 and 0-8wks of age. No-significant differences were noticed on BWG due to different levels of Av.P in the diets. During 0-8wks of age, significantly ($P<0.05$) higher FI was recorded in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P than those observed in other dietary combinations. Significantly ($P<0.05$) higher FI was recorded at 1.0-0.8% Ca than 1.2-1.0% Ca in the diet during 0-8wks of age. No-significant differences were noticed on cumulative FI due to different levels of Av.P in the diets during 0-8wks of age. During 0-8wks of age, cumulative FCR did not differed significantly due to interactions between Ca and Av.P levels in the diets. During 0-8 wks of age, significantly lower and better FCR was recorded at 1.0-0.8 and 1.4-1.2% Ca than that observed at 1.2-1.0% Ca in the diets. No-significant differences were recorded on

cumulative FCR due to different levels of dietary Av.P during 0-8wks of age. The mortality or liveability of growing turkey did not change due to different levels of Ca and Av.P. No marked clinical sign of illness and skeletal defects were observed in the flock due to feeding different levels of Ca and Av.P. Even the slight extent of lameness, deviated toe, and swollen hock joint and general depression had been unnoticed due to various dietary regimens.

Significantly ($P<0.01$) higher cellular immune response foot web index to PHAP was recorded in a dietary combination of 1.2-1.0% Ca with 0.6-0.5% Av.P than those recorded in other dietary combinations. Significantly ($P<0.05$) higher cellular immune response (foot web index to PHAP) was recorded at 1.2-1.5% Ca than 1.0-0.8% Ca in the diet. Humoral immune response (HA titre to SRBC) was recorded significantly ($P<0.05$) higher at 1.2-1.0 and 1.4-1.2% Ca than that recorded at 1.0-0.8% Ca in the diet. Humoral immune response (HA titre to SRBC) was recorded significantly ($P<0.05$) higher at 0.6-0.5% Av.P than that recorded at 0.5-0.4% Av.P. Significantly ($P<0.01$) higher thymus weight was recorded in a dietary combination of 1.2-1.0% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. Significantly ($P<0.05$) higher bursa weight was recorded at 1.2-1.0% Ca than 1.4-1.2% Ca in the diet. Significantly ($P<0.05$) higher spleen weight was observed at 1.2-1.0% Ca than 1.0-0.8% Ca in the diet. Significantly ($P<0.05$) higher thymus weight was observed at 1.2-1.0% Ca than those recorded at other two levels of Ca in the diets. Significantly ($P<0.01$) higher thymus weight was recorded at 0.5-0.4 and 0.6-0.5% Av.P than that observed at 0.7-0.6% Av.P.

The various blood biochemical parameters namely serum total protein, albumin, globulin, albumin/globulin ratio, glucose, serum alkaline phosphatase (ALP), serum calcium and phosphorus did not differ significantly due to interaction between Ca and Av.P levels in the diets. Significantly ($P<0.01$) linear increased in serum Ca as increasing Ca levels from 1.0-0.8 to 1.4-1.2% in the diet. Significantly ($P<0.01$) higher alkaline phosphatase activity was recorded at 0.5-0.4% Av.P than those recorded in other levels of Av.P in the diets.

Significantly ($P<0.05$) higher tibia bone length was observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P followed by 1.0-0.8% Ca with 0.6-0.5% Av.P, 1.4-1.2% Ca with 0.5-0.4% Av.P, 1.0-0.8% Ca with 0.7-0.6% Av.P, 1.2-1.0 % Ca with 0.7-

0.6% Av.P than those observed in other dietary combinations. Significantly ($P < 0.01$) higher tibia bone length and width were recorded at 1.0-0.8% Ca than those recorded at other levels of Ca in the diets. Non-significant differences were recorded on various bone morphometry parameters due to different levels of dietary available phosphorus in the diets.

