EFFECT OF GARLIC SUPPLEMENTATION ON THE PERFORMANCE, CARCASS CHARACTERISTIC AND BLOOD PROFILE OF BROILER CHICKEN

Thesis

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in partial fulfilment of requirements for the Degree

of

Doctor of Philosophy

in

LIVESTOCK PRODUCTION AND MANAGEMENT

by

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2019

Affectionately

Dedicated

to

my

Parents

DECLARATION

I, Khaidem Archana hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree to any other Universities/Institute.

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This is to certify that the thesis entitled **"Effect of garlic supplementation on the performance, carcass characteristic and blood profile of broiler chicken"** submitted to Nagaland University in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** (Agriculture) in **Livestock Production and Management** is the record of research work carried out by Miss **Khaidem Archana,** Registration No. 826 (2019) under my personal supervision and guidance.

The result of the investigation reported in the thesis have not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN LIVESTOCK PRODUCTION AND MANAGEMENT

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LIST OF ABBREVIATIONS

ABBREVIATIONS	FULL FORM
ANOVA	Analysis of variance
Df	Degree of freedom
Fig	Figure
i.e.	That is
Kg	Kilogram
S.S	Sum of square
viz.	Such as
WBC	White blood cells
RBC	Red blood cells
LDL	Low density lipoprotein
HDL	High density lipoprotein
PCV	Packed cell volume
COL	Cholesterol
TG	Triglyceride
Hb	Haemoglobin
mg/dl	Milligram per deciliter
g/dl	Grams per decilitre
%	Per cent
@	At the rate of
mmol/L	Millimoles per litre
FCR	Feed conversion ratio
nm	Nanometers

CHAPTER I

INTRODUCTION

INTRODUCTION

The poultry and livestock sector plays an important role because of its tremendous contribution in Indian economy. Among the livestock species, poultry has emerged as one of the most versatile and remunerative sectors. As per APEDA (2016), poultry is the most organized component in livestock sector, worth rupees one lakh crores with annual growth rate of 6-8 per cent in layer production and 10-12 per cent in broiler meat production against 2.5 per cent growth in agriculture. India occupies third place in egg production after China and USA and fourth-largest broiler producer after China, Brazil and USA. The share of poultry in meat production during 2015-2016 was reported to be 46 per cent (DAHD, 2016-17). According to National Institute of Nutrition recommendation, per capita consumption of poultry egg should be 180 numbers and 11 kg meat however, the actual availability is 61 eggs and 3.9 kg chicken meat (Thaper, 2018). Poultry industry can harvest first class protein for human nutrition as well as a source of revenue in many countries and also play an important role in economic growth of any country (Tarhyel *et al.,* 2012). Poultry farming is not only an organised and advanced sector that makes considerable contribution to the national economy but also engages farmers and unemployed youths on fulltime or part-time for additional source of income and provides nutritional security. Poultry meat and eggs are nutritious and has no social or religious prejudices. Poultry requires minimum investment and land to start the business. By products of poultry which includes litter and offals are good source of organic manure and has important industrial use. Broiler production dominates the poultry sector in India which accounts for 40 per cent and the states of Tamil Nadu, Andhra Pradesh, Maharashtra, Uttar Pradesh, and Telangana are the key broiler producing areas. Two third of broiler production is done by contract farming under backward integration system providing opportunities for the rural masses with all the technical inputs and assured remunerations (DAHDF, 2017). Broilers are fast growing birds that give quick returns. It can be reared throughout the year. In India, broilers are usually reared for 35-40 days to a market weight of 1.8 to 2.2 kg. It has superior feed conversion ratio which has reportedly improved considerably over the years to 1.65 from 2.2 in the 1990s. Broiler farming is not only suitable for commercial production but it is also recognised as an important tool for poverty alleviation and rural livelihood.

There has been steep rise in consumption and demand for poultry meat which has been driven by increase in per capita consumption, growing population, increase in income, changing food habits, opening up of food chains and high demand for diversified and value added products (DAHDF, 2017).

Feed represents the major part of cost in poultry production. Rise in feed cost, availability, consumer's awareness and preference determines its production and profitability. There has been a pressing need to develop ideal, safe and cost effective feed that will virtually meet all aspects of production and reproduction. Efforts have been made since the beginning of the poultry industry to increase the feed utilization efficiency and to minimize the cost of production per unit. As a result, numerous works have been carried out using different types of feed additives which could potentially reduce the feed cost, enhance broiler performance and improve the quality of the product. Feed additives are non-nutritive substances used in poultry feed including antibiotics, enzymes, antioxidants, pellet-binders, antifungal, coloring pigments and flavoring agents.These feed additives are termed as "growth promoters" and often called as non-nutrient feed additives. Growth promoters are added to nutritionally balanced diet. Several synthetic drugs and growth promoters have been in use in poultry to effect better performance, improve the utilization of feed and in this way realize better production and financial results. However, it has shown many disadvantages such as cost ineffectiveness, residual and adverse side effect on health of birds, etc. There is an increased consumers concern over drug residues in meat and bacterial resistance (Demir *et al*., 2003 and Issa and Omar, 2012), environmental contamination and general health. Hence, poultry scientists today are challenged to find out new alternatives particularly to the synthetic growth promoters and to opt for natural feed supplements (Iji *et al*., 2001). As a result, there has been a rising trend in research that is focussed on using natural products such as essential oils and extracts of edible and medicinal plants, herbs and spices to develop novel products in animal and poultry feeding. Since January 1, 2006, EU had ban on use of antibiotics as growth promoters in animal feed leading to its withdrawal (Nollet, 2005; Cervantes, 2006; Michard, 2008 and Toghyani *et al.,* 2010). One of the major determinants when it comes to the use of alternative feed additives in poultry rations is its availability and cost effectiveness. Another important issue in this regard is the level of inclusion and its safety which demands well-established information through well planned research. Considering the residual effect and bacterial resistance of antibiotics, herbal products had been advocated as alternatives to chemical growth promoters as they are safe, suitable and preferred in relation to food quality due to low risk toxicity and health implications and cost effective. Several works on herbal products including garlic, ginger, oregano, du-sacch, quiponin, black pepper and thyme, etc. as growth promoters has proved its positive effect on gain in body weight, feed efficiency, mortality, immunity status and livability in poultry birds (Guo *et al*., 2000; Demir *et al*., 2003; El- Faham, *et al*., 2014 and Makwana, 2014)

Garlic (*Allium sativum),* a member of allium family (liliaceace) is a well known spice which is widely used and distributed in most parts of the world. Garlic contains bioactive substances like sulfur compounds such as allin, allicin and diallylsulfide, ajoene, S-allyl cysteine and diallyltrisulfide that act as antibacterial, antifungal, antiparasitic, antiviral, antioxidant and antithrombotic (Mikaili *et al*., 2013 and Puvaca *et al*., 2014), vitamins, minerals and flavonoids (Pekowska and Skupien, 2009). The use of garlic is not only important for culinary but also for therapeutic and medicinal purposes in both traditional and modern medicine. Allicin which is responsible for the characteristic smell and flavour of garlic as well as most of its biological properties is known to be the active ingredient of garlic that lowers serum lipid and cholesterol (Tucker *et al*., 2000; Amagase *et al*., 2001; Onu 2010 and Ahmed, 2012). Allicin do not exist in the garlic bulb until it is crushed or cut that activates the enzyme allinase which metabolizes allin to allicin (Tucker *et al.,* 2000 and Woodward, 1996). Researchers such as Prasad and Sharma (1981); Reuter *et al*. (1996); Konjufca *et al*. (1997); Sivam (2001) and Adibmoradi *et al*. (2006) also reported the antibacterial, antifungal, antiviral, anti-parasite, anti-cancer, antioxidant, immunomodulatory, anti-inflammatory, hypoglycemic and cardiovascular- protecting effects of garlic. Ramakrishna *et al.* (2003) stated that garlic supplementation increase the pancreatic enzyme activity and leads to better nutrient absorption, reduced serum and liver cholesterol (Qureshi *et al*., 1983; Hamodi and Al-Hamdany 2006 and Samanthi *et al*., 2015) and enhanced productive performance, feed conversion ratio and dressing percentage of broiler chicks (Demir *et al*., 2003; Hamodi and Al-Hamdany 2006; Banuree *et al*., 2009 and Broszka *et al*., 2015). Similarly, significant changes in blood haematological parameters and its biochemical constituents due to supplementation of garlic have been reported by several researchers (Fadlalla *et al*., 2010; Ahmed, 2012; Issa and Omar, 2012and Eid and Iraqi, 2014). Hence, the beneficial properties of garlic affecting the gut microflora, blood lipid profile and immune status, supports its use for nutritional manipulation of both human and farm animals (Sallam *et al*., 2004). Different forms of garlic preparations are now commercially available in the form of garlic oil, garlic powder and pills.

North-eastern region of India is mostly dominated by various tribal communities who are non-vegetarian. The region meets its requirement for poultry eggs and meat mostly from the neighbouring states. About 82 per cent of the population lives in rural areas of the region and agriculture and allied sectors like backyard poultry are the main source for their livelihood. Majority of the farmers practice traditional system of poultry farming which is characterized with no or meagre inputs. High cost of concentrate feeds, diseases and lack of technical knowhow and lack of finances are some of the constraints faced by the livestock farmers. Garlic is also widely used in this region as a spice and in traditional medicines for human as well as for animals. Considering the benefits of garlic and its possible use as an alternative to antibiotic growth promoters, the present study entitled "**Effect of garlic supplementation on the performance, carcass characteristic and blood profile of broiler chicken**" was conceived to study the effects of garlic on the performance of broilers under agro-climatic conditions of Nagaland with the following objectives:

OBJECTIVES:

1. To study the effects of different levels of garlic on the productive traits of broilers in three different seasons.
2. To study the effects of different levels of garlic on the edible organs and carcass yield of broilers in three different seasons.
3. To study the effects of different levels of garlic on some haematological and biochemical constituents in blood of broilers in three different seasons.
4. To find out the economy of the use of different levels of garlic in three different seasons.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Garlic is a widely used spice which is known to have therapeutic and medicinal properties. Recognizing its importance as a potential alternative feed supplement to antibiotic growth promoter, several researchers have carried out trials to study its effect on the performance of broilers. Some of the important findings have been discussed below under the following heads.

2.1 Garlic and its composition

Garlic is known to have antimicrobial, antioxidative and antihypertensive properties (Prasad and Sharma, 1981; Konjufca *et al*. 1997 and Sivam, 2001).

The genus *Allium* comprises more than 500 species that are characterized by the presence of sulphur-containing volatile compounds and the constituents of these volatile compounds are diallyldisulphide and diallyltrisulphide (El- Sofany, 1985).

Garlic has been used in treating various diseases such as skin infections, diarrhea, ulcers, and respiratory infections (Fenwick and Hanley, 1985).

According to Tariq *et al.* (1988) sulfur compounds such as Allicin is an important alkaloid which is responsible for the beneficial effects of garlic.

In Chinese medicine the use of garlic for medicinal purpose had started 5000 years ago and it has been used for at least 3000 years. The antibacterial properties of garlic and was also used during World War I and World War II to prevent gangrene (Murray, 1995).

Garlic (*Allium sativum*) is one of the most important bulb vegetables used as spice and flavoring agent for foods (Velisek *et al.,* 1997).

Garlic contains sugars, cellulose, mucilage, peptides, pectin (Woodward, 1996), polysaccharides and saponins (Gruenwald *et al*., 2000)

Medicinal uses of garlic includes lowering blood pressure and cholesterol and aids in prevention and treatment of cardiovascular disease, as a cancer preventive agent and antimicrobial and can be attributed to its bioactive components, the most important being sulphuric compounds including allin, diallylsulphide, allyldisulphide and allicin (Kumar and Berwal ,1998).

A garlic bulb is composed of about 65 per cent water, 28 per cent carbohydrates, 2 per cent protein, 1.5 per cent fiber and only 0.15 per cent fats (Blumental, 2000).

Garlic supplementation influenced positively on culinary traits of poultry meat. The positive influence of garlic supplementation on meat can be correlated to the presence of volatile compounds, phenolic content and antioxidant active compounds (Kim *et al*., 2009).

Mikaili *et al.* (2013) reported that the organo sulfur volatile compounds contribute to the effective bioactive properties of garlic which includes allicin, diallyldisulphide, S- allyl cysteine and diallyltrisulfide.

