EFFECT OF SUPPLEMENTATION OF BUTYRATE ON PERFORMANCE OF BROILER CHICKEN

T H E S I S

Submitted
in partial fulfillment of the requirements for the degree of

M A S T E R O F V E T E R I N A R Y S C I E N C E
IN
ANIMAL NUTRITION

BY
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(INDIA)
2019

DECLARATION OF STUDENT

I, hereby declare that the experimental research work and interpretation of the thesis entitled **"EFFECT OF SUPPLEMENTATION OF BUTYRATE ON PERFORMANCE OF BROILER CHICKEN"** or part there of has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

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We also certify that the thesis or part thereof has not been previously submitted by him for a degree of any other University.

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Date: / / 2019

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This is to certify that the thesis entitled **"EFFECT OF SUPPLEMENTATION OF BUTYRATE ON PERFORMANCE OF BROILER CHICKEN"** submitted by Shri. **SONALE PRAVIN DEVIDAS** to the Maharashtra Animal and Fishery Sciences University in partial fulfillment of the requirement for the degree of **MASTER OF VETERINARY SCIENCE** has been approved by the Student's Advisory Committee after oral examination in collaboration with the External Examiner.

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I Dedicated
This Thesis In The
Memories of My Late Baba
Laxmanrao Narwade

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Place : Parbhani

Date : / /2019 ***(Sonale Pravin Devidas)***

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	:	Per cent
@	:	At the rate of
A:G ratio	:	Albumin : Globulin ratio
AIA	:	Acid Insoluble Ash
ANOVA	:	Analysis of variance
AOAC	:	Association of Official Analysis Chemist
Avg	:	Average
BA	:	Butyric Acid
BIS	:	Bureau of Indian standard
BUN	:	Blood urea nitrogen
BW	:	Body weight
BWG	:	Body weight gain
Ca	:	Calcium
CF	:	Crude fiber
cfu	:	Colony forming unit
CP	:	Crude protein
CRD	:	Complete randomized design
DM	:	Dry matter
DMB	:	Dry matter basis
DP	:	Dressing Percentage
EU	:	European union
EE	:	Ether extract
F	:	Finisher
FCR	:	Feed conversion ratio
FI	:	Feed Intake
GALT	:	Gut Associated Lymphoid Tissue
g	:	Gram
g/dl	:	Gram per deciliter
HDL	:	High Density Lipoprotein
Hb	:	Hemoglobin
IBD	:	Infectious Bursal Disease
Kcal	:	Kilo-calorie

mg/dl	:	Milligram per deciliter
LDL	:	Low Density Lipoprotein
K	:	Potasium
Kg	:	Kilogram
Ltd.	:	Limited
ME	:	Metabolizable Energy
Mg	:	Magnesium
N	:	Nitrogen
MS	:	Mean square
NA	:	Sodium
NR	:	Nitrogen Retention
NFE	:	Nitrogen free extract
OA	:	Organic Acid
OM	:	Organic matter
P	:	Phosphorus
PS	:	Pre-starter
Pvt.	:	Private
RBC	:	Red Blood Cells
Rs.	:	Rupees
S	:	Starter
SS	:	Sum of squares
SCFA	:	Short Chain Fatty Acid
SEM	:	Standard error of mean
T	:	Treatment
TA	:	Total ash

Introduction

CHAPTER - I

INTRODUCTION

The poultry industry in India has emerged as the most dynamic and rapidly expanding segment of livestock economy sector. Rapid growth in poultry sector is due to substantial genetic improvement and intensive nutritional feeding of poultry, involving the fastest growth of poultry birds and the highest production potential. India ranks 3rd in egg production and 4th in meat production. So, there is further vast scope for increase in the production (Poultry Sector in India, 2017). The proper nutritional management practices are helpful to achieve success of broiler production which involves the maximum weight gain within minimum period. A large population comprising middle class in India is becoming aware of the importance of healthy food habits and avoiding food that contain higher cholesterol and bad fat. Hence, there is the importance for the role of feed additives which can modify the quality attribute of final product such as meat and make it stand up to consumer expectations.

To enhance growth performance of broiler chicken, different synthetic growth promoters like antibiotics is utilized but residual effect of these antibiotics is having health hazards in human population. Due to the negative effects of these products like microbial resistance in the poultry it has lead to the ban of these commercial antibiotics. So, there is an increasing interest in finding alternatives to antibiotics in poultry production. Probiotics, prebiotics or organic acids have been included as an alternative to antibiotics of which, prebiotics are costlier, while probiotics have different degrees of survivability in feed during processing and in the gut environment. Organic acids could be the possible choice as alternative to antibiotics (Deepa *et al.,* 2018). Nowadays, there are a lot of concerns to finding non-synthetic alternatives for antibiotics among the scientists. Thus, searching for effective substitute for antibiotics in animal production is important. Evaluating newer technologies to enhance the production and health of poultry is vital for today's poultry industry. One such non-synthetic alternative to antibiotics for broilers is Butyrate (butyric acid). Organic acids and their salts are considered as safe feed additives and their use in animal diets is approved by most EU member states (Adil *et al*., 2010). Their general mode of action relates to their antimicrobial activity and ability to reduce gastrointestinal tract pH and to enhance the digestion and absorption of nutrient (Dibner and Buttin, 2002).

Butyric acid (or butanoic acid or 1-Propanecarboxylic acid or Propanecarboxylic acid) is a carboxylic acid containing four carbon atoms. Butyric acid is available as salt with Na, K, Mg and Ca which can be used as commercial feed additive. Butyric acid, a short-chain fatty acid primarily produced by microbial fermentation in the large intestine, is known to be involved in the immune response of the mucous membrane and to have an anti-inflammatory effect in animals (Sengupta *et al*., 2006). Addition of butyric acid increased carcass weight, breast meat yield and growth performance of broilers challenged with coccidiosis infection. After supplementation of butyrate, an increase in villi height and crypt depth has been observed in pigs and poultry (Galfi and Bokori, 1990; Leeson *et al*., 2005). The growth in villi height increases the absorptive surface of the small intestine leading to better nutrient absorption and utilization, The recent studies have shown that when butyrate is orally ingested it can impart beneficial effects on animal performance (Bergman, 1990; Smulikowska *et al*., 2006; Biagi *et al*., 2007; Hu and Guo 2007; Mazzoni *et al*., 2008; Czerwinski *et al*., 2012).

Supplementation of butyric acid (BA) as a feed additive may be another way to improve ileal protein digestibility of poorly digestible protein sources. Amongst Short Chain Fatty Acids (SCFA), butyric acid (BA) is considered as a prime enterocytes energy source required for the correct development of the gut associated lymphoid tissue (GALT) (Friedman and Bar-shira ,2005). Butyric acid products must be included in the diet in conjunction with or encapsulated with other chemicals to reduce their unpleasant odor and enhance the palatability of the ration (Antongiovanni *et al.,* 2010).

Despite the ban of antibiotic as a growth promoter in Europe and a few countries in North Africa, different countries across the world continue to use these antibiotics as a common poultry and livestock feed additives (Adil *et al*.,

2010) which have adverse effect as mentioned earlier. Thus there is need to find cost effective alternatives to antibiotic growth promoters. There is very limited and inconsistent research work by using butyrate as growth promoter. Hence the present experiment is designed to examine the effect of supplementation of Butyrate as growth promoter in broiler chicken.

Objectives

1) To assess the growth performance of broilers chicken fed butyric acid supplemented diet
2) To assess the blood biochemical profile of broiler chicken fed butyric acid supplemented diet
3) To study the carcass traits in broiler chicken fed butyric acid supplemented diet
4) To study the economics of broiler production

Review of Literature

CHAPTER - II

REVIEW OF LITERATURE

Butyric acid is a short-chain fatty acid produced primarily by microbial fermentation in the large intestine and is recognized to be involved in the mucosal immune response and to have an anti-inflammatory action in animals. Also Addition of butyric acid increased growth performance, carcass characteristics, villi height and crypt depth of broilers chickens (Galfi and Bokori, 1990; Leeson *et al*., 2005). Hence, to evaluate butyrate as an alternative to antibiotic growth promoter the present study was carried out. The review of literature regarding effect of dietary supplementation of butyrate on performance, carcass traits, hematological parameters, blood biochemical profile, gut parameter, nutrient digestibility, N retention and economics of broiler chicken production is presented in the following pages.

1. Growth performance
2. Carcass traits
3. Hematological parameters
4. Blood biochemical profile
5. Gut health parameters
6. Nutrient digestibility and N retention
7. Economic of broiler chicken production

2.1 Growth Performance

Leeson *et al*., (2005) conducted experiments to evaluate the efficacy of butyric acid on performance of broiler chickens. In experiment 1, male broiler chickens were fed diets supplemented with 0 or 11 ppm virginiamycin or 0.2 or 0.4% butyric acid (as mono-, di-, and triglyceride). In experiment 2, broilers were fed bacitracin methylene disalicylate or 0.1 or 0.2% butyric acid. Results indicated that in experiment 1, dietary treatments had no any negative effect on body weight gain and the bird fed with 0.4% butyric acid showed decreased feed intake ($P < 0.01$) compared with non medicated birds during the starter period, whereas birds fed 0.2% butyric acid had similar feed intake to the control birds. In experiment 2, dietary treatments had no effect on the performance of broiler chicks. Authors concluded that 0.2% butyric acid can help to maintain the performance of birds.

Hu and Guo (2006) investigated the effects of dietary sodium butyrate (SB) on the growth performance in broiler chickens. For the study 336 day-old AA broiler chicks were distributed randomly into four groups with six replicates each. Four groups were fed with basal diet (control) or diets supplemented with SB at the level of 500, 1000, 2000 mg/kg. Authors opined that during the period from 0 to 21 days the body weight gain increased linearly as the dietary supplementation of SB increased ($P<0.05$). Dietary supplementation of SB affected positively feed conversion ratio (FCR) the period from 0 to 42 days ($P<0.05$).

Antongiovanni *et al*., (2007) evaluated the butyric acid glycerides, as a supplemental ingredient in the diet, on performance of broiler chickens. An experiment was carried out on 150 Ross 308 female chickens, grouped into 5 treatments for the period of 35 days. The treatments were as follows: the control with soybean oil as the energy supplement and 4 treatments with increasing amounts (0.2, 0.35, 0.5, 1% mixed feed) of a mixture of butyric acid glycerides (mono-, di- and tri- glycerides). Results showed that live weight was higher at slaughtering ($P<0.05$) with a better feed conversion rate. Author concluded that, the blend of butyrate glycerides supplemented through broilers diets proved its beneficial effects on live performance at the level of 2 g/kg mixed feed.

Panda *et al*., (2009) studied the effect of graded levels of butyric acid (butyrate) on performance in young broiler chickens. Control starter (0-3 wk) and finisher (4-5 wk) diets were formulated to contain 2,900 kcal ME/kg and 22% CP, and 3,000 kcal ME/kg and 20% CP, respectively. Likewise, four other experimental treatment diets were formulated to contain 0.05% antibiotic (furazolidone) or 0.2, 0.4 and 0.6% butyric acid. Each diet was fed a randomly to 8 replicates of 6 chicks each throughout the experimental period (0-5 wk). The results showed that, 0.4% butyrate in the diet was similar to antibiotic in maintaining body weight gain but superior for feed conversion ratio and feed intake were not influenced by the dietary treatments. From these findings, Authors concluded that, 0.4% butyric acid supplementation maintained performance in broiler chickens.

Mahdavi and Torki (2009) investigated the effect of dietary inclusion of protected butyric acid (BA) glycerides on growth performance of broiler chicks. For the study 408 days old unsexed Arbor-acres broiler chicks were randomly grouped between 48 battery pens. Four dietary inclusion of BA (0-2 or 3 g kg^{-1}) on different (starting, growing, finishing) periods was examined. The results indicated that there was no significant difference in body weight (BW), body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR) between treatment groups (P>0.05). Chicks fed diet fed with 2 g BA kg^{-1} showed higher BWG during 0-21 days of age (P>0.05). Authors concluded that butyric acid did not show a clear positive effect on performance of broiler reared under good hygiene conditions.

Taherpour *et al*., (2009) conducted an experiment on ROSS 308 male broilers to evaluate probiotic, prebiotic and butyric acid glycerides on broiler performance. For the study 704 day-old broilers were randomly divided into eight treatments with four replicates (22 birds/ pen) with two levels of probiotic, prebiotic and butyric acid glycerides. Three-way interaction between dietary treatments were observed for final body weight (P<0.05), feed intake (P<0.01) and feed conversion ratio (P<0.01) in the experiment. Author observed that body weight, feed intake and feed conversion ratio between supplementary treatments and control group were significantly different (P<0.01). Authors opined that dietary supplementation improved the body weight, feed conversion ratio but affects the feed intake of broiler chickens.

Adil *et al*., (2010) studied the effect of dietary supplementation of organic acids on the performance of broiler chicken. The birds in the control (T_1) group were fed the basal diet whereas in other treatment groups basal diet was supplemented with 2% butyric acid (T_2), 3% butyric acid (T_3), 2% fumaric acid

(T_4), 3% fumaric acid (T_5), 2% lactic acid (T_6) and 3% lactic acid (T_7). Author found that, broiler chicken fed diets supplemented with organic acids had improved body weight gains and feed conversion ratio significantly ($P<0.05$). There was no any effect ($P>0.05$) on cumulative feed consumption. Authors opined that, the organic acid supplementation, irrespective of type and level of acid used, showed a beneficial effect on the performance of broiler chicken.

Zou *et al*., (2010) explored the effects of dietary supplement of Sodium Butyrate (SB), either powder (uncoated) or coated on performance of broilers. One-day-old 408 AA broilers were randomly distributed into four treatments with three replicates of forty chickens each. Broilers were fed the diets: A) Ctr: control diet (without any SB and antibiotics); B) Antibiotic: supply antibiotics (Zinc Bacitracin 40 mg/kg + Colistin Sulfate 8 mg/kg) into the basal diet; C) PSB: control diet + 200 mg/kg PSB (powder Sodium Butyrate); D) CSB: control diet + 200 mg/kg CSB (coated Sodium Butyrate). Results showed that the addition of SB tended improved growth performance, but no significant differences were observed among treatments ($P > 0.05$) except for feed efficiency in grower period (21 - 42 d, $P = 0.040$).

Jang (2011) examined the effects of addition of achillea and butyric acid on performance of broiler chickens. The study was performed on 225 day old broiler chicks distributed into 15 groups of 15 chicks each. Each 3 groups were randomly assigned to one of the three treatments. There were four treatments, Experimental groups included, G1, control group. G2, butyric acid glycerides (BaBy C4) containing 0.2%. G3, fed with basal diet plus 2 gr/Kg achillea. Results showed that the G2 group had improved FCR and weight gain, but the highest level of food intake showed in the group 3.

Zhang *et al*., (2011) investigated the effects of dietary sodium butyrate on the growth performance of broiler chickens. In experiment 1, 240 1-d-old chickens were distributed into 4 dietary groups (0, 0.25, 0.50 or 1.00 g sodium butyrate/kg) with 6 replicates each. In experiment 2, 120 1-d-old chickens were fed a control diet (without sodium butyrate) or 1.00 g sodium butyrate/kg diet. Results found that dietary sodium butyrate did not affect growth performance and it maintained the body weight gain and feed intake. Author concluded that the dietary sodium butyrate supplementation can improve the growth performance in chickens under stress condition.

Sayrafi *et al*., (2011) examined the effect an organic acid (butyric acid glycerides, Baby c4®) as substitute for antibiotic growth promoters on the growth performance of broiler chickens. One hundred and forty four 1-day old broiler chicks were randomly divided into one of three dietary treatments with four replicates (12 birds each) for 6 wks. Dietary treatments were as follow: 1) control (basal diet), 2) basal diet plus bacitracin methylene disalicyate and 3) basal diet plus butyric acid glycerides. The parameters evaluated were average body weight, body weight gain, feed intake and feed conversion ratio. The results showed that body weight, weight gain, feed intake and feed conversion ratio were not statistically affected by dietary treatments ($P>0.05$). However, at the end of the experiment, chicks fed diets included with antibiotic showed better performance than that of the other treatments, and the control birds were intermediate ($P>0.05$). Authors opined that the butyric acid could not perform as growth promoter.

Mansoub (2011) conducted an experiment to evaluate the effects butyric acid, probiotic and garlic on performance of broiler chickens. Study was carried out for 42 days on 300 day old broiler chicks that were divided to 20 groups of 15 chicks each. There were four treatments and each of the 4 groups were randomly assigned to one of the 4 treatments. Experimental groups included control group (T_1), basal diet containing 1% probiotic (L. acidophilus and L. casei) (T_2) for 1-28 days, Using powder form of butyric acid glycerides (BaBy C) containing 0.2% (T_3), fed by basal diet plus 1 gr/Kg Garlic powder (T_4). Results revealed that, other experimental groups show improved gain in weight as compared to control ($P<0.05$).

Aghazadeh and TahaYazdi (2012) evaluated the effects of butyric acid (BA) levels and wheat form (WF) on the performance of broiler chickens. Day-old 320 Ross 308 broiler chicks were randomly distributed among 32 floor pens. Four levels of BA (B_1: 0 g BA/kg in both starter and grower feed; B_2: 2.5 g BA/kg in both starter and grower feed; B_3: 2.5 g BA/kg in starter and 1 g BA/kg in grower feed; and B_4: 2.5 g BA/kg in starter and 0 g BA/kg in grower feed) and two forms of wheat (whole (WW) vs. ground (GW)) were used. Results indicated that, dietary supplementation with BA had no effect on average weight gain (AWG) or feed conversion ratio (FCR) in the starter, grower/finisher and throughout the experimental periods (0 - 42 d). However, birds consumed more when the diet was supplemented with butyrate (B2) compared to the control and other experimental diets during 0 - 42 d, but this increase was not associated with improved AWG or FCR as compared with that of the control.

Czerwinski *et al*., (2012) investigated the effect of dietary sodium butyrate (SB) or salinomycin (SAL) or both additives on performance of broiler chickens. A growth trial was conducted with 308 female broilers (96 Ross) from 1 to 30 days of age. Four treatment groups were fed with a non-supplemented control diet or three experimental diets supplemented with i) 300 mg SB (Adimix 30 coated) per kg, ii) 60 mg SAL (Sacox) per kg or iii) both additives in combination. Results depicted that addition of SB had no effect on performance compared with control diet but positively affected feed intake and body-weight gain in comparison with birds fed the SAL-supplemented diet. Authors concluded that the SAL alone negatively affected feed intake and body-weight gain; however, the effect was improved by SB supplementation.

Shahir *et al*., (2013) explored the effects of cereal type (corn vs. wheat), enzyme supplementation (0 or 0.4 g/kg diet), and sodium butyrate addition (0 or 2 g/kg diet) on growth performance of male broilers from 10 to 42 d. A total of 600 male Arbor Acres chickens were assigned to eight dietary treatments assigned five replicate pens per treatment. Author observed that feed intake was significantly increased by adding sodium butyrate to experimental diets ($P < 0.01$); however, no significant differences were observed in weight gain or feed per gain ratio when sodium butyrate added to experimental diets. The results showed that addition of enzyme and sodium butyrate improve growth performance especially to the wheat based diet.

Salmanzadeh (2013) studied the effects of dietary supplementation of different contents of butyric acid on performance of Japanese quails. A total of

384 one day old quails were randomly grouped to 4 dietary treatments with 4 replicates of 24 quails and fed with basal diet including 0, 40, 50 and 60 mg of butyric acid/ kg of feed. Author concluded that the weight gains and feed conversion ratio were significantly improved in quails supplemented with butyric acid compared to the controls.

Pouraziz *et al*., (2013) evaluated the effects of dietary supplementation of live yeast *Saccharomyces cerevisiae* (SC) and butyric acid glycerides (BAG) on broiler performance. 378 ROSS 308 female chicks (One-day-old) were randomly distributed for the period of 42 days with three replicates for each fed with increasing levels of (0, 0.002, and 0.004 g/g) BAG and (0, 0.003, and 0.006 g/g) SC respectively. It consisted of starter (1-21 day) and grower (22-42 day) periods. Results revealed that, the chicks fed 0, 0.002, and 0.004 g/g BAG had higher BW and better FCR than control diet ($P<0.05$) and in the grower period chicks fed 0.006 g/g SC had higher BW than other treatments ($P<0.05$). For BAG both levels had positive effect on BW and FCR ($P<0.05$). Authors concluded that, the dietary BAG improves growth performance in starter and grower periods but SC was only effective in grower period.

Cerisuelo *et al*., (2014) investigated the effect of a specific blend of EO and a combination of this blend of EO with sodium-butyrate on growth performance in broilers. A total of 480 (day old) male broilers were divided into 5 treatments (8 pens per treatment and 12 birds per pen) for the period of 42 days. Dietary treatments consisted of the inclusion of different doses of EO (0 mg/kg, control; 50 mg/kg, EO50 and 100 mg/kg, EO100) or a combination of EO with 1 g/kg of sodium- butyrate (B; EO50 + B, EOB50 and EO100 + B, EOB100) in the basal diet. Weekly individual BW and feed intake per pen were measured. Author observed that, there were no differences on growth performance among treatments. Authors concluded that, EO or its combination with sodium-butyrate did not affect growth performance.

Chamba *et al*., (2014) evaluated the effect of partially protected sodium butyrate (PSB) on performance. 924 one-day-old mixed Cobb® chicks were assigned in 3 treatments with 7 replicates each. Treatment was a control diet without any growth promoter (T_1), treatment the control diet plus colistin at 100,000 IU/kgBW (T_2) and treatment was the control diet with PSB at 700 ppm (T_3). Results indicated that, there were no significant differences on performance among all treatments in starter phase. Chicks fed PSB in grower and finisher phases showed the highest weight gain and the good feed conversion ratio. Author opined that, partially protected sodium butyrate and colistin can improve performance.

Kamal and Ragaa (2014) explored the effects of dietary supplementation of different types of organic acids on the performance of broiler chicken. The control group birds were fed with basal diet (T_1) whereas in other treatment groups basal diet was supplemented with 3% butyric acid (T_2), 3% fumaric acid (T_3) and 3% lactic acid (T_4). Results revealed that, the broiler chicken fed diets supplemented with organic acids showed significant improvement in the body weight gains and feed conversion ratio. There was no negative effect was seen on cumulative feed consumption ($P < 0.05$).

Anas and Al-Fataftah (2015) evaluated the effect of butyric acid on heat-stressed broilers performance. A total 128 Hubbard male broilers were distributed equally into 4 treatment groups, with 8 replicates per treatment (4 birds each). At 21 day of age, birds were allotted to 2 dietary treatments and fed either a control diet (CONTR) or the control diet+0.5 g/Kg butyric acid (BUT). Each dietary treatment was further divided into 2 experimental groups; Thermoneutral (TN) or heat stress(HS), each of which included one group fed with CONTR and one fed with BUT. Author observed that during the heat stress period, HS-CONTR birds showed reduced ($P<0.05$) body weight, daily gain as compared to other treatment groups, while HS-BUT birds exhibited growth performance similar to TN-CONTR birds ($P>0.05$). They also found that during the recovery period, butyric acid enhanced the recovery of body weight. Butyric acid had extra positive effects in heat-stressed broilers as revealed by temperature in to diet interactions ($P<0.05$) detected in final body weight, daily gain, feed conversion ratio. Authors concluded that dietary inclusion of butyric acid for heat-stressed broilers can hasten the recovery of growth performance.

Qaisrani *et al*., (2015) studied the diet structure, butyric acid, and fermentable carbohydrates influence growth performance, gut morphology, and cecal fermentation characteristics in broilers. The experiment was conducted to test coarse diet supplemented with butyric acid (BA) and fermentable carbohydrates (FC) improves performance of broilers with a poorly digestible protein source. 288 male (Ross 308) 1-d-old broilers were used. The combination effects of diet structure (fine or coarse), FC supplementation (with or without), and BA supplementation (with or without) in a poorly digestible diet based on rapeseed meal (RSM) were tested. The results indicated that the coarseness of the diet positively affected feed intake (FI) ($P < 0.001$), BW gain ($P = 0.001$), and the feed conversion ratio (FCR) ($P = 0.001$). Broilers fed BA-supplemented diets had an improved FCR ($P = 0.004$) as compared to those without BA. Therefore, authors concluded that the feeding a coarse diet supplemented with BA improved performance of broilers fed a diet containing a poorly digestible protein source.

Dolan *et al*., (2016) examined the performance, safety and tissue residue study for coated sodium butyrate added to broiler feed. The study was conducted to evaluate whether the administration of feed containing 0.1, 0.5 or 1.0% fat-coated sodium butyrate (coated sodium butyrate) to one-day old broiler chicks for 49 consecutive days caused toxicity to the animal, or altered the fatty acid profile or butyric acid metabolites concentration (β-hydroxybutyrate, acetoacetate and acetone) of ingestible tissues compared to control animal. Results revealed that, treatments groups that consumed coated sodium butyrate exhibited low mortality and good general health. Author found there were no statistical differences between groups for performance parameters, with exception of feed: gain ratio in the period day 0 to day 21, which was improved by coated sodium butyrate at the 1.0% concentration. Conclusion given by author was coated sodium butyrate may be safely used in poultry feed at up to 10,000 g/tonne feed (1.0%), from the day of hatching to 49 days of age.

Ocejo *et al*., (2017) evaluated effects of dry whey powder and calcium butyrate supplementation of corn/soybean based diets on productive performance, duodenal histological integrity, and Campylobacter colonization in broilers. Six hundred one-day-old Ross-308 chickens were placed into 20 ground pens (5 replicates of 30 chicks per treatment) and allotted to one of 4 corn/soybean-based dietary treatments: 1) basal diet with no supplementation (control) 2) diet supplemented with 6% dry whey powder, 3) diet containing 0.1% coated calcium butyrate, and 4) diet containing 6% whey and 0.1% calcium butyrate. The results showed that the growth and feed efficiency were improved with supplementation of the corn/soybean-based diet with 6% whey alone or preferably in combination with 0.1% coated calcium butyrate.