Significantly ($P < 0.01$) higher dry tibia bone weight and ash weight were observed in a dietary combinations of 1.0-0.8% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. Fresh bone weight was significantly ($P < 0.05$) higher at 1.0-0.8% Ca than that recorded at 1.2-1.0% Ca in the diet. Significantly ($P < 0.05$) higher bone weight and ash weight were recorded at 1.0-0.8 and 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca in the diet. Linear improvement ($P < 0.01$) in tibia bone Ca content was observed with increase Ca concentration in the diet from 1.0-0.8 to 1.4-1.2 %. Linear decreased ($P < 0.01$) in tibia bone Ca content was observed with increase Av.P concentration in the diet from 0.5-0.4 to 0.7-0.6 %. Significantly ($P < 0.01$) higher tibia bone phosphorus was recorded at 0.6-0.5 and 0.7-0.6 % Av.P than that recorded at 0.5-0.4% Av.P in the diet.

Significantly ($P < 0.01$) higher copper content in tibia bone was observed in a dietary combinations of 1.4-1.2% Ca with 0.6-0.5% Av.P than those recorded in other dietary combinations. Significantly ($P < 0.05$) higher manganese content in tibia bone was recorded in a dietary combination of 1.2-1.0% Ca with 0.5-0.4% Av.P than those recorded in other dietary combinations. Significantly ($P < 0.01$) linear increased in copper content in tibia bone was recorded as increasing dietary Ca concentration from 1.0-0.8% to 1.4-1.2% during 0-4 - 5-8wks of age. Significantly ($P < 0.05$) higher tibia manganese content was recorded at 1.2-1.0% Ca than 1.0-0.8% Ca. Significant ($P < 0.01$) gradual decreased in tibia iron content as increasing the dietary Av.P in the diet from 0.5-0.4% to 0.7-0.65 Av.P during 0-4 – 5-8wks of age.

Calcium intake was significantly ($P < 0.01$) linear increased with increased concentration of Ca in the diet. Similarly, Ca excretion was also significantly ($P < 0.01$) increased linearly as increasing the dietary concentration of Ca in the diet. The absolute retained value of Ca was significantly ($P < 0.01$) higher at 1.4-1.2% Ca than those recorded at its lower levels of Ca in

the diet. None- significant differences were recorded on Ca intake, excreted, retained and percent Ca retention due to different concentration of Av.P in the diet.

Significantly ($P<0.05$) higher P intake was observed at 1.4-1.2% Ca than those recorded at its lower levels of Ca in the diet. Significantly ($P<0.05$) higher absolute retained value of P was recorded at 1.4-1.2% Ca than that recorded at 1.2-1.0% Ca. However, absolute retained value of P recorded at 1.0-0.8% Ca was found intermediary. P intake and P excreted were significantly ($P<0.01$) increased linearly with increasing dietary concentration of Av.P in the diet. Percent phosphorus retention was significantly ($P<0.01$) decreased linearly with increased dietary concentration of Av.P in the diet.

Salient observations

- Significantly ($P<0.01$) higher body weight and gain in body weight with better efficiency of feed utilization and livability of growing turkey were found in a dietary combination of 1.0-0.8 % calcium with 0.5-0.4% available phosphorus during 0 to 4 – 5 to 8 weeks of age.
- Skeletal defects were not observed in the flock due to feeding different levels of Ca and Av.P. Even the slight extent of lameness, deviated toe, and swollen hock joint and general depression had been unnoticed due to various dietary regimens.
- Significantly better cellular and humoral immune response was achieved in a dietary combination of 1.2-1.0% Ca with 0.6-0.5% Av.P.
- Significantly higher immune organs weight was achieved in a dietary combination of 1.2-1.0% Ca with 0.5-0.4 or 0.6-0.5% Av.P.
- Various serum biochemical parameters did not influenced significantly due to interaction between Ca and Av.P in the diet. However, serum Ca increased with increased concentration of Ca in the diet but alkaline phosphatase activity decreased with increased concentration of Av. P in the diet.
- Serum albumin and albumin/globulins ratio was increased significantly with higher level of Ca in the diet.

- Tibia bone length was found significantly ($P < 0.05$) higher in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P during 0 to 4 - 5 to 8 wks of age.
- Tibia bone length, mid shaft and distal width were significantly higher at 1.0-0.8 % Ca in diet during 0 to 4 – 5 to 8wks of age.
- Tibia dry bone weight and total ash weight was significantly higher in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P.
- Tibia bone Ca was significantly increased with increased dietary concentration of Ca. Similarly, tibia bone Ca decreased significantly with increased dietary concentration of Av.P.
- Tibia bone phosphorus was significantly increased with increased concentration of Av.P in the diet.
- Tibia Copper and manganese concentration were increased with increasing dietary Ca levels in the diets. Whereas, tibia iron concentration was significantly reduced with increasing dietary concentration of Av.P.
- Significantly higher excretion of calcium and phosphorus were observed at higher levels of calcium and available phosphorus in the diet.
- Significantly higher retention/utilization of calcium and phosphorus was recorded at lower levels of calcium and available phosphorus in the diet.