Effects of garlic powder on

2.2 Body weight and weight gain

Islam and Howlider (1990) reported that growth rate decreased by 14.5 and 23.3 per cent in broilers reared during summer and rainy season, respectively.

Rahman *et al.* (2003) reported highest weight gain during winter, lowest in rainy and intermediate in summer season.

Ramakrishna *et al.* (2003) reported that garlic supplementation had positive influenced by improving absorption of nutrients by enhancing the pancreatic enzymes.

Ademola *et al.* (2004) reported that broiler birds fed on garlic (5, 10 and 15 g/kg) treatments had better weight gain as compared to control diet.

Hamodi and Al-Hamdany (2006) observed that dietary supplementation of garlic at 0.2 and 0.4 per cent had shown significantly increased body weight and daily live weight gain.

Ademola *et al.* (2009) observed that broiler birds supplemented with garlic at the rate 1.5 and 2 per cent significantly ($P<0.01$) decreased the final live weights as compared to the control group.

Mahmood *et al.* (2009) reported that garlic supplementation at 0.5 per cent in broiler diet had significant ($P<0.05$) improvement in body weight gain, live weight (1588 g) and FCR (1.91).

Onibi *et al*. (2009) reported that garlic at high level (5,000 mg per kg diet) improved weight gain in broiler birds.

Banuree *et al.* (2009) observed that inclusion of 2.25 per cent garlic juice, 0.75 per cent garlic powder and 1 per cent garlic powder in the broiler diet had significant ($P<0.01$) improvement in body weight gain.

Fadlalla *et al.* (2010) reported increase in weight gain with inclusion of garlic at 0.00, 0.15, 0.3, 0.45 and 0.6 per cent of garlic however; it was statistically non- significant.

Kumar *et al.* (2010) reported that there was significant increase in gain in body weight and feed conversion ratio when garlic powder was fed in diet at 250 ppm of broilers chickens.

Onu (2010) reported that supplementation of garlic at 0.25 per cent enhanced growth rate of broilers.

Pourali *et al.* (2010) reported that the best body weight gain was obtained in groups fed 0.2 per cent garlic.

Raeesi *et al.* (2010) found that the birds which received 3 per cent garlic powder had greater live body weight than those groups fed on diet contains 0.5 per cent garlic powder .

Fayed *et al.* (2011) reported that birds supplemented with 0.5 kg garlic per ton of feed showed significantly higher live weight gain among the garlic supplemented groups.

Ibrahim (2011) reported that addition of 3 per cent garlic significantly ($P<0.05$) increased the weight gain and live body weight in broiler birds.

Mansoub (2011) found that garlic inclusion had significantlyincreased gain in body weight of the birds when garlic was supplemented at 1 g per kg.

Ari *et al.* (2012) reported that garlic added at the level of 0, 10, 15 and 20 per cent had no significant ($P>0.05$) variation in all growth parameters of the birds.

Issa and Omar (2012) reported that birds supplemented with garlic powder at the rate of 0.2 and 0.4 per cent did not show any significant effect on body weight gain of broilers.

Suriya *et al.* (2012) found that the body weight gain and feed conversion ratio of the birds was increased significantly when garlic was supplemented at 0.5 per cent.

Tazi *et al.* (2012) found non-significant (P>0.05) variation in body weight gain among all treatment groups fed with garlic essential oil at different levels of 0.1, 0.2 and 0.3 per cent garlic essential oil.

Thirumalesh *et al*. (2012) reported non-significant difference between summer, rainy and winter season in weight gain.

Al-Kassie *et al.* (2013) reported that the diet with garlic extract (35ppm/kg) and Jerusalem artichoke tuber powder (70 ppm/kg) at different levels improved body weight gain when compared with control group.

Amouzmehr *et al.* (2013) observed no significant effect on body weight gain of broilers supplemented with different rates of garlic.

Jimoh *et al*. (2013) reported that when broilers were fed with garlic powder at rate of 0.0, 0.5, 1.0, 1.5, 2.0 and 2.5 g per kg it had no significant effect on weight gain.

Saeid *et al.* (2013) observed that growth performance was significantly higher with addition of garlic powder and black seed plant premix in diet of the birds.

Eid and Iraqi (2014) reported that the broiler fed with 200 g garlic powder per ton of feed had significantly greater live body weight than the control group.

Jakubcova *et al.* (2014) stated that garlic at rate of 10 g and 15 g/kg feed did not affect the body weight gain of the birds.

Kharde and Soujanya (2014) found that the body weight gain of broilers was improved significantly (P<0.05) when fed with garlic and neem leaf powder alone and their combination.

Oleforuh-Okoleh *et al.* (2014) showed that broiler chicken when fed with garlic powder resulted in significant variation in the final body weight and weekly body weight gain among the treatments and control groups.

Patel *et al*. (2014) showed that garlic fed in diet at 0.5 per cent improved productive performance as compared to control.

Puvaca *et al.* (2014) showed that the highest body weight was achieved in treatment with 0.5 per cent garlic powder (2371.1 g) which was followed by treatment with 1.0 per cent garlic powder (2336.1 g).

Brzoska *et al.* (2015) reported that broilers fed with diet supplemented with 1.00, 1.50 and 2.25 ml kg^{-1} of garlic liquid extract showed increased body weight.

Lukanov *et al.* (2015) observed increase in live body weight at 56 days with control group-4220 ± 60.35 g, 0.2 per cent garlic powder- 4230.3 ± 65.55 g, 0.4 per cent garlic powder-4246.7 ± 60.91 g and 0.8 per cent garlic powder-4287 ± 54.77 g).

Samanthi *et al.* (2015) stated the highest ($P<0.05$) weight gain was observed in birds fed with 1 kg garlic per ton of feed.

El-katcha *et al*. (2016) provided dietary allic in to broilers at the rate of0.0, 25, 50, 75 and 100 mg allic in/kg diet for five continuous weeks. They reported that dietary allic in supplementation at 25, 50 and 75 mg/kg diet significantly (P□0.05) improved final body weight and total gain by about (6.87, 12.76 and, 10.13 per cent) and (6.9, 13.03 and 10.3 per cent), respectively when compared with control broiler chick group. In contrast high level (100mg/kg) addition of allic in non significantly (P□0.05) decreased final body weight and total gain of broiler chicks by about 1.13 and 1.2 per cent, respectively, when compared with control.

Karangiya *et al.* (2016) showed that weight gain was ($P<0.05$) higher in birds fed with diets containing 1 per cent garlic.

Adebiyi *et al*. (2017) reported that growth performance was not affected by dietary supplementation of raw and sundried garlic at 1, 2 and 3 per cent.

Borgohain *et al*. (2017) observed better performance in garlic supplemented group with significantly higher body weight in groups supplemented with 1 per cent garlic.

Osti *et al*. (2017) observed that body weight and feed conversion ratio was significantly (P□0.05) higher during winter season as compared to the summer season.

2.3 Feed intake and feed efficiency

Islam and Howlider (1990) reported that during summer and rainy season, there was decrease in feed intake by 9 and 2.72 per cent, respectively, and FCR was observed to be 2.55, 2.71 and 2.24 during winter, summer and rainy season.

Demir *et al*. (2003) found non- significant variation in feed consumption and feed efficiency between broilers fed with five different feed additives *viz*. oregano, du-sacch, quiponin, garlic and thyme powder in broiler diet.

Ademola *et al.* (2004) stated that birds had higher feed intake when fed on garlic (5 g per Kg, 10 g per kg, 15 g per kg).

Hamodi and Al-Hamdany (2006) stated that dietary supplementation of garlic at 0.2 and 0.4 per cent had shown significantly decreased total feed consumption and better feed efficiency than birds in control diet.

Ayeni *et al.* (2008) stated that garlic did not have any significant effect on feed FCR in broiler chicken.

Javandel *et al.* (2008) showed that garlic inclusion at 0.125, 0.5 or 1 per cent levels did not affect the daily feed intake.

Banuree *et al.*(2009) observed that inclusion of 2.25 as well as 3.00 per cent garlic juice and 0.75 per cent garlic powder in broiler ration significantly ($P<0.01$) reduced feed consumption. However, garlic supplementation had no significant effect on FCR.

Fadlalla *et al.* (2010) observed FCR was significantly ($P<0.05$) improved in broiler chicken fed with 0.3 per cent garlic.

Onu (2010) stated that ginger and garlic were assigned at 0.25 per cent level in broiler finisher diets resulted in better feed conversion ratio (2.88) of broiler chicken as compared to the control group (3.28).

Pourali *et al.* (2010) stated that chickens fed at 0.2 per cent garlic powder had the best feed conversion ratio (1.81).

Raeesi *et al.* (2010) observed that broiler chickens fed 3 per cent garlic powder had better feed conversion ratio (1.82) and higher feed consumption than the control group.

Aji *et al.* (2011) reported that inclusion of garlic at the rate of 25, 50 and 100 mg per kg diet improved feed conversion ratio at 21 days of age in all the birds fed with garlic.

Fayed *et al.* (2011) reported that birds fed with 0.5 kg garlic per ton of feed gained the best FCR.

Ibrahim (2011) reported that when 3 per cent garlic was added in diet of broiler birds resulted in significant ($P<0.05$) increased in feed intake and efficiency of feed utilization.

Mansoub (2011) stated that garlic inclusion at 1 g per kg of feed significantly increased the feed conversion ratio of broiler chickens

Issa and Omar (2012) reported that dietary inclusion of garlic at 0.2 and 0.4 per cent had no significant effects on broilers feed consumption and efficiency of feed utilization.

Suriya *et al.* (2012) showed that garlic as feed additive at the level 0.5 per cent significantly improved the FCR (1.86) in broiler birds as compared to birds with control diet (1.92).

Tazi *et al.* (2012) reported that inclusion of 0.1, 0.2 and 0.3 per cent garlic essential oil had no significant variation between all treatment groups in the values of feed conversion ratio

Thirumalesh *et al*. (2012) reported non-significant difference between summer, rainy and winter season in feed intake and FCR.

Al-Kassie *et al.* (2013) stated that garlic and Jerusalem artichoke tuber extract at different levels improved feed conversion ratio (1.98 and 1.88) when compared with control group (2.01).

Amouzmehr *et al.* (2013) showed that there were no significant effects among the treatments when fed with garlic extract supplemented at the level of 0.3 and 0.6 per cent, respectively on feed conversion ratio over the entire trial of 42 days.

Elagib *et al.* (2013) showed that addition of garlic at 3 per cent increased feed intake of broiler chicken.

Jimoh *et al*. (2013) reported significant reduction in feed consumption and better feed conversion ratio with garlic powder at rate of 0.0, 0.5, 1.0, 1.5, 2.0 and 2.5 g kg^{-1}.

Saeid *et al.* (2013) stated that addition of garlic powder and black seed plant premix to the diet resulted in significantly higher feed consumption while FCR was not affected by the inclusion of garlic.

Eid and Iraqi (2014) observed highly significant (P<0.001) effect of garlic on cumulative feed intake. They reported that the mean cumulative feed intake was highest in control group which tend to decrease gradually with increasing level of garlic. The mean FCR was found to be 1.58, 1.66, 1.71 and 1.79 for groups fed on 200, 150, 100 and 0 g garlic powder per ton of feed, respectively.

Eltazi *et al.* (2014) showed that the diet with 3 per cent garlic powder had the best feed conversion ratio (1.92) when compared with control group (2.00).

Makwana *et al.* (2014) reported that birds with 0.1 per cent garlic had significantly higher feed consumption as compared to birds that were supplemented with 0.5 per cent garlic and birds with control diet.

Oleforuh-Okoleh *et al.* (2014) concluded that broiler chicken supplemented with garlic at 14 g/kg had better feed conversion ratio (2.17) than control (2.53) group.

Patel *et al*. (2014) reported that garlic added at 0.5 per cent improved the feed efficiency in broilers chicken.

Puvaca *et al.* (2014) showed that feed conversion ratio was lowest in garlic (0.5 and 1.0 per cent) treated group (1.80) as compared to control group (2.10).

Ramiah *et al.* (2014) stated that feeding birds with garlic powder (0.5 per cent) had increased (P<0.05) the total feed intake (3953.5 g) as compared to the control group (3774 g).