Lum *et al*., (2018) studied two treatment diets formulated with iso- butyric and tributyrin or fat- coated sodium butyrate and compared to control diet for body weight gain and feed conversion ratio in ROSS broiler. Experiment was lasted 35 days. Author observed that, treatment had significant improvement in body weight gain during the grower and finisher phases; with tributyrin having numerical advantages over the sodium butyrate group but these advantages was not significant. Feed conversion ratio also significantly improved in both treatment groups during the grower phase and entire trial. Between the tributyrin and sodium butyrate group were no significant differences recorded. Authors concluded that, tributyrin is as effective as a fat- coated sodium salt for improvement of broiler performance and may confer advantages over traditional protected butyric acid salts.

2.2 Carcass traits

Leeson *et al*., (2005) explored the effect of butyric acid on the Carcass Yield of Broiler Chickens. Results showed that in experiment 2, carcass weight and breast meat yield increased ($P<0.01$) in birds fed with 0.2% butyric acid. Authors concluded that, 0.2% butyric acid can help to maintain carcass quality of broilers.

Antongiovanni *et al*., (2007) studied butyric acid glycerides in the diet of broiler chickens: effects on gut histology and carcass composition. Result showed that, the carcass characteristics were not affected.

Panda *et al*., (2009) examined effect of butyric acid on Carcass Characteristics in Broiler Chickens. Results showed that compared to the control or antibiotic group the Carcass yield was higher and abdominal fat content was poorly significant in all the butyrate treatment groups. From these findings, authors concluded that 0.4% butyric acid supplementation maintained carcass quality in broiler chickens.

Mahdavi and Torki (2009) investigated the effect of dietary inclusion of protected butyric acid (BA) glycerides on carcass traits of broiler chicks. Author found that, chicks fed diet supplemented with 2 g BA/kg showed that the relative weights of breast, thighs, abdominal fat, liver, pancreases, gall bladder, spleen, bursa of fabricus, thymus, and caecum not affected by experimental treatment diets ($P>0.05$).

Jang (2011) explored the effects of addition of achillea and butyric acid on carcass traits of broiler chickens. Results showed that, the highest percent of liver and breast was observed in experimental group 3 But the lowest level of abdominal fat were seen.

Mansoub *et al*., (2011) conducted an experiment to evaluate the effects of various levels and forms of butyric acid glycerides (BaBy C4) on carcass characteristics of broiler chickens. Results showed that, Carcass yield, abdominal fat percentage and weight of bursa were not significant between all groups.

Aghazadeh and TahaYazdi (2012) examined effect of butyric acid supplementation and whole wheat inclusion on the performance and carcass traits of broilers. Results indicated that, the BA had no significant effect on fat pad, gizzard or breast meat, but increased liver weight. By feeding of BA and WW (Whole wheat) the length of the entire gut was increased. Feeding WW increased the relative weight of the gizzard and liver, but decreased the relative weight of abdominal fat. Only for breast meat significant interaction was observed between butyric acid (BA) and wheat form (WF) however two-way interactions were not significant for any of the carcass traits or organ-size parameters except for breast meat, in which a significant interaction was observed between butyric acid (BA) and wheat form (WF).

Salmanzadeh (2013) made an attempt to know the effects of dietary supplementation of different contents of butyric acid on carcass traits of Japanese quails. Carcass traits (carcass weight and relative weights of breast, heart, liver and gizzard) were assessed on days 21 and 42. Authors concluded that, in the treated birds the Carcass and breast yields were markedly increased.

Shahir *et al*., (2013) determined the effects of Cereal Type, Enzyme and Sodium Butyrate Addition on Growth Performance, Traits and Intestinal Morphology of Broilers. Authors opined that the enzyme and sodium butyrate addition had no significant effects ($p > 0.05$) on the relative weights of the proventriculus, gizzard, pancreas, liver and heart.

Tafti and Jahanian (2015) investigated the effect of dietary supplementation of organic acids (OA) on carcass characteristics of broiler chickens fed diets with different crude protein (CP) levels. Dietary treatments consisted of 3 different CP levels (high, medium, and low) and 3 dietary OA supplementation (control, 2.5 g citric acid/kg, and 2.5 g butyric acid/kg). At the end of study, 2 birds randomly selected for slaughter to measure carcass traits. Results showed that the relative liver weight and carcass yield were decreased ($P < 0.05$) by reducing dietary CP level (medium + low), while abdominal fat percentage was increased ($P < 0.001$), with the greatest ($P = 0.004$) abdominal fat broilers fed low-CP diet. Dietary OA supplementation (citric + butyric) increased ($P = 0.016$) carcass yield, while reduced ($P < 0.001$) relative gizzard weight. Authors concluded that the dietary supplementation OA increased carcass yield of broiler chickens.

Lakshmi and Sunder (2015) studied the effect of supplementation of organic acids, propionic acid (PA) and butyric acid (BA) or antibiotic (AB) in diets and their influence on broiler performance, carcass parameters and immune response. In this study antibiotic (AB-Virginiamycin 11mg/kg) was replaced by two levels (0.2 and 0.3%) of organic acids, propionic acid (PA) and butyric acid (BA). Results showed that, the both organic acids improved tibia weight (5.75-5.31g), tibia length (7.96-6.16 cm), breast muscle yield (13.68-14.77%), and reduced abdominal fat (7.5%) compared to AB and control diets.

Dolan *et al*., (2016) explored the effect of administration of feed containing 0.1, 0.5 or 1.0% fat-coated sodium butyrate (coated sodium butyrate) on one-day old broiler chicks for 49 consecutive days caused toxicity to the animal, or altered the fatty acid profile or butyric acid metabolites concentration (β-hydroxybutyrate, acetoacetate and acetone) of ingestible tissues compared to control animal. Results showed that, there was no effect of coated sodium butyrate on organ weight or organ histology of broiler chicken. The fatty acid profile of breast, liver, kidney or subcutaneous fat (with skin) tissues from chickens fed diets containing coated sodium butyrate did not differ from control group of chicken, with the exception of a statistically significant decreases in palmitoleic acid (C16:1) in liver tissue in the 0.5% and 1.0% groups.

2.3 Haematological parameter

Dolan *et al.*, (2016) explored the effect of administration of feed containing 0.1, 0.5 or 1.0% fat-coated sodium butyrate (coated sodium butyrate) on one-day old broiler chicks for 49 consecutive days caused toxicity to the animal, or altered the fatty acid profile or butyric acid metabolites concentration (β-hydroxybutyrate, acetoacetate and acetone) of ingestible tissues compared to control animal. Results showed that, no effect of coated sodium butyrate on hematology.

2.4 Blood Biochemical Profile

Mahdavi and Torki (2009) investigated the effect of dietary inclusion of protected butyric acid (BA) glycerides on blood metabolites of broiler chicks. Four hundred and eighty days-old unsexed Arbor-acres broiler chicks were randomly distributed between 48 battery pens. Four dietary inclusion of BA (0-2 or 3 g kg^{-1}) on different (starting, growing, finishing) periods was tested. The results showed that, serum metabolites except calcium were not significantly affected by BA (P>0.05).

Taherpour *et al.*, (2009) conducted a study on ROSS 308 male broilers to evaluate the effect of probiotic (Primalac), prebiotic (Fermacto) and butyric acid glycerides (Baby C4) on broiler serum composition. Results showed that, the total cholesterol concentration, LDL, HDL/LDL ratio and cholesterol/HDL ratio between supplementary treatments and control group were significantly different ($P<0.05$ and $P<0.01$). Serum triglyceride, HDL and VLDL cholesterol concentrations were not significantly different among dietary treatment when compared to control group ($P>0.05$). Authors concluded that, the dietary supplementation improved the HDL/LDL ratio and decreased total cholesterol, LDL cholesterol and cholesterol/HDL ratio in the serum of broiler chickens.

Adil *et al*., (2010) examined the effect of dietary supplementation of organic acids on the blood biochemistry of broiler chicken. Results revealed that Serum calcium and phosphorus concentrations were increased ($P < 0.05$) but no effect ($P < 0.05$) was observed on the concentration of serum glucose and cholesterol.

Jang (2011) examined the effects of addition of achillea and butyric acid on serum composition of broiler chickens. Results showed that the amount of total Chol, TG and LDL in the serum did show a significant differences in groups 2 and 3, but HDL were not significantly different among groups.

Zhang *et al*., (2011) carried out two different experiments on one day old chickens to evaluate the effects of dietary sodium butyrate on serum composition of broiler chickens. Authors opined that the Sodium butyrate supplementation inhibited the increase serum glucose and total protein concentrations at 20 day of age.

Mansoub *et al*., (2011) conducted an experiment to evaluate the effects of various levels and forms of butyric acid glycerides (BaBy C4) on serum composition of broiler chickens. Total cholesterol (Chol), triglyceride (TG), HDL, LDL and VLDL were measured in blood samples of day 42. Results showed that the amount of total Chol and LDL in the serum did showed a significant difference, but TG, HDL and VLDL were not significantly different amoung groups.

Mansoub., (2011) evaluated the effect of Butyric Acid, Probiotic and Garlic on serum composition of broiler chickens. The chicks showed significant difference in gain ($P<0.05$) in treatment groups as compared to the control group.

Authors concluded that, the amount of total Chol and LDL in the serum significantly decreased, but TG, HDL and VLDL were not significantly different amoung groups.

Pouraziz *et al*., (2013) conducted an experiment to evaluate the effects of dietary supplementation of live yeast *Saccharomyces cerevisiae* (SC) and butyric acid glycerides (BAG) on broiler serum lipid composition. Results showed that, in serum composition both BAG and SC decreased cholesterol concentrations ($P<0.05$), but the HDL levels were higher ($P<0.05$) only in 0.006g/g SC fed chicks. There were no significant effects in triglyceride levels among treatments. Authors concluded that, the both BAG and SC had positive effect on serum lipid composition.

Kamal and Ragaa (2014) explored the effects of dietary supplementation of different types of organic acids on the blood biochemistry of broiler chicken. The control (T_1) groups were fed the basal diet whereas in other treatment groups basal diet was supplemented with 3% butyric acid (T_2), 3% fumaric acid (T_3) and 3% lactic acid (T_4). Results showed that the broiler chicken fed acidified diets had better immune response as indicated by a higher serum globulin level than the control. On the other hand, significant reduction in serum level of cholesterol, total lipid or low density lipoprotein (LDL) was achieved due to dietary acidification.

Tafti and Jahanian (2015) investigated the effect of dietary supplementation of organic acids (OA) on serum metabolites of broiler chickens fed diets with different crude protein (CP) levels. Results indicated that, the serum concentrations of high- and low-density lipoproteins and cholesterol were not affected by dietary CP level. However, feeding low-CP diet increased ($P< 0.001$) serum triglyceride level compared with higher CP levels. As dietary CP levels were reduced (medium + low) the serum concentration of uric acid was decreased ($P < 0.001$).

Riboty *et al*., (2016) conducted an experiment to evaluate the effect of partially- protected sodium butyrate (PPSB) and virginiamycin (VM) on serum metabolites broiler chicken. Authors opined that, the VM (T_2) group had decreased cholesterol (P<0.01) and triglycerides (P=0.04) at 31 days as compared to control group. Also PPSB had increased cholesterol at 11 days (P=0.04) and lowered uric acid at 31 days (P=0.02) respect to control and VM, respectively.

Dolan *et al.,* (2016) explored the effect of administration of feed containing 0.1, 0.5 or 1.0% fat-coated sodium butyrate (coated sodium butyrate) on one-day old broiler chicks for 49 consecutive days caused toxicity to the animal, or altered the fatty acid profile or butyric acid metabolites concentration (β-hydroxybutyrate, acetoacetate and acetone) of ingestible tissues compared to control animal. Results showed that, there was no effect of coated sodium butyrate on blood biochemical parameter.

2.5 Gut health parameter and pH

Hu and Guo (2006) investigated the effects of dietary sodium butyrate (SB) on microbial count of chickens. The result indicated that SB supplementation did not significantly influence the number of *E. coli* (P<0.01).

Panda *et al*., (2009) studied the effect of graded levels of butyric acid (butyrate) gastrointestinal tract health in young broiler chickens. The results showed that 0.4% butyrate in the diet was reducing *E. coli* numbers. As compared to either control or antibiotic-fed group pH of the upper GI tract was reduced (crop, proventiculus and gizzard) by inclusion of butyrate in the diets of broilers. Butyrate at 0.4% was more effective in reducing the pH than 0.2% butyrate. Authors concluded that, within the lower GI tract 0.4 and 0.6% butyrate was effective in lowering pH in the duodenum, but no effect was found in either the jejunum or ileum.

Mahdavi and Torki (2009) investigated the effect of dietary inclusion of protected butyric acid (BA) glycerides on gastrointestinal tract parameter of broiler chicks. Four dietary inclusion of BA (0-2 or 3 g kg-1) on different (starting, growing, finishing) periods was tested. Birds Results showed that, the ileal pH not significantly affected by BA (P<0.05).

Rubio *et al*., (2009) conducted an experiment on fifty 1-d-old broilers allocated in three groups were fed the diets containing: standard broiler diet (control); T1 = standard broiler diet supplemented with 0.92 g/kg of an additive with free sodium butyrate (Gustor XXI B92); and T2 = standard broiler diet supplemented with 0.92 g/kg of an additive with sodium butyrate partially protected with vegetable fats (Gustor XXI BP70). 20% birds were orally infected with *Salmonella Enteritidis* at day 5 post hatching and fecal *Salmonella* shedding was assessed at day 6, 9, 13, 20, 27, 34, and 41 of the trial. At day 42, all birds were slaughtered and 20 of them dissected: crop, cecum, liver, and spleen were sampled for bacteriological analyses. Results showed that a significant reduction ($P < 0.05$) of *Salmonella Enteritidis* infection in birds from day 27 onward. Authors concluded that the supplementation of partially protected butyrate successfully decreased infection not only in the crop and cecum but also in the liver.

Zou *et al*., (2010) investigated the effects of dietary supplement of Sodium Butyrate (SB), either powder (uncoated) or coated on Gut pH value and Caecal Microflora in broilers. Result showed that, there was no any effect was observed in duodenum, jejunum and ileum. Populations of *Salmonella* (14 day, $P < 0.001$), *Escherichia coli* (14 day, $P = 0.003$) and *Clostridium perfringens* (35 day, $P < 0.001$) in the cecum were decreased by supplementation of SB, and Lactobacillus counts in cecum was significantly higher in 14-d-old ($P < 0.001$) and 35-d-old ($P = 0.033$) birds fed a SB-supplemented diet compared with control diets. Authors concluded that, the effects of SB mainly appeared at 35 days.

Czerwinski *et al*., (2012) explored the effect of dietary sodium butyrate (SB) or salinomycin (SAL) or both additives on microbial ecology of broiler chickens. Study was conducted with 96 Ross 308 female broilers from 1 to 30 days of age. Four treatment groups were fed with a non-supplemented control diet or three experimental diets supplemented with i) 300 mg SB (Adimix 30 coated) per kg, ii) 60 mg SAL (Sacox) per kg or iii) both additives in combination. Authors concluded that, the SAL supplementation was accompanied by a pH increase in ileum and a pH decrease in caecum. No significant effect of SB addition was observed for these parameters.

Cerisuelo *et al*., (2014) investigated the effect of a specific blend of EO and a combination of blend of EO with sodium-butyrate on *Salmonella* colonization in broilers. All birds were orally infected with 10^8 cfu of *Salmonella* Enteritidis on day 7 of study. The prevalence and enumeration of *Salmonella* in feces was determined per treatment at 72 hrs post infection and on day 23 and 37 of study. At slaughter, caecal content and liver samples from 16 birds per treatment were cultured for *Salmonella* and caecal pH was measured. Results revealed that all fecal samples were positive for *Salmonella* from day 10 to the end of the rearing period. At slaughter, *Salmonella* contamination (positive samples) in caecum was lower in birds fed EOB50 compared with the other treatments ($P < 0.05$), whereas birds of control group showed the highest colonization rates. The pH of the caecal content was not different among treatments. Authors concluded that a low dose of EO combined with sodium-butyrate (EOB50) to observed clear effect on *Salmonella*.

Chamba *et al*., (2014) evaluated the effect of partially protected sodium butyrate (PSB) on E. coli development in broilers chickens. Treatment T_1 was a control diet without any growth promoter, treatment T_2 was the control diet plus colistin at 100,000 IU/kgBW and treatment T_3 was the control diet with PSB at 700 ppm. Results showed that, the intestinal *E. coli* growth was not affected by any treatment.

2.6 Nutrient digestibility and N retention

Hassan *et al.,* (2015) studied the effect of corn-soybean meal diets supplemented with a commercial phytogenic product (Bedgen 40®) contained artichoke extract (Cynara scolymus), a commercial mixture of organic acids (Galliacid®) and a combination of both on nutrients digestibility of broiler chicks. Dietary treatments were examined on 200 one day-old Cobb broiler chicks and lasted from 1-39 days of age. The results showed that, addition of artichoke extract improved the digestibility coefficients ($P<0.01$) of CP and CF, while, addition of organic acids mixture improved the digestibility coefficients ($P<0.01$) of DM, OM, CP, CF and NFE compared to the un-supplemented diet.

Riboty *et al*., (2016) evaluated the effect of partially protected sodium butyrate (PPSB) and virginiamycin (VM) on nutrient digestibility of broiler chicken. Three treatments were used: without antibiotics (T_1), with 20 ppm of VM (T_2) and with 700ppm of PPSB (T_3). In experiment 2, nutrient digestibility and metabolizable energy were determined in 168 chicks allocated in 3 treatments of 8 replicates. All excreta were collected between 10-13 and 30-33 days. Dry matter, crude protein, fat digestibility, true metabolizable energy and true metabolizable energy corrected by nitrogen were higher with PPSB ($P<0.01$). Author found that, dry matter and crude protein digestibility improved at 11 days as well as fiber at 31 days ($p<0.01$) by diet supplemented with VM as compared to control group.

Ndelekwute *et al*., (2016) investigated the effect of organic acids (acetic, butyric, citric and formic acids) on nutrient digestibility of broilers. One hundred fifty (150) day old Hubbard chicks distributed in five dietary treatments by supplemented Diet 1 as control contained no organic acid, diets 2, 3, 4, and 5 contained 0.25% acetic, butyric, citric and formic acids respectively. Results showed that, the crude protein and ether extracts digestibility were improved by all the organic acids ($P<0.05$).

Kaczmarek *et al*., (2016) applied four dietary treatments in experiments I and II to determine the effect of protected calcium butyrate (BP) on nutrient digestibility in broiler chickens. Author observed that, in experiment I, after supplementation of protected calcium butyrate BP apparent total tract crude fat digestibility and apparent metabolizable energy corrected for nitrogen (AME_N) were improved ($P < 0.05$).

2.7 Economic of broiler chicken production

Hassan *et al*., (2015) conducted an experiment on economic efficiency of broiler chicks fed corn-soybean meal diets supplemented with a commercial phytogenic product (Bedgen 40®) contained artichoke extract (*Cynara scolymus*), a commercial mixture of organic acids (Galliacid®) and a combination of both. Results showed that, the supplementation of artichoke extract and organic acids reduced total feed cost/kg body weight and improved net profit and economic efficiency. Therefore authors concluded that, the artichoke extract or organic acids mixture improved broiler performance and economic efficiency of broilers fed corn-soybean meal diets.

Kamel and Mohamed (2016) conducted an experiment on effect of different feed additives (Probiotics, Prebiotic, Synbiotic, Organic acids and Enzymes) on economic efficiency of Cobb and Ross broiler breeds. Results showed that, the net profit was the highest for synbiotic group of Ross breed and organic acid group of Cobb breed (L.E 5.35 and 4.95 /chicken, respectively). Authors concluded that, organic acids and synbiotic feed additives were better than other used feed additives, and they had an important role in improving productive and economic efficiency of broiler chicks.

Naveenkumar *et al*., (2017) conducted an experiment on 240 day old commercial broiler chicks to evaluate the effectiveness of replacing antibiotic growth promoters with organic acid salts on the production performance. Treatment diets were supplemented with lincomycin HCl (4.4ppm), bacitracin methylene disalicylate (BMD; 50 ppm), each two levels (ppm) of calcium propionate (1000, 2000) and coated sodium butyrate (500, 1000) either alone or in combination (1000+500) with control. The results indicated that, the calcium propionate (2000) group had the highest body weight gain with 6.48% more than lower levels (1000). Improved EEF and COP were observed in organic acid treated groups. Authors concluded that, the Calcium propionate and coated sodium butyrate could be safely supplemented as an alternative to antibiotic growth promoters (AGPs) in the commercial broiler diet without affecting the production performance.

Materials and Methods

CHAPTER - III

MATERIALS AND METHODS

The experiment entitled "Effect of supplementation of butyrate on performance of broiler chicken" was conducted to study the effect of supplementation of butyrate at different level T_1 (0.5%), T_2 (1%) and T_3 (1.5%) on performance of broiler chicken through assessment of performance (feed intake, body weight gain, feed conversion ratio), carcass traits (Live weight (g), dressing percentage, carcass weight (g), edible meat percentage, edible meat weight (g), giblet weight (g), giblet percentage, Liver Weight (g), weight of immune organ (g), dressed breast weight (g), weight of Intestine (g)), blood biochemical parameters (HB, RBC and PCV), serum profile (Total protein, albumin, globulin, A:G ratio, blood urea nitrogen, total cholesterol, HDL, LDL, Triglycerides and blood glucose), gut parameters (caecal *E.coli, salmonella, clostridia* count and ileal pH), nutrient digestibility, N retention and economics of broiler production. The experiment was conducted in the Department of Animal Nutrition, College of Veterinary and Animal Sciences, MAFSU, Parbhani, Maharashtra. Details regarding the experiment during the study period are presented in following paragraphs.

3.1 Procurement of feed ingredient and feed formulation.

The Feed Ingredients were procured locally and stored properly until the experimental rations were prepared. Feed formulation for experimental broiler birds was as per BIS standard (2007) recommendation and by considering the nutrient requirement of birds.

3.2 Experimental birds

The experiment was carried out on 240, day-old (Vencobb-400) straight run commercial broiler chicks for a period of 42 days (6 weeks) in the experimental broiler shed, Department of Poultry Science, College of Veterinary and Animal Sciences, MAFSU, Parbhani. The chicks were obtained from M/s

Venkateshwara Hatcheries PVT. LTD. Pune, Maharashtra. On arrival, the chicks were weighed individually and distributed randomly on equal body weight basis in to four treatment groups *viz*, T_1, T_2, T_3, and one control group T_0 with four replicates of 15 chicks in each groups. The total birds were allocated to different treatment groups as presented in Table 3.1.

Table 3.1 Experimental details

Sr. no.	Treatment group	No. of birds/pen/ replication	No. of replication	Total no. of birds
1	**T_0** standard broiler diet	15	4	60
2	**T_1** standard broiler diet with 0.5% supplementation of butyric acid	15	4	60
3	**T_2** standard broiler diet with 1% supplementation of butyric acid	15	4	60
4	**T_3** standard broiler diet with 1.5% supplementation of butyric acid	15	4	60
	Total no. of birds			**240**

3.3 Housing and management

Before arrival of broiler chicks, all the pens, separators, drinkers, feeders, brooder and floor were cleaned, washed, disinfected and poultry shed was fumigated. The birds were housed under deep litter system with rice husk as a litter material. The uniform management practices viz. feeding, watering and lighting were followed for all the groups throughout the experimental period.

The experimental chicks were housed in separate pens and one square foot floor space was provided to each chick. Each pen was partitioned for treatment groups to have four replications accommodating fifteen birds in each. The brooding was carried out using electric bulb as source of heat and light, following standard management protocol. Brooding was continued up to two weeks of age in the respective pen of each replication and treatment groups. After second week sufficient light was provided to all the birds during night hours. The birds were offered *ad libitum* fresh, clean and cool drinking water throughout the experiment.

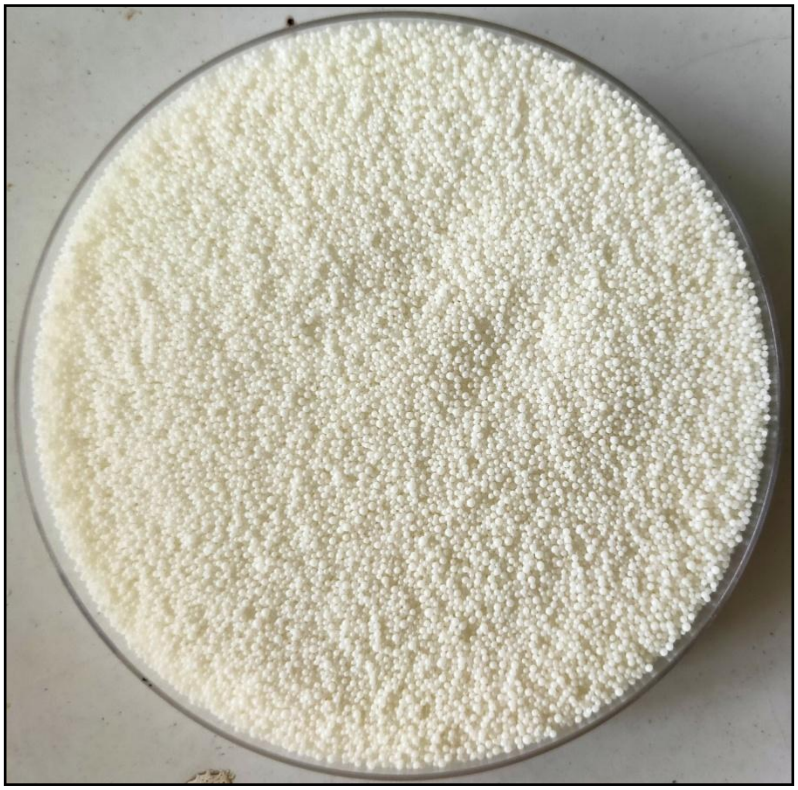


Plate 3.1 Butyrate (Butyric acid)

Plate 3.2 Brooding management of experimental birds fed diet supplemented with butyrate

Plate 3.3 Weighing of experimental birds fed diet supplemented with butyrate

Water sanitizer [sockreina] added in drinking water at the rate of 1 ml per 10 liters of water. The experiment was conducted in the month of April to May. The experiment was conducted at the minimum and maximum diurnal temperature ranging 23.5°C to 41°C. During trial on some of the days maximum temperature up to 45 to 46°C had been recorded.