Conclusions

A dietary concentration of 1.0 and 0.80% Calcium with 0.50 and 0.40% available phosphorus during 0-4 and 5-8 weeks of age respectively was found adequate to achieve optimum growth performance, skeletal health, serum biochemical parameters and better utilization of calcium and phosphorus in CARIVirat growing turkey. However, better immune response was realized with dietary concentration of 1.2 and 1.0 % calcium with 0.60 and 0.50 % available phosphorus during 0-4 and 5-8 weeks of age, respectively.





Mini Abstract

The proposed study was undertaken with aim to evaluate the effect of feeding varying dietary calcium and phosphorus levels on the growth performance and skeletal health of turkey poults. A eight weeks (0-8wks) feeding trial was conducted as per (3*3) factorial design involving three levels of calcium (1.0/0.8, 1.2/1.0 and 1.4/1.2%) each with three levels of available phosphorus (0.5/0.4, 0.6/0.5 and 0.7/0.6%) during 0-4 and 5-8 weeks of age were formulated in an standard turkey diet. Day old (n=288) CARIVIRAT turkey poults distributed into nine dietary treatments with four replicates and each replicates having 8 poults each. Results indicated that Significantly ($P<0.01$) higher body weight and gain in body weight with better efficiency of feed utilization and livability of growing turkey were found in a dietary combination of 1.0-0.8 % calcium with 0.5-0.4% available phosphorus during 0-4 and 5-8 weeks of age. Significantly better cellular & humoral immune response and higher immune organs weight were achieved in a dietary combination of 1.2-1.0% Ca with 0.5-0.4 or 0.6-0.5% Av.P. Serum Ca increased with increased concentration of Ca in the diet and serum ALP activities decreased as increased level of Av.P in the diet. Serum albumin and albumin/globulins ratio was increased significantly with higher level of Ca in the diet. Tibia bone length ($P<0.05$), mid shaft and distal width were significantly higher at 1.0-0.8 % Ca in diet during 0-4 and 5-8wks of age. Tibia dry bone weight and total ash weight were significantly higher in a dietary combination of 1.0-0.8% Ca with 0.5-0.4% Av.P. Tibia bone Ca was significantly increased with increased dietary concentration of Ca. Similarly, tibia bone Ca decreased significantly with increased dietary concentration of Av.P. Tibia bone phosphorus was significantly increased with increased concentration of Av.P in the diet. Tibia Copper and Manganese concentration were increased with increasing dietary Ca levels in the diets. Whereas, Tibia Iron concentration was significantly reduced with increasing dietary concentration of Av.P. Significantly higher excretion of Ca and P were observed at higher levels of Ca and Av.P in the diet. Significantly higher retention/utilization of calcium and phosphorus was recorded at lower levels of Ca and Av.P in the diet. Based on the results it was concluded that dietary concentration of 1.0 and 0.80% Ca with 0.50 and 0.40% Av.P during 0-4 and 5-8 weeks of age respectively was found adequate to achieve optimum growth performance, skeletal health, serum biochemical parameters with better utilization of calcium and phosphorus in CARIVIRAT growing turkey. However, better immune response was realized with dietary concentration of 1.2 and 1.0 % calcium with 0.60 and 0.50 % available phosphorus during 0-4 and 5-8 weeks of age, respectively.