Brzoska *et al.* (2015) reported better feed efficiency in birds fed with 1.00, 1.50 and 2.25 ml kg^{-1} of garlic liquid extract.

Lukanov *et al.* (2015) stated that with increasing doses of garlic powder, feed conversion maintained a stable positive tendency up to the 7th week of age (control group- 1.97 ± 0.03, 0.2 per cent garlic powder-1.94 ± 0.03, 0.4 per cent garlic powder-1.93 ± 0.03 and 0.8 per cent garlic powder-1.95 ± 0.0) with garlic powder supplementation.

Samanthi *et al*. (2015) observed that highest feed consumption occurred in broiler chicken without garlic as additive and significantly the lowest (P<0.05) feed conversion ratio was observed in birds fed with 1 kg garlic per ton of feed.

El-katcha *et al*. (2016) had reported that garlic addition in feed of broiler chicken increased feed consumption while garlic at 25, 50 or 75 mg /kg level in diet improved FCR.

Adebiyi *et al*. (2017) observed that birds fed with 1, 2 and 3 per cent garlic significantly did not affect the feed intake and FCR of the birds.

Borgohain *et al*. (2017) reported that inclusion of garlic at 0.5, 1.0 and 1.5 per cent resulted in best feed conversion ratio.

2.4 Dressing percentage and carcass characteristics

Sarica *et al.* (2005) found that garlic powder fed at 0.1 per cent did not have any significant (P>0.05) effect of on the carcass characteristics of the broiler chicken.

Hamodi and Al-Hamdany (2006) observed that dressing percentage and the relative carcass weight increased significantly with the dietary inclusion of 0.4 per cent garlic powder.

Javandel *et al.* (2008) observed no significant variation in dressing percentage and internal organs among the garlic (0.125, 0.25, 0.5, 1 and 2 per cent) supplemented group.

Ademola *et al.* (2009) reported that inclusion of garlic, ginger and their mixtures in diet of broiler had significant ($P<0.001$) effect on carcass per cent and organs weight.

Ashayerizadeh *et al.* (2009) reported that supplementation of garlic at 1kg per ton level resulted in higher dressing percentage as compared to the control.

Mahmood *et al.* (2009) revealed that addition of 0.5 per cent garlic in the broiler ration showed no significant variation ($P>0.05$) in carcass yield, and organ weight of the birds fed diet with or without addition of garlic.

Onibi *et al*. (2009) found that the carcass yield and organ development of the birds had no significant affect ($P>0.05$) by dietary garlic inclusion of garlic.

Pourali *et al.* (2010) reported that carcass parts were not affected by ginger and garlic supplementation.

Raeesi *et al.* (2010) observed that garlic (0.5, 1 and 3 per cent) significantly ($P<0.001$) influenced better carcass characteristic.

Fayed *et al.* (2011) stated that garlic fed at the rate of 0, 0.5 and 1.0 kg per ton of feed had significant variation in the carcass yield while variation in giblet weight among the birds with or without garlic supplementation was non-significant.

Ibrahim (2011) stated that spleen weight decreased significantly (P□0.05) at 3 and 5 per cent garlic powder. The dressing percentage, bursa and thymus weights showed non-significant (P>0.05) difference between the groups.

Brzoska *et al.* (2015) reported that dressing percentage at the rate of 2.25 ml per kg liquid garlic extract was significantly (P□0.01) higher than control group (74.8 vs 72.5 per cent). They observed significant (P□0.01) increase in liver weight at the rate of 1.50 ml per kg.

Samanthi *et al*. (2015) reported that garlic did not have any positive effect on carcass per cent of the birds.

Singh *et al.* (2015) reported that garlic extract (1.0, 1.5 and 2.0 per cent) did not affect the carcass characteristic of the broiler birds.

2.5 Mortality/Live ability and performance index

Horton *et al.* (1991) concluded that garlic did not affect performance of the birds.

Fadlalla *et al.* (2010) investigated the effects of different levels of garlic (0.00, 0.15, 0.3, 0.45 and 0.6 per cent) added to the diet of broiler and observed significantly (P<0.05) lower mortality rate in treatment group supplemented with 3 per cent garlic.

Pourali *et al.* (2010) showed that the performance index was best (56.5 per cent) in chickens fed with 2 per cent garlic powder and it was worst (50.4 per cent) in group fed with 1 per cent garlic powder.

Fayed *et al.* (2011) assessed productive performance, carcass quality and organ weight of broilers fed with garlic powder at 0.0, 0.5 and 1.0 kg per ton of feed and observed non- significant difference in mortality rate of the broilers.

Ahmed (2012) reported that there was no mortality in broilers when fed with garlic extract based diet and stated that it was due to antimicrobial and immune stimulatory properties of garlic extract.

Tazi *et al.* (2012) conducted an experiment to study the effect of garlic as growth promoter in broiler chicken and found cent per cent liveability in all treated groups.

Thirumalesh *et al*. (2012) reported non-significant difference between summer, rainy and winter season in high mortality and dressing percentage during rainy season as compared to summer and winter seasons.

Al-Kassie *et al.* (2013) reported that the diet with garlic extract at 0.035 per cent level improved liveability per cent (93.7 per cent) when compared with control group (91.7 per cent).

Elagib *et al.* (2013) reported that inclusion of garlic as growth promoter at 3 per cent level had significant improvement in productive parameters of broiler chicks.

Jimoh *et al*. (2013) indicated that supplementation of garlic (1.0 to 1.5 g kg^{-1}) improved performance in broiler birds.

Milosevic *et al.* (2013) studied the effect of garlic on production parameters of broiler birds and concluded that the values of European Production Efficiency Factor (EPEF) were in usual range and showed no significant differences between groups (control group- 280 ± 9.93, 1.5 per cent garlic powder- 281 ± 6.68 and 3 per cent garlic powder- 273 ± 7.53).

Eid and Iraqi (2014) found that broilers fed with diet containing 200 g garlic powder per ton had significantly decreased mortality rate as compared with the other groups that received 0, 100 and 150 g garlic powder per ton.

Eltazi *et al.* (2014) reported that mortality rate was not affected significantly by the addition of powdered garlic in diet of broiler chicken at the level of 2, 3 and 4 per cent. The liveability percentage in the treated and control group was 99.0 per cent.

Patel *et al.* (2014) showed that inclusion of garlic alone or mixed with fenugreek seed improved performance index as compared to control group (44.68).

Puvaca *et al.* (2014) reported that garlic significantly improved European Broiler Index as 295.1 per cent and 283.7 per cent fed 0.5 and 1.0 per cent garlic powder, respectively in comparison to control treatment (220.4 per cent)

Brzoska *et al.* (2015) reported that broilers fed with diet supplemented with 1.00, 1.50 and 2.25 ml kg^{-1} of garlic liquid extract showed lower mortality rate of 0.10, 0.63 and 0.60 per cent, respectively with 2.78 per cent in the control group.

El-katcha *et al*. (2016) reported that garlic supplementation at the rate of 25, 50 or 75 and 100 mg garlic/kg diet had improved the performance index (139.37±3.02, 155.58±3.88, 147.94±4.07, respectively) when compared with control (125.59±3.79).

Borgohain *et al*. (2017) stated that inclusion of garlic powder at 0.5, 1.0 and 1.5 per cent resulted in highest broiler performance efficiency index (BPEI) and 100 per cent liveability and higher gross profit.

2.6 Blood profile

Sharma *et al.* (1979) observed that supplementing garlic powder at the rate 1, 2 and 3 per cent in broiler birds reduced egg and yoke cholesterol by 5.45, 4.10 and 3.83 mg per g, respectively.

The values for Haemoglobin (g/100 ml), RBC (10^6/mm^3, PCV (per cent), WBC (10^3/mm^3, heterophil, eosinophil, basophil, lymphocytes, monocytes /100 WBC was 10.1± 1.90, 2.82± 0.42, 29.1± 3.13, 24.992 ± 6.569, 26.5 ± 9.2, 2.9 ± 2.1, 4.3 ± 2.9, 61.8 ± 11.2, 4.2 ± 3.1, respectively (Maxwell *et al.* 1990).

Horton *et al*. (1991) stated that garlic reduced serum cholesterol and plasma high density lipoprotein cholesterol by approximately l0 per cent at dietary garlic (10000 mg kg^{-1}) while plasma triglycerides and plasma glucose were found to be non- significant due to garlic. They reported the values for cholesterol and HDL to be 127.9, 131.70, 122.20, 118.80 mgdl^{-1} and 101.40, 109.80, 102.70 and 90.90 mgdl^{-1}, respectively. The values for plasma glucose and triglycerides were reported to be 164, 159, 166.10, 166.40 and 35.80, 32.5, 32.70, 33.80 mgdl^{-1}, respectively.

Reddy *et al*. (1991) stated there was no significant effect on serum cholesterol at 0.02 per cent garlic oil.

According to Jain (1993) total leukocyte counts in chickens ranges from 12000 – 30000 cell/□1

Birrenkott *et al.* (2000) reported that supplementing garlic in laying hens increased total white blood cells reflecting good immune response.

Yeh and Liu (2001) stated that the mechanism which involved in decreasing the cholesterol, triglyceride and LDL is that it reduces the activities of hepatic lipogenic and cholesterogenic enzymes such as fatty acid synthesis, malic enzyme, 3-hydroxy-3-methylglutaryl- CoA (HMG CoA) reductase and glucose-6 phosphate dehydrogenase.

Ademola *et al*. (2004) reported that birds fed with garlic with 10 g per Kg reduced the packed cell volume and increased in total white blood cells and neutrophils for birds on garlic treatment.

Hamodi and Al-Hamdany (2006) observed that dietary supplementation of garlic at 0.2 and 0.4 per cent significantly ($P<0.05$) increased packed cell volume while the cholesterol level was significantly ($P<0.01$) decreased for the group fed with 0.4 per cent garlic.

Lim *et al*. (2006) reported that addition of 0, 1, 3, or 5 per cent garlic did not change the high density lipoprotein level in laying hens.

Blahova *et al*. (2007) reported that low environmental temperature during winter negatively influenced some indices of performance and blood system in broiler chickens. They observed that winter season had influenced significantly ($P<0.05$) the level of total proteins, uric acid, phosphorus (in female broiler chickens), glucose (in male broiler chickens), haemoglobin and liver weight (in male broiler chickens). They further stated that both low and high temperatures act in a negative way.

Jafari *et al*. (2008) reported that leukocyte numbers was not affected by garlic supplementation in birds.

Ademola *et al.* (2009) observed that garlic, ginger and their mixtures did not affect red blood cells and haemoglobin concentration in chickens.

Prasad *et al*. (2009) found that garlic increased lymphocyte and heterophil counts while values of haemoglobin and total erythrocyte count were decreased in garlic treated groups.

Banuree *et al.* (2009) reported that when broilers were subjected to five dietary treatment *viz*. control, 3 per cent garlic juice, 2.25 per cent garlic juice, 0.75 per cent garlic powder and 1 per cent garlic powder to study its effect on growth performance and serum cholesterol level in broilers chicks, garlic supplementation either in powder or juice significantly ($P<0.01$) lowered serum cholesterol level.

Choi *et al.* (2010) observed that addition of garlic along with □-tocopherol considerably reduced total and low-density lipoprotein cholesterol and increased high-density lipoprotein cholesterol in broiler blood.

Fadlalla *et al.* (2010) investigated the effects of garlic (0.00, 0.15, 0.3, 0.45, and 0.6 per cent) added in diet of broiler chicks and found significantly ($p<0.05$) higher total white blood cells (TWBC) in birds fed 0.3 per cent garlic while lower TWBC was recorded in the control treatment.

Hanieh *et al*. (2010) reported that supplementation of garlic increased white blood cells counts in broiler chicken.

Onu (2010) reported that supplementation of garlic at 0.25 per cent did not adversely influenced the haematological characteristics of the birds.

Toghyani *et al*. (2010) reported significant ($P<0.05$) increase in the red blood cells count, haemoglobin concentration and haematocrit percentage when garlic powder was added at the rate of 4 g per kg.

Ibrahim (2011) stated that broilers fed garlic (0, 3 and 5 per cent) resulted in no significant ($P>0.05$) effects on RBC, WBC, PCV and the differential count of white blood cells including lymphocytes, neutrophile, basophile, eosinophile, and monocytes between the different treatments.