3.4 Vaccination and Medications

All the experimental chicks were vaccinated with Marek's disease vaccine on the first day of life at hatchery and subsequent vaccination schedule was carried out as follows.

Table 3.2 Vaccination schedule for experimental birds

Sr. No.	Disease	Vaccine	Age of Vaccination	Dose / route
1.	Ranikhet	Lasota vaccine (F_1 Strain)	7th day	One drop in eye (Intraocular)
2.	Gumboro (IBD)	Gumboro vaccine	14th day	One drop in eye (Intraocular)
3.	Gumboro (IBD) Booster Dose	Gumboro vaccine	21st day	Through drinking water
4.	Ranikhet Booster Dose	Lasota vaccine	28th day	Through drinking water

3.5 Diets and feeding regime

The required quantities of feed ingredients used in the present experiment were purchased from local market and rations were prepared at feed mixing plant of the college of veterinary and animal sciences, Parbhani by following BIS (2007) standard recommendation.

Table No. 3.3 Percent composition of control ration

Sr. No.	Particulars	Control Group		
		Pre-starter	Starter	Finisher
1.	Maize	52.26	53.22	57.36
2.	Soybean meal	40.5	38.1	33
3.	Vegetable oil	3.4	4.8	5.8
4.	Limestone	1.36	1.4	1.36
5.	Di-calcium phosphate	1.65	1.65	1.65
6.	Salt	0.5	0.5	0.5
7.	Dl-methionine	0.13	0.13	0.13
8.	Lysine	0.05	0.05	0.05
9.	Trace Mineral Mixture	0.05	0.05	0.05
10.	Vitamin Premix	0.05	0.05	0.05
11.	Choline chloride	0.05	0.05	0.05
	Total	**100.00**	**100.00**	**100.00**
	CP (%)	22.93	21.93	20.01
	ME (Kcal/Kg)	2992.38	3091.49	3198.42
	LYSINE (%)	1.30	1.24	1.11
	METHIONINE (%)	0.50	0.49	0.46

The butyric acid was added in the ration @ 0.5%, 1% and 1.5% in T_1, T_2, and T_3 treatment groups respectively. Toxin binder and coccidiostate are added over and above at required quantity at the time of feed preparation.

All the broiler chicks were fed with ground maize for first day of age and thereafter, the feed (experimental ration prepared as per BIS (2007) standards) was offered in chick feeders and then in grower feeders throughout the experiment (up to 42^{nd} day of age). The *ad-lib* feeding and ample of clean drinking water was made available during the experiment.

Weighed amount of feed was offered to all the treatment groups and the left over feed was collected and weighed separately. From this data, the average weekly feed consumption was calculated.

3.6 Growth performance

3.6.1 Weekly Feed Intake

Records of feed offered and residues left over were maintained weekly. The feed consumption was calculated by subtracting weekly residue from the total weekly feed offered. Cumulative feed consumption of particular week was calculated by adding up the weekly average feed consumption of the previous week with the feed consumption of that particular week.

3.6.2 Weekly Body Weight Gain

The live body weights of all birds were recorded individually accurately replicates wise on the electronic weighing machine at weekly interval in morning hours before feeding. From this data, the average weekly body weight and weekly weight gain per bird were calculated for various treatments groups.

3.6.3 Weekly Feed Conversion Ratio (FCR)

Weekly feed conversion ratio was calculated by dividing the weekly feed consumption by weekly weight gain. The weekly cumulative feed conversion ratio was calculated by dividing total amount of feed consumed up to the particular week by the body weight gain recorded up to that week.

$$\text{FCR} = \frac{\text{Total feed consumed (g)}}{\text{Gain in body weight (g)}}$$

3.6.4 Proximate, Calcium and Phosphorus Analysis

Proximate analysis of ground feed of various groups including control group was done as per the methods of AOAC (2000).

3.6.4. (a) Dry Matter (DM)

A known weight of ground sample was dried out at 100 ± 2^0C in a hot air oven in a moisture cup overnight to a constant weight to determine the dry matter after deducting the loss of weight from the sample taken.

$$DM\ (\%) = \frac{\text{Weight of sample after drying}}{\text{Weight of sample}} \times 100$$

3.6.4. (b) Nitrogen (N) and Crude Protein (CP)

The nitrogen was determined by digesting a known quantity of ground sample in a presence of digestion mixture (copper sulphate and potassium sulphate in the ratio of 1:10) and commercial laboratory grade concentrated sulphuric acid. The sample was digested for 3 hrs in the digestion system of Pelican equipments, chennai having model and serial no. digestion 18178. Then 30 ml of distilled water was added in it. The digested sample was made up to known volume and a suitable aliquot was distilled in the presence of excess of 40% sodium hydroxide in distillation apparatus of Pelican equipments, Chennai having model no. DISTYL-EM BA 18205 and distillate so collected in 2% boric acid (w/v) having 7 drops of methyl red indicator and 4 drops of bromocresol green indicator was titrated against standard N/10 H_2SO_4 (1 ml of N/10 H_2SO_4 = 0.0014 g N) and simultaneously a blank without sample in equal quantity of commercial H_2SO_4 was also run to arrive at the nitrogen content.

$$\text{Nitrogen}\ (\%) = \frac{14.01\times(\text{ml titran of sample} - \text{ml titran of blank})\times \text{Normality}\times 100}{\text{Sample weight (gms)}\times 1000}$$

The percent crude protein in feed was calculated by multiplying nitrogen percent with the factor 6.25.

3.6.4. (c) Ether Extract

A known amount of moisture free sample was extracted with petroleum ether (BP 60-80^0 C) for 2 hours in a pre-weighed flask using Soxhlet extraction apparatus of Pelican equipments, Chennai having mode no. SCS 04 and serial no. 18027. The weight of extract was recorded after oven drying it (100±2^{0}C) for 20 minutes to a constant weight to express as percent ether extract (EE) in the sample on dry matter basis (DMB).

$$\text{Ether Extract (\%)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Weight of sample}} \times 100$$

3.6.4. (d) Total Ash (TA)

A known quantity of sample was decarbonized and ignited in the muffle furnace at 550^{0}c for 3 hours to arrive at the total ash (TA) content.

$$\text{Total ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.6.4. (e) Acid Insoluble Ash (AIA)

After boiling the known quantity of total ash with dilute HCL (1:4) filter it with repeated washing with hot distilled water and then filter paper with residue ignited in muffle furnace at 550^{0}c to 600^{0}C for 2-3 hours to arrive at insoluble ash content.

$$\text{Acid insoluble ash (\%)} = \frac{\text{Weight of insoluble ash}}{\text{Weight of sample}} \times 100$$

3.6.4. (f) Crude Fibre (CF)

Moisture and fat free samples of feed were boiled with 1.25 % sulphuric acid solution for 30 minutes and washed with hot distilled water to make acid free. This was followed by boiling the residue with 1.25 % sodium hydroxide solution for 30 minutes and washed with hot distilled water. Residue sample with Crucible was dried, weighed and then ignited in muffle furnace to obtain its ash content. Crude fiber was calculated by deducting ash from the weight of dried residue.

$$\text{Crude Fibre (\%)} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

3.6.4. (g) Nitrogen Free Extract (NFE)

NFE was calculated by using following formula

NFE (%) =100 – (CP% + CF% + EE% +TA %)

3.6.4. (h) Calcium % (Ca)

Calcium estimation of ground feed of various treatment groups including control group was done as per Talapatra *et al*., (1940).

Procedure:

Calcium in the sample was estimated from mineral extract (aliquot). Took 10 ml aliquot of mineral extract in a 250 ml glass beaker and added 2-3 drops of methyl red indicator in it. Heated, the content of beaker up to boiling, cooled and then added 10 ml of saturated ammonium oxalate solution with constant stirring until the precipitate was coarsely granular. Heated the contents to boiling, cooled and added 1:4 liquor ammonia solution with constant stirring till the color was faint pink. If colour changed to yellow, added hydrochloric acid (1:4) drop by drop until the faint pink colour appeared, kept overnight for proper precipitation of calcium as calcium oxalate. Next day, the contents of beaker were filtered through Whatman filter paper no. 40 and washed several times with hot distilled water. Transferred the filter paper containing calcium oxalate precipitate again to the beaker and dissolve the precipitate by badding dilute sulphuric acid (1:9).

Heated the contents of the beaker to 60-70^{0}C and titrated with standard N/10 $KMnO_4$ solution. Calcium % in the sample was calculated as follows:

$$\text{Calcium (\%)} = \frac{\text{N/10 KMnO4 used (ml)} \times 0.002 \times \text{dilution factor}}{\text{Sample weight (g)}} \times 100$$

3.6.4. (i) <u>Phosphorus % (P)</u>

Phosphorus estimation of ground feed of various groups including control group was done as per AOAC (2005) and Sastry et al., (1999).

Procedure:

Mineral extract (aliquot) 10-50 ml was taken in a clean and dry 250 ml beaker. Then 10 ml of 20% ammonium molybdate and 10 ml of concentrated nitric acid in two separate measuring cylinders were taken and poured simultaneously, into the mineral extract containing beaker. A yellow precipitate of ammonium phosphomolybdate formed. The precipitate in beaker was stirred with the help of glass rod and keep it overnight to allow it to settle. The filtrate was decated without disturbing the precipitate through Whatman filter paper no. 42. Washed the precipitate only once with 2% HNO_3 and then several times with 3% KNO_3 solution untill it is acid free. Filter paper containing precipitate was transferred to the original beaker and add 2 drops of phenolphthalein. Standard N/7 NaOH in excess was added and the total quantity of N/7 NaOH used (X) was noted. The contents were back filtered with solution with N/7 HNO3 to arrive at the actual quantity of N/7 NaOH needed to dissolve the precipitate (Y). Calcium % in the sample was calculated as follows:

Actual volume of N/7 NaOH required to dissolve precipitate was calculated bu substracting X from Y (X-Y).

$$\text{Phosphorous (\%)} = \frac{\text{(X-Y)} \times 0.0001925 \times \text{total volume of ash solution}}{\text{Aliquot of ash solution taken} \times \text{Sample weight (g)}} \times 100$$

3.7 Carcass traits

3.7.1 Sacrifice of Bird

At the end of the experiment, two birds from each replicate of each group were selected for sacrifice. Accurate positioning of head was assured. Birds were sacrificed manually by passing a knife across the side of neck at the base of the birds head which should severed the jugular vein and carotid artery (Islamic/ Halal method).

Scalding of the birds was done by immersion in hot water in the scald tank. The temperature of water was kept 50-51^{0}C to prevent discoloration and drying.

Defeathering was done by removing feathers mechanically, immediately after scalding. Manual evisceration was carried out to determine carcass traits.

3.7.2 Dressing Percentage

Dressing percentage was calculated as follows:

$$\text{Dressing percentage} = \frac{\text{Carcass weight}}{\text{Live weight}} \times 100$$

3.7.3 Giblet Weight and Percentage

The combined weight of heart, liver and gizzard recorded on digital weighing balance and was expressed on percent basis. Giblet percentage was calculated as follows.

$$\text{Giblet meat (\%)} = \frac{\text{Giblet weight}}{\text{Live body weight before slaughter}} \times 100$$

Plate 3.4 Dressed experimental birds fed diet supplemented with butyrate

3.7.4 Edible Meat Percentage

Edible meat percentage was calculated as follows:

$$\text{Edible meat (\%)} = \frac{\text{Edible meat weight}}{\text{Live body weight before slaughter}} \times 100$$

3.7.5 Carcass weight

The carcass was weighed after removal of blood, feathers, viscera, head and legs by keeping the skin intact with the carcass.

3.7.6 Weight of Immune Organs

At the time of sacrifice bursa and spleen of sacrificed bird were collected, weighed accurately and recorded for further analyses.

3.7.7 Weight of breast

Breast weight was determined directly after aseptical removal of breast and weighedusing digital weighing balance.

3.7.8 Weight of Liver

Liver weight was determined directly after aseptical removal of liver weighed in digital weighing balance.

3.7.9 Weight of Intestine

Intestine weight was determined directly after aseptical removal of intestine and weighed on digital weighing balance.

3.8 Blood Parameters

3.8.1 Hematological Parameters

3.8.1. (a) Collection of Blood

At the end of sixth week, blood was collected randomly from two birds of each replicate. The 1 ml blood was collected from wing vein using vacuum tubes containing potassium salts of ethylene di-amine tetra acetate (EDTA) as anticoagulant and the hematological estimations were carried out. The methodology and set of reagents used in respect of each parameter were as per the recommendation of the manufacturer of the analyzer system. The methods used for these estimations are given.

3.8.1. (b) Hemoglobin (g/dl)

Blood hemoglobin was determined using cyanmethaemoglobin method (Martha *et al*., 2012).

3.8.1. (c) Packed Cell Volume (%)

Packed cell volume was determined by Wintrobe microhaematocrit method (Martha *et al*., 2012).

3.8.1. (d) Total Erythrocyte Count ($\times 10^6/\mu l$)

Red blood cells were estimated by using haemocytometer.

3.8.2 Blood Biochemical Parameter

Blood biochemical estimations were carried out at the end of sixth week of age. The biochemical estimations were performed on Clinical Analyzer 636 make Systronics. The methodology and the set of reagents used in respect of each parameter were as per the recommendations of the manufacturer of the analyzer system. The methods used for these estimations are given below.

3.8.2. (a) Collection of Blood

At the end of sixth week, blood samples of two birds from each replicate were collected. The 3 ml blood was collected from wing vein in syringe without any anticoagulant and kept in clot activator tubes. After 3 hrs, clear serum samples were carefully drawn and transferred to dry, clean, eppendorf tubes and stored at -20^0C in a deep freeze until the time of biochemical estimations. The biochemical estimations of blood serum were determined calorimetrically, using commercial kits.

3.8.2. (b) Total Protein

Serum total protein was estimated by Biuret method. (Kaneko, 1980) 10 µl of serum was added in 1000 µl of working reagent and incubated for 5 minutes at 37^oC. After incubation period the absorbance was measured at 578 nm under UV Spectrophotometer and the values were expressed in g/dl. Prior to analysis internal calibration with 1000 µl of working reagent + 10 µl distilled water as blank and 1000 µl of working reagent + 10 µl protein standard as standard (Varley, 2005) was carried out.

3.8.2. (c) Serum Albumin

Serum albumin was estimated by BCG end point method. (Dumas *et al.* 1971) 10 µl of serum was added in 1000 µl of working reagent and incubated for 1 minute at room temperature. After incubation period, two absorbance were measured at 630 nm under UV Spectrophotometer and the values were expressed in g/dl. Prior to analysis internal calibration with 1000 µl of working reagent as blank and 1000 µl of working reagent + 10 µl albumin standard as standard was carried out.

3.8.2. (d) Serum Globulin

Serum globulin was calculated by subtracting serum albumin from total protein.

3.8.2. (e) Albumin and Globulin Ratio

A: G ratio was calculated by dividing albumin by globulin.

3.8.2. (f) Blood urea nitrogen

Urea level was estimated by using urea reagent kit on Ebra-Chem 7 by Berthelot method.

10 µl of serum was added in 1000 µl of working reagent and incubated for 10 minutes at room temperature. After incubation period, two absorbance were measured at 578 nm under UV Spectrophotometer and the values were expressed in mg/dl. Prior to analysis internal calibration with 1000 µl of working reagent + 10 µl standard was performed. (Chaney and Marbach,1962); Brar (2002). The blood urea nitrogen was calculated by multiplying the urea value by 0.467.

3.8.2. (g) Blood glucose

Blood glucose was estimated in the blood samples by GOD-POD, glucose (GOD-POD) LS kit. Glucose oxidizes glucose to gluconic acid and hydrogen peroxide. In the presence of enzyme peroxidase, released Hydrogen Peroxide is coupled with phenol and 4- aminoantipyrine (4-AAP) to form coloured Quinoneimine dye. Absorbance of coloured dye is measured at 505 nm and is directly propotional to glucose concentration in the sample.

10 μl of serum was added in 1000 μl of working glucose reagent and incubated for 10 minutes at 37^0C. After incubation period the absorbance was measured at 505 nm under UV Spectrophotometer and the values were expressed in mg/dl. Prior to analysis internal calibration with 1000 μl of working reagent as blank and 1000 μl of working reagent + 10 μl reagent 3 standard as standard were carried out (Trinder, 1969).

3.8.3 Serum lipid Profile of experimental birds

3.8.3. (a) Serum Total Cholesterol

Serum cholesterol was estimated by cholesterol oxidase/peroxidase method (Allain *et al*., 1974).

10 μl of serum was added in 1000 μl of working reagent and incubated for 10 minute at 37^oC. After incubation period, two absorbance were measured at 505 nm under UV Spectrophotometer and the values were expressed in mg/dl. Prior to analysis internal calibration with 1000 μl of working reagent as blank and 1000 μl of working reagent + 10 μl cholesterol standard as standard was carried out. (Allain *et al*., 1974).

3.8.3 (b) Serum HDL

Serum high density lipoprotein was estimated by cholesterol oxidase/peroxidase method (Allain *et al*., 1974).

The supernatant was made by adding 0.2 ml of serum and 0.3 ml of HDL PPT reagent. Mix it gently for 5 minutes and stand at room temperature for 10 minutes and then centrifuge at 3000 rpm for 10 minutes. 100 μl of supernatant was added in 1000 μl of working reagent and incubated for 20 minute at room temperature. After incubation period, two absorbance were measured at 630 nm under UV Spectrophotometer and the values were expressed in mg/dl. Prior to analysis internal calibration with 1000 μl of working reagent + 100 μl distilled water as blank and 1000 µl of working reagent + 10 µl HDL standard + 100 µl distilled water as standard was carried out.

3.8.3. (c) Serum LDL

Serum low density lipoprotein was estimated by cholesterol oxidase/peroxidase method (Allain *et al*., 1974).

3.8.3 (d) Serum Triglycerides

Serum triglyceride was estimated by glycerol 3 phosphate oxidase/peroxidase methods (Jacobs *et al*., 1981)

10 µl of serum was added in 1000 µl of working triglyceride enzyme reagent and incubated for 10 minutes at 37^0C. After incubation period the absorbance was measured at 546 nm under UV Spectrophotometer and the values were expressed in mg/dl. Prior to analysis internal calibration with 1000 µl of working reagent as blank and 1000 µl of working reagent + 10 µl standard reagent as standard were carried out. Jacobe and Van Demrk (1960); Trinder (1969); Werner *et al*., (1981).

3.9 Gut Parameters

On day 42, two birds from each replicate from each treatment were randomly selected and slaughtered to determine each of microbial count in caecum (*E.coli, Salmonella and Clostridia*) and ileum pH. The carcasses of broilers were subsequently opened and the entire gastrointestinal tract was removed aseptically.

3.9.1 Total microbial count (*E. coli, Salmonella, Clostridia*)

Caecal content of the specimens were taken aseptically and were transfered into sterile plastic bags or zip pouch and immediately transported in cold chain to the laboratory. One gram of each sample was diluted 1:9 (wt/vol) in sterile saline. All samples were subjected to 10 sequential dilutions 1:9 (vol/vol), and 0.1 mL of each sample was plated as duplicates by using spread plate method for *E coli*-EMB agar, *Salmonella*-shegella agar and *Clostridium*-nutrient agar. The samples were incubated for 22 ± 2 h at 37 ºC. Incubation procedure was conducted under aerobic (*E coli* and *Salmonella*) and anaerobic (*Clostridium*) condition in incubator. After incubation, typical colonies were counted. Results were expressed as log10 colony-forming units per g of ileal digesta (log10 CFU/g).Results for each bacterium (*E. coli*, *Salmonella* and *Clostridia* spp.) were also checked about its presence.

3.9.2 Gut pH

To determine the pH, 10 gm of intestinal content from ileum were collected aseptically in 90 ml sterilized physiological saline (1:10 dilution) (Al-Natour and Alshawabkeh, 2005) and pH was measured by using digital pH meter.

3.10 Nutrient digestibility and N retention

In order to observe nitrogen retention metabolic trial was carried out for a period of three consecutive days at the end of 6^{th} week of age. In this trial, four birds from each group representing the average body weight of the group were randomly chosen and housed in metabolic cage with provision of separate feeders and drinkers. The arrangement was also made for collection of excreta using clean dry polythene sheet spread over the dropping trays of metabolic cages. On first day, the polythene sheet was spread over the dropping trays and birds were offered weighed quantity of experimental diets.

During the metabolic trial, the droppings from individual birds from different groups were collected daily on 24 hours interval. The excreta was made free from feathers and extraneous and then weighed. The 1/10threpresentative samples from each group were drawn and stored in labeled wide mouth glass bottle containing 10% H_2SO_4 used for nitrogen analysis. However, remaining dried fecal sample was stored in polythene bags use further for the nitrogen analysis as per AOAC (2000). All birds were individually weighed before and after metabolic trial.

3.10.1 Collection and Sampling of faecal excreta

The faecal excreta voided by bird each treatment group during 24 hours of metabolic trial were weighed daily at 08.00 A.M. The excreta of bird of each treatment group which was voided during preceding 24 hours was mixed thoroughly in plastic trough and representative sample was transferred into suitable air tight sampling bottle for further analyses in laboratory.

3.10.2 Aliquoting of faecal excreta

Depending upon the daily faecal output, a suitable fraction for daily aliquoting was mixed for the estimation of dry matter.

3.10.3 Proximate composition of faeces

The chemical analysis of the broiler faeces were carried out as per AOAC (2000) for all the proximate principles.

3.11 Economics of Broiler Production

The cost of rearing the chicks for complete experiment was calculated by taking into consideration the cost of chick, cost of total feed consumed by bird, cost of litter, vaccination and medication expenses. Mean feed cost per chick was

Plate 3.5 Blood collection of experimental birds fed diet supplemented with butyrate

Plate 3.6 Collection of faecal samples of experimental birds to determine nutrient digestibility and nitrogen retention

calculated according to the market rate of each feed ingredient per kg basis including the cost of butyrate. Gross return per chick was calculated according to market rate for live weight of bird per kg basis. The relative economic efficiency percent was calculated by considering the net profit per Kg live weight of birds incurred in all treatment groups than control and expressed it on percent basis.

3.12 Statistical Analysis

The data collected during the experiment were subjected to statistical analyses as per Completely Randomized Design (CRD) method with treatment as factor following statistical procedure of Snedecor and Cochran (1994). Means were compared as per Duncan's multiple range test and data were processed for statistical analyses using SPSS Software package (23.0).

Results and Discussion

CHAPTER - IV

RESULTS AND DISCUSSION

The present experiment was undertaken to assess effect of dietary inclusion of butyrate at different level (0.5%, 1% and 1.5%) in broiler chicken on the growth performance, carcass traits, blood biochemical's, gut parameter, nutrient digestibility, N retention and cost economic of production. The data collected during the experiment was statistically analyzed for various response parameters and results obtained are presented and discussed in this chapter.

4.1 Proximate principle composition of experimental broiler diets

The proximate composition, calcium, phosphorus and calculated metabolizable energy (ME Kcal/Kg) of experimental broiler diets for various treatments during various phases i.e. pre-starter (PS), starter (S) and finisher (F) is given in table 4.1. The crude protein percentage of various treatments groups confirmed well with BIS (2007) feeding standard for broiler in the said phases i.e. pre-starter (23), starter (22) and finisher (20) in said order. The per cent crude fibre, ether extract, total ash, acid insoluble ash, nitrogen free extract, calcium and phosphorus were within normal range as per BIS (2007) standards. The calculated ME Kcal/Kg for various treatments diets was comparable with BIS (2007) standards for the said phase (ME Kcal/Kg: PS-3000, S-3100, F-3200.)

From the results, it was observed that content of various proximate compositions, calcium, phosphorus, and calculated metabolizable energy (ME Kcal/Kg) of experimental broiler diets is in agreement with BIS (2007) standards for broiler chickens. The CP per cent in pre-starter [22.78 (T_1) to 22.93 (T_3)], starter [21.84 (T_0) to 21.91 (T_3)], finisher [19.88 (T_0) to 19.98 (T_3)]. And other all proximate principle namely crude fibre, ether extract, total ash, acid insoluble ash, nitrogen free extract were well within the normal range as per BIS (2007) standard. Also the calculated metabolizable energy (ME Kcal/Kg: pre-starter-

2992.38, starter-3091.49, finisher-3198.42), calcium (Ca) and phosphorus (P) in normal range as per BIS (2007) standard.

In the present study CP values were pre-starter 22.78 to 22.93, starter 21.84 to 21.91 and finisher 19.88 to 19.98 and calculated metabolizable energy was pre-starter-2992.38, starter-3091.49 and finisher-3198.42. The CP per cent and ME values of present study were well matched with findings of Taherpour *et al.,* (2009) [CP values: starter 23, grower 20 and finisher 18, and ME value: starter 3010, grower 3150 and finisher 3200]. CP per cent and ME value of present study was well matched with CP and ME values of Pouraziz *et al.,* (2013) [CP values: starter 21.45 and grower 19.48, and ME value: starter 2990 and grower 3032].