लघु सारांश

प्रस्तावित अध्ययन टर्की के मुर्गे के विकास प्रदर्शन और कंकाल स्वस्थ पर अलग-अलग आहार कैल्शियम और फास्फोरस के स्तर को खिलाने के प्रभाव का मूल्यांकन करने उद्देश्य से किया गया था। उपलब्ध फास्फोरस (0.5/0-4 और 5-8 सप्ताह की आयु के दौरान 0.4, 0.6/0.5 और 0.7/0.6%) एक मानक टर्की आहार में तैयार किए गए थे। एक दिन पुराने (n=288) CARIVIRAT टर्की के मुर्गे को नौ आहार उपचारों में वितरित किया गया जिसमें चार प्रतिकृतिया थी और प्रत्येक प्रतिकृति में 8 मुर्गे थे। परिणामों ने संकेत दिया कि महत्वपूर्ण रूप से ($P<0.01$) उच्च शरीर के वजन और शरीर के वजन में वृद्धि के साथ फीड उपयोग की बेहतर दक्षता और बढ़ती टर्की की रहने की क्षमता 0-4 एवं 25-8.4 और 5-8 सप्ताह की आयु के दौरान 0.5-0.4 या 0.6-0.5% Av. P के साथ 1.2-1.0% Ca के आहार संयोजन में उल्लेखनीय रूप से बेहतर सेलुलर और ह्यमूरल प्रतिरक्षा प्रतिक्रिया और उच्च प्रतिरक्षा अंगों का वजन प्राप्त किया गया। सीरम Ca आहार में Ca की बढ़ी हुई एकाग्रता के साथ बढ़ा और आहार में Av. P के स्तर में वृद्धि के रूप में सीरम ALP गतिविधियों में कमी आई। आहार में Ca के उच्च स्तर के साथ सीरम एल्ब्यूमिन और एल्ब्यूमिन/ग्लोब्युलिन अनुपात में काफी वृद्धि हुई थी। तिबिया हड्डी की लंबाई ($P<0.05$), मध्य शापट और बाहर की चौड़ाई 0-4 और 5-8 सप्ताह की आयु के दौरान आहार में 1.0-0.8% Ca पर काफी अधिक थी। 0.5-0.4% Av. P के साथ 1.0-0.8% Ca के आहार संयोजन में तिबिया सूखी हड्डी का वजन और कुल राख का वजन काफी अधिक था। तिबिया बोन Ca को Ca की बढ़ी हुई आहार सांद्रता के साथ काफी बढ़ाया गया था। इसी तरह तिबिया बोन Ca, Av. P की बढ़ी हुई आहार एकाग्रता के साथ काफी कम हो गया। आहार में Av. P की बढ़ी हुई सांद्रता के साथ तिबिया बोन फॉस्फोरस में काफी वृद्धि हुई थी। तिबिया कॉपर और मैंगनीज की सांद्रता आहार में Ca के बढ़ते स्तर के साथ बढ़ गई थी। जबकि, Av. P की बढ़ती आहार सांद्रता के साथ तिबिया आयरन की सघनता काफी कम हो गई थी। आहार में Ca और Av. P के उच्च स्तर पर Ca और P का महत्वपूर्ण रूप से उच्च उत्सर्जन देखा गया। आहार में Ca और Av. P के निचले स्तर पर कैल्शियम और फास्फोरस का महत्वपूर्ण रूप से उच्च प्रतिधारण उपयोग दर्ज किया गया था। CARIVIRAT टर्की में कैल्शियम और फास्फोरस के बेहतर उपयोग के साथ पैरामीटर। परिणामों के आधार पर यह निष्कर्ष निकाला गया कि 0-4 और 5-8 सप्ताह की आयु के दौरान क्रमशः 0.50 और 0.40% Av. P के साथ 1.0 और 0.8% Ca की आहार सांद्रता इष्टतम विकास प्रदर्शन, कंकाल स्वास्थ्य, सीरम जैव रासायनिक प्राप्त करने के लिए पर्याप्त पाई गई थी। हालांकि, क्रमशः 0-4 और 5-8 सप्ताह की आयु के दौरान 0.60 और 0.50% उपलब्ध फास्फोरस के साथ 1.2 और 1.0% कैल्शियम की आहार एकाग्रता के साथ बेहतर प्रतिरक्षा प्रतिक्रिया प्राप्त किया गया।