Rahimi *et al.* (2011) stated that garlic fed at 0.1 per cent reduced the total cholesterol, low density lipoprotein and triglyceride while increasing the high density lipoprotein.

Toghyani *et al.* (2011) showed that in 42 days broilers fed with garlic powder @ 5 g per kg feed, decreased the serum low density lipoprotein and increased high density lipoprotein.

Ahmed (2012) evaluated the effect of garlic extract in broiler chickens supplemented in drinking water at 2 per cent. The total erythrocyte count and packed cell volume levels of treated group showed significant variation among the groups.

Ari *et al.* (2012) studied performance of broilers fed with of 0, 10, 15 and 20 per cent resulting in increased in all serum metabolites at higher levels of garlic except cholesterol which was decreased when garlic level was increased.

Biochemical blood parameters of broilers at 42 days of age were 25.88, 68.39, 100.72 and 32.23 mg/dl for HDL, LDL, COL, TG (Café *et al.*, 2012).

Issa and Omar (2012) showed that addition of garlic powder at 0, 2 and 0.4 per cent significantly ($P<0.05$) lowered the cholesterol, triglycerides, low density lipoprotein and increased high density lipoprotein levels as compared to control birds.

Onyimonyi *et al.* (2012) reported that when broilers were fed with 0.25, 0.50 and 0.75 per cent garlic, there was non-significant ($P>0.05$) effect on haematological and serum chemistry of the birds.

The normal values for PCV (per cent), haemoglobin (g/dl), RBC (10^6/ml) and WBC (10^3/ml) are 35.9 to 41.00, 11.60 to 13.68, 4.21 to 4.84, 4.07 to 4.34, respectively (Wikivet, 2012).

Elagib *et al.* (2013) reported that RBC, PCV, WBC and the differential count of white blood cells including neutrophils, eosinophils, monocytes and lymphocytes had no significant effect (P>0.05) in broiler supplemented with garlic at 3 and 5 per cent.

El-Faham *et al*. (2014) observed that there was no significant difference in most of the blood parameters between broilers fed with diet supplemented with natural feed additives and antibiotic growth promoters.

Patel *et al*. (2014) observed improvement (P<0.05) in the biochemical parameters including cholesterol, triglyceride and low density lipoprotein in broiler supplemented with 0.5 per cent of garlic powder.

Brzoska *et al.* (2015) stated that there was no significant (P□0.01) variation in the level of glucose, triglycerides, total cholesterol or high density lipoprotein in the blood serum of birds fed with liquid garlic extract at the rate of 0,1,1.5, 2,25 $mlkg^{-1}$.

Jones (2015) stated that bird haematology varies with age, sex, seasons, environment and hormonal influence.

Oleforuh-Okoleh *et al*. (2015) reported that broilers fed with diet supplemented with extract of ginger and garlic at the level of 0, 50 ml ginger extract, 50 ml of garlic extract and a mixture of ginger and garlic 25 ml each per liter of water significantly (P< 0.01) increased the Hb concentration, PCV, WBC and RBC and increased cholesterol.

Samanthi *et al*. (2015) reported lower total serum cholesterol levels for broiler chicken supplemented with 2 kg garlic per ton of feed followed by those with 1 kg garlic per ton of feed. They also observed higher HDL level and lower LDL level in birds fed with garlic in their diet as compared to control.

Varmaghany *et al*. (2015) conducted a trial by adding 5, 10 and 15 g garlic bulbs in 1 kg diet of broilers to study its effects on the haematological parameters and found that the red blood cell count decreased linearly ($P< 0.05$) with increasing garlic bulb levels in the diet under standard temperature conditions.

El-katcha *et al*. (2016) stated that garlic increased RBCs, Hb per cent, PCV per cent, blood serum units and reduced blood serum triglycerides and total cholesterol concentrations in broiler birds.

The reference values for PCV, heterophils, lymphocytes, monocytes, eosinophils and basophils was in the range of 32 to 41, 42 to 60, 2 to 8, 2 to 5, 0 to 2 and 0 to 2 per cent, respectively while the value for cholesterol and glucose was 1 to 3, 7.0 to 14.0 mmo1/L, respectively (Nambol *et al.* 2016). They observed increase in glucose level from four to five weeks in broilers while cholesterol increased from four to fifty two weeks in layers which they opined is due to accumulated cholesterol content in the feed and aging.

2.7 Economics

Islam and Howlider (1990) reported that maximum profit was obtained from broilers reared during winter, intermediate in summer and minimum in rainy season.

Demir *et al*. (2003) reported that when broilers were fed diets supplemented with oregano, garlic and thyme the feed costs per kg of weight gain was higher than in those given diets supplemented with du-sacch, quiponin and antibiotic growth promoter.

Fayad *et al.* (2011) stated that supplementation of garlic was profitable and efficient for production of broilers birds.

Tazi *et al.* (2012) reported that garlic essential oil supplemented at 0.3 per cent had the highest profitability ratio (1.27) among the treated groups.

Eevuri and Putturu (2013) stated that herbal supplementation had positive influence on lowering the feed cost per unit of live weight gain.

El-Faham *et al*. (2014) reported that chicks fed with diet supplemented with pungent substance (ginger + black pepper + red pepper) had the best economical and relative efficiency values of which they opined that it could be due to lower feed cost per chick and better performance as compared with control group.

Eltazi *et al.* (2014) reported that the highest profitability ratio (1.30) was recorded by the diet with 3 per cent garlic powder as compared to control (1.00) and other experimental diets of broiler chicken.

Hossain *et al.* (2014) reported birds supplemented with 1 per cent garlic had significantly higher profitability per broiler as compared to the control group.

Makwana *et al.* (2014) showed that dietary supplementation of 0.1 per cent garlic powder had beneficial effect in broilers for improving performance and also served as one of the potential alternatives to antibiotic growth promoter as well as reducing the cost of production in commercial broiler farming.

Samanthi *et al*. (2015) reported lower feed cost in garlic fed broilers and they were of the view that it might be due to improved feed efficiency which helped to gain more weight with lower feed intake.

Singh *et al.* (2015) observed that garlic supplementation at the rate of 1.5, 1 and 2 per cent garlic lowered feed cost per kg gain in weight than the control group.

2.8 Seasonal effect on broiler performance and blood profile

Rahman *et al.* (2003) had reported highest weight gain during winter season, lowest in rainy and intermediate in summer season.

Thirumalesh *et al*. (2012) who had reported that there was no significant difference between summer, rainy and winter season in weight gain and feed intake while dressing percentage was higher during rainy season as compared to summer and winter seasons.

Osti *et al*. (2017) studied the effect of season on body weight and feed conversion ratio and observed that body weight at 42 days was significantly (P□0.05) higher during winter season as compared to the summer season.

Mohamed *et al*. (2012) reported that Packed Cell Volume decreased significantly ($P<0.05$) during summer season, whereas, it was significantly ($P<0.05$) increased in Ross strain during the same season. Haemoglobin concentration decreased significantly ($P<0.05$) in Cobb strain during the summer. Total red blood cells count (TRBC count) was not significantly affected by the season. Serum glucose concentration decreased significantly ($P<0.05$) during summer in both Ross and Hubbard strains.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

Present study was carried out to study the growth pattern, feed intake, feed conversion efficiency, mortality/liveability, carcass yield, haematological and biochemical constituents and relative economics on broilers fed with garlic powder supplemented diet following standard management practices.

3.1 Location of the study

The experiment was conducted in the poultry unit of the Instructional Animal Farm of the Department of Livestock Production and Management, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, Nagaland. The farm is located at 93.20^0E to 95.15^0E longitude and latitude between 25.6^0N at an elevation of 310 meter above mean sea level (MSL).

3.2 MATERIALS

3.2.1 Experimental birds

In order to carry out the trial, altogether 360 numbers of straight run day old Cobb-400 strain of broiler chicks were procured from reliable source (M/S Dilip, Poultry Feeds and Chicks, Khatkhati, Assam). The experimental birds were procured in three different batches with 120 numbers in each batch and reared in three different seasons covering winter (November-February), summer (March-June) and monsoon (July-October). The chicks were vaccinated against Marek's disease at the hatchery itself.

3.2.2 Experimental diet

Commercially available standard broiler starter and broiler finisher feeds was used for the experiment which was procured from reputed commercial manufacturers. The birds were subjected to four different dietary levels of garlic *viz*. 0.00, 0.25, 0.50 and 0.75 per cent (on dry matter basis) which was added in the basal diet.

3.2.3 Garlic Powder Preparation:

Good quality garlic (*Allium sativum*) was purchased from local market for preparation of garlic powder. The skin was removed manually after which it was oven dried till it was properly dried up. The dried garlic was then grounded into fine powder and stored in air tight containers at room temperature.

3.3 Management of Experimental Stock

Preparation of Brooder House

The brooder house and all the equipment such as feeders, waterers and brooders were thoroughly clean and disinfected before the start of the experiment. The walls were whitewashed and the floor was scrubbed and cleaned. Feeders and waterers were fixed at proper height and the brooder was checked and kept functional. The foot bath was also cleaned and filled with disinfectant.

Brooding and Rearing

During the first 21 days of the experimental period, the chicks were reared in battery brooder. Newspaper was spread on the floor of the brooder which was removed after 3 days. Prior to the arrival of the chicks, the optimum temperature of the brooder as recommended was maintained. During power failure, it was dealt with the timely use of generator. The birds were reared under uniform conditions of temperature, humidity, light, ventilation and floor space. Good sanitation and hygiene was maintained during the entire rearing

Dried garlic

Day old chicks

Brooding in Battery Brooder

Birds in rearing cage

Weighing of birds

Vaccination

Plate 1. Brooding and rearing of experimental birds

period. After the completion of 21 days of brooding, the chicks were transferred to finisher house and reared in individual cages.

Feed, Watering and Health

After arrival, the chicks were provided with glucose water to give energy and to reduce the stress caused due to transportation. Gradually, the birds were provided with feed and water ensuring that optimum temperature is maintained and the chicks were comfortable. The birds received feed and water *ad libitum* during the experimental period. Starter ration was fed from 0-3 weeks and thereafter replaced by finisher ration. Measured quantity of feed was offered daily at 6.00 a.m. and 4.00 p.m. The left over feed was measured the next day in the morning to assess the daily feed consumption of the bird.

Chicks were vaccinated against Ranikhet and Infectious Bursal Disease at first week and second week, respectively.

3.4 Experimental Design

The experiment was carried out as per Completely Randomized Block Design (CRD). One hundred and twenty (120) chicks were randomly divided into four (4) different groups (designated as T_1, T_2, T_3 and T_4) with thirty (30) chicks in each group having five replicates of six (6) birds each. Day old chicks were reared for the first 21 days in the brooder house in battery brooder and for the rest 21 days in the finisher house in cages. Chicks were fed with standard broiler starter from 0-3 weeks of age followed by broiler finisher from 4-6 weeks of age which was supplemented with garlic at different levels. Group T_1 served as control and was provided with just the basal diet while groups T_2, T_3 and T_4 were provided the same basal diet as in T_1 but supplemented with garlic powder as mentioned in the table below:

Table 3.1: Details of dietary supplementation of garlic powder

Experimental Group	Level of garlic supplementation
T_1	Basal diet
T_2	Basal diet + Garlic powder at the rate of 0.25 per cent
T_3	Basal diet + Garlic powder at the rate of 0.50 per cent
T_4	Basal diet + Garlic powder at the rate of 0.75 per cent

3.5 Experimental Procedure

3.5.1 Body Weight and Growth Rate

Initial body weight of the chicks was recorded on the day of arrival and thereafter it was recorded on weekly basis which was taken in the morning hours prior to feeding them. A digital weighing balance having a maximum capacity of 10 kg was used for the entire experiment for weighing the birds. During the first three weeks, the average weight of the chicks was recorded in groups. This was done by placing 10 chicks each in a pre – weighed bamboo basket. After 21 days, the birds were weighed individually at weekly intervals till they attained six weeks of age that is 42 days of age.