Table 4.1 Proximate Principles, Ca, P and Metabolizable energy content of Experimental Diets Fed to Broiler

Nutrients		CP (%)	CF (%)	EE (%)	TA (%)	AIA (%)	NFE (%)	Ca (%)	P (%)	Calculated ME Kcal/Kg
T_0	PS	22.8	3.84	3.25	4.29	1.65	66.1	1.05	0.73	2992.38
	S	21.8	3.57	3.68	5.12	1.99	67.8	1.08	0.71	3091.49
	F	19.9	4.17	4.19	5.7	1.9	66.7	1.09	0.71	3198.42
T_1	PS	22.8	3.54	3.4	4.12	2.02	65.7	1.07	0.7	2992.38
	S	21.9	3.45	3.7	5.4	1.47	67.6	1.09	0.72	3091.49
	F	19.9	3.89	4.33	6.14	1.52	65.9	1.1	0.73	3198.42
T_2	PS	22.8	3.7	3.24	4.46	1.92	66.4	1.08	0.71	2992.38
	S	21.9	3.89	3.54	5.92	1.65	65.9	1.1	0.7	3091.49
	F	19.9	4.1	3.95	6.22	2.24	66.1	1.12	0.71	3198.42
T_3	PS	22.9	4.01	3.04	4.21	2.07	65.8	1.1	0.7	2992.38
	S	21.9	3.93	3.63	5.87	1.41	65.8	1.11	0.73	3091.49
	F	20	4.24	4.1	6.5	2.12	65.2	1.13	0.7	3198.42
PS- pre-starter; S-starter; F-finisher										

4.2 Feed Intake (g) of experimental birds fed diet supplemented with butyrate

4.2.1 Cumulative feed intake (g) of experimental birds fed diet supplemented with butyrate

The cumulative feed intake from 1st to 6th week in experimental birds supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is given in Table 4.2.1 and ANOVA is given in appendices and graph is shown in fig. 4.1. It is evident from table 4.2.1 that in 1st week cumulative feed intake in all the experimental groups was almost comparable. From 2nd week until end of experiment the cumulative feed intake was non-significantly ($P>0.05$) lower in T_3 as compared to other experimental groups. The cumulative feed intake (g) at the end of 6th week was 4323.72 ±24.72, 4317.37 ±4.41, 4302.66 ±13.04 and 4288.64 ±8.97 in T_0, T_1, T_2 and T_3 respectively.

Results of the present findings are in line with the findings of Dolan *et.al.*, (2016) who observed that the non-significant differences pertaining to weekly feed intake when the diets supplemented with different level of coated sodium butyrate in broiler chickens. Similarly Hernandez *et al.*, (2006) found that the cumulative feed intake did not differ significantly ($P>0.05$) for the diets supplemented with formic acid at different levels in broiler chickens. Also Adil *et al.*, (2010) and Kamal and Ragaa (2014) found non-significant differences pertaining to feed intake when experimental birds were supplemented with different levels of organic acids in broiler chickens.

In contrast to the present findings Lesson *et al.*, (2005) reported that the feed intake was significantly ($P<0.01$) decreased by supplemented with 0.4% butyric acid as compared to other groups in broiler chickens. Similarly Ogunwole *et al.*, (2011) who found significant differences pertaining to feed intake when diet of experimental broiler chickens was supplemented with acidifier diet.

Table 4.2.1 Cumulative feed intake (g) in experimental birds fed diet supplemented with butyrate

Age in weeks	Treatment				SEM	P
	T0	T1	T2	T3		
1	130.37 ±2.52	132.75 ±0.46	131.69 ±0.89	131.27 ±4.53	3.73549	0.934
2	503.44 ±3.28	505.22 ±0.40	503.06 ±3.17	499.39 ±3.65	4.13786	0.570
3	1108.05 ±16.43	1105.92 ±7.95	1098.42 ±4.88	1090.46 ±5.00	13.81835	0.588
4	1958.04 ±15.77	1954.66 ±3.86	1942.36 ±3.02	1930.27 ±5.49	12.30751	0.152
5	2961.56 ±22.04	2956.64 ±4.28	2943.37 ±9.15	2930.33 ±3.56	17.32484	0.315
6	4323.72 ±24.72	4317.37 ±4.41	4302.66 ±13.04	4288.64 ±8.97	20.99200	0.381

4.2.2 Weekly feed intake (g) in experimental birds fed diet supplemented with butyrate

The weekly feed intake (g) in experimental bird's diets supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is detailed in table 4.2.2 and ANOVA is given in appendices and graph is depicted in fig. 4.2. In 1st week the weekly feed intake (g) in all experimental groups almost similar. In 2nd week the weekly feed intake (g) was numerically lower in treatment groups T_3 as compared to experimental group T_2, T_1 and control group T_0. The weekly feed intake (g) in 3rd to 6th week was not-significantly different (P<0.05) in treatment group T_3 as compared to treatment group T_2, T_1 and control group T_0. Weekly feed intake on 6th week was 1362.17 ±5.97, 1360.74 ±4.70, 1359.29 ±6.01 and 1358.31 ±5.46 in T_0, T_1, T_2 and T_3 respectively.

Results of the present findings are agreement with Dolan *et.al*., (2016) who observed that the non-significant differences pertaining to weekly feed intake (g) when the diets supplemented with different level of coated sodium butyrate in broilers. Similarly Hernandez *et al*., (2006) observed that the cumulative feed

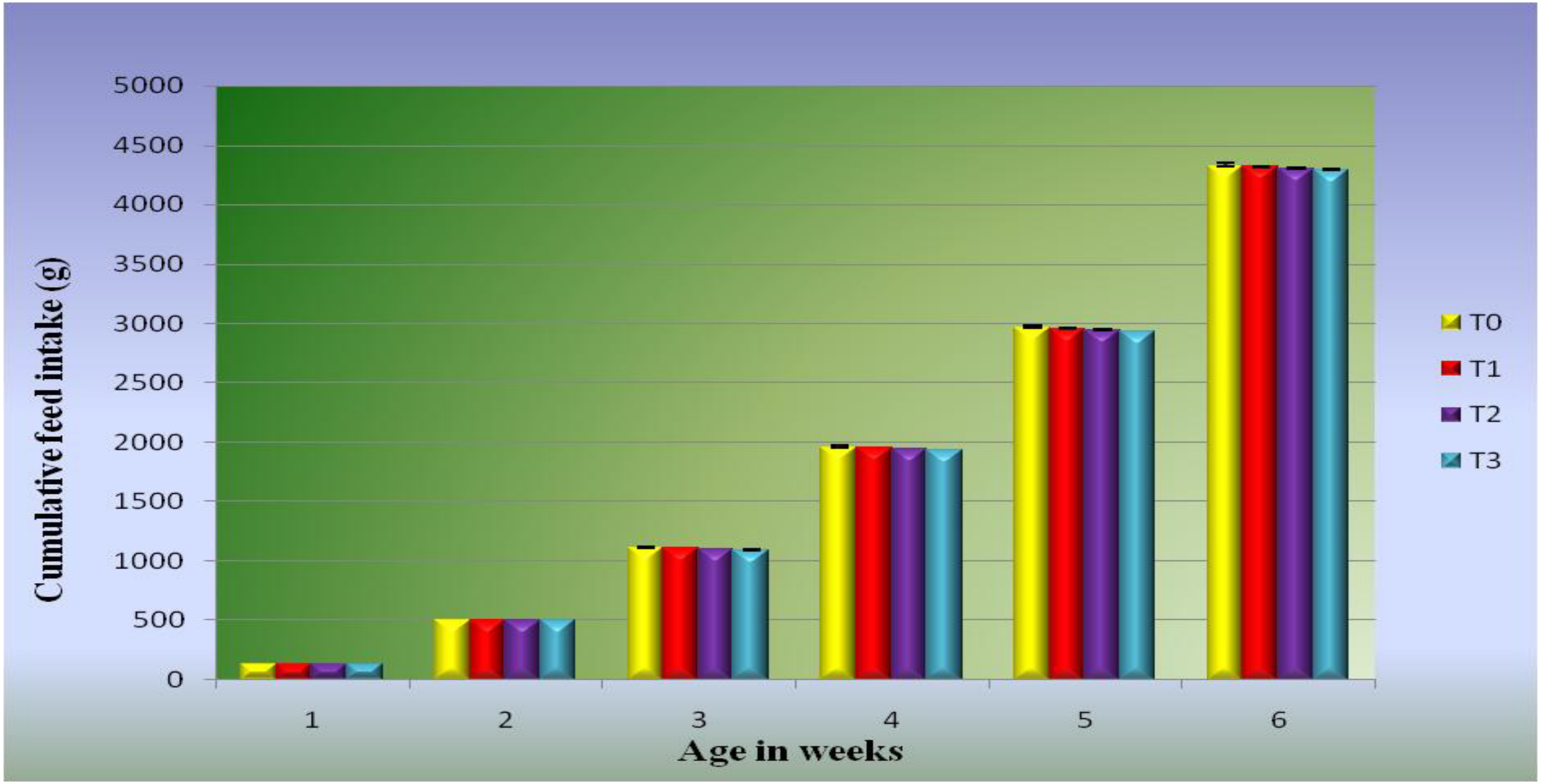


Fig.4.1 Cumulative feed intake (g) of experimental birds fed diet supplemented with butyrate

intake was not differ significantly (P>0.05) dietary supplemented with formic acid at different inclusion levels in broiler chickens. Also Adil *et.al*., (2010), Kamal and Ragaa (2014) they found that the non-significant differences pertaining to weekly feed intake when experimental birds were supplemented organic acids at different levels in broiler chickens.

Outcomes of the present findings are antithetical to the findings of Lesson *et al*., (2005) who reported that the feed intake differed significantly (P<0.01) when supplemented with 0.4% butyric acid in broiler chickens. Ogunwole *et al*., (2011) who recorded significant increase in feed intake following acidifier supplementation in the broilers diet.

Table 4.2.2 Weekly feed intake (g) in experimental birds fed diet supplemented with butyrate

Age in weeks	Treatment				SEM	P
	T0	T1	T2	T3		
1	130.37 ±2.52	132.75 ±0.46	131.69 ±0.89	131.27 ±4.53	3.73549	0.934
2	373.06 ±2.66	372.47 ±0.68	371.37 ±2.74	368.12 ±5.78	4.92422	0.755
3	604.62 ±13.35	600.70 ±7.70	595.36 ±2.40	591.08 ±3.84	11.35649	0.659
4	849.99 ±3.24	848.75 ±10.41	843.94 ±5.60	839.81 ±3.42	8.99830	0.665
5	1003.52 ±6.76	1001.97 ±4.42	1001.01 ±6.86	1000.06 ±5.13	8.32496	0.978
6	1362.17 ±5.97	1360.74 ±4.70	1359.29 ±6.01	1358.31 ±5.46	7.86488	0.963

4.3 Growth performance of experimental birds fed diet supplemented with butyrate

4.3.1 <u>Cumulative body weight gain (g) of experimental birds fed diet supplemented with butyrate</u>

Data pertaining to the cumulative body weight of experimental birds influenced by supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is presented in table 4.3.1 and ANOVA is given in appendices and graph is shown in fig. 4.3.

In 1st week cumulative body weight gain was non-significant but numerically higher in T_0 and T_3 as compared to T_1 and T_2. In 2nd week the cumulative body weight gain was significantly higher (P<0.01) in T_3 followed by T2 as compared to T_0 and T_1. In 3rd week the cumulative body weight gain did not differ significantly but numerically higher in T3 as compared to other treatment groups and control. In 4th week the cumulative body weight gain was significantly higher (P<0.05) in T_3 as compared to T_0 and T_1 and the value for T_2 was comparable amongst all treatment groups. In 5th and 6th week the cumulative body weight gain was significantly higher in T_3 as compared to T_0 and T_1, the value for T_1 and T_2 comparable, similarly values of the T_2 and T_3 were also comparable. Cumulative body weight gain (g) on 6th week of experimental groups was 2425.20 ±12.21, 2442.61 ±2.33, 2461.76 ±1.90 and 2475.39 ±0.32 in T_0, T_1, T_2 and T_3 respectively.

Results of the present findings are in accordance with the findings of Panda *et al*., (2009) who reported that the significantly (P<0.05) higher body weight was observed when supplemented with 0.4 and 0.6% butyric acid in broiler chickens. Similarly Adil *et.al*., (2010) and Kamal and Ragaa (2014) they recorded significant differences (P<0.05) pertaining to body weight gain when experimental birds were supplemented with different levels of organic acids. Lakshmi and Sunder (2015) they found significantly (P<0.01) higher body weight compared to control diet supplemented with different levels of organic acids in broiler chickens.

The enhancement in the cumulative body weight gain may be accredited to the improved weekly body weight gain with the supplementation of different levels of butyric acids in the diet of the experimental broiler chickens of the aforesaid experiments. On the contrary to the present findings, Lesson *et al*., (2005) observed that diet supplemented with butyric acid had no effect on body weight gain. Dolan *et.al.,* (2016) noted non-significant differences when an coated

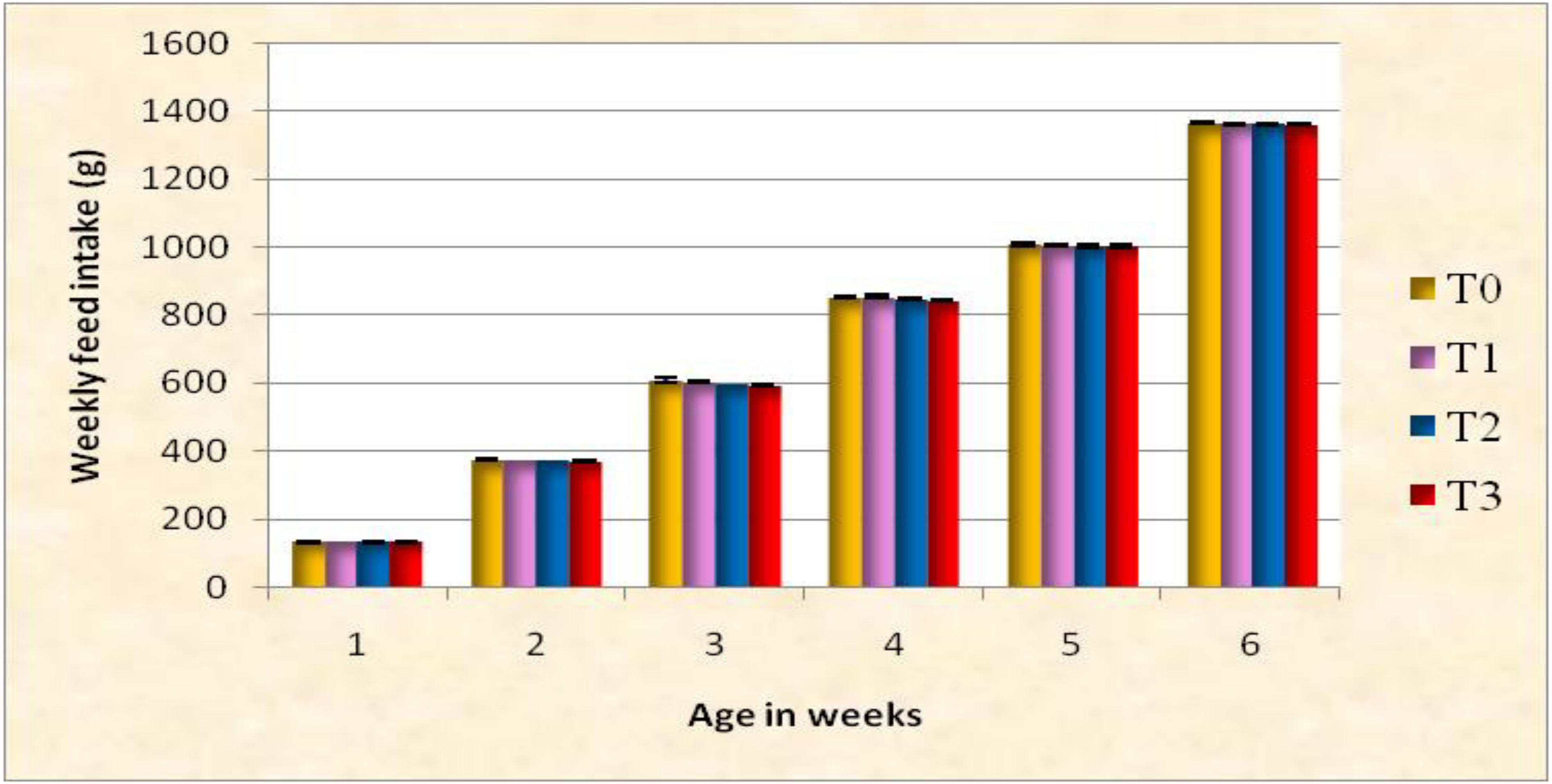


Fig.4.2 Weekly feed intake (g) of experimental birds fed diet supplemented with butyrate

sodium butyrate was incorporated in the diet of experimental broiler chickens at different levels.

Table 4.3.1 Cumulative body weight gain (g) of experimental birds fed diet supplemented with butyrate

Age in weeks	Treatment				SEM	P
	T0	T1	T2	T3		
1	115.64 ±2.08	110.22 ±0.49	112.32 ±0.50	115.35 ±3.36	2.83685	0.226
2	381.45^{a} ±0.79	383.60^{a} ±1.25	387.40^{b} ±0.80	391.13^{c} ±0.44	1.23027	0.001
3	770.29 ±8.37	774.93 ±4.57	779.09 ±2.30	786.84 ±1.56	7.02213	0.168
4	1271.76^{a} ±9.17	1278.60^{a} ±1.39	1285.95^{ab} ±1.48	1294.36^{b} ±1.59	6.73149	0.031
5	1792.37^{a} ±10.90	1805.25^{ab} ±2.32	1819.45^{bc} ±2.42	1832.40^{c} ±0.73	8.08185	0.002
6	2425.20^{a} ±12.21	2442.61^{ab} ±2.33	2461.76^{bc} ±1.90	2475.39^{c} ±0.32	8.89850	0.001

**Means bearing different superscripts a, b and c in a row differ significantly (P<0.01)

*Means bearing different superscripts a, b and c in a row differ significantly (P<0.05)

4.3.2 Weekly body weight gain (g) of experimental birds fed diet supplemented with butyrate

Data recorded about weekly body weight gain of experimental birds influenced by supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is presented in table 4.3.2 and ANOVA is given in appendices and graph is given in fig. 4.4.

In 1st week the weekly body weight gain was numerically higher in experimental group viz. T_3 and control group T_0 as compared to T_2 and T_1. In 2nd week weekly body weight gain was significantly higher (P<0.05) in group T_3 followed T_2 and then T_1 as compared to control group T_0. In 3rd and 4th week weekly body weight gain was non-significantly higher in group T_3 followed T_2 and then T_1 as compared to control T_0. In 5th and 6th week the weekly body weight gain was significantly higher (P<0.01) in T_3 and T_2 as compared to control group T_0 and T_1.

Outcomes of the present findings are in tune with the findings of Panda *et al*., (2009) observed that the weekly body weight was significantly (P<0.05) higher when diet supplemented with 0.4 and 0.6% butyric acid in broiler chickens. Adil *et.al*. (2010) and Kamal and Ragaa (2014) who recorded significant differences pertaining to weekly body weight gain when experimental birds were supplemented with different levels of organic acids.

The body weight gain improvement may be attributed to the beneficiary effect of organic acids on the gut flora by lowering the pH. The beneficial microbiological and pH-decreasing abilities of organic acids might have resulted in the inhibition of intestinal bacteria leading to the lowered metabolic needs and thereby increasing the availability of nutrients to the host. This also might have decreased the level of toxic bacterial metabolites as a result of reduced bacterial fermentation causing an improvement in the protein and energy digestibility. Thus, enhancing the weight gain and performance of experimental birds (Adil *et al*., 2010).

Table 4.3.2 Weekly body weight gain (g) of experimental birds fed diet supplemented with butyrate

Age in weeks	Treatment				SEM	P
	T0	T1	T2	T3		
1	115.64 ±2.08	110.22 ±0.49	112.32 ±0.50	115.35 ±3.36	2.83685	0.226
2	265.81^a ±2.26	273.38^b ±0.88	275.09^b ±0.45	275.79^b ±3.49	3.02225	0.023
3	388.85 ±8.53	391.34 ±5.02	391.69 ±1.54	395.71 ±1.27	7.14168	0.814
4	501.47 ±0.97	503.66 ±4.40	506.86 ±1.72	507.52 ±1.65	3.60460	0.341
5	520.61^a ±1.85	526.66^b ±1.28	533.50^c ±1.93	538.04^c ±1.86	2.47243	0.001
6	632.83^a ±1.78	637.35^b ±1.76	642.31^c ±1.15	643.00^c ±0.92	2.05466	0.001

**Means bearing different superscripts a, b and c in a row differ significantly (P<0.01)

*Means bearing different superscripts a, and b in a row differ significantly (P<0.05)

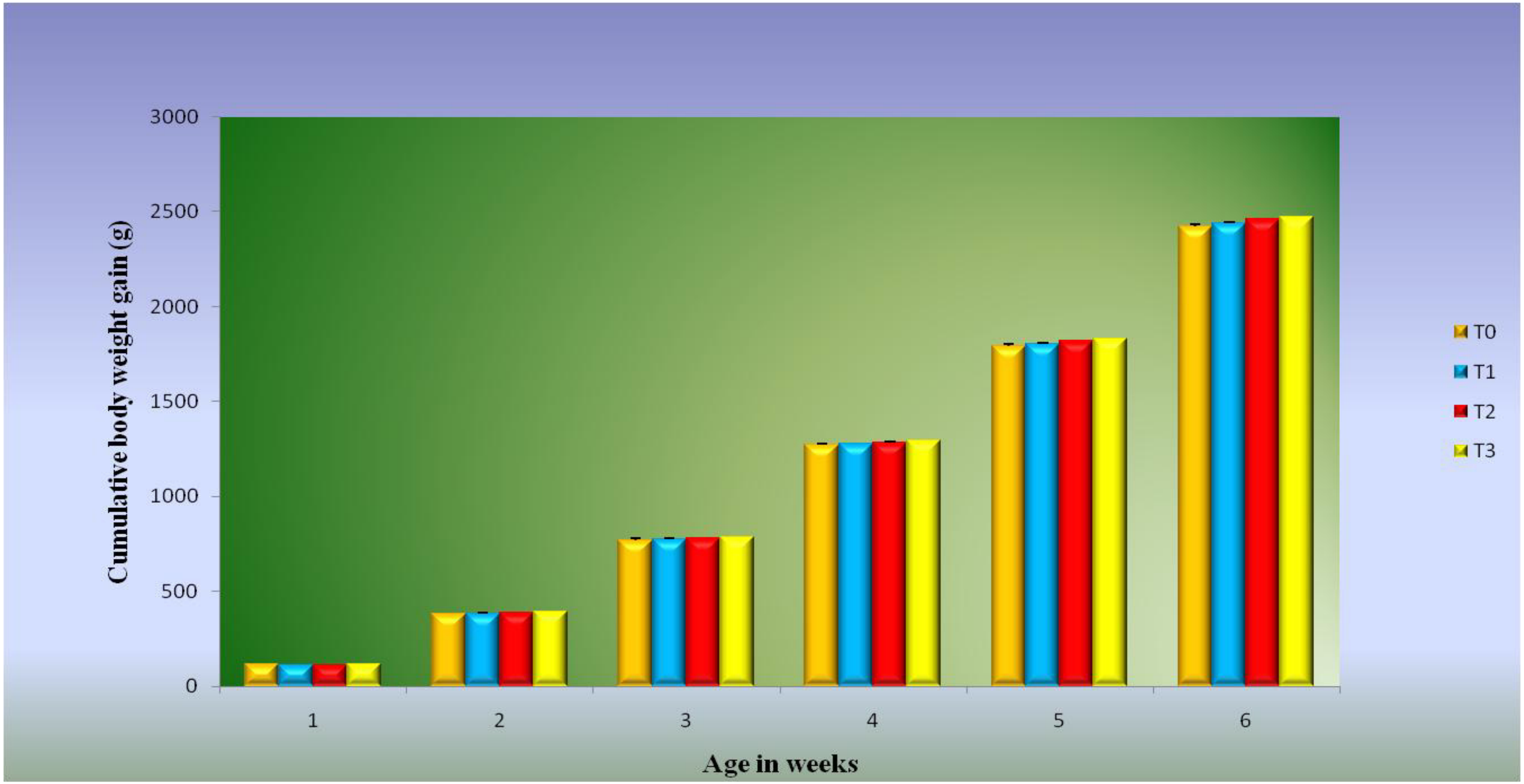


Fig.4.3 Cumulative body weight gain (g) of experimental birds fed diet supplemented with butyrate

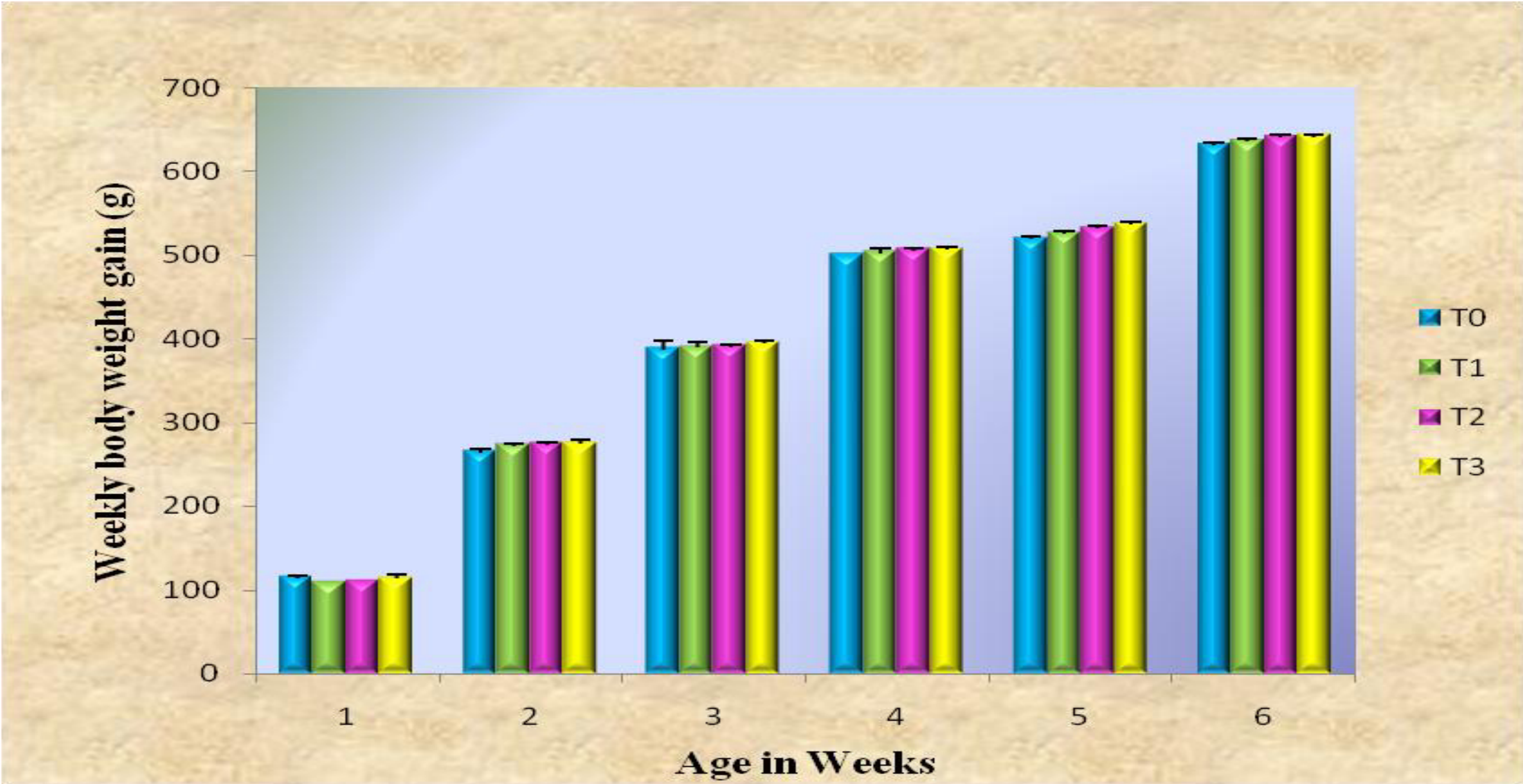


Fig.4.4 Weekly body weight gain (g) of experimental birds fed diet supplemented with butyrate

On the contrary to the present findings, Lesson *et al*., (2005) reported that the weekly body weight gain did not differ significantly (P>0.05) when diet supplemented with butyric acid at different levels in broiler chickens. Similarly Dolan *et.al*., (2016) noted non-significant differences when an coated sodium butyrate was incorporated in the diet of experimental broiler chickens at different levels.