REFERENCES

- Angel, R., Saylor, W.W., Mitchell, A.D., Powers, W. and Applegate, T.J. 2006. Effect of dietary phosphorus, phytase, and 25-hydroxycholecalciferol on broiler chicken bone mineralization, litter phosphorus, and processing yields. *Poultry science*. **85(7)**:1200-1211.
- AOAC. 1990. Official methods of analysis (15th ed.), Association of Official Analytical Chemists, Arlington, VA (1990)
- Atia et al., 2000 F.A. Atia, P.E. Waibel, I. Hermes, C.W. Carlson, M.M. Walser Effect of dietary phosphorus, calcium, and phytase on performance of growing turkeys *Poult. Sci.*, **79 (2000)**:231-239.
- Attia Y.A., Al-Harhi M.A. and Abo El-Maaty H.M. 2020. Calcium and cholecalciferol levels in late-phase laying hens: effects on productive traits, egg quality, blood biochemistry, and immune responses. *Frontiers in Veterinary Science*. **7**:389.
- Baginski, E.S., Marie, S.S., Clark, W.L. and Zak, B. 1973. Direct microdetermination of serum calcium. *Clinica chimica acta*. **46(1)**:46-54.
- BAHS-2019 <https://dahd.nic.in/circulars/basic-animal-husbandry-statistics-2019>
- Biehl R.R. and Baker D.H. 1997. Utilization of phytate and nonphytate phosphorus in chicks as affected by source and amount of vitamin D3. *Journal of Animal Science*. **75(11)**:2986-2993.
- Chen, X. and Moran Jr, E.T. 1994. Response of broilers to omitting dicalcium phosphate from the withdrawal feed: live performance, carcass downgrading and further-processing yields. *Journal of Applied Poultry Research*. **3(1)**:74-79.
- Chen, X. and Moran Jr, E.T. 1995. The withdrawal feed of broilers: Carcass responses to dietary phosphorus. *Journal of Applied Poultry Research*. **4(1)**:69-82.

- Collins, N. E. and Moran, E. T., Jr. 1999a. Influence of supplemental manganese and zinc on live performance and carcass quality of broilers. *Journal Applied Poultry Research*. **8**: 222-27.
- Corrier, D.E. and DeLoach, J.R. 1990. Evaluation of cell-mediated, cutaneous basophil hypersensitivity in young chickens by an interdigital skin test. *Poultry science*. **69(3)**:403-408.
- de Matos, R. 2008. Calcium metabolism in birds. *Veterinary clinics of North America: exotic animal practice*. **11(1)**:59-82.
- Deo C., Shrivastava H.P. and Singh N.B. 2006. Effect of feeding different phosphorus levels and depletion on the performance and blood biochemicals in broilers. *Animal Nutrition and Feed Technology*. **6(1)**:41-47.
- Duncan, D.B. 1955. Multiple range and multiple F tests. *Biometrics*, **11(1)**:1-42.
- Economic survey 2019-20 <https://www.indiabudget.gov.in/economicsurvey/>
- El Boushy A.R. 1979. Available phosphorus in poultry. 1. Effect of phosphorus levels on the performance of laying hens and their egg quality, hatchability, bone analysis and strength in relation to calcium and phosphorus in blood plasma. *Netherlands Journal of Agricultural Science*. **27(2)**:176-183.
- Elerođlu, H., Yalçyn, H. and Yıldırym, A. 2011. Dietary effects of Ca-zeolite supplementation on some blood and tibial bone characteristics of broilers. *S. Afr. J. Anim. Sci.* **41(4)**:319-330.
- Emami N. Khodambashi Emami, S. Zafari Naeini, C.A. Ruiz-Feria . 2013. Growth performance, digestibility, immune response and intestinal morphology of male broilers fed phosphorus deficient diets supplemented with microbial phytase and organic acids *Livest. Sci.*, **157** : 506-513.
- Fernandes, F.R. Lima, C.X. Mendonca Jr., I. Mabe, R. Albuquerque, P.M. Leal. 1999 Relative bioavailability of phosphorus in feed and agricultural phosphates for poultry. *Poult. Sci.*, **78** :1729-1736
- Formica, S. D., M. J. Smidt, M. M. Bacharach, W. F. Davin and J. C. Fritz. 1962. Calcium and phosphorus requirements of growing turkeys and chickens. *Poult. Sci.* **41**: 771-776.
- Fritz J.C., Roberts T., Boehne J.W. and Hove E.L. 1969. Factors affecting the chick's requirement for phosphorus. *Poultry Science*. **48(1)**: 307-320.