3.5.2 Feed Intake and Feed Conversion Efficiency

The amount of feed supplied to the birds was recorded daily and the feed residue, if any, was recorded next morning. Feed intake was calculated by offering weighed quantity of feeds according to the treatments with the help of a precise digital weighing balance and expressed in gram. The left over feed was subtracted from the total amount of feed supplied the previous day to arrive at the exact quantity of feed consumed by the birds per day. From these data, the average per day and weekly feed consumption was calculated for each bird in each group and expressed in grams. The feed conversion efficiency (FCE) of different experimental groups was calculated by adopting the following formula:

$$\text{Feed Conversion Efficiency (FCE)} = \frac{\text{Total body weight gain (g)}}{\text{Quantity of feed consumed (g)}}$$

3.5.3 Mortality/Liveability and Performance Index

Mortality was observed daily throughout the period of investigation to record if any. Mortality was calculated by using the following formula:

$$\text{Mortality (per cent)} = \frac{\text{Total birds died}}{\text{Total live birds}} \times 100$$

Liveability per cent was calculated by subtracting the mortality per cent from 100.

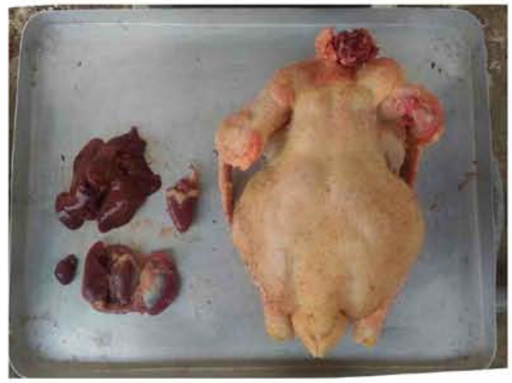
Performance Index (PI) was calculated by adopting the formula of Sapcota *et al,* (2014). Feed conversion ratio was calculated by taking the quantity of feed consumed by the birds and dividing it by the total body weight gain of the birds in grams.

$$\text{PI} = \frac{\text{Live weight in Lbs}}{\text{Feed conversion ratio}} \times 100$$

3.5.4 Dressing Percentage, Carcass Yield and Organ Weight

At the end of the experiment, four birds from each group were randomly selected for carcass evaluation studies. Live weight of the individual bird was recorded before slaughter. Slaughtering was done by using Kosher Method (Mountney, 1976). The dressed weight of the bird was obtained after complete bleeding, removal of feathers and evisceration. Heart, liver, spleen and gizzard (empty) were also weighted individually and the average weight of each of these organs was recorded for the four respective groups. The dressing percentage was calculated by using the following formula:

Collection of blood samples



Dressed bird with organs

Haematological/Biochemical analysis in the laboratory

Plate 2. Carcass, Haematological and Biochemical evaluation

$$\text{Dressing (per cent)} = \frac{\text{Dressed weight (g)}}{\text{Live weight}} \times 100$$

3.6 Haematological / biochemical studies

3.6.1 Collection of blood sample

In order to study the blood parameters, blood samples were collected via wing vein from randomly selected three birds from each treatment at the end of the trial period. Two ml of blood was collected from each bird using sterile disposable syringe. The blood was discharged immediately into collection tube with anticoagulant (Heparin: Dose: 25 µl/ml blood) for the blood cells examinations of all the haematological and biological constituents using standard laboratory procedures.Plasma was separated and stored at -20°C. However, for estimation of RBC and WBC fresh whole blood was used.

3.6.2 Red blood cells count

Red blood cells (RBCs) or erythrocytes are the most abundant blood cells and its main function is to transport oxygen to all the parts of the body and remove carbon dioxide as a waste product.

The number of RBCs was counted by using an improved neubeurhaemacytometer as per the method described by Sastry (1985).

Procedure

1. Blood sample was drawn upto 0.5 mark in RBC tube which was indicated by the red colour bead in the bulb of the pipette.
2. Immediately RBC diluting fluid was drawn up to the mark 101.

Plate 3. Blood samples for analysis

3. After proper mixing, the diluted blood was allowed to flow on to the counting chamber of the haemacytometer by holding the pipette at an angle of 45º till the counting chamber was completely filled.

4. The cells were allowed to settle down by keeping it for 2-3 min in the counting chamber.

5. The cells counted from the five squares of the central area were added and multiplied by 10,000 and expressed in cubic millimeters.

3.6.3 Total white blood cells (WBCs) count

White blood cells (WBCs) or leukocytes are the cells of the immune system that fights against infection and diseases.

Procedure

1. Blood sample was drawn upto 0.5 mark in WBC pipette
2. Immediately WBC diluting fluid was drawn up to 101 mark.

3. After proper mixing, the diluted blood was allowed to flow on to the counting chamber of the haemacytometer by holding the pipette at an angle of 45º till the counting chamber was completely filled.

4. WBC was counted in the 9 large squares and the figure obtained was multiplied by 2000 and was expressed in cubic millimetres.

3.6.4 Haemoglobin concentration

Haemoglobin is a protein in the red blood cells which is responsible for the transport of oxygen from the lungs to all the parts of the body.

Haemoglobin concentration was estimated by Cyanmethemoglobin method and expressed in g/dl.

Procedure

1. 5 ml of Drabkin's solution was taken in a test tube.
2. 0.02 ml of blood sample was drawn with the help of pipette and after wiping the outer surface of the pipette to remove excess blood it was slowly released into the solution.
3. After proper mixing, it was allowed to stand undisturbed for 5minutes.
4. The absorbance of this solution was measured at 540 nm in a spectrophotometer after adjusting the optical density at 0 and by using Drabkin's solution as blank. The reading was accordingly recorded.
5. The values obtained were calculated as per the following formula and expressed in g/dl:

$$\text{Haemoglobin} = \frac{\text{Value of test}}{\text{Value of standard}} \times \text{Conc. of standard (60)} \times 0.251$$

3.6.5 Determination of Packed cell volume

Packed cell volume was calculated by using the formula Hb (g/dl) = 0.304 * PCV + 0.461 (Velguth *et al*., 2010).

3.6.6 Differential leukocytes count

Differential leukocytes count was determined by examining whole blood smears. The count includes relative percentages of Lymphocytes, Heterophiles, monocytes, Basophiles and Eosinophils.

a. Preparation of blood smears:

   The blood smears were prepared from freshly drawn blood by placing a drop of blood in the center line near the end of a clean slide; then the blood was spread using the spreader slide. The smear was dried at room temperature.

b. Staining the blood smear:

   1. Giensa's solution was made by mixing 90 ml of distilled water and 7-10 ml of Giensa solution.
   2. The solution was poured over the slides and kept for 30 minutes.
   3. The slides were washed with water.

c. Differential count:

   The blood smear was examined using immersion lens (X100) magnification in the ideal area of the films to give representative sampling of all portions of the blood films.

3.6.7 Lipid profile measurements

Total plasma cholesterol (TC), glucose, triglycerides (TG) and high density lipoprotein (HDL) and low density lipoprotein (LDL) were determined by using biochemical analysis kits from DIATEK HEALTH care Pvt. Ltd.

3.6.7.1 Determination of total plasma cholesterol

Cholesterol is the main lipid found in blood, bile and brain tissues. Liver metabolizes cholesterol and it is transported in the blood stream with the help of lipoproteins.

Total plasma cholesterol concentration was estimated by following the procedure and expressed in mg/dl.

Procedure

1. The test tubes were marked as per the sample numbers with one test tube marked as S (standard).
2. 1 ml of reagent (R1) was taken in all the sample test tubes.
3. In the test tube marked as S (standard) 10 µl of the cholesterol standard was added.

4. In the sample test tubes, 10 µl of all the sample serum was added, mixed and incubated at room temperature (25^{o} -30^{o} C) for 10 minutes.
5. The absorbance of this solution was measured at 510 nm in a spectrophotometer after adjusting the optical density at 0 by using distilled water and reagent (R1) as blank. The reading was accordingly recorded.
6. The values obtained were calculated as per the following formula and expressed in mg/dl.

$$\text{Cholesterol} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times 200$$

3.6.7.2 Determination of glucose

Glucose is the major carbohydrate present in blood. Its oxidation in the cells is the source of energy for the body. Increased levels of glucose are found in diabetes mellitus, hyperparathyroidism, pancreatitis and renal failure. Decreased levels are found in insulinoma, hypothyroidism, hypopituitarism and extensive liver disease.

Glucose concentration was expressed in mg/dl.

Procedure

1. The test tubes were marked as per the sample numbers with one test tube marked as S (standard).
2. 1 ml of reagent (A) was taken in all the sample test tubes.
3. In the test tube marked for standard 10 µl of the glucose standard was added.
4. In the sample test tubes, 10ul of serum was added, mixed and incubated at room temperature (25-30^{o}C) for 10 minutes.

5. The absorbance of this solution was measured at 500 nm in a spectrophotometer after adjusting the optical density at 0 by mixing distilled water and reagent (A) as blank. The reading was accordingly recorded.
6. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{Glucose} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times 100$$

3.6.7.3 Determination of triglycerides

Triglycerides concentration was expressed in mg/dl.

Procedure

1. The test tubes were marked as per the sample numbers with one test tube marked as S (standard).
2. 1 ml of reagent (R1) was taken in all the sample test tubes.
3. In the test tube marked for standard, 10 µl of the standard was added.
4. In the sample test tubes 10 µl of serum was added mixed and incubated at room temperature (25-30^{o} C) for 10 minutes.
5. The absorbance of this solution was measured at 510 nm in a spectrophotometer after adjusting the optical density at 0 by mixing distilled water and reagent (R1) as blank. The reading was accordingly recorded.
6. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{Triglycerides} = \frac{\text{Absorbance of test}}{\text{Absorbance of standard}} \times 200$$

3.6.7.4 Determination of high density lipoprotein (HDL)

High density lipoproteinconcentration was expressed in mg/dl.

Procedure

1. The test tubes were marked as per the sample numbers with two other test tubes marked as B (blank) and S (standard).
2. 450 µl of reagent (R1) was taken in all the test tubes except S.
3. In the test tube marked for standard 6 µl of the calibarator was added.
4. In the sample test tubes 6 µl of serum was added mixed and incubated at 37^{o}C for 5 minutes.
5. After 5 minutes 150 µl of reagent (2) was added to all test tubes except S mixed and incubated for 5 minutes at 37^{o}C.
6. The absorbance of this solution was measured at 600 nm in a spectrophotometer after adjusting the optical density at 0 by using distilled water as blank. The reading was accordingly recorded.
7. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{HDL} = \frac{\text{Absorbance of test - Absorbance of blank}}{\text{Absorbance of standard - Absorbance of blank}} \times \text{Caliberator concentration}$$

3.6.7.5 Determination of low density lipoprotein (LDL)

Low density lipoproteinconcentration was expressed in mg/dl.

Procedure

1. The test tubes were marked as per the sample numbers and two other test tubes marked as B (blank) and S (standard).
2. 450 µl of reagent (R1) was taken in all the test tubes except S.
3. In the test tube marked for standard 6 µl of the calibarator was added.

4. In the sample test tubes 6 µl of serum was added mixed and incubated at 37^{o}C for 5 minutes.
5. After 5 minutes 150 µl of reagent (2) was added to all test tubes except S mixed and incubated for 5 minutes at 37^{o}C.
6. The absorbance of this solution was measured at 600 nm in a spectrophotometer after adjusting the optical density at 0 by using distilled water as blank. The reading was accordingly recorded.
7. The values obtained were calculated as per the following formula and expressed in mg/dl:

$$\text{HDL} = \frac{\text{Absorbance of test - Absorbance of blank}}{\text{Absorbance of standard - Absorbance of blank}} \times \text{Caliberator concentration}$$

3.7 Economics of Feeding garlic powder

The economics of feeding diet supplemented with garlic powder was calculated on the basis of overall cost of inputs, *i.e.* the cost of chicks, feeds, test material, labour, medicines and other miscellaneous cost. Final live weight of the bird and gain in weight was considered for calculating the gross return per bird and net profit per kg gain in weight.

3.8 Statistical Analysis

The data recorded were analysed by one-way analysis of variance (ANOVA) using SPSS computer programme (version16.0) and the means were separated using Duncan's multiple range test of the same software for comparisons. The overall level of statistical significance was defined as $P<0.05$. The interaction effect of seasons x treatment was done using split plot method and the significance of the result was evaluated using Analysis of variance (ANOVA) in Microsoft excel.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Present study was carried out with 360 numbers of day old Cobb-400 strain which were reared in three different seasons *viz*. summer, monsoon and winter with 120 numbers in each season. The birds were subjected to four dietary treatments containing 0, 0.25, 0.50 and 0.75 per cent of garlic powder. Data on body weight, gain in body weight, feed consumption , feed conversion efficiency, mortality, liveability, performance index, carcass characteristics, haematological and biochemical parameters and economy of feeding were collected and analysed statistically and are presented in tables and illustrated by graphs in order to give a quick visual access to the salient findings. The findings from the present study are discussed in this chapter under the following heads.