4.4 Feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

4.4.1 Cumulative feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

Data related to the cumulative feed conversion ratio (FCR) of experimental birds supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is detailed in table 4.4.1 and ANOVA is given in appendices and graph is depicted in fig. 4.5.

In 1st week the cumulative feed conversion ratio was significantly better (P<0.01) in T_0 and T_3 as compared to T_1 and T_2. In 2nd week the cumulative feed conversion ratio was significantly better (P<0.05) in T_3 as compared to T_0 and T_1 and the value for T_2 was comparable amongst treatment groups. In 3rd week cumulative feed conversion ratio was significantly better in T_3 fallowed by T_2 as compared to T_0 and the value for T_1 was comparable with T_0 and T_2. In 4th week it was observed that the significantly better cumulative feed conversion ratio in T_3 followed by T_2 as compared to T_0 and T_1. In 5th and 6th weeks the cumulative feed conversion ratio was significantly (P<0.01) better in T_3 followed by T_2, T_1 and then T_0. On 6th week cumulative feed conversion ratio were ranges between 1.78 ±0.00, 1.77 ±0.00, 1.75 ±0.00 and 1.73 ±0.00 in T_0, T_1, T_2 and T_3 groups respectively.

Results of the present study are in close agreement with the findings of Panda *et al*., (2009) observed that the feed conversion ratio was significantly

(P<0.05) improved in diet supplemented with butyric acid (0.2%, 0.4%, and 0.6%) in broiler chickens. Adil *et.al*., (2010) and Lakshmi and Sunder (2015) who noticed significantly better cumulative feed conversion efficiency when diet of the experimental broilers was incorporated with different levels of organic acids. Similar findings also observed when diet supplemented with butyric acid glycerides was significantly improved feed conversion ratio (Lesson *et al*., 2005, Antongiovanni *et al*., 2007 and Taherpour *et al*., 2009).

The feed conversion ratio improved with addition of probiotic, prebiotic and organic acid in broiler diet by maintaining a better microbial environment in digestive tract of bird by reducing the number of pathogenic microbes which enhanced the digestion, absorption and efficiency of utilization of feed (Yeo and Kim, 1997, Khaksefidi and Ghoorchi, 2006).

Findings of the present study are antithetical to the recordings of Mahdavi and Torki (2009), Kamal and Ragaa (2014) and Dolan *et al*., (2016) who noted non-significant differences pertaining to cumulative feed efficiency when experimental broiler birds were supplemented with different levels of organic acids.

Table 4.4.1 Cumulative Feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

Age in weeks	Treatment				SEM	P
	T0	T1	T2	T3		
1	1.13^{a} ±0.01	1.20^{c} ±0.00	1.17^{b} ±0.01	1.14^{a} ±0.01	0.01172	0.001
2	1.32^{b} ±0.01	1.32^{b} ±0.00	1.30^{ab} ±0.01	1.28^{a} ±0.01	0.01159	0.011
3	1.44^{c} ±0.01	1.43^{bc} ±0.00	1.41^{b} ±0.00	1.39^{a} ±0.01	0.00700	0.001
4	1.54^{c} ±0.00	1.53^{c} ±0.00	1.51^{b} ±0.00	1.49^{a} ±0.01	0.00510	0.001
5	1.65^{d} ±0.00	1.64^{c} ±0.00	1.62^{b} ±0.00	1.60^{a} ±0.00	0.00382	0.001
6	1.78^{d} ±0.00	1.77^{c} ±0.00	1.75^{b} ±0.00	1.73^{a} ±0.00	0.00421	0.001

**Means bearing different superscripts a, b, c and d in a row differ significantly (P<0.01)
*Means bearing different superscripts a, and b in a row differ significantly (P<0.05)

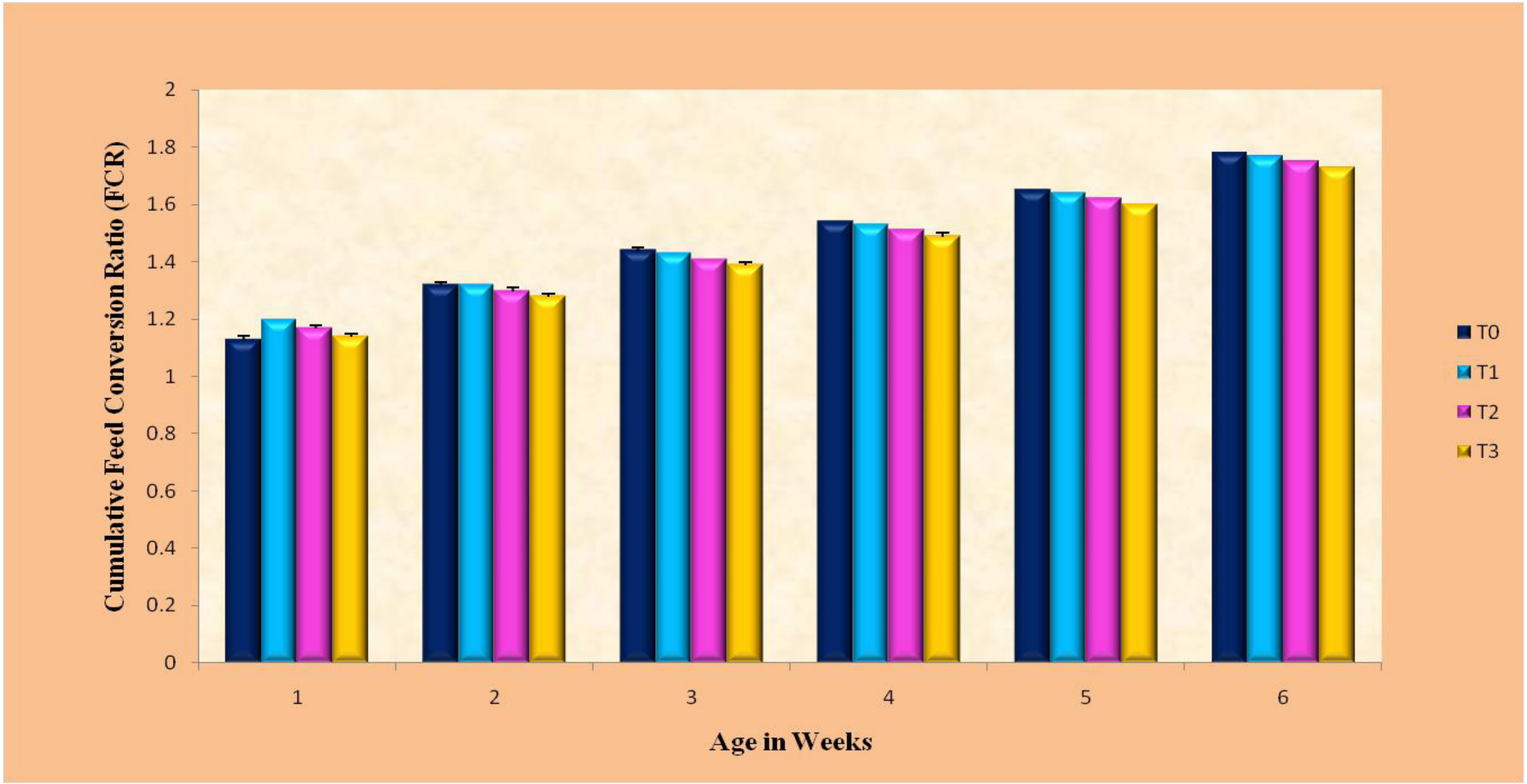


Fig.4.5 Cumulative feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

4.4.2 Weekly feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

The observations recorded of the weekly feed conversion ratio of experimental broiler birds supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is shown in table 4.4.2 and ANOVA is detailed in appendices and graph is shown in fig. 4.6. The weekly FCR was calculated from the data recorded for average weekly body weight gain and weekly feed consumption. In 1st week the weekly FCR was significantly better (P<0.01) in control T_0 and T_3 as compared to T_2 and T_1. In 2st week the average weekly FCR were significantly improved (P<0.05) in T_3 followed by T_2 and then T_1 as compared to control group T_0. In 3rd and 4th week the weekly FCR was significantly better in T_3 and T_2 as compared to T_1 and control group T_0. In 5th week, weekly FCR was significantly better in T_3 and T_2 as compared to T_0 and T_1. But in the 6th week there was significantly better (P<0.05) FCR in the T_3 and T_2 group as compared to control. While FCR of T_1 was comparable to all experimental groups.

Findings of the present study pertaining to weekly feed conversion ratio are in accordance with the findings of Adil *et.al*., (2010) and Lakshmi and Sunder (2015) who recorded significantly better feed efficiency in the organic acids supplemented groups when compared with the control. Similar findings reported when the diets supplemented with different inclusion of butyric acid glycerides was significantly improved feed conversion ratio. (Lesson *et.al*., 2005, Antongiovanni *et al*., 2007, Taherpour *et al* ., 2009).

The weekly feed conversion ratio improved by addition of organic acid in broiler diet by improving a better microbial environment in digestive tract of bird by decreasing the number of pathogenic microbes which was responsible enhancement in the digestion, absorption and efficiency of utilization of feed (Gil *et. al.,* 2005, Khaksefidi and Ghoorchi, 2006 and Chicholowski *et. al.,*2007).

On the contrary to the present findings, Mahdavi and Torki (2009) and Kamal and Ragaa (2014) they recorded non-significant differences pertaining to weekly feed efficiency when experimental broiler birds were supplemented with different levels of organic acids. Similarly Dolan *et al*. (2016) who observed that the weekly feed conversion ratio did not differ significantly when dietary supplemented of coated sodium butyrate (0.1%, 0.5% and 1%) in broiler feed.

Table 4.4.2 Weekly Feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

Age in weeks	Treatment				SEM	P
	T0	T1	T2	T3		
1	1.13^{a} ±0.01	1.20^{c} ±0.00	1.17^{b} ±0.01	1.14^{a} ±0.01	0.01172	0.001
2	1.40^{b} ±0.01	1.36^{a} ±0.01	1.35^{a} ±0.01	1.33^{a} ±0.01	0.01437	0.003
3	1.56^{c} ±0.01	1.54^{bc} ±0.00	1.52^{b} ±0.00	1.49^{a} ±0.01	0.01055	0.001
4	1.70^{b} ±0.01	1.69^{b} ±0.01	1.67^{a} ±0.01	1.65^{a} ±0.01	0.00911	0.003
5	1.93^{c} ±0.01	1.90^{b} ±0.00	1.88^{a} ±0.01	1.86^{a} ±0.01	0.00997	0.001
6	2.15^{b} ±0.00	2.14^{ab} ±0.01	2.12^{a} ±0.01	2.11^{a} ±0.01	0.01045	0.008

**Means bearing different superscripts a, b and c in a row differ significantly (P<0.01)
*Means bearing different superscripts a and b in a row differ significantly (P<0.05)

4.5 Carcass traits of experimental birds fed diet supplemented with butyrate in broiler chickens

Data pertaining to the carcass traits of experimental birds supplemented with different levels of butyric acid in the treatment groups T_1(0.5%), T_2(1%) and T_3(1.5%) is presented in table 4.5 and ANOVA is detailed in appendices and graph is given in fig. 4.7. The live body weight of birds (g) in all experimental treatments almost same viz.T_0, T_1, T_2, T_3. The dressing percentage was numerically higher in experimental groups T_3 followed by T_2, T_1 and then T_0. The average value of dressing percentage (%) in the T_0 (71.11 ±0.52), T_1 (72.05 ±0.63), T_2 (72.15 ±0.12) and T_3 (72.45 ±.019). Carcass weight was numerically

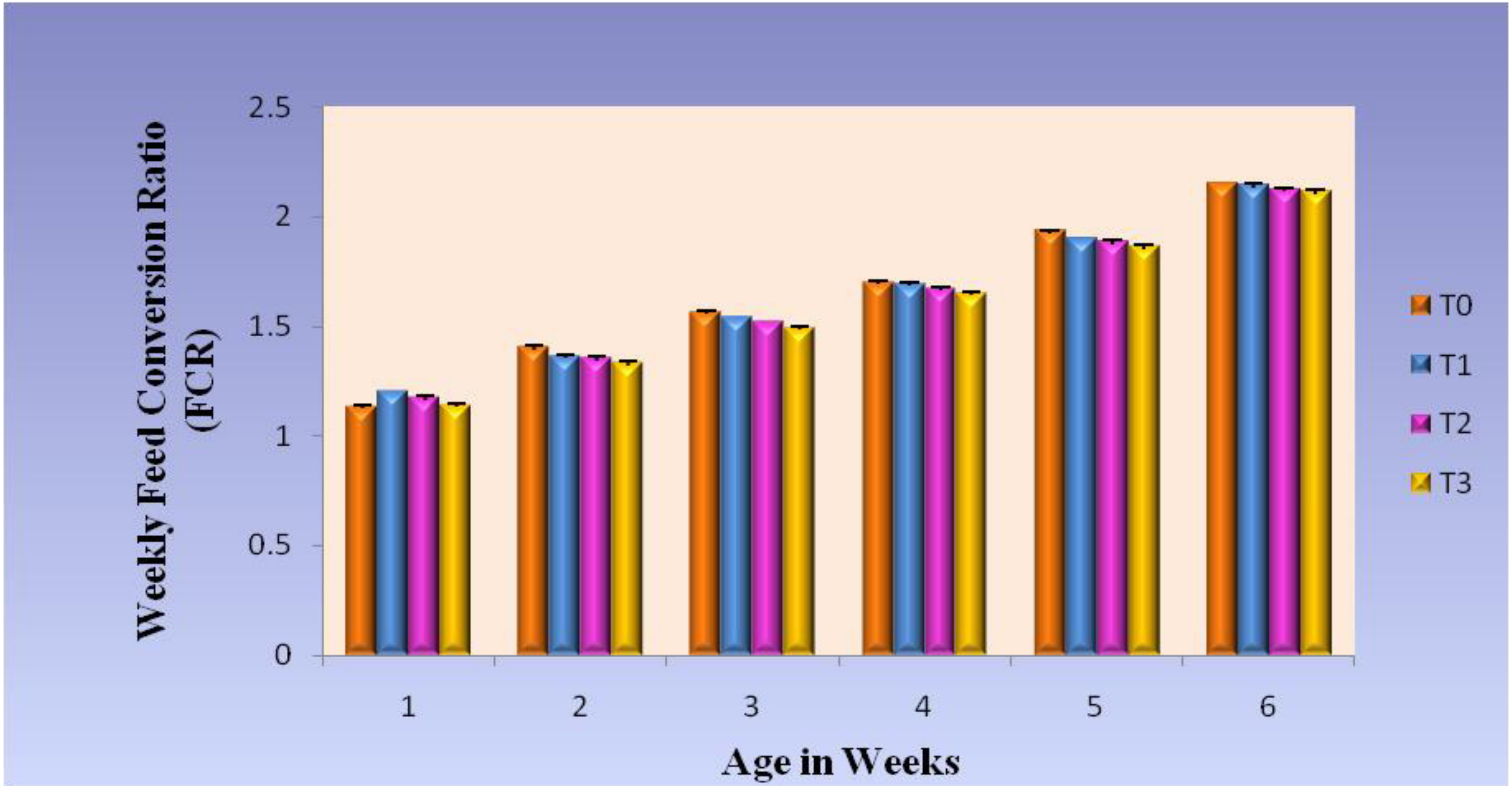


Fig.4.6 Weekly feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

increased in group T_3 followed by T_2, T_1 and then T_0. The average value of carcass weight (g) in T_0 (1770.13 ±18.40), T_1 (1793.00 ±41.02), T_2 (1803.63 ±8.07) and T_3 (1818.75 ±.10.79).

Similar results were observed by Adil *et. al.,* (2010) and Kamal and Raga (2014) they observed that the dressing percentage did not differ significantly (P>0.05) when supplemented with organic acid i.e butyric acid, fumaric acid and lactic acid at different inclusion levels. Similarly Mansoub *et.al*., (2008) who reported that the carcass weight did not affected by broiler fed different level of butyric acid glycerides.

Contrary to the present findings, Lesson *et. al*., (2005) reported that the carcass weight was significantly increased (P<0.01) in diet supplemented with 0.2% butyric acid in broiler chickens. Panda *et al*., (2009) reported that the significant differences (P>0.05) among all the treatment groups supplemented with different inclusion levels of butyric acids when dressing percentage was considered.

Giblet weight (g) was found to be increased non-significantly in group T_3 followed by T_2, T_1 and then T_0. The value for giblet weight (g) was T_0 (91.13 ±1.44), T_1 (91.75 ±1.49), T_2 (92.71 ±1.23) and T_3 (93.98 ±2.12) and the percent giblet remained comparable amongst all treatment groups (3.66 ±0.06, 3.69 ±0.04, 3.71 ±0.04 and 3.74 ±0.07 respectively).

The giblet weight (g) and giblet percentage (%) were found to be did not differ significant (P>0.05) when supplemented with butyrate at the different levels T_1-0.5%, T_2-1% and T_3-1.5%. These results corroborates with Adil *et. al*., (2010) and Kamal and Ragaa (2014) they reported that the weight of giblet (g) did not differ significantly (P>0.05) supplemented with different level of organic acids.

The weight of edible meat (g) was increased linearly (P>0.05) when the increased in dietary supplemented of butyric acids T_1 (0.5%), T_2 (1%) and T_3 (1.5%) and edible meat percentage was comparable amongst treatment groups.

In present study weight of immune organ i.e spleen and bursa were did not influenced by the dietary supplementation of butyric acids in different inclusion levels. The weight of immune organ was comparable amongst all treatment groups. The average weight (g) for spleen was T_0 (2.40 ±0.06), T_1 (2.38 ±0.05), T_2 (2.37 ±0.08), T_3 (2.36 ±0.11) and that for bursa was T_0 (1.25 ±0.01), T_1 (1.23 ±0.02), T_2 (1.22 ±0.03) and T3 (1.22 ±0.01).

Results of the present study is similar with Chamba *et al*., (2014) who observed that the weight of spleen did not differ significantly (P>0.05) by diet containing partially protected sodium butyrate in broiler chickens. Similarly Donal *et al*., (2016) who found the weight of the spleen was not differ significantly by dietary supplemented with coated sodium butyrate at different levels in broiler. Mansoub *et al*., (2011) reported that weight of bursa did not differ significantly when diets supplemented with different levels of butyric acid glycerides in broiler chickens.

In contrast to the present finding Lakshmi and Sunder (2015) reported that the weight of spleen and bursa were differ significantly (P<0.01) in diet supplemented with different level of organic acids.

The weight of liver (g) was numerically increased in group T_3 followed by T_2, T_1 and then T_0 and the average weight (g) for liver was T_0 (38.91 ±0.45), T_1 (39.33 ±0.98), T_2 (39.92 ±0.87) and T_3 (41.06 ±1.82).

The weight of liver did not differ significantly (P>0.05) supplemented with butyrate. The similar finding observed by Panda *et al* (2009) who observed that the weight of liver was not influenced by the diet supplemented with butyric acid at inclusion level 0.2%, 0.4% and 0.6% in broiler chickens. Adil *et al*., (2010) and Kamal and Ragaa (2014) found the liver weight did not differ significantly (P>0.05) fed organic acid on different inclusion levels. And similarly Dolan *et al* (2016) observed the diet supplemented with coated sodium butyrate in broiler weight of liver did not differ significantly.

Findings of the present study are contradictory to the recordings of Jang (2011) and Aghazadeh and Tahayazdi (2012) they found that significant difference ($P<0.05$) of weight of liver as compared to control by supplemented with butyric acid.

The breast weight (g) was significantly higher ($P<0.01$) in group T_3 (664.38 ±2.05) and T_2 (652.88 ±4.54) as compared to T_1 (635.38 ±7.41) and T_0 (623.00 ±4.95). And the breast percentage was significantly higher ($P<0.01$) in T_3 (26.47 ±0.13) as compared to control T_0 (25.03 ±0.27) and the value for T_1 (25.55 ±0.22) and T_2 (26.11 ±0.11) comparable amongst themselves.

The finding of the present study similar with Lesson *et al*., (2005) who reported that the breast meat yield was increased significantly ($P<0.01$) birds fed 0.2% butyric acid, Jang (2011) observed that the breast meat differ significantly ($P<0.05$) increases when supplemented with butyric acid in broiler chickens. Lakshmi and Sunder (2015) they found breast meat yield was significantly higher ($P<0.01$) in groups supplemented with different inclusion level of organic acids.

Using butyric acid for its essential role as a source of energy, for absorptive cells and its impact on growth regulation of the gut lymphatic tissues of poultry can also be mentioned, due to lucrative impacts of butyric acid on broiler chickens digestive system, their consumption will enhance their performance and hence increase the weight of breast meat (Jang, 2011)

Contrary to the present findings, Panda *et al* (2009) and Mahdavi and Torki (2009) were revealed that the breast meat yield did not differ significant ($P>0.05$) by dietary supplementation of butyric acid at different level in broiler chickens.

The weight of intestine was significantly higher in T_3 and T_2 as compared to T_0 and value for T_1 was comparable among treatment groups. The average weight (g) for intestine was T_0 (125.75 ±3.79), T_1 (131.75 ±3.57), T_2 (136.13 ±1.68) and T_3 (140.25 ±2.57).

The weight of intestine was significantly differ ($P<0.05$) as compared to control group. Similar finding were observed by Mahdavi and Torki (2009), and

Aghazadeh and Tahayazdi (2012) they found significant increased (P<0.05) the weight of intestine diet supplemented with butyric acid.

Butyric acid supplementation in broiler diet raises the height of villus and the width of the villus could be considered as an active functioning of intestine. Increased villus height offers a greater surface area for absorption of nutrients and consequently higher efficiency to improve the intestine weight.