- Gogel, W.C. and Tietz, J.D. 1976. Adjacency and attention as determiners of perceived motion. *Vision Research*. **16(8)**:839-845.
- Gough, R.E. and Allan, W.H. 1976. Aerosol vaccination against Newcastle disease using the Ulster strain. *Avian Pathology*. **5(2)**:81-95.
- Gustafsson, J.E. 1978. Automated serum albumin determination by use of the immediate reaction with bromocresol green reagent. *Clinical chemistry*. **24(2)**:369-373.
- Halley, J.T., Nelson, T.S., Kirby, L.K. and Johnson, Z.B. 1987. Effect of altering dietary mineral balance on growth, leg abnormalities, and blood base excess in broiler chicks. *Poultry Science*. **66(10)**:1684-1692.
- Hocking, P.M., Wilson, S., Dick, L., Dunn, L.N., Robertson, G.W. and Nixey, C. 2002. Role of dietary calcium and available phosphorus in the aetiology of tibial dyschondroplasia in growing turkeys. *British poultry science*. **43(3)**:432-441.
- Hofmann, T., Schmucker, S., Sommerfeld, V., Huber, K., Rodehutschord, M. and Stefanski, V. 2021. Immunomodulatory effects of dietary phosphorus and calcium in two strains of laying hens. *Animals*, **11(1)**:129.
- Hurwitz S., Plavnik I., Shapiro A., Wax E., Talpaz H. and Bar A. 1995. Calcium metabolism and requirements of chickens are affected by growth. *The Journal of nutrition*. **125(10)**:2679-2686.
- ICAR–Nutrient requirements of poultry 2013.
- Kidd. 2004. Nutritional modulation of immune function in broilers *Poult. Sci.*, **83**: 650-657.
- Kind, P.R.N. and King, E. 1954. Estimation of plasma phosphatase by determination of hydrolysed phenol with amino-antipyrine. *Journal of clinical Pathology*. **7(4)**:322.
- Lalpanmawia H., Elangovan A.V., Sridhar M., Shet, D., Ajith S. and Pal D.T. 2014. Efficacy of phytase on growth performance, nutrient utilization and bone mineralization in broiler chicken. *Animal Feed Science and Technology*. **192**: 81-89.
- Leeson, S. and Atteh, J.O. 1995. Utilization of fats and fatty acids by turkey poults. *Poultry science*. **74(12)**:2003-2010.
- Makola, M.D., Motsei, L.E., Ajayi, T.O. and Yusuf, A.O. 2021. Dietary nano-dicalcium phosphate improves immune response and intestinal morphology of broiler chickens. *South African Journal of Animal Science*. **51(3)**:362-370.

- Martens P.J., Gysemans C., Verstuyf A. and Mathieu C. 2020. Vitamin D's effect on immune function. *Nutrients*. **12(5)**:1248.
- McMurtry, R.W. Rosebrough, N.C. Steele. 1983. A homologous radioimmunoassay for chicken insulin. *Poult. Sci.* **62**: 697-701
- Mitchell R.D. and Edwards Jr H.M. 1996. Effects of phytase and 1, 25-dihydroxycholecalciferol on phytate utilization and the quantitative requirement for calcium and phosphorus in young broiler chickens. *Poultry Science*. **75(1)**:95-110.
- Mohamed Y.S., Abdel_Azeem F., Thabel H. and Hassan A.M. 2020. Impact of phytase supplementation in restricted calcium and phosphorus broiler diets on performance, blood parameters and bone characteristics. *Arab Universities Journal of Agricultural Sciences*. **28(2)**: 663-672.
- Moran Jr, E.T. and Todd, M.C. 1994. Continuous submarginal phosphorus with broilers and the effect of preslaughter transportation: Carcass defects, further-processing yields, and tibia-femur integrity. *Poultry science*. **73(9)**:1448-1457.
- Morin, L.G. and Prox, J. 1973. New and rapid procedure for serum phosphorus using o-phenylenediamine as reductant. *Clinica Chimica Acta*. **46(2)**:113-117.
- Motzok, I. and Slinger, S.J. 1948. Studies on the calcium and phosphorus requirements of Broad Breasted Bronze turkeys. *Poultry Science*. **27(4)**:486-491.
- Nakagi, C.M. Costa do Amaral, M.R. Stech, A.C. Frizzas de Lima, F.A. Ribiero Harnich, A.C. Laurentiz, J.M. Pizauro Júnior. 2013. Acid and alkaline phosphatase activity in broiler chicks fed with different levels of phytase and non-phytate phosphorus *J. Appl. Anim. Res.* **41**: 229-233
- Nelson, F.E., Jensen, L.S. and McGinnis, J. 1961. Requirement of developing turkeys for calcium and phosphorus. *Poultry Science* **40(2)**:407-411.
- Nie W., Wang B., Gao J., Guo Y. and Wang, Z. 2018. Effects of dietary phosphorous supplementation on laying performance, egg quality, bone health and immune responses of laying hens challenged with *Escherichia coli* lipopolysaccharide. *Journal of animal science and biotechnology*. **9(1)**:1-11.
- NRC (National Research Council). (1994). *Nutrient Requirements of Poultry*. 9th revised edition. National Academy Press, Washington, DC, USA.
- NRC. 1994. *Nutrient Requirements of Poultry*. 9th rev. ed. Natl. Acad. Press, Washington, DC