4.1 Summer Season

4.1.1 Body weight

The observation on variation in body weight from day old to six weeks of age in different treatments groups during summer season are presented in table 4.1.1 The mean body weight of different experimental groups at weekly interval up to the end of six weeks has been graphically plotted in Fig 4.1.1.The statistical analysis of the average body weight at sixth week of age is given in Appendix 1(Body Weight).

Table 4.1.1: Body weight (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks						
	0	1st	2nd	3rd	4th	5th	6th
T_1	50.59	147.10	409.23	811.53	1212.23	1655.96	2189.50±28.62
T_2	48.87	147.60	395.17	781.23	1184.00	1703.36	2262.90±58.15
T_3	50.91	146.60	380.30	769.67	1178.33	1688.36	2269.60±27.89
T_4	50.95	148.06	395.57	795.73	1219.23	1726.96	2314.63±63.55

As per table 4.1.1, body weight at day-old was 50.59, 48.87, 50.91 and 50.95 g per bird for different treatment groups i.e. T_1, T_2, T_3 and $T_{4,}$ respectively. Corresponding body weight in different groups recorded at the end of the 6^{th} week was 2189.50 ± 28.62, 2262.90 ± 58.15, 2269.60 ± 27.89 and 2314.63 ± 63.55 g per bird, respectively. Numerically, body weight was observed to be higher in garlic treated groups. However, analysis of variance revealed that there was no significant difference in the average body weight among the different treatment groups under the prevailing agro-climatic condition. The result indicated that supplementation of garlic powder within the given range in the present study had no significant influence on the body weight of the birds. These findings were in agreement with the earlier findings of Issa and Omar (2012) who reported that broilers fed with diet supplemented with garlic powder at 0.2 and 0.4 per cent did not show difference in body weight and Adebiyi *et al*. (2017) also reported that raw and sundried garlic at 1, 2 and 3 per cent did not influence the growth performance. On the contrary, Hamodi and Al-Hamdany (2006) reported that dietary addition of garlic at 0.2 and 0.4 per cent had shown significantly increased body weight. Similarly, Puva□a *et al*. (2014) also observed significant increase in body weight due to dietary supplementation of garlic. Variation in results might be due to factors like strain differences, differences in experimental conditions, type of feed, difference in levels of garlic and seasons, etc.

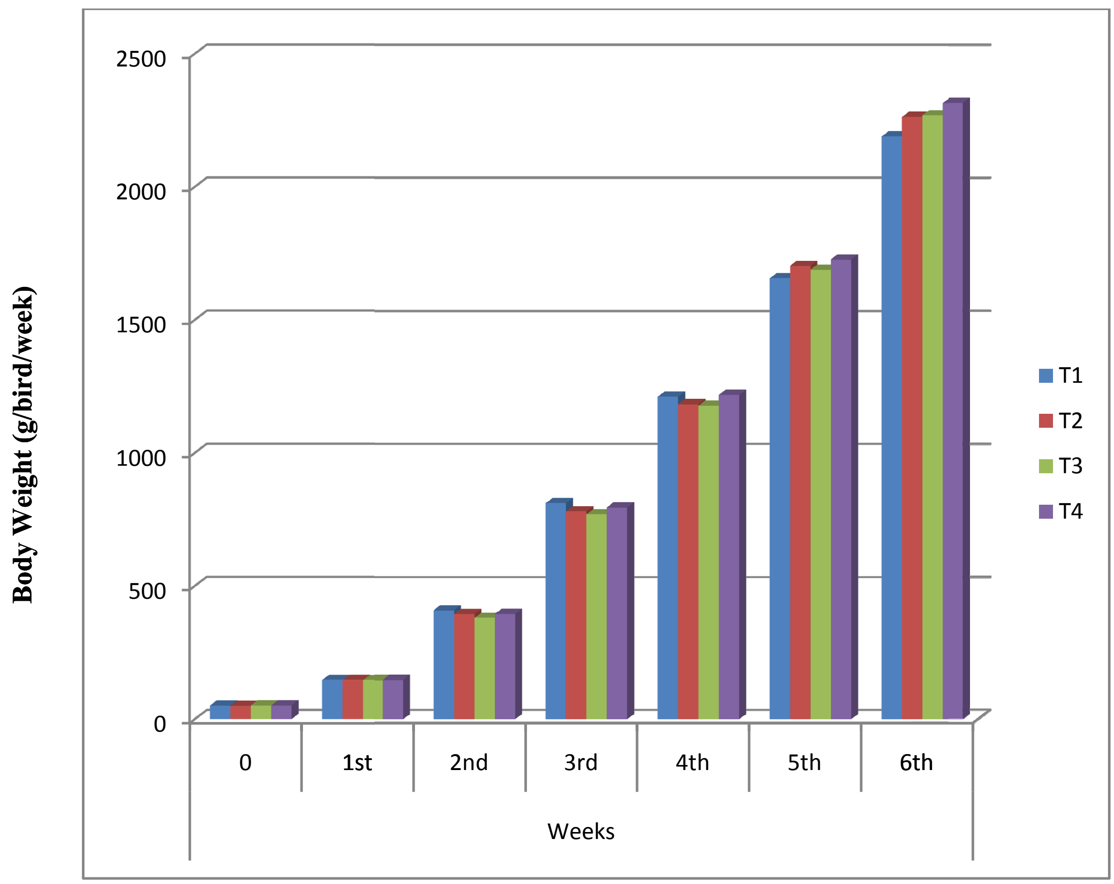


Fig 4.1.1 Body weight (g/bird) of broiler birds in different treatment groups

4.1.2 Gain in body weight

The average weekly gain in body weight and total gain in weight in different treatment groups are given in table 4.1.2 and their mean statistical analysis are presented in Appendix 1 (Gain in Body Weight). The pattern of growth during experimental period are plotted graphically in Fig. 4.1.2.

Table 4.1.2: Gain in body weight (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks						Total gain in weight
	1st	2nd	3rd	4th	5th	6th	
T_1	96.51	262.13	402.30	400.69	443.73	533.54	2138.698±28.62
T_2	98.72	247.56	386.06	402.76	519.36	559.54	2214.020±58.15
T_3	95.69	233.70	389.36	408.67	510.03	581.24	2218.692±27.89
T_4	97.11	247.51	400.17	423.49	507.73	587.66	2263.68±3.98

From the data given in table 4.1.2, the gain in body weight ranged from 96.51 to 533.54, 98.72 to 559.54, 95.69 to 581.24 and 97.11 to 587.66 g/bird/week for the groups T_1, T_2, T_3 and T_4, respectively. The corresponding overall total body weight gain was 2138.698 ± 28.62, 2214.020 ± 58.15, 2218.692 ± 27.89 and 2263.68 ± 3.98 g/bird/week.

Analysis of variance revealed that there was no significant difference in weight gain due to garlic supplementation. Similar findings were reported by Fadlalla *et al.* (2010) who reported non- significant effect of garlic on weight gain at the rate of 0, 0.15, 0.3, 0.45 and 0.6 per cent of garlic and Jimoh *et al*. (2013) who also reported that graded levels ranging from 0 to 2.5 g kg^{-1} of garlic powder showed non- significant effect on weight gain. On the contrary, Mahmood *et al*. (2009) and Ibrahim (2011) had found increase ($P<0.05$) in body weight gain in broiler birds fed with garlic powder. Variation in the

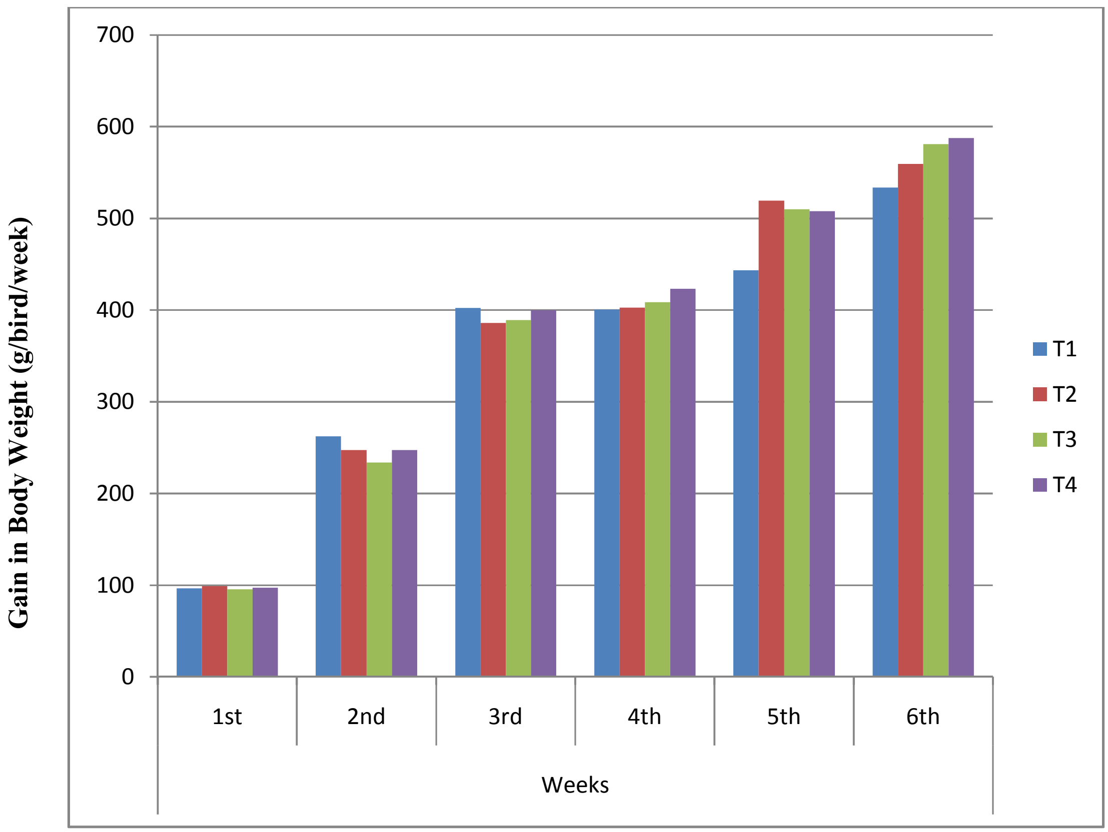


Figure 4.1.2 Gain in body weight (g/bird) of broiler birds in different treatment groups

findings might be due to differences in experimental conditions, type of feed and its composition, level and form of garlic, agro-climatic differences and seasons, etc.

4.1.3 Feed Intake

The weekly feed intake and total feed intake of different experimental groups during the trial period are presented in table 4.1.3 and the statistical analysis for total feed consumption has been shown in Appendix-1(Feed Intake). The pattern of feed consumption has been graphically illustrated in Fig 4.1.3.

Table 4.1.3: Feed intake (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks						Total
	1st	2nd	3rd	4th	5th	6th	
T_1	124.85	379.58	598.63	785.46	889.94	1084.00	3862.46±53.23
T_2	121.56	346.34	597.76	802.83	936.20	1148.14	3952.83±35.92
T_3	120.70	336.63	554.44	793.43	920.60	1164.66	3890.46±27.15
T_4	122.56	342.76	611.55	809.90	972.36	1142.73	4001.86±53.14

From the table 4.1.3, the total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 3862.46 ± 53.23, 3952.83 ± 35.92, 3890. 46 ± 27.15 and 4001.86 ± 53.14 g per bird, respectively. Numerically, feed intake was higher in birds fed with garlic based diet. However, statistically it was revealed that there was no significant difference between the control and the birds fed with garlic treated feed. Hence, it was indicative that within the given level of garlic supplementation, feed consumption of the birds was unaffected. The result corroborated with the findings of Javandel *et al.* (2008) who found that garlic meal levels at 0.125, 0.25, 0.5, 1 and 2 per cent did not affect the daily feed intake. Similarly, Issa and Omar (2012) did not observe any difference in feed intake at 0.2 and 0.4 per cent garlic supplementation.