Table 4.5 Carcass traits of experimental birds fed diet supplemented with butyrate

Parameters	Treatment				SEM	P
	T0	T1	T2	T3		
Live Wt (g)	2489.13 ±8.12	2487.63 ±35.87	2500.00 ±9.77	2510.38 ±11.35	28.07658	0.835
Dressing %	71.11 ±0.52	72.05 ±0.63	72.15 ±0.12	72.45 ±0.19	0.59611	0.187
Carcass Wt (g)	1770.13 ±18.40	1793.00 ±41.02	1803.63 ±8.07	1818.75 ±10.79	33.19019	0.539
Giblet Wt (g)	91.13 ±1.44	91.75 ±1.49	92.71 ±1.23	93.98 ±2.12	2.27037	0.628
Giblet %	3.66 ±0.06	3.69 ±0.04	3.71 ±0.04	3.74 ±0.07	0.07638	0.754
Edible meat Wt (g)	1678.99 ±18.57	1701.25 ±39.91	1710.91 ±7.07	1724.77 ±9.38	32.21454	0.562
Edible Meat %	67.45 ±0.53	68.36 ±0.63	68.44 ±0.13	68.71 ±0.20	0.60836	0.237
Liver Wt (g)	38.91 ±0.45	39.33 ±0.98	39.92 ±0.87	41.06 ±1.82	1.61760	0.590
Wt of Spleen (g)	2.40 ±0.06	2.38 ±0.05	2.37 ±0.08	2.36 ±0.11	0.10956	0.983
Wt of Bursa (g)	1.25 ±0.01	1.23 ±0.02	1.22 ±0.03	1.22 ±0.01	0.02949	0.715
Wt of Breast (g)	623.00^{a} ±4.95	635.38^{a} ±7.41	652.88^{b} ±4.54	664.38^{b} ±2.05	7.21850	0.001
Breast %	25.03^{a} ±0.27	25.55^{ab} ±0.22	26.11^{bc} ±0.11	26.47^{c} ±0.13	0.27316	0.001
Wt of Intestine (g)	125.75^{a} ±3.79	131.75^{ab} ±3.57	136.13^{b} ±1.68	140.25^{b} ±2.57	4.27413	0.030

**Means bearing different superscripts a, b and c in a row differ significantly (P<0.01)

*Means bearing different superscripts a and b in a row differ significantly (P<0.05)

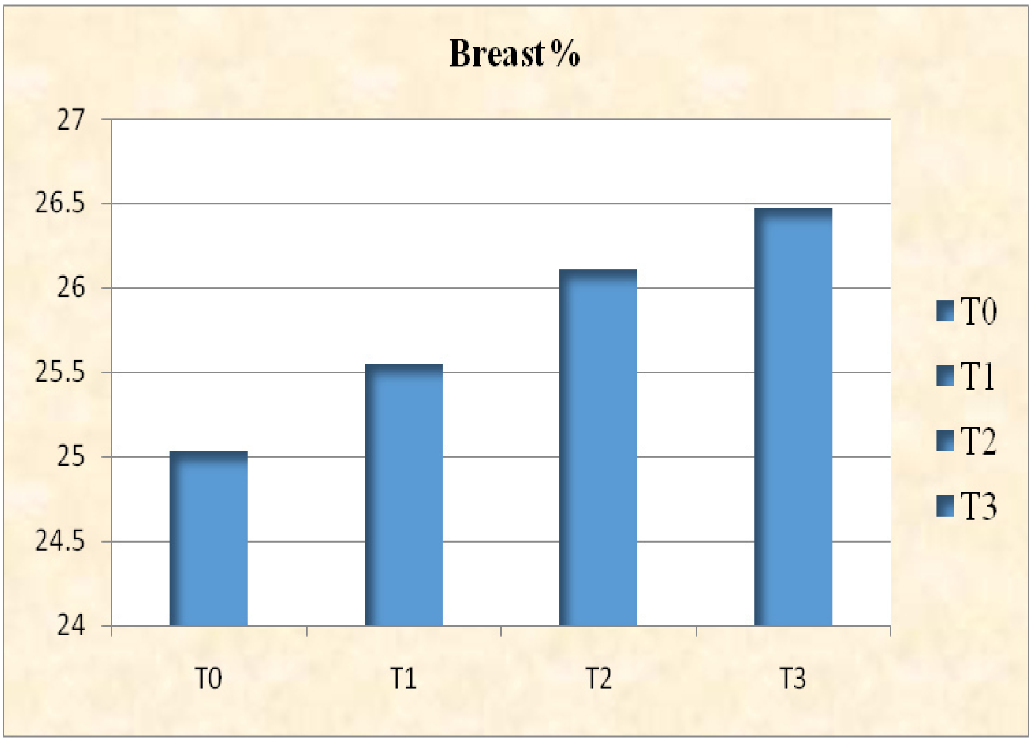


Fig.4.7 Carcass traits of experimental birds fed diet supplemented with butyrate

4.6 Blood biochemical picture in experimental birds fed diet supplemented with butyrate

4.6.1 Haematology parameter in experimental birds fed diet supplemented with butyrate in broiler chickens

Data pertaining to the haematology parameter of experimental birds supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is given in table 4.6.1 and ANOVA is given in appendices.

The haemoglobin (g/dl), RBC and PCV (%) was found almost comparable amongst the all treatment groups T_0, T_1, T_2 and T_3 and the value are T_0 (8.73 ±0.09), T_1 (8.75 ±0.07), T_2 (8.78 ±0.06) and T_3 (8.80 ±0.14)., T_0 (2.41 ±0.07), T_1 (2.40 ±0.07), T_2 (2.43 ±0.13) and T_3 (2.40 ±0.07). and T_0 (26.81 ±0.23), T_1 (26.97 ±0.25), T_2 (27.51 ±0.31) and T_3 (28.02 ±0.84) respectively.

The haemoglobin (g/dl), RBC and PCV (%) was statistically similar to all experimental group supplemented with butyrate. The present results corroborates with Dolan *et al* (2016) who found the statistically non-significant difference amongst groups supplemented with coated sodium butyrate added to broiler feed.

Table 4.6.1 Haematology parameter in experimental birds fed diet supplemented with butyrate

Parameters	Treatment				SEM	P
	T0	T1	T2	T3		
Hb (g/dl)	8.73 ±0.09	8.75 ±0.07	8.78 ±0.06	8.80 ±0.14	0.14310	0.954
RBC ($\times 10^6/\mu l$)	2.39 ±0.07	2.40 ±0.07	2.43 ±0.13	2.40 ±0.07	0.13185	0.989
PCV (%)	26.81 ±0.23	26.97 ±0.25	27.51 ±0.31	28.02 ±0.84	0.68218	0.318

4.6.2 Blood biochemical parameter in experimental birds fed diet supplemented with butyrate

Blood biochemical parameter in experimental birds supplemented with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) presented in table 4.6.2 and ANOVA is given in appendices and graph is shown in fig. 4.8.

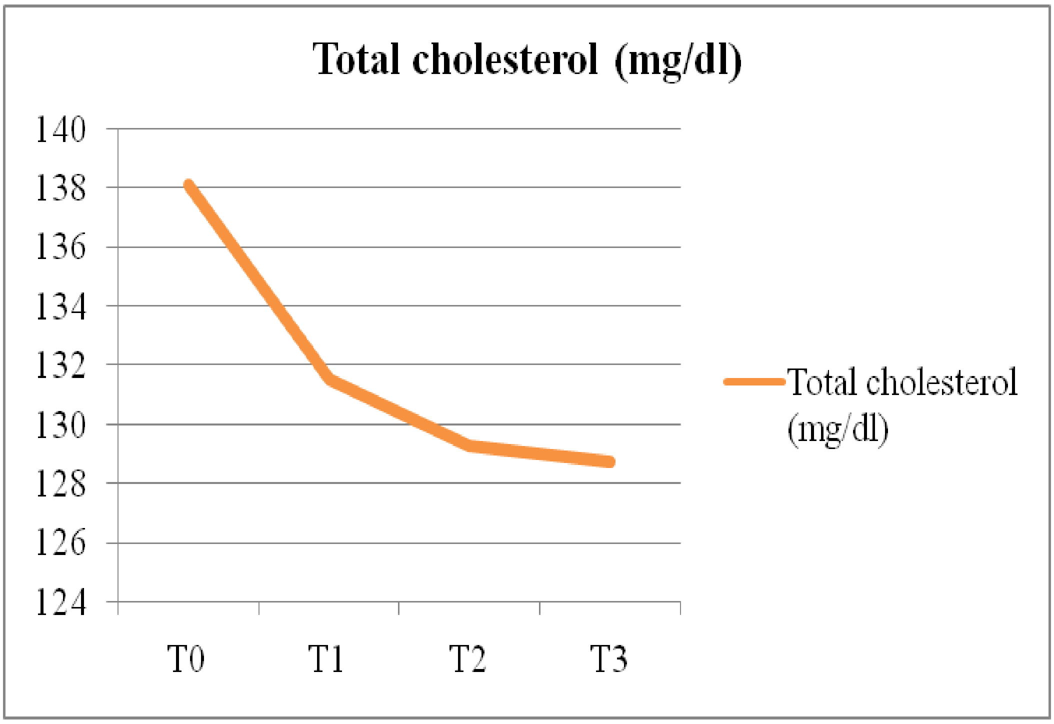
The total protein (g/dl), albumin (g/dl), globulin (g/dl), and A:G ratio was almost comparable in all experimental groups T_0, T_1, T_2 and T_3.

The present finding are in agreement with Kamel and Ragaa (2014) who did not observed any significant ($P>0.05$) effect of supplementation of 3% butyric acid on serum total protein and albumin. Similarly, Dolan *et.al.,* (2016) in agreement with present finding reported that dietary inclusion of coated sodium butyrate at calculated value of T_1 (0%), T_2 (0.01%), T_3 (0.5%) and T_4 (1%) in broiler chickens did not affected the serum total protein, albumin, globulin (g/dl) and A:G ratio.

Increased levels of globulin and low albumin/globulin ratio which means better disease resistance and immune response in line with the increased immune response of OA-supplemented birds (Griminger, 1986 and Abdel-Fattah *et.al*., 2008).

The concentration of serum total protein, albumin and globulin (g/dl) were improved in broiler chickens dietary supplemented with butyric acid glycerides when compared with control group (Ali *et. al*., 2014).

The serum total cholesterol (mg/dl) in present study significantly decreased ($P<0.05$) when linear increased in dietary supplemented of butyric acids T_1 (0.5%), T_2 (1%), T_3 (1.5%). The LDL (mg/dl) was significantly higher ($P<0.05$) in T_0 then all other treatments group except for T_1 which ranged intermediate. The HDL and triglycerides (mg/dl) were almost comparable ($P>0.05$) amongst all experimental groups.



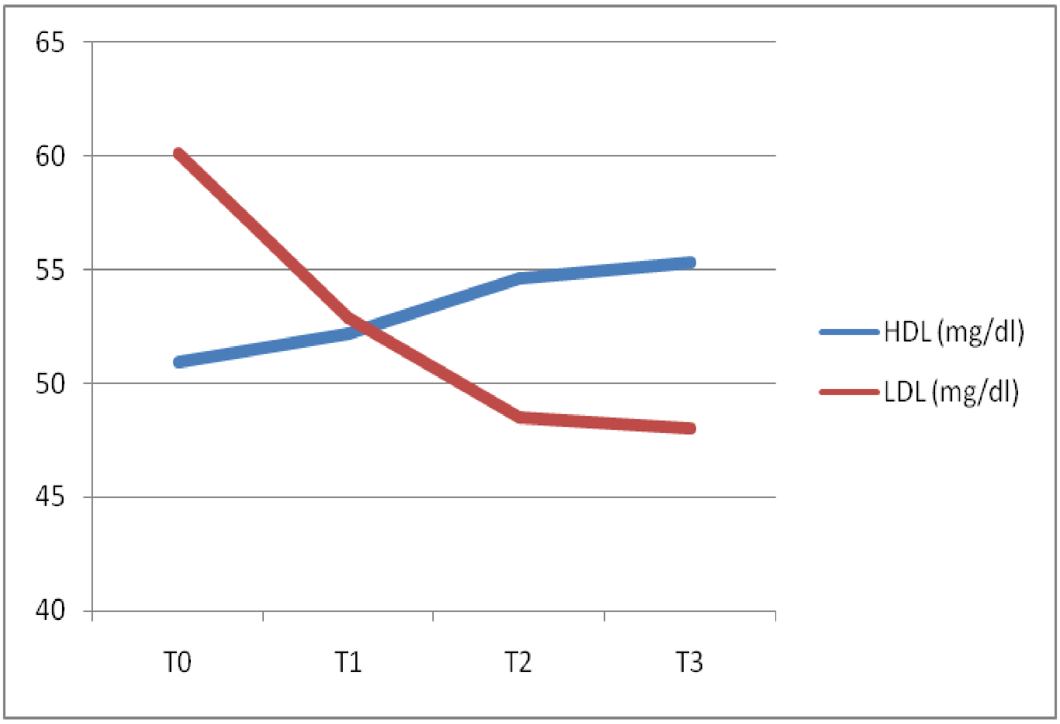


Fig.4.8 Serum biochemical picture of experimental birds fed diet supplemented with butyrate

Agreement with present finding Kamal and Ragaa (2014) revealed that, broilers fed organic acids supplemented diet (3%) were exhibited a lowest level ($P<0.05$) of serum total cholesterol and LDL compared with non supplemented control group however triglycerides and HDL did not differ significantly ($P>0.05$) among treatment groups.

Abdel-Fattah *et al*., (2008) observed that the lower consumption of feed during the period of growth and consequently reduced fat intake that resulting in deposition of fat may also lead to lower blood lipid content.

In contrast with present finding Dolan *et al*., (2016) reported that the effect of dietary inclusion level of sodium butyrate did not affect serum total cholesterol.

The blood glucose (mg/dl) and BUN remained comparable ($P>0.05$) in all treatment groups.

Table 4.6.2 Blood biochemical parameter in experimental birds fed diet supplemented with butyrate

Parameters	Treatment				SEM	P
	T0	T1	T2	T3		
Total protein (g/dl)	3.59 ±0.14	3.60 ±0.07	3.61 ±0.15	3.63 ±0.05	0.15971	0.997
Albumin (g/dl)	1.67 ±0.05	1.64 ±0.03	1.59 ±0.03	1.55 ±0.02	0.05380	0.166
Globulin (g/dl)	1.92 ±0.11	1.96 ±0.08	2.02 ±0.12	2.08 ±0.05	0.14384	0.727
A:G ratio	0.88 ±0.05	0.84 ±0.05	0.80 ±0.05	0.77 ±0.04	0.07185	0.497
Total cholesterol (mg/dl)	138.13^{b} ±0.75	131.52^{a} ±2.01	129.28^{a} ±3.43	128.76^{a} ±0.47	2.88599	0.025
HDL (mg/dl)	50.91 ±2.52	52.16 ±1.64	54.60 ±1.81	55.30 ±1.39	2.67493	0.358
LDL (mg/dl)	60.15^{b} ±2.19	52.89^{ab} ±2.73	48.52^{a} ±3.81	48.01^{a} ±2.12	3.95708	0.034
Triglyceride (mg/dl)	135.36 ±2.05	132.30 ±5.81	130.80 ±5.68	127.19 ±4.31	6.67545	0.678
Blood glucose(mg/dl)	189.18 ±1.52	186.65 ±7.84	181.37 ±4.02	178.21 ±1.81	6.45486	0.356
BUN (mg/dl)	0.53 ±0.01	0.53 ±0.01	0.51 ±0.00	0.50 ±0.00	0.01707	0.260

*Means bearing different superscripts a and b in a row differ significantly ($P<0.05$)

In agreement with present findings Jang (2011) and Adil *et al*., (2010) revealed that dietary inclusion of butyric acid in broiler chickens diet did not affect serum glucose concentration. Also Dolan *et al*., (2016) observed that the dietary supplementation of coated sodium butyrate did not affect blood urea nitrogen in broiler chickens.

4.7 Gut parameter in experimental birds fed diet supplemented with butyrate in broiler chickens

Gut parameter like *E.coli, Salmonella, Clostridia* and ileal pH were observed in the present study when supplemented with butyric acid in the diet at different levels T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is detailed in table 4.7 and ANOVA is given in appendices and graph is depicted in fig. 4.9.

It was observed from the table that, there was significant decrease (P<0.01) in the *E.coli* count in T_3 and T_2 as compared to T_0. The T_1 was comparable amongst T_0 and T_2. The value for *E.coli* (10^7 CFU/gm) was T_0 (6.94 ±0.10), T_1 (6.63 ±0.10), T_2 (6.63 ±0.10) and T_3 (5.92 ±0.11).

In agreement with present study Zou *et. al*., (2010) observed that *E. coli* count was significantly decreased (P<0.05) in groups supplemented with powder and coated sodium butyrate. Similarly Panda *et. al*., (2009) reported that *E. coli* count was decreased significantly (P<0.05) in groups supplemented with 0.4% and 0.6% butyric acid in broiler chickens but when supplemented with 0.2% butyric acid did not decreased *E. coli* count significantly (P>0.05).

The reduced *E. coli* count might be due to protonated form of organic acids can penetrate across the bacterial cell wall and after penetration these acid within bacterial cells dissociate into conjugate base form (Non protonated) with concomitant reduction in cellular pH and once the reduced pH create stressful environment and it leads to affect cellular dysfunction and prevent bacterial growth (Mani-Lopez *et al* ., 2012).

Organic acids enhance protein and energy digestibility by decreasing microbial competition with the host for nutrients and endogenous nitrogen losses, by decreasing the incidence of sub clinical disease and immune mediator secretion, by decreasing the production of ammonia and other microbial metabolites that depress development (Dibner and Butin, 2002).

In contrast to the present finding Hu and Guo (2006) observed jejuna *E. coli* count content did not differ significantly (P>0.05) when supplemented with dietary sodium butyrate in different inclusion levels i.e 0.05%, 0.1% and 0.2% in chickens. Similarly Chamba *et. al*., (2014) found the jejuna *E. coli* count content did not differ significantly (P>0.05) in groups supplemented with 700ppm (0.07%) of partially protected sodium butyrate

It is evident from the table, *Salmonella* count was significantly lower (P<0.01) in T_3 and T_2 as compared to control T_0 and T_1. The values for salmonella count T_0 (5.24 ±0.05), T_1 (4.80 ±0.17), T_2 (4.46 ±0.08) and T_3 (4.20 ±0.08).

Similar results was found to Cox *et al.,* (1994) observed that the *Salmonella* count was significantly decreased (P<0.05) by supplemented with butyric or lactic acid.

Reduction in *Salmonella* count is due to the fact that organic acid will decreased the activity total microbial load but will be particularly effective against *E. coli* and also other acid-intolerant organisms *Salmonella*. A resultant reduction in subclinical infections may contribute to improved nutrient digestibility and a reduction in nutrient requirement by the gut-associated immune tissue (Dibner and Butin, 2002).

Organic acid properties such as chain length, side chain composition, pkA value and hydrophobicity might be factor that effect biocidal activity (Hsiao and Siebert, 1999).

Findings of the present study are antithetical to the recordings of Zou *et al*., (2010) observed that salmonella count did not decreased significantly (P>0.05) supplemented with powder and coated sodium butyrate.

It was revealed from the table 4.7 that, there was significant reduced ($P<0.01$) count of *Clostridia* in groups T_1, T_2 and T_3 as compared to control T_0 and while T_2 was comparable amongst treatment groups. The means value of clostridia was T_0 (5.84 ±0.28), T_1 (5.12 ±0.26), T_2 (4.58 ±0.08) and T_3 (4.12^a ±0.15).

This results obtained in present study are in concord with Zou *et al*., (2010) observed that clostridia count was significantly decreased ($P<0.01$) in groups supplemented with powder and coated sodium butyrate. Biggs and Parsons (2008) they observed that the *Clostridia* count was significantly decreased ($P<0.05$) by supplemented of 4% glyconic acid in young chick.

It is evident from the table 4.7; ileal pH was reduced numerically in all treatment groups. Mean value for ilea pH was T_0 (6.72 ±0.18), T_1 (6.69 ±0.23), T_2 (6.67 ±0.21) and T_3 (6.64 ±0.16).

Results of the present study are in agreement with Zou *et al*., (2010) reported that ileal pH did not differ significantly ($P>0.05$) in diet supplemented with powder and coated sodium butyrate. Panda *et. al*., (2009) observed that the ileum pH was comparable among all the dietary butyrate (0.2%, 0.4% and 0.6%) supplemented treatment groups in broiler chickens.

Reduction in pH is due to undissociated organic acids are lipophilic and can enters across cell membranes, including those of bacteria and molds. Once entered in the bacterial cell, the higher pH of its cytoplasm causes dissociation of the acid, and the resulting decline in pH of the cell contents which might be disrupting enzymatic reactions and nutrient transport systems. In addition, the process of transporting the free proton out of the cell requires energy, which might be contributing to reduced energy availability for proliferation, resulting in some degree of bacteriostasis (Dibner and Butin, 2002).

The free butyrate (butyric acid) quickly absorbed in the upper digestive tract, and while almost 60% of the feed source was intact in the crop, less than 1% is recovered from the upper small intestine. This could be the reason that butyrate

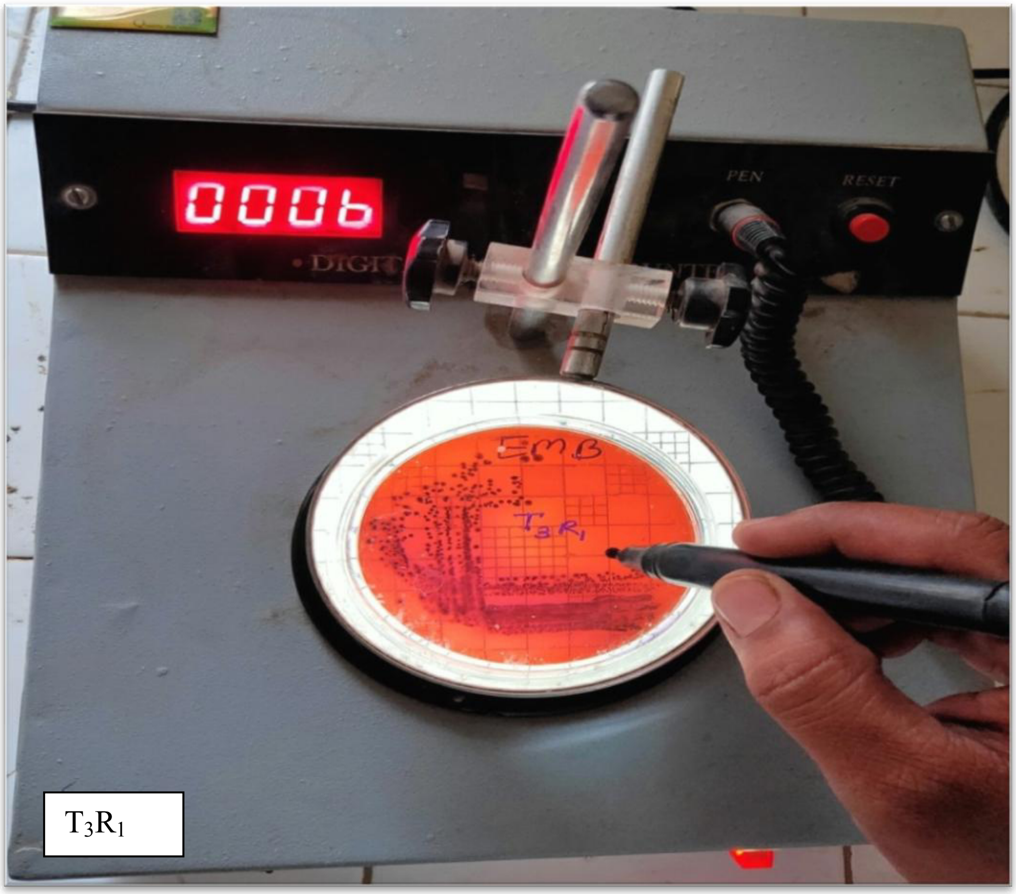


Plate 4.1 E. coli count on EMB agar in caecal content of experimental birds fed diet supplemented with butyrate

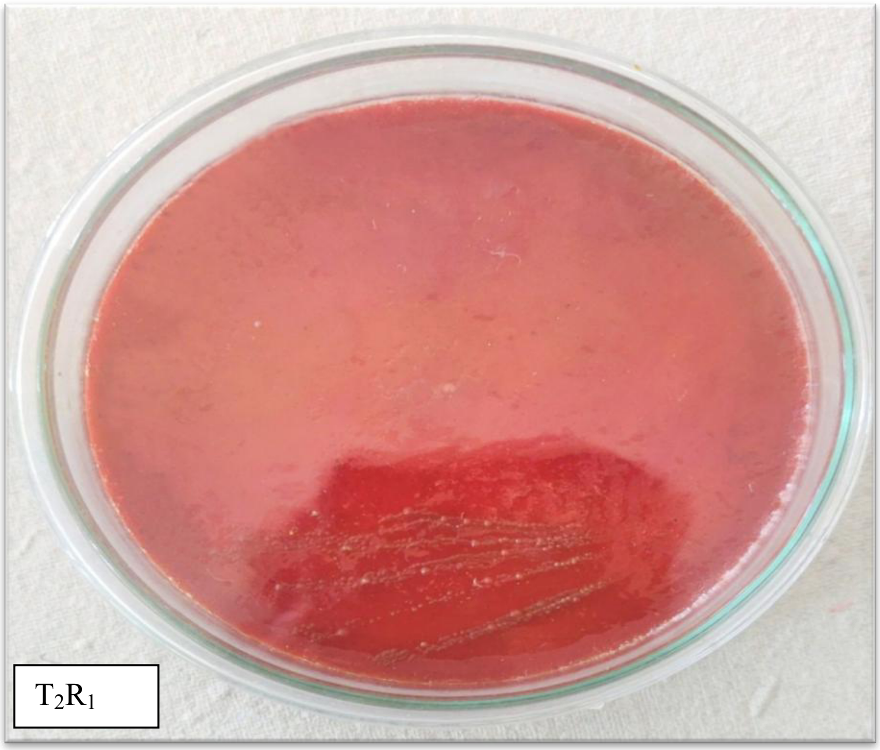


Plate 4.2 Salmonella count on shegella agar in caecal content of experimental birds fed diet supplemented with butyrate

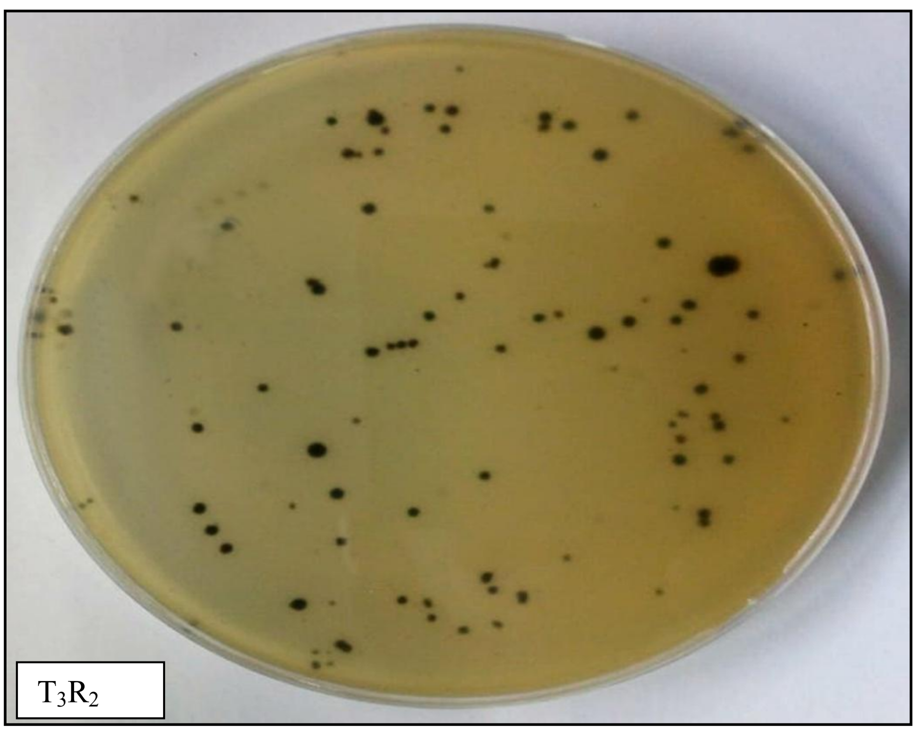


Plate 4.3 Clostridium count on nutrient agar in caecal content of experimental birds fed diet supplemented with butyrate

was more effective in reducing the pH in the upper GI tract and only in duodenum in lower GI tract but not in ileum (Bolton and Dewar, 1965).