- Oblakova, M. 2004. Study of growth potentials and slaughter analysis of BUT- 9 broiler turkey poult. *Bulgarian J. Ani. Sci.*, **10**: 137-142.
- Pensack, J. M., C. N. Huhtanen and E. L. R. Stokstad. 1959. Laboratory evaluation of methods for potentiating antibiotics. *Proc. Amer. Cyanamid 10th Animal Feed Symposium*: **33**-64.
- Qian, H., Kornegay, E.T. and Denbow, D.M. 1996. Phosphorus equivalence of microbial phytase in turkey diets as influenced by calcium to phosphorus ratios and phosphorus levels. *Poultry Science*. **75(1)**:69-81.
- Rama Rao SV, MVLN Raju and MR Reddy. 2007. Performance of broiler chicks fed high levels of cholecalciferol in diets containing suboptimal levels of calcium and non-phytate phosphorus. *Anim Feed Sci Tech*, **134**: 77-88.
- Rao S.V., Raju M.V.L.N., Reddy M.R., Pavani P., Sunder G.S. and Sharma, R.P., 2003. Dietary calcium and non-phytin phosphorus interaction on growth, bone mineralization and mineral retention in broiler starter chicks. *Asian-australasian journal of animal sciences*. **16(5)**:719-725.
- Roberson K.D. and EDWARDS JR H.M. 1994. Effects of 1, 25-dihydroxycholecalciferol and phytase on zinc utilization in broiler chicks. *Poultry Science*. **73(8)**:1312-1326.
- Sanders, A. M., H. M. Edwards, Jr. and G. N. Rowland III. 1992. Calcium and phosphorus requirements of the very young turkey as determined by response surface analysis. *Br. J. Nutr.* **67**: 421-435.
- Scheideler S.E., Rives, D.V., Garlich J.D. and Ferket P.R. 1995. Dietary calcium and phosphorus effects on broiler performance and the incidence of sudden death syndrome mortality. *Poultry Science*. **74(12)**:2011-2018.
- Sebastian S., Touchburn S.P., Chavez E.R. and Lague P.C. 1996. Efficacy of supplemental microbial phytase at different dietary calcium levels on growth performance and mineral utilization of broiler chickens. *Poultry Science*. **75(12)**:1516-1523.
- Shafey T.M. 1993. Calcium tolerance of growing chickens: effect of ratio of dietary calcium to available phosphorus. *World's Poultry Science Journal*. **49(1)**:5-18.
- Shafey, T.M., McDonald, M.W. and Pym, R.A.E. 1990. Effects of dietary calcium, available phosphorus and vitamin D on growth rate, food utilisation, plasma and bone constituents and calcium and phosphorus retention of commercial broiler strains. *British poultry science*. **31(3)**:587-602.