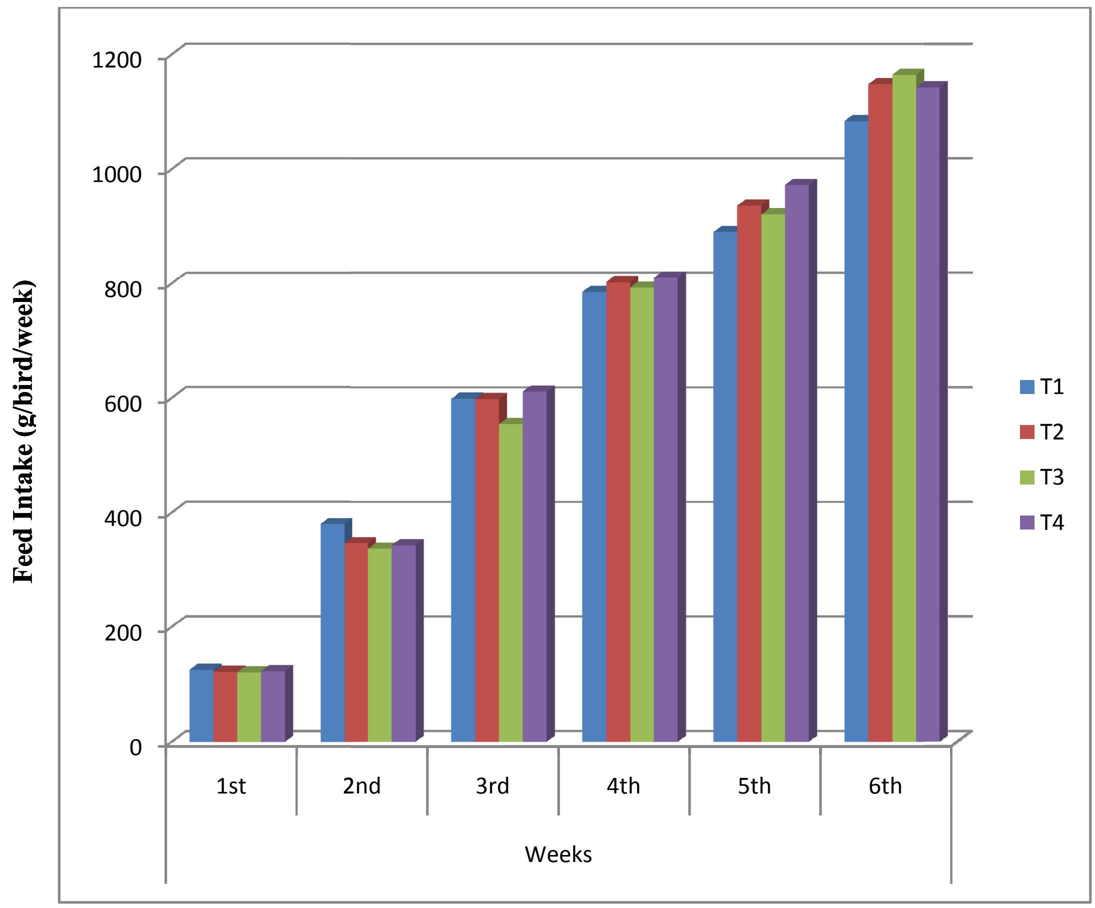


Figure 4.1.3 Feed intake (g/bird) of broiler birds in different treatment groups

However, these findings were contrary to the observations of Jimoh *et al.* (2013) who reported that garlic (P>0.05) depressed feed intake and Saeid *et al.* (2013) observed a significantly higher feed intake due to addition of garlic powder and black seed plant premix to the basal diet. The differences in the results could be due to the differences in experimental conditions such as feed, strains of bird used, level of garlic, agro-climatic differences, seasons etc.

4.1.4 Feed Conversion Efficiency

The weekly feed conversion efficiency and cumulative feed efficiency of the different experimental groups up to six weeks of age are depicted in table 4.1.4 and their mean statistical analysis are shown in Appendix 1 (Feed Conversion Efficiency). The graph representing the average weekly feed conversion efficiency in various groups upto six weeks of age are plotted in Fig 4.1.4.

Table 4.1.4 Feed conversion efficiency of broiler birds in different treatment groups

Treatment	Weeks						Mean
	1st	2nd	3rd	4th	5th	6th	
T_1	0.707	0.651	0.612	0.501	0.444	0.411	0.554±0.0052
T_2	0.750	0.513	0.643	0.524	0.503	0.422	0.560± 0.0107
T_3	0.733	0.618	0.666	0.515	0.500	0.412	0.570 ±0.0092
T_4	0.711	0.556	0.654	0.523	0.514	0.429	0.565± 0.0089

As per the data given in table 4.1.4, the average feed conversion efficiency was in the range of 0.411 to 0.707, 0.422 to 0.750, 0.412 to 0.733 and 0.429 to 0.711for the treatment groups T_1, T_2, T_3 and T_4, respectively. The corresponding mean feed conversion efficiency of broiler birds in different treatment groups at the end of the study was recorded as 0.554 ± 0.0052, 0.560 ± 0.0107, 0.570 ± 0.0092 and 0.565 ± 0.0089. Though the FCE was observed to be better in the garlic treated groups, the statistical analysis had revealed that

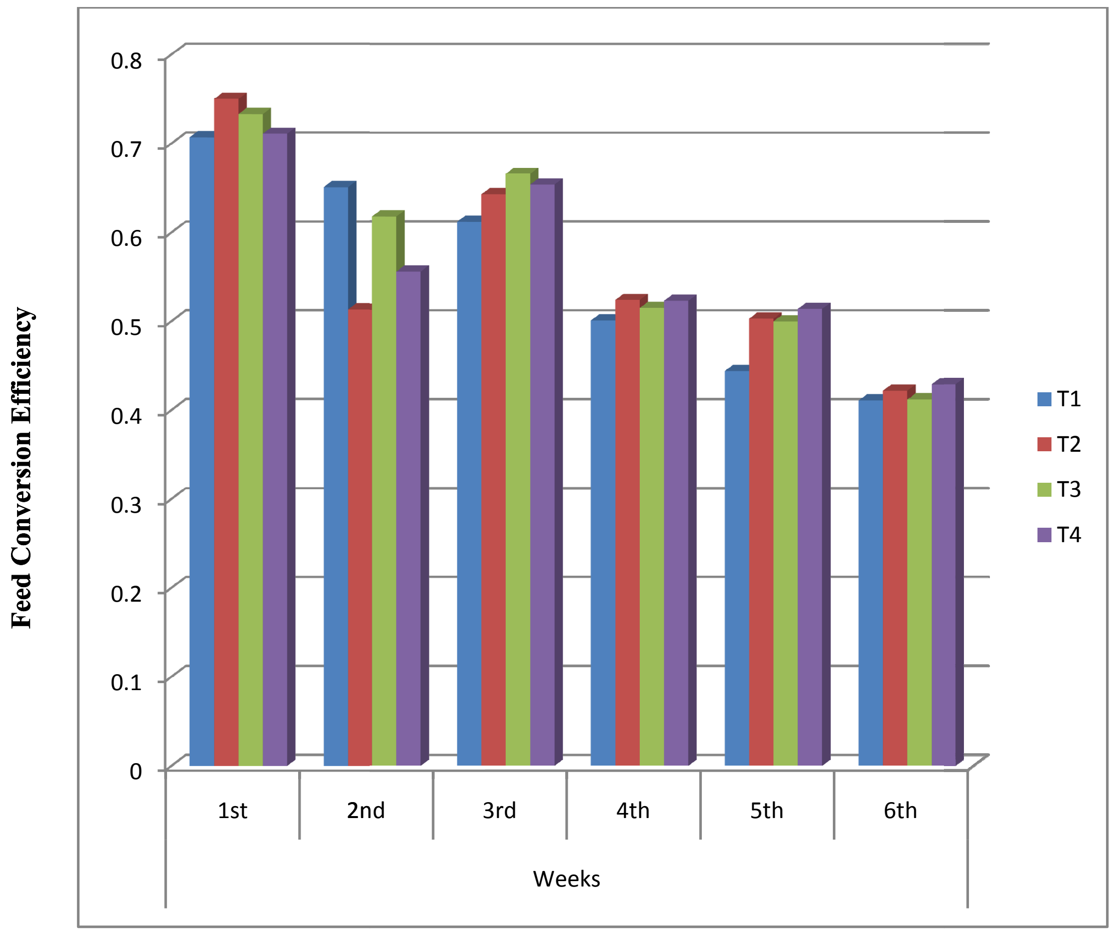


Fig 4.1.4 Feed conversion efficiency of broiler birds in different treatment groups

there was non- significant difference in feed efficiency probably due to the level of garlic used in the present study which might not have been sufficient enough to cause any significant effect. The result of the present study was in line with the findings of Mahmood *et al.*(2009) who observed that inclusion of 2.25, 3.00 per cent garlic juice and 0.75 per cent garlic powder in broiler ration had no significant effect on FCR; Issa and Omar (2012) also observed garlic powder supplementation at 0.2 and 0.4 per cent did not show any significant effects on feed conversion ratio and Saeid *et al.* (2013) also reported that feed conversion ratio of broilers was not influenced by dietary treatment with garlic powder.

However, these findings were dissimilar to the observations of Samanthi *et al.* (2015) who observed the lowest feed conversion ratio in birds fed with 1 kg per ton of feed and Fadlalla *et al.* (2010) who reported better feed conversion ratio of birds fed with 0.3 per cent garlic. The contradictory results in the findings might be due to be to type/strain of birds used, difference in levels of garlic and form of garlic, agro-climatic differences, seasons, etc.

4.1.5 Mortality/Liveability and Performance Index

The average mortality, liveability percentage and performance index (PI) for the different treatment groups are shown in table 4.1.5 and their mean statistical analysis are shown in Appendix 1 (Performance Index). The graph representing the performance index in various groups upto six weeks of age are plotted in Fig 4.1.5.

Table 4.1.5: Mortality and liveability (per cent) and performance index of broiler birds in different treatment groups

Groups	Mortality (per cent)	Liveability (per cent)	Performance Index
T_1	0.00	100	266.96± 4.93
T_2	0.00	100	279.02± 12.06
T_3	0.00	100	285.18± 7.87
T_4	0.00	100	288.27± 12.29

Irrespective of the treatment, the mortality percentage of broiler birds was zero per cent. Hence, liveability percentage was recorded to be 100 per cent in all the groups which might be attributed to favourable climatic condition, good quality feed and proper management practices. It was also indicative that supplementation of garlic did not have adverse effect on the survivability of the birds.

The performance index at 0, 0.25, 0.50 and 0.75 per cent garlic was 266.956 ± 4.931, 279.015 ± 12.060, 285.177 ± 7.873 and 288.272 ± 12.293, respectively. The values for performance index was observed to be higher in groups fed with garlic based diet however, statistically it was non- significant. Similar to the present findings, Borgohain *et al*. (2017) reported that inclusion of 0.5, 1.0 and 1.5 per cent of garlic powder resulted in highest broiler performance efficiency index (BPEI) and 100 per cent liveability.

4.1.6 Carcass characteristics of broiler birds in different treatment groups

The carcass characteristics in terms of dressing percentage, carcass yield and organ weight observed in the trial groups are presented in table 4.1.6 and their mean statistical analysis are shown in Appendix 1 (Dressing Percentage). The graph representing the dressing percentage and carcass yield in various groups are plotted in Fig 4.1.6.