Table 4.7 Gut parameter in experimental birds fed diet supplemented with butyrate in broiler chicken

Parameters	Treatment				SEM	P
	T0	T1	T2	T3		
***E.coli* Count (10^7 CFU/gm)**	6.94^{c} ±0.10	6.63^{bc} ±0.10	6.32^{b} ±0.13	5.92^{a} ±0.11	0.15647	0.001
***Salmonella* Count (10^7 CFU/gm)**	5.24^{c} ±0.05	4.80^{b} ±0.17	4.46^{a} ±0.08	4.20^{a} ±0.08	0.15310	0.001
***Clostridia* Count (10^7 CFU/gm)**	5.84^{c} ±0.28	5.12^{b} ±0.26	4.58^{ab} ±0.08	4.12^{a} ±0.15	0.29532	0.001
Ileal pH	6.72 ±0.18	6.69 ±0.23	6.67 ±0.21	6.64 ±0.16	0.27910	0.992
** Means bearing different superscripts a, b and c in a row differ significantly at (P<0.01)						

4.8 Nutrient digestibility and N retention in experimental birds fed diet supplemented with butyrate

Nutrient digestibility and N retention in experimental birds supplemented butyric acid in the diet at different levels T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is detailed in table 4.8 and ANOVA is given in appendices and graph is shown in fig. 4.10.

It was evident from the table that, the digestibility of organic matter and dry matter (%) were significantly (P<0.01) increased in T_3 and T_2 as compared to T_1 and T_0, However, that of T_1 was significantly higher than T_0. The average means value for organic matter digestibility was 70.70 ±0.04, 72.10 ±0.07, 73.74 ±0.12 and 73.96 ±0.11 for T_0, T_1, T_2 and T_3 respectively. Similarly dry matter digestibility was 68.95 ±0.04, 70.31 ±0.07, 72.64 ±0.13 and 72.89 ±0.11 in T_0, T_1, T_2 and T_3 respectively.

This results obtained in present study are in agreement with Smulikowska *et al.,* (2009) who observed that the organic matter digestibility was significantly (P<0.05) improved by supplementation of sodium butyrate in broiler chicken diet. Similarly, Hassan *et al*., (2015) who reported that the addition of organic acids mixture increased the digestibility of coefficients ($P<0.01$) of OM and DM compared to the non-supplemented broiler diet.

Dibner and Butin (2002) the reduced microbial proliferations of organic acid in the gastrointestinal tract reduce microflora host competition for nutrients, improve nutrient absorption and reduce endogenous loss of nitrogen. A consequent reduction in subclinical infections may contribute to an improved digestibility of nutrients and a reduction in the demand for nutrient from the intestinal immune system.

In contrast with the present finding, Hernandez *et al.,* (2006) found that the dry matter digestibility of organic acid supplementation in broiler chicken was non-significantly differ when compared with control group. Also, Rodjan *et al*., (2017) reported that the digestibility of the dry matter in broiler chicken was found non-significantly different in the treated group when compared with non treated group.

The result observed in present study for nitrogen retention (%) and ether extract digestibility (%) are given in the table 4.8 showing that non-significantly difference in treatment when compared with control. nitrogen retention (%) and ether extract digestibility (%) were non-significantly increased in T_3 followed by T_2, T_1 and then control T_0. The average means value for nitrogen retention (%) in groups T_0, T_1, T_2 and T_3 was 70.63 ±0.04, 70.70 ±0.07, 70.78 ±0.14 and 70.89 ±0.12 respectively. Similarly for ether extract digestibility were 80.65 ±0.03, 80.66 ±0.05, 80.74 ±0.09 and 80.83 ±0.08 in T_0, T_1, T_2 and T_3 respectively.

Results of the present study are in line with Abd EI-Hakim *et al*., (2009) reported that the nitrogen retention (%) did not influenced by diet supplementation of organic acid in broiler chickens. Similarly Hassan *et al*., (2015) who noticed that the ether extract digestibility was not influenced by diet supplementation of organic acids mixture in broiler diet.

Findings of the present study are antithetical to the recordings of Thirumeignanam *et al*., (2006) who showed that the nitrogen retention (%)

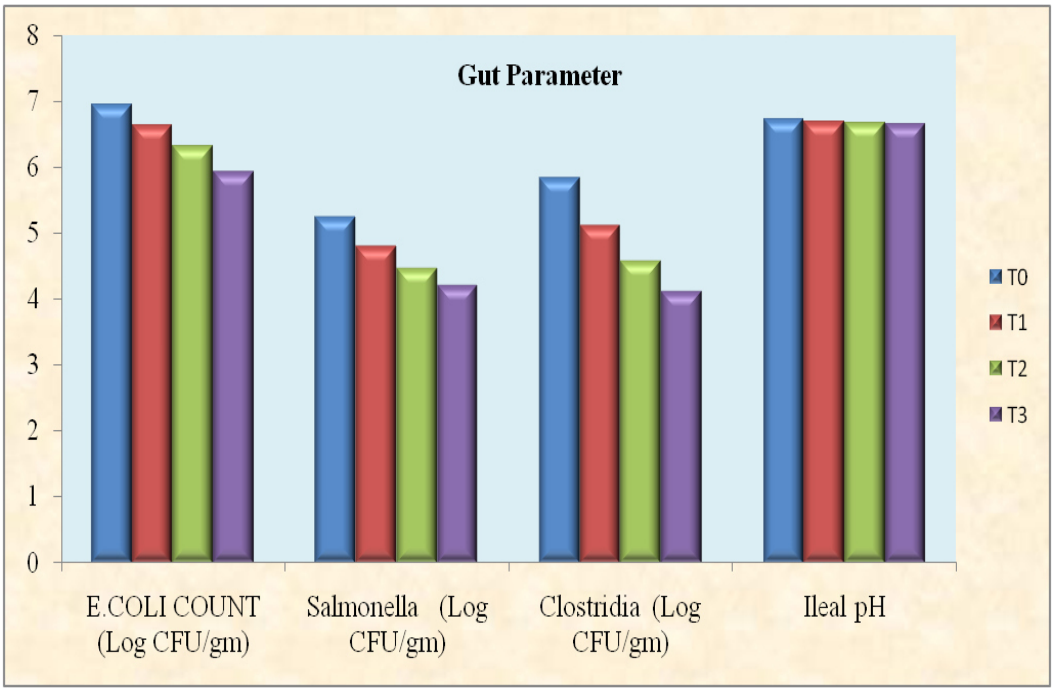


Fig.4.9 Gut parameters of experimental birds fed diet supplemented with butyrate

differed significantly (P<0.05) when diet supplemented with organic acid in broiler chicken. Similarly, Smulikowska *et al.,* (2009) who found that the nitrogen retention (%) was significantly increased (P<0.01) when diet supplemented with fat coated organic acid salt in broiler chickens. The ether extract digestibility was significantly (P<0.05) improved after addition of different type of organic acids (Acetic acid, butyric acid, citric acid and fumaric acid) in diet of broiler chicken (Ndelekute *et al.,* 2016).

The present study showed that the crude fibre digestibility (%) was significantly higher (P<0.01) in T_3 compared with T_1 and T_0. However, in T_2 group value was comparable with T_3. The average means values for crude fibre digestibility were 27.48 ±0.10 (T_0), 28.86 ±0.17 (T_1), 29.33 ±0.33 (T_2) and 29.99 ±0.29 (T_3).

Hassan *et al*., (2015) who observed that the digestibility of crude fibre (%) was differ significantly (P<0.05) when diet supplemented with different level of organic acid mixture in broiler chicken. Also, these observations were significantly similar to the result showed by Ndelekute *et al.,* (2016). Rodjan *et al*., (2017) who observed that crude fibre digestibility was significantly more when compared with control.

In contrast with the present findings, Tomar, (2017) who observed that the digestibility of crude fibre (%) did not differ significantly when fed diet supplemented with different organic acid at different levels in broiler chicken.

The present study showed that digestibility of NFE (%) was significantly increased (P<0.01) in T3 followed by T_2, T_1 and control T_0. The average means value for NFE (%) digestibility was 66.71 ±0.05, 68.67 ±0.07, 70.18 ±0.14 and 70.87 ±0.12 in groups T_0, T_1, T_2 and T_3 respectively.

The result of the present study are in line with Hassan *et al*., (2015) who observed that the digestibility of NFE (%) was significantly differed (P<0.05) when diet supplemented with different level of organic acid mixture in broiler chicken.

Van Der Sluis (2002) observed that the organic acid was having positive effect on the digestion, which was related to slower passage of feed in the intestinal tract better absorption of required necessary nutrient and less wet droppings.

In contrasts with the present study, Rodjan *et al*., (2017) reported that the digestibility of the NFE did not differ significantly (P>0.05) when diet supplemented with organic acids in broiler chickens. Similarly, Tomar, (2017) who noticed that the digestibility of NFE (%) did not influenced significantly when diet supplemented with different organic acid at different levels in broiler chicken.

Table 4.8 Nutrient digestibility and N retention in experimental birds fed diet supplemented with butyrate

Parameters	Treatment				SEM	P
	T0	T1	T2	T3		
OM digestibility (%)	70.70^{a} ±0.04	72.10^{b} ±0.07	73.74^{c} ±0.12	73.96^{c} ±0.11	0.12878	0.001
DM digestibility (%)	68.95^{a} ±0.04	70.31^{b} ±0.07	72.64^{c} ±0.13	72.89^{c} ±0.11	0.13464	0.001
Nitrogen Retention (%)	70.63 ±0.04	70.70 ±0.07	70.78 ±0.14	70.89 ±0.12	0.14182	0.329
CF digestibility (%)	27.48^{a} ±0.10	28.86^{b} ±0.17	29.33^{bc} ±0.33	29.99^{c} ±0.29	0.34277	0.001
EE digestibility (%)	80.65 ±0.03	80.66 ±0.05	80.74 ±0.09	80.83 ±0.08	0.09346	0.281
NFE digestibility (%)	66.71^{a} ±0.05	68.27^{b} ±0.07	70.18^{c} ±0.14	70.87^{d} ±0.12	0.14552	0.001

**Means bearing different superscripts a, b, c and d in a row differ significantly at (P<0.01)

4.9 Cost economics of production of experimental broiler birds fed diet supplemented with butyrate

The cost economics of broiler production for experimental birds fed with different levels of butyric acid in the treatment groups T_1 (0.5%), T_2 (1%) and T_3 (1.5%) is detailed in Table 4.9 and graph is shown in fig. 4.11.

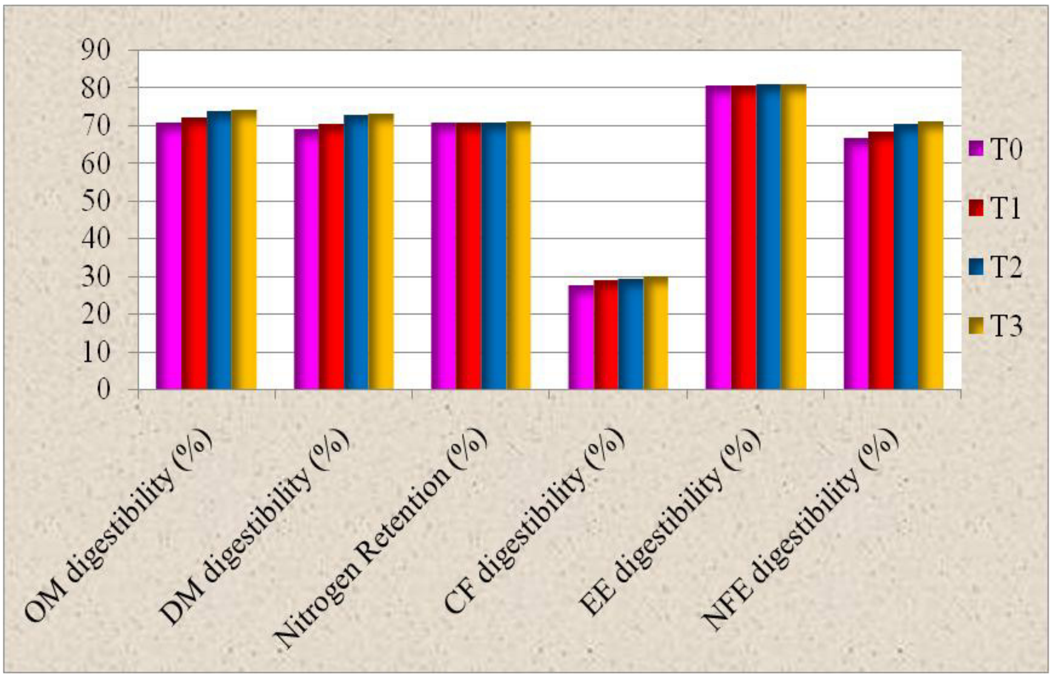


Fig.4.10 Nutrient digestibility and N retention in experimental birds fed diet supplemented with butyrate

Table 4.9 Cost economics of production of experimental broiler birds fed diet supplemented with butyrate

Sr. No.	Particulars	T0	T1	T2	T3
1	Cost of day old chicks (Rs.)	38	38	38	38
2	Total cost of feed (Rs/Kg)	32.87	33.21	33.67	33.96
3	Average total feed consumed per bird (g)	4323.72	4317.37	4302.66	4288.64
4	Cost of feed consumed per bird (Rs)(Sr. no. 2x3÷1000)	142.12	143.38	144.87	145.64
5	Average body weight at the end of 6th week (g)	2472.16	2489.06	2508.44	2522.00
6	Feed consumption per Kg live weight gain (Kg)(Sr. no. 3÷5)	1.75	1.73	1.72	1.70
7	cost of feed per Kg live weight gain (Rs)(Sr. no. 4÷5)×1000	57.49	57.60	57.75	57.75
8	Miscellaneous (vaccines, medicines and litter material) cost Per bird (Rs)	13	13	13	13
9	Total cost of production (Rs) (Sr. no. 1+4+8)	193.12	194.38	195.87	196.64
10	Average price realized @ Rs. 90 per Kg live weight (Rs)(Sr. no. 5×90)/1000	222.49	224.04	225.76	226.98
11	Net profit per bird (Rs) (Sr. no. 10-9)	29.37	29.64	29.89	30.34
12	Net profit per Kg live weight of birds (Rs.)	11.88	11.91	11.92	12.03
13	Relative economic efficiency per cent	0	0.25	0.34	1.26

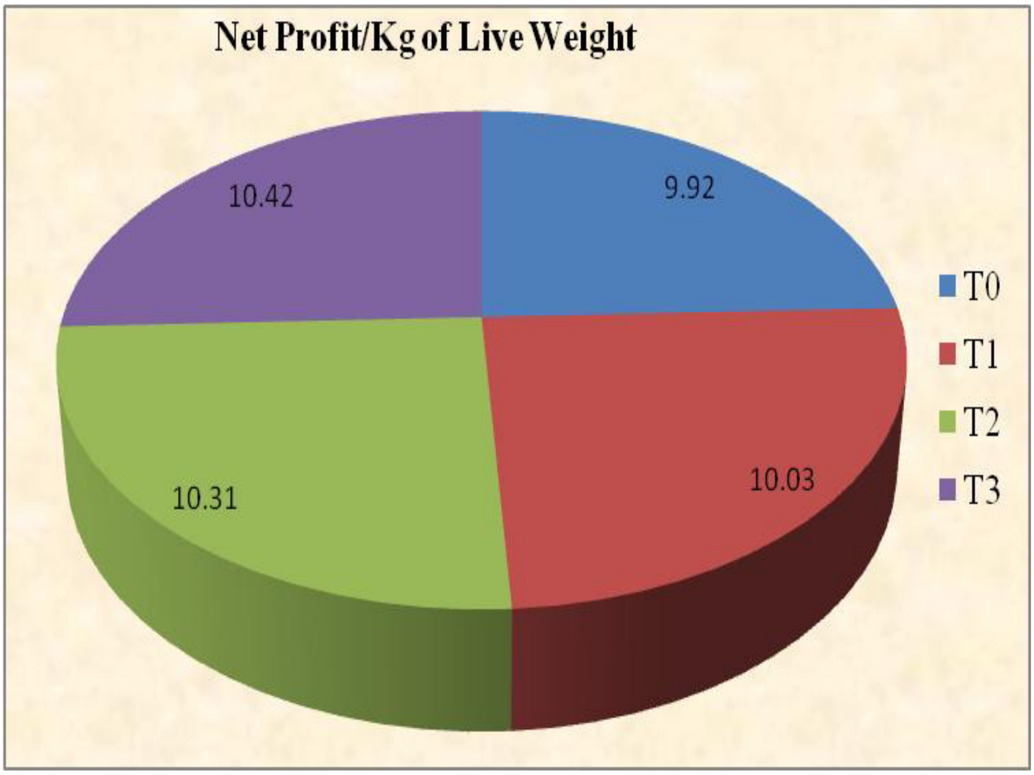


Fig.4.11 Cost economics of production of experimental broiler birds fed diet supplemented with butyrate

The cost of day old chick was Rs.38/bird. It was evident from the table the total cost of standard broiler feed T_0 Rs/kg was 32.87; while that in treatment groups (T_1), (T_2) and (T_3) Rs.33.21, Rs.33.67 and Rs.33.96 respectively. The average total feed consumed g/per bird ranged from 4288.64 for T_3 to 4323.72 for T_0. The cost of feed consumed per bird was T_0 to T_3 Rs.142.12, 143.38, 144.87, 145.64 respectively. The average body weight at the end of the sixth week was higher in treatment group T_3 (2522.00 g) and lower in control group T_0 (2472.16 g). The total cost of production was higher in treatment group T_3 (Rs.196.64) and was lower in control group T_0 (Rs.193.12). The average price achieved from auction of birds on the basis of Rs. 90/ kg of live weight was highest in T_3 (Rs. 226.98) followed by T_2 (Rs. 225.76), T_1 (Rs. 224.04) and lowest in T_0 (Rs. 222.49) .The net profit per bird in present study was higher in T_3 group (Rs. 30.34) followed by T_2 (Rs. 29.89), T_1 (Rs. 29.64) and lower price was from in T_0 (Rs. 29.37). Net profit per Kg live weight of bird was highest in T_3 (Rs. 12.03) and lowest in T_0 (Rs. 11.88).

The findings of present study was in agreement with Kamel and Mohamed (2016) they reported that the diet supplemented with organic acids and synbiotic were better feed additives because of the role in improving productive and economic efficiency of broiler chicks. Similarly Naveenkumar *et al*., (2017) who observed the diet supplemented at various concentrations either alone or in combination of coated sodium butyrate at 500ppm could be considered for achieving the performance and better cost of production in broiler chickens.

The butyric acid supplemented groups had higher net profit because it might be due to better FCR and higher retention of nutrient in these groups.

Summary and Conclusions

CHAPTER - 5

SUMMARY AND CONCLUSIONS

The present experiment entitled "Effect of supplementation of butyrate on performance of broiler chicken" was undertaken to assess the growth performance, carcass traits, blood biochemical, gut parameter, nutrient digestibility, nitrogen retention and cost economics of production influenced by dietary inclusion of butyrate at different level T_1 (0.5%), T_2 (1%) and T_3 (1.5%) in broiler chickens.

Two hundred and forty, day old (Vencobb-400) straight run commercial broiler chicks reared for a period of 42 days. On arrival, individually weighed chicks were distributed randomly on equal body weight basis into four treatment group's *viz*. T_1, T_2, T_3 and one control T_0 with four replicates of 15 chicks each. The control group T_0 was given standard broiler diet as per BIS (2007). Groups T_1, T_2 and T_3 were fed with standard broiler diets with supplementation of butyrate at the rate 0.5%, 1% and 1.5% respectively.

The cumulative and weekly feed intake throughout the experiment did not differ significantly ($P>0.05$) amongst all experimental groups and control but numerically lower in T_3 as compared to other groups.

In 1st week cumulative body weight gain was non-significant but numerically higher in T_0 and T_3 as compared to T_1 and T_2. On 3rd week the cumulative body weight gain did not differ significantly but was numerically higher in T3 as compared to other treatment groups and control. On 2nd, 4th, 5th and 6th week the cumulative body weight gain was significantly higher in T_3 as compared to other treatment groups and control. Weekly body weight gain on 1st week did not differ significantly while on 2nd week weekly body weight gain was significantly higher ($P<0.05$) in group T_3 followed T_2 and then T_1 as compared to control group T_0. In 3rd and 4th week weekly body weight gain was numerically higher in group T_3 followed T_2 and then T_1 as compared to control T_0. In 5th and 6th week the weekly body weight gain was significantly higher ($P<0.01$) in T_3 and T_2 as compared to control group T_0 and T_1.

In 1st week the cumulative feed conversion ratio was significantly better ($P<0.01$) in T_0 and T_3 as compared to T_1 and T_2. From 2nd to 6th week the cumulative feed conversion ratio was significantly better in T_3 followed by T_2, T_1 and then T_0. In 1st week the weekly FCR was significantly better ($P<0.01$) in control T_0 and T_3 as compared to T_2 and T_1. From 2st week onward until end of experiment the weekly FCR was significantly improved in T_3 followed by T_2 and then T_1 as compared to control group T_0.

At the end of experiment live body weight of birds (g) was numerically higher in T_3 as compared to other experimental groups. The dressing percentage, carcass weight, giblet weight and liver weight were not statistically significant but numerically higher in experimental groups T_3 followed by T_2, T_1 and then T_0. However, giblet percent and edible meat percent were comparable amongst all treatment groups. The linear increase ($P>0.05$) was observed in weight of edible meat (g) when the diet supplemented with increased levels of butyric acid. The weight of immune organ such as spleen and bursa was comparable amongst all treatment groups. The dressed breast weight and breast meat percentage was significantly higher ($P<0.01$) in group T_3 and T_2 as compared to T_1 and T_0. The weight of intestine was significantly higher ($P<0.05$) in T_3 and T_2 as compared to T_0 and value for T_1 is comparable among treatment groups.

The haematological parameters such as Hb (g/dl), RBC and PCV (%) did not differ significantly amongst the all treatment groups and control. Serum total protein (g/dl), albumin (g/dl), globulin (g/dl), and A:G ratio, HDL, triglycerides (mg/dl), blood glucose (mg/dl) and BUN (mg/dl) was almost comparable in all experimental groups (T_0, T_1, T_2 and T_3). Total serum cholesterol and LDL significantly decreased linearly ($P<0.05$) as the level of butyric acid supplementation in diet was increased. The gut parameter like *E. coli*, *Salmonella* and *Clostridia* count were significantly decreased ($P<0.01$) in butyrate supplemented groups as compared to control.

The digestibility of organic matter and dry matter percent were significantly ($P<0.01$) increased in T_3 and T_2 as compared to T_1 and T_0.The percent nitrogen retention and ether extract digestibility percent were did not differ significantly amongst the treatment groups and control. Crude fibre and NFE digestibility percent was significantly higher in T_3 as compared to other treatment groups and control

The average total feed consumption (g/bird) was in the range of 4288.64 (T_3) to 4323.72 (T_0). The average body weights (g) were observed at the end of experiment ranging from 2472.16 for T_0 to 2522.00 for T_3. Total cost of production ranged from Rs.193.12 for T_0 to Rs.196.64 for T_3. The net profit per bird was minimum for control i.e. Rs. 29.37 (T_0), Whereas;it was maximum for T_3 i.e. Rs.30.34. The overall net profit per Kg live weight of birds was increased linearly from T0 to T3 (Rs. 11.88, Rs.11.91, Rs.11.92 and Rs. 12.03 respectively).