- Singh R., Joyner C.J., Peddie M.J. and Taylor T.G. 1986. Changes in the concentrations of parathyroid hormone and ionic calcium in the plasma of laying hens during the egg cycle in relation to dietary deficiencies of calcium and vitamin D. *General and comparative endocrinology*. **61(1)**:20-28.
- Skinner J.T., A.L. Waldroup and P.W. Waldroup. 1992. Effects of removal of vitamin and trace mineral supplements from grower and finisher diets on live performance and carcass composition of broilers. *J. Appl. Poult. Res.* **1**: 280-286.
- Snedecor, G. W. and Cochran, W. G. 1989. *Statistical Methods*, 8th ed., Ames, IA: Iowa State University Press
- Sohail S.S. and Roland Sr D.A. 1999. Influence of supplemental phytase on performance of broilers four to six weeks of age. *Poultry Science*. **78(4)**:550-555.
- Stevens V.I., R.E. Salmon .1988. Effects of dietary protein on leg disorders in turkeys *Nutr. Rep. Int.* **38**:915-925.
- Sullivan, 1959. Phosphorus requirement of turkeys for late growth *Poultry Sci.*, **38 (1959)**: 1252.
- Szabo, A., Mezes, M., Horn, P., Sütő, Z., Bázár, G.Y. and Romvari, R. 2005. Developmental dynamics of some blood biochemical parameters in the growing turkey (*Meleagris gallopavo*). *Acta Veterinaria Hungarica*. **53(4)**:397-409.
- Talpatra, S.K., Ray, S.C. and Sen, K.C. 1940. Estimation of phosphorus, chlorine, calcium, magnesium, sodium and potassium in foodstuffs. *Indian J. Vet. Sci. Anim. Husb.* **10**:243-258.
- Tatara, M.R., Krupski, W., Jankowski, M., Zduńczyk, Z., Jankowski, J. and Studziński, T. 2011. Effects of dietary calcium content and vitamin D source on skeletal properties in growing turkeys. *British poultry science*. **52(6)**:718-729.
- Vatzidis, H. 1977. A practical procedure for determination of total serum protein in blood. *Clin Chem*. **23**:908-911.
- Veldman C.M., Cantorna M.T. and DeLuca, H.F., 2000. Expression of 1, 25-dihydroxyvitamin D3 receptor in the immune system. *Archives of biochemistry and biophysics*. **374(2)**:334-338.
- Vohra A., Kaur P. and Satyanarayana T. 2011. Production, characteristics and applications of the cell-bound phytase of *Pichia anomala*. *Antonie van Leeuwenhoek*. **99(1)**:51-55.

- Waldroup P.W., Ammerman C.B. and Harms R.H. 1963. The relationship of phosphorus, calcium, and vitamin D3 in the diet of broiler-type chicks. *Poultry Science*. **42(4)**:982-989.
- Waldroup, P.W., Watkins, S.E., Skinner, J.T., Adams, M.H. and Waldroup, A.L. 1992. Effect of dietary amino acid level on response to time of change from starter to grower diets for broiler chickens. *Journal of Applied Poultry Research*. **1(4)**:360-366.
- Wise. 1975. Skeletal abnormalities in table poultry-A review *Avian Pathol.* **4 (1975)**: 1-10







VITAE

Name : **Dr. VIKASH BHARDWAJ**
Father's name : Mr. Vijay Kumar Bhardwaj
Mother's name : Mrs. Meera Bhardwaj
Date of Birth : 26-06-1995
Permanent address : 160, Jiwaji Ganj
Morena District, Madhya Pradesh- 476001
Email : Vikashbhardwaj2608@gmail.com
Mobile : 9144207789

Educational Qualification

Degree	Board/university	Year of passing	OGPA
B.V.Sc. & A.H.	JVC (NDVSU)	2020	7.5
M.V.Sc.	ICAR-IVRI, Izatnagar, U.P.	2022	8.458

Awards & Membership

-  ICAR-JRF fellowship, All India rank 8 for M.V.Sc degree programme, 2020-20221
-  Member of Madhya Pradesh State Veterinary Council
-  Member of Indian Poultry Science Association
-  Member of World Poultry Science Association



This document was created with the Win2PDF "Print to PDF" printer available at

<https://www.win2pdf.com>

This version of Win2PDF 10 is for evaluation and non-commercial use only.

Visit <https://www.win2pdf.com/trial/> for a 30 day trial license.

This page will not be added after purchasing Win2PDF.

<https://www.win2pdf.com/purchase/>