CONCLUSIONS

The conclusions drawn from the present research work are enlisted below;

1. Growth performance of broiler was positively influenced by supplementation of butyrate (butyric acid) at the level of 0.5%, 1% and 1.5% in the diet especially at 1.5% inclusion level.
2. Supplementation of butyrate at 1.5% inclusion level in broiler chicken diet improved carcass characteristics like dressed breast weight, breast per cent and weight of intestine.
3. Butyrate supplementation in diet of broiler indicated positive effect on serum total cholesterol and LDL cholesterol.
4. Gut health parameters were improved by reducing the *E. coli, Salmonella and Clostridium* count and ileal pH after supplementation of butyrate in broiler.
5. Supplementation of butyrate in broiler chickens had positive effect on DM, OM, CF and NFE digestibility while percent N retention and EE digestibility was not affected.
6. The improvement in the net profit per kg live weight of broiler over the conventional standard broiler ration when diets supplemented with butyrate at 1.5% level was observed.

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Appendices

APPENDIX

Analysis of variance of cumulative feed intake (g) in experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
First week				
Between Group	3	11.680	3.893	0.140
Within Group	12	334.893	27.908	-
Total	15	346.573	-	-
Second week				
Between Group	3	71.850	23.950	0.699
Within Group	12	410.926	34.244	-
Total	15	482.776	-	-
Third week				
Between Group	3	765.146	255.049	0.668
Within Group	12	4582.725	381.894	-
Total	15	5347.871	-	-
Fourth week				
Between Group	3	1921.115	640.372	2.114
Within Group	12	3635.398	302.950	-
Total	15	5556.514	-	-
Fifth week				
Between Group	3	2368.481	789.494	1.315
Within Group	12	7203.605	600.300	-
Total	15	9572.086	-	-
Sixth week				
Between Group	3	2593.122	984.374	1.117
Within Group	12	10575.942	881.328	-
Total	15	13529.064	-	-

Analysis of variance of weekly feed intake (g) in experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
First week				
Between Group	3	11.680	3.893	0.140
Within Group	12	334.893	27.908	-
Total	15	346.573	-	-
Second week				
Between Group	3	58.361	19.454	0.401
Within Group	12	581.951	48.496	-
Total	15	640.312	-	-
Third week				
Between Group	3	423.992	141.331	0.548
Within Group	12	3095.276	257.940	-
Total	15	3519.268	-	-
Fourth week				
Between Group	3	261.748	87.249	0.539
Within Group	12	1943.266	161.939	-
Total	15	2205.014	-	-
Fifth week				
Between Group	3	26.135	8.712	0.063
Within Group	12	1663.319	138.610	-
Total	15	1689.454	-	-
Sixth week				
Between Group	3	34.141	11.380	0.092
Within Group	12	1484.551	123.713	-
Total	15	1518.693	-	-

Analysis of variance of Cumulative body weight gain (g) of experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
First week				
Between Group	3	80.539	26.846	1.668
Within Group	12	193.145	16.095	-
Total	15	273.684	-	-
Second week				
Between Group	3	218.975	72.992	24.112
Within Group	12	36.326	3.027	-
Total	15	255.301	-	-
Third week				
Between Group	3	591.819	197.273	2.000
Within Group	12	1183.448	98.621	-
Total	15	1775.267	-	-
Fourth week				
Between Group	3	1131.877	377.292	4.163
Within Group	12	1087.510	90.626	-
Total	15	2219.388	-	-
Fifth week				
Between Group	3	3606.460	1202.153	9.203
Within Group	12	1567.593	130.633	-
Total	15	5174.053	-	-
Sixth week				
Between Group	3	5784.974	1928.325	12.1766
Within Group	12	1900.401	158.367	-
Total	15	7685.375	-	-

Analysis of variance of Weekly body weight gain (g) of experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
First week				
Between Group	3	80.539	26.846	1.668
Within Group	12	193.145	16.095	-
Total	15	273.684	-	-
Second week				
Between Group	3	252.164	84.055	4.601
Within Group	12	219.216	18.268	-
Total	15	471.379	-	-
Third week				
Between Group	3	96.697	32.232	0.316
Within Group	12	1224.085	102.007	-
Total	15	1320.782	-	-
Fourth week				
Between Group	3	95.962	31.987	1.231
Within Group	12	311.836	25.986	-
Total	15	407.798	-	-
Fifth week				
Between Group	3	703.158	234.386	19.171
Within Group	12	146.710	12.226	-
Total	15	849.869	-	-
Sixth week				
Between Group	3	270.776	90.259	10.690
Within Group	12	101.319	8.443	-
Total	15	372.095	-	-

Analysis of variance of cumulative Feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
First week				
Between Group	3	0.015	0.005	17.941
Within Group	12	0.003	0.000	-
Total	15	0.018	-	-
Second week				
Between Group	3	0.005	0.002	5.853
Within Group	12	0.003	0.000	-
Total	15	0.008	-	-
Third week				
Between Group	3	0.006	0.002	19.128
Within Group	12	0.001	0.000	-
Total	15	0.007	-	-
Fourth week				
Between Group	3	0.005	0.002	32.760
Within Group	12	0.001	0.000	-
Total	15	0.006	-	-
Fifth week				
Between Group	3	0.007	0.002	74.857
Within Group	12	0.000	0.000	-
Total	15	0.007	-	-
Sixth week				
Between Group	3	0.006	0.002	56.647
Within Group	12	0.000	0.000	-
Total	15	0.006	-	-

Analysis of variance of Weekly Feed conversion ratio (FCR) of experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
First week				
Between Group	3	0.015	0.005	17.941
Within Group	12	0.003	0.000	-
Total	15	0.018	-	-
Second week				
Between Group	3	0.011	0.004	8.486
Within Group	12	0.005	0.000	-
Total	15	0.015	-	-
Third week				
Between Group	3	0.008	0.003	11.979
Within Group	12	0.003	.000	-
Total	15	0.011	-	-
Fourth week				
Between Group	3	0.004	0.001	8.118
Within Group	12	0.002	0.000	-
Total	15	0.006	-	-
Fifth week				
Between Group	3	0.011	0.004	18.241
Within Group	12	0.002	0.000	-
Total	15	0.013	-	-
Sixth week				
Between Group	3	0.004	0.001	6.251
Within Group	12	0.003	0.000	-
Total	15	0.007	-	-

Analysis of variance of carcass traits of experimental birds fed diet supplemented with butyrate in broiler chickens

source	DF	SS	MSS	F
Live Wt				
Between Group	3	1350.422	450.141	0.289
Within Group	12	18919.063	1576.589	-
Total	15	20269	-	-
Dressing %				
Between Group	3	4.011	1.337	1.881
Within Group	12	8.528	0.711	-
Total	15	12.539	-	-
Carcass weight				
Between Group	3	5014.625	1671.542	0.759
Within Group	12	26438.125	2203.177	-
Total	15	31452.750	-	-
Giblet weight				
Between Group	3	18.508	6.169	0.598
Within Group	12	123.710	10.309	-
Total	15	142.218	-	-
Giblet %				
Between Group	3	0.014	0.005	0.402
Within Group	12	0.140	0.012	-
Total	15	0.154	-	-
Edible meat weight				
Between Group	3	4448.144	1482.715	0.714
Within Group	12	24906.633	2075.553	-
Total	15	29354.777	-	-
Edible Meat %				
Between Group	3	3.591	1.197	1.617
Within Group	12	8.882	0.740	-
Total	15	12.474	-	-

Analysis of variance of carcass traits of experimental birds fed diet supplemented with butyrate in broiler chickens

source	DF	SS	MSS	F
Liver weight				
Between Group	3	10.416	3.472	0.663
Within Group	12	62.799	5.233	-
Total	15	73.215	-	-
Wt of Spleen				
Between Group	3	0.004	0.001	0.054
Within Group	12	0.288	0.024	-
Total	15	0.292	-	-
Wt of Bursa				
Between Group	3	0.002	0.001	0.461
Within Group	12	0.021	0.002	-
Total	15	0.023	-	-
Wt of Breast				
Between Group	3	4037.047	1345.682	12.913
Within Group	12	1250.563	104.214	-
Total	15	5287.609	-	-
Breast %				
Between Group	3	4.791	1.597	10.700
Within Group	12	1.791	0.149	-
Total	15	6.581	-	-
Wt of Intestine				
Between Group	3	462.297	154.099	4.218
Within Group	12	438.438	36.536	-
Total	15	900.734	-	-

Analysis of variance of haematology parameter in experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
HB				
Between Group	3	0.013	0.004	0.108
Within Group	12	0.491	0.041	-
Total	15	0.505	-	-
RBC				
Between Group	3	0.004	0.001	0.039
Within Group	12	0.417	0.035	-
Total	15	0.421	-	-
PCV				
Between Group	3	3.641	1.214	1.304
Within Group	12	11.169	0.931	-
Total	15	14.809	-	-

Analysis of variance of blood biochemical parameter in experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
Total protein				
Between Group	3	0.003	0.001	0.017
Within Group	12	0.612	0.051	-
Total	15	0.615	-	-
Albumin				
Between Group	3	0.035	0.012	2.013
Within Group	12	0.069	0.006	-
Total	15	0.104	-	-
Globulin				
Between Group	3	0.055	0.018	0.442
Within Group	12	0.497	0.041	-
Total	15	0.551	-	-
A:G ratio				
Between Group	3	0.026	0.009	0.842
Within Group	12	0.124	0.010	-
Total	15	0.150	-	-
Total cholesterol				
Between Group	3	222.944	74.315	4.461
Within Group	12	199.894	16.658	-
Total	15	422.839	-	-
HDL				
Between Group	3	50.678	16.893	1.180
Within Group	12	171.726	14.311	-
Total	15	222.404	-	-

Analysis of variance of blood biochemical parameter in experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
LDL				
Between Group	3	378.184	126.061	4.025
Within Group	12	375.803	31.317	-
Total	15	753.987	-	-
Triglyceride				
Between Group	3	138.197	46.066	0.517
Within Group	12	1069.479	89.123	-
Total	15	1207.676	-	-
Blood glucose				
Between Group	3	296.761	98.920	1.187
Within Group	12	999.965	83.330	-
Total	15	1296.726	-	-
BUN				
Between Group	3	0.003	0.001	1.520
Within Group	12	0.007	0.001	-
Total	15	0.010	-	-

Analysis of variance of gut parameter in experimental birds fed diet supplemented with butyrate in broiler chicken

source	DF	SS	MSS	F
***E.coli* Count**				
Between Group	3	2.299	0.766	15.649
Within Group	12	0.588	0.049	-
Total	15	2.887	-	-
***Salmonella* Count**				
Between Group	3	2.425	0.808	17.243
Within Group	12	0.563	0.47	-
Total	15	2.988	-	-
***Clostridia* Count**				
Between Group	3	6.604	2.201	12.619
Within Group	12	2.093	0.174	-
Total	15	8.697	-	-
Ileal pH				
Between Group	3	0.15	0.005	0.32
Within Group	12	1.870	0156	-
Total	15	1.884	-	-

Analysis of variance of Nutrient metabolizability in experimental birds fed diet supplemented with butyrate

source	DF	SS	MSS	F
OM digestibility				
Between Group	3	28.173	9.391	283.145
Within Group	12	0.398	0.033	-
Total	15	28.571	-	-
DM digestibility				
Between Group	3	43.167	14.389	396.885
Within Group	12	0.435	0.036	-
Total	15	43.602	-	-
Nitrogen Retention				
Between Group	3	0.153	0.051	1.269
Within Group	12	0.483	0.040	-
Total	15	0.636	-	-
CF digestibility				
Between Group	3	13.604	4.535	19.297
Within Group	12	2.820	0.235	-
Total	15	16.423	-	-
EE digestibility				
Between Group	3	0.075	0.025	1.436
Within Group	12	0.210	0.017	-
Total	15	0.285	-	-
NFE digestibility				
Between Group	3	42.560	14.187	334.973
Within Group	12	0.508	0.042	-
Total	15	43.068	-	-

Vitae

VITAE

The author Dr. Sonale Pravin Devidas is born on 1st June, 1992 at Kamtha, Tq. Kalmnuri Dist. Hingoli Maharashtra State. He completed secondary school certificate (SSC) examination in 2008 from Mahatma phule high school kamtha fata, Tq. Kalmnuri Dist. Hingoli and subsequently completed higher secondary examination in 2010 from Yeshwant college Nanded, Dist. Nanded in first class and second class respectively.

Later he joined Veterinary Profession due to his special aptitude and interest for animal welfare activities and has successfully completed B.V.Sc. & A.H. from Nagpur veterinary College, Nagpur, in July 2017. He joined postgraduate (M.V.Sc.) studies in the discipline of Animal Nutrition in the College of Veterinary and Animal Sciences, MAFSU, Parbhani.

He actively participated in National Service Scheme (NSS) and National cadet corp (NCC) units of Nagpur veterinary College, Nagpur during graduation studies.

Thesis Abstract

THESIS ABSTRACT

a)	Title of the thesis	**:EFFECT OF SUPPLEMENTATION OF BUTYRATE ON PERFORMANCE OF BROILER CHICKEN**
b)	Full name of student	**:SONALE PRAVIN DEVIDAS**
c)	Name and address of Major Advisor	**:Dr. V. K. Munde** **Assistant Professor** **Department of Animal Nutrition,** **COVAS, Parbhani.**
d)	Degree to be awarded	:M.V.Sc.
e)	Year of award of degree	:2019
f)	Major subject	:Animal Nutrition
g)	Total number of pages in the thesis	: 73
h)	Number of words in the abstract	:568
i)	Signature of Student	:
j)	Signature, name and address of forwarding authority (HOD/SH)	:Dr. S. M. Wankhede Incharge Head of Department, Dept. of Animal Nutrition COVAS, Parbhani.

ABSTRACT

An experiment was conducted to investigate the growth performance, carcass traits, blood biochemical, gut parameter, nutrient digestibility, N retention and cost economics of production influenced by dietary inclusion of butyrate in broiler chicken up to 6 weeks. Two hundred forty, day old (Vencobb 400) straight run commercial broiler chicken were divided into four groups such as T_0, T_1, T_2 and T_3 on the basis of equal body weight. Group T_0 fed with standard broiler diet as per BIS (2007) and treatment groups (T_1, T_2 and T_3) were fed with 0.5%, 1% and 1.5% of butyrate respectively. The cumulative feed intake throughout the experiment did not differ significantly ($P>0.05$) amongst all experimental groups and control but numerically lower in T_3 as compared to other groups. The cumulative body weight gain was significantly higher in T_3 as compared to other treatment groups and control. While, cumulative feed conversion ratio was significantly ($P<0.01$) better at the end of 6^{th} weeks in T_3 followed by T_2, T_1 and then T_0. The carcass weight, dressing percentage, giblet weight (g) and liver weight was numerically higher in group T_3 followed by T_2, T_1 and then T_0, while giblet per cent remained comparable amongst all groups. Different level of butyrate supplementation leads to linear increase ($P>0.05$) in weight of edible meat (g), whereas edible meat percentage and weight spleen and bursa was comparable amongst groups. The dressed breast weight (g) was significantly higher ($P<0.01$) in group T_3 and T_2 as compared to T_1 and T_0 and breast meat percentage was significantly higher ($P<0.01$) in T_3 as compared to T_0.The weight of intestine was significantly higher in T_3 and T_2 as compared to T_0 and value for T_1 is comparable among groups. The haemoglobin (g/dl), RBC and PCV (%) did not differ significantly amongst the all groups. The serum total protein (g/dl), albumin (g/dl), globulin (g/dl), and A:G ratio, HDL and triglycerides (mg/dl) were not differed significantly in all groups. The serum total cholesterol (mg/dl) and LDL (mg/dl) significantly decreased ($P< 0.05$) as the level of butyrate in diet increased. The blood glucose (mg/dl) and BUN remained comparable ($P> 0.05$) in all groups. The ceacal *E. coli* and *Salmonella* count was significantly decreased ($P<0.01$) in the T_3 and T_2 when compared to T_0, whereas; the T_1 was comparable.

Also, there was significant reduction (P<0.01) in *clostridial* count in groups T_1, T_2 and T_3 as compared to T_0 and the ileal pH was reduced numerically in all treatment groups. The digestibility of organic matter and dry matter (%) were significantly (P<0.01) increased in T_3 and T_2 as compared to T_1 and T_0. The percent nitrogen retention and ether extract digestibility were did not differ significantly amongst the treatment groups and control. Crude fibre and NFE digestibility (%) was significantly higher in T_3 as compared to other treatment groups and control. Net profit per Kg live weight of birds was higher in T3 than other groups.

From the study it was concluded that inclusion of butyrate at the 1.5% level in the diet positively influenced growth performance, carcass characteristics and all the haematological and serum profile of broiler. Also, Gut health parameters were improved by reducing the *E. coli, Salmonella and Clostridium* count and ileal pH. Butyrate also had positive effect on digestibility of DM, OM, CF and NFE. There was improvement in the net profit per kg live weight of broiler when diets supplemented with butyrate at 1.5% level.

प्रबंध सारांश

प्रबंधाचे नाव	: "ब्यूटायरेटचा समावेश केल्याने मांसल पक्षांच्या वाढीवर होणारा परिणाम"
विद्यार्थ्याचे नाव	: प्रविण देविदास सोनाळे
प्रमुख मार्गदर्शकाचे नाव व हुद्दा	: डॉ. व्हि.के. मुंडे सहाय्यक प्राध्यापक, पशुपोषण व आहारशास्त्र विभाग, पशुवैद्यक व पशुविज्ञान महाविद्यालय, परभणी
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पदवी प्रदान वर्ष	: २०१९
मुख्य विभाग	: पशुपोषण व आहारशास्त्र विभाग
प्रबंधातील एकुण पाने	: ७३
सारांशातील एकुण शब्द संख्या	: ५४८
विद्यार्थ्याची स्वाक्षरी	:
पुढे पाठवणाऱ्या अधिकाऱ्याचे नाव व हुद्दा	: डॉ. एस.एम.वानखेडे प्रभारी प्राध्यापक, पशुपोषण व आहारशास्त्र विभाग, पशुवैद्यकीय व पशुविज्ञान महाविद्यालय, परभणी

सारांश

प्रस्तुत प्रयोगामध्ये मांसल कोंबड्यांच्या वाढीवर जसे की, वजन, मासांची गुणवत्ता, रक्तातील घटकाचे प्रमाण, आतड्यांचे मापदंड, पोषकतत्वांची चयापचय क्षमता आणि मांसल कोंबड्यांमधील उत्पादन अर्थशास्त्र यांचा अभ्यास करण्यासाठी सहा आठवड्यापर्यंत मांसल कोंबडयांच्या आहारात ब्युटायरेटचा विविध प्रमाणात समावेश केला गेला. सदर प्रयोगासाठी एक दिवसीय वयाची २४० (वेनकोब-४००) पिल्ले समान वजनाच्या आधारावर मुक्त पध्दतीने चार गटात जसे की, टी$_{०}$, टी$_{१}$, टी$_{२}$ आणि टी$_{३}$ मध्ये विभाजीत करण्यात आले. बी.आय.एस. (२००७) नुसार प्रमाणित मांसल कोंबडयांच्या आहारासह गट टी$_{०}$, आणि टी$_{१}$, टी$_{२}$, टी$_{३}$गटाच्या प्रमाणित खाद्यामध्ये अनुक्रमे ०.५%, १% आणि १.५% ब्युटायरेट दिले गेले. संपुर्ण प्रयोग काळात मांसल कोंबडयात खाद्यांचे सेवन हे टी$_{१}$, टी$_{२}$, टी$_{३}$गट आणि नियंत्रण टी$_{०}$गटामध्ये लक्षणिय फरक आढळुन आला नाही. इतर ब्युटायरेट खाद्य संपुरक दिलेले गट आणि नियंत्रण गट यांच्यामध्ये टी$_{३}$ गटात मांसल कोंबड्यांचे एकत्रित शरीर वजन हे लक्षणियरित्या जास्त होते. ६ व्या आठवड्यामध्ये अन्न परिवर्तन गुणोत्तर हे टी$_{३}$ गटात टी$_{२}$, टी$_{१}$ आणि टी$_{०}$ या गटांपेक्षा चांगले आढळुन आले. कत्तल केलेल्या मांसल कोंबड्याच्या शरीराचे खाद्यक्षम वजन व टक्केवारी, गिबलेटची आणि यकृताचे वजन गट टी$_{३}$, टी$_{२}$, टी$_{१}$ आणि टी$_{०}$यामध्ये संख्यात्मक दृष्टया उतरत्या क्रमाणे आढळुन आले. मात्र गिबलेटची टक्केवारी सर्व गटात तुलनात्मक आढळुन आली होती. ब्युटायरेटच्या वेगवेगळ्या प्रमाणातील पुरकतेमुळे खाद्य योग्य मासांच्या (ग्राम) वजनात सरळ वाढ आढळून आली तर खाद्य योग्य मासांच्या टक्केवारीत आणि प्लिहा व बरसा हे सर्व गटांमध्ये तुलनात्मक समान

होते. टी$_{१}$ आणि टी$_{०}$ च्या तुलनेत गट टी$_{३}$ आणि टी$_{२}$ मध्ये छातीच्या मासांचे वजन (पी < ०.०१) लक्षणियरित्या जास्त प्रमाणात होते आणि टी$_{०}$ च्या तुलनेत टी$_{३}$ मध्ये छातीच्या मासांची टक्केवारी लक्षणिय प्रमाणात (पी < ०.०१) जास्त होती. टी$_{०}$सह तुलना करता टी$_{३}$ आणि टी$_{२}$ मध्ये आतड्यांचे वजन लक्षणियरित्या जास्त व टी$_{१}$ मध्ये तुलनात्मक प्रमाणात होते. रक्तातील हिमोग्लोबीन, पी.सी.व्ही. आणि तांबड्या पेशींचे प्रमाण सर्व गटांमध्ये तुलनात्मक समान आढळुन आले. सर्व गटांमध्ये रक्तद्रव्यातील एकुण प्रथिने, अल्ब्यूमीन, ग्लोब्युलीन, अल्ब्यूमीन व ग्लोब्युलीन चे गुणोत्तर, एच.डी.एल. आणि ट्रायग्लिसराईड यांमध्ये फारसा फरक आढळून आला नाही. खाद्यात ब्युटायरेटचे प्रमाण वाढल्यानंतर रक्त द्रव्यातील एकुण कोलेस्टेरॉलचे आणि एल.डी.एल. कोलेस्टेरॉलचे प्रमाण लक्षणियदृष्ट्या कमी झाल्याचे आढळून आले. रक्तातील साखरेचे प्रमाण आणि रक्तातील नत्र युरिया यांचे प्रमाण जवळपास सर्व गटात सारखे होते. आतडयांमधील सिकम भागातील जिवाणू जसे की, ई.कोलाय आणि सालमोनेलाची संख्या टी$_{३}$ आणि टी$_{२}$ मध्ये टी$_{०}$ च्या तुलनेत लक्षणिय प्रमाणात कमी आढळुन आले. तसेच टी$_{०}$ च्या तुलनेत टी$_{१}$, टी$_{२}$ आणि टी$_{३}$ गटात क्लॉस्ट्रिडीयम जिवाणूच्या संख्येत लक्षणिय घट झाल्याचे आढळून आले आणि टी$_{३}$, टी$_{२}$ आणि टी$_{१}$ गटांमध्ये इलियम पीएच चे प्रमाण कमी झाल्याचे दिसून आले. टी$_{१}$ आणि टी$_{०}$ गटाच्या तुलनेत सेंद्रिय पदार्थ आणि शुष्क पदार्थांची पचन क्षमता टि$_{३}$ आणि टी$_{२}$ मध्ये लक्षणिय प्रमाणात वाढल्याचे आढळुन आले. नत्रधारणा आणि स्निग्धांश यांची पचन क्षमता टी$_{३}$, टी$_{२}$, टी$_{१}$ गट व नियंत्रण गटांमध्ये जवळपास एकसारखी दिसुन आली. टी$_{३}$ गटामध्ये बाकी सर्व गटांच्या तुलनेत क्रुड फायबर आणि नत्र मुक्त उध्दरणाची पचन क्षमता ही

लक्षणिय प्रमाणात जास्त असल्याचे आढळून आले. एकुण फायद्याचा विचार करता टी$_3$ मध्ये इतर गटाच्या तुलनेत प्रति किलो वजनामागे जास्त नफा आढळून आला. वरिल प्रयोगातुन असे निदर्शनास येते की, आहारात १.५% स्तरावर ब्युटायरेटचा समावेश केल्यास मांसल कोंबड्यांच्या वाढीवर, मांसाच्या विशेषतेवर आणि रक्तातील घटकाचे प्रमाण यांच्यावर सकारात्मक प्रभाव आढळून आला. तसेच ई.कोलाय, सालमोनेला आणि क्लॉस्ट्रिडीयमचे प्रमाण व इलियमचा पीएच कमी करुन आतड्यांच्या मापदंडात सुधारणा दिसून आली. मांसल कुक्कुट पक्षांच्या आहारात ब्युटायरेटचा १.५% वापर केल्याने शुष्क पदार्थ खाद्यांश, सेंद्रीय पदार्थ खाद्यांश, क्रुड फायबर व नत्र मुक्त उध्दरण या अन्नद्रव्यांच्या पचन क्षमतेत लक्षणिय वाढ दिसुन आली. संशोधनात असे दिसून आले की, १.५% ब्यूटायरेट खाद्य संपूरक वापरल्यामुळे मांसल कोंबड्यांच्या प्रति किलो मांस उत्पादन नफ्यात सुधारणा आढळून आली.