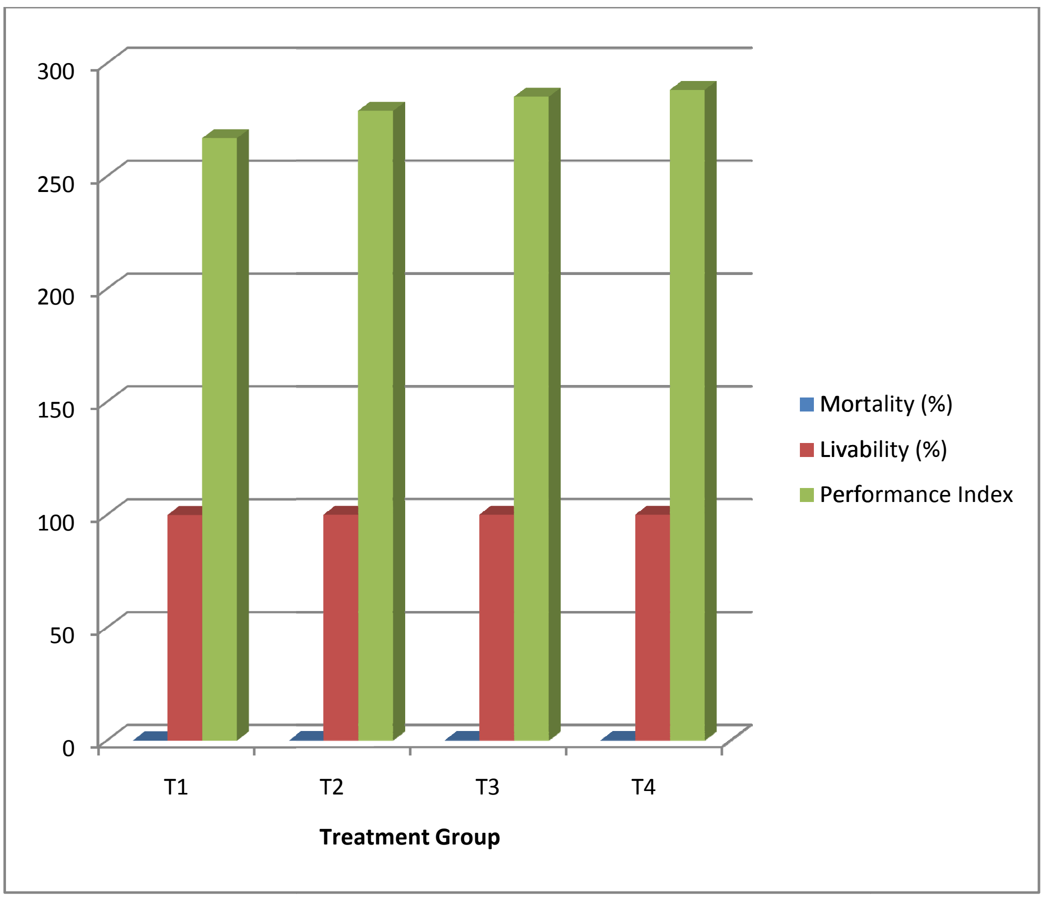


Fig 4.1.5 Mortality and liveability (per cent) and performance index of broiler birds in different treatment groups

Table 4.1.6: Carcass characteristic of broiler birds in different treatment groups

Group	Dressing per cent	Carcass Weight (g)	Organ Weight (g)			
			Heart	Liver	Gizzard	Spleen
T_1	72.22	2203.50	15.55	88.62	45.10	5.75
T_2	73.57	2638.00	16.87	88.14	45.83	8.86
T_3	74.03	2573.00	17.43	97.80	41.61	8.65
T_4	73.19	2400.50	18.33	88.65	48.96	8.24

The average dressing percentage of broiler birds at 0, 0.25, 0.50 and 0.75 per cent garlic was 72.22, 73.57, 74.03 and 73.19 per cent, respectively and the corresponding average carcass weight of birds was 2203.50, 2638.00, 2573.00 and 2400.50 g/bird.

The average heart weight and liver weight for the treatment groups T_1, T_2, T_3 and T_4 was 15.55, 16.87, 17.43 and 18.33 g; 88.62, 88.14, 97.8 and 88.65 g, respectively.

The average gizzard weight was 45.10, 45.83, 41.61 and 48.96 g for the treatment groups T_1, T_2, T_3 and T_4, respectively while the corresponding spleen weight was 5.75, 8.86, 8.65 and 8.24 g.

From the perusal of the table 4.1.6, the garlic treated groups showed higher values for dressing percentage, carcass and the organs yield. However, statistically the above parameters were unaffected by garlic which indicated that there was no negative effect on the above parameters within the level of garlic used. Similar to the present findings researchers such as Onibi *et al.* (2009) also found that dietary garlic supplementation did not have significant (P>0.05) effect on the carcass and organ weight. Further, Mahmood *et al.* (2009) had also reported that the supplementation of 0.5 per cent garlic in the broiler ration showed no difference (P>0.05) in dressing percentages, giblet

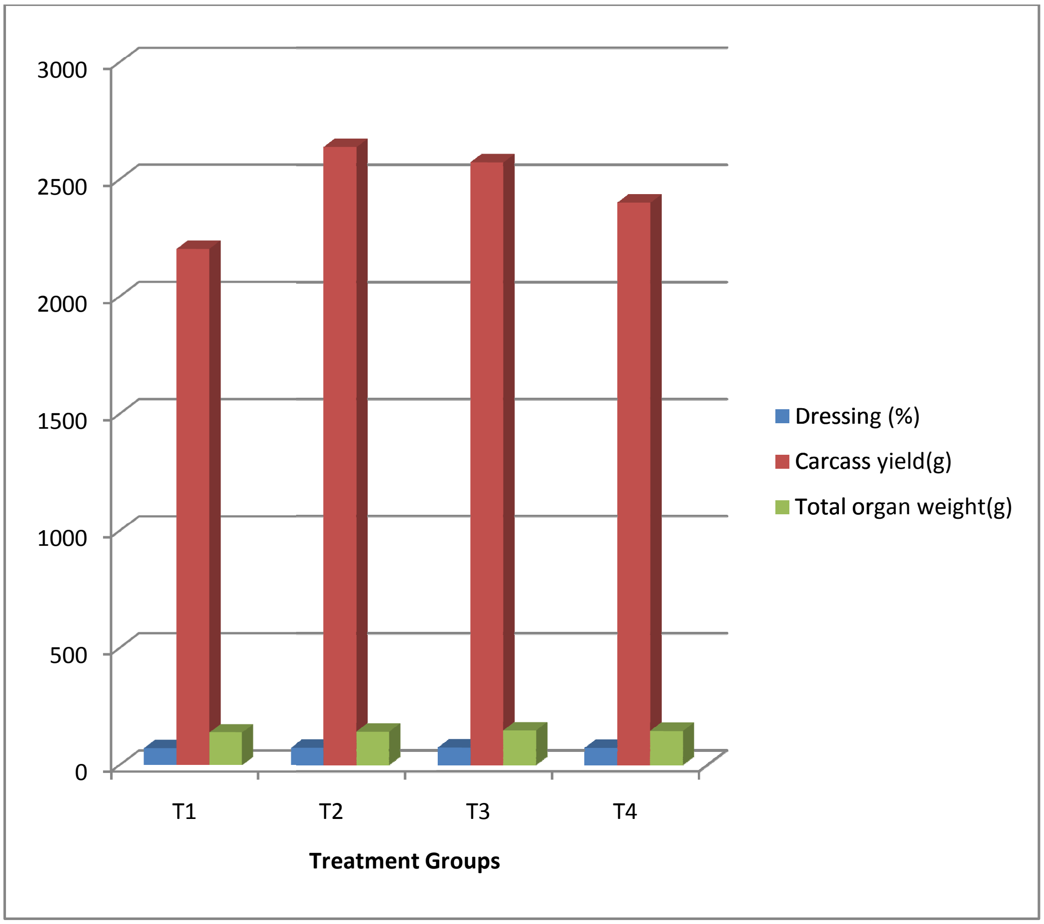


Fig 4.1.6 Carcass characteristics of broiler birds in different treatment groups

(spleen, liver, heart and gizzard) and pancreas weight of the broilers which were served either basal diet or garlic based diet. Positive effect of garlic on carcass traits have been reported by Ashayerizadeh *et al.* (2009) who revealed that inclusion of garlic (1 kg/ton) resulted in significantly higher carcass percentage as compared to the control; Ademola *et al.* (2009) reported that dietary treatment with garlic had significant effect (P<0.001) on the carcass parts and organs of broiler chickens and Brzoska *et al.* (2015) reported higher dressing percentage and liver weight in birds treated with 2.25 ml kg^{-1} and 1.50 ml $kg^{-1}$of liquid garlic extract, respectively.

4.1.7 Haematological parameters

The haematological parameters as influenced by incorporation of garlic are presented in table 4.1.7. The statistical analysis has been shown in Appendix 1 **(**Haematological /biochemical parameters).

Table 4.1.7: Haematological parameters of broiler birds in different treatment groups

Treatment	Haemoglobin g/dl	Total White blood cells ($10^3/mm^3$)	Total Red blood cells ($10^6/mm^3$)	Packed cells volume (per cent)	Differential white blood cells count (per cent)				
					Monocytes	Basophils	Heterophils	Eosinophils	Lymphocytes
T_1	9.98 ±0.18	18.0^c ±5.67	2.56^c ±.03	32.35 ±0.62	1.00±0.58	0	30±2.08	0	69±2.52
T_2	9.92 ±0.35	22.3^b ±7.73	2.89^b ±.04	32.18 ±1.15	1.39±0.88	0	27±2.08	0	71±2.96
T_3	9.99 ±0.41	24.3^b ±7.96	2.68^c ±.05	32.43 ±1.35	1.03±0.33	0	28±3.28	0	71±3.21
T_4	9.77 ±0.19	32.0^a ±9.44	3.03^a ±.06	31.67 ±0.61	1.0 0±0.67	0	23±2.03	0	75±1.45

a, b, c

Means bearing different superscripts within the column differ significantly (P<0.05)

Perusal of table 4.1.7 revealed that there was significant ($P<0.05$) difference on total white blood cells and total red blood cells between the groups fed with 0 per cent and those fed on 0.25 per cent, 0.50per cent and 0.75 per cent levels. The values for total WBC in group T_4 was higher ($P<0.05$) followed by T_3, T_2 and the least was in control group T_1. However, group T_2 and T_3 showed no difference. It was indicative of the immuno -modulatory effect of garlic and thereby reflected good immune response (Birrenkott *et al.*, 2000). The results were in line with the findings of Fadlalla *et al*. (2010) who also reported higher WBC values due to garlic supplementation. Similarly, the values for RBC was significantly higher in T_4 followed by T_2, T_3 and the control group T_1 which was in agreement with the findings of Toghyani *et al*. (2011) who reported increased ($P<0.05$) in red blood cells count in birds fed with garlic as compared to control group.

There was no significant effect on haemoglobin, packed cells volume and differential white blood cells count due to inclusion of garlic in broiler feed. Similiar findings was reported by Ademola *et al.* (2009) who could not observe variation in haemoglobin concentration of the chickens when fed with dietary garlic, ginger and their mixtures. Ahmed (2012) also reported that haemoglobin estimation at 2 per cent of garlic did not show difference from control group and garlic supplementation at 3 and 5 per cent did not have significant ($P>0.05$) effect on the differential count of white blood cells including neutrophils, basophils, eosinophils, monocytes and lymphocytes (Ahmed El Amin , 2011 and Elagib *et al.*, 2013).The values for PCV, RBC, WBC and the differential white blood cells was within the normal range as reported by Maxwell *et al*. (1990).

Conversely, Ari *et al.* (2012) and Oleforuh-Okoleh *et al*. (2015) reported significant increase in haemoglobin concentration and packed cell volume. Variation in the results might be due to levels and form of garlic used, seasons, feed, strain differences etc.

4.1.8 Biochemical studies

The biochemical studies in terms of average high density lipoprotein, low density lipoprotein, glucose, triglycerides and cholesterol of broiler birds in different treatment groups upto six weeks of age during the trial period are presented in table 4.1.8 and the statistical analysis has been shown in Appendix 1 (Haematological / biochemical parameters).

Table 4.1.8: Biochemical constituents of blood (mg/dl) of broiler birds in different treatment groups

Treatment	LDL	HDL	Glucose	Triglycerides	Cholesterol
T_1	69.82^{ab}±1.50	99.37^{b}±20.80	139.34±12.18	100.31±20.84	146.00±7.28
T_2	72.35^{a}±1.63	125.11^{b}±31.98	134.46±9.11	125.2±29.45	138.23±19.23
T_3	69.99^{ab}±1.54	242.39^{a}±39.20	131.51±7.27	66.68±18.15	143.21±24.23
T_4	65.06^{b}±1.09	193.44^{ab}±38.98	126.18 ±7.06	79.82±14.09	131.85±24.35

a, b

Means bearing different superscripts within the column differed significantly (P<0.05).

From table 4.1.8, it was observed that there was significant (P<0.05) effect of garlic on LDL and HDL. The values for LDL was observed to be least (P<0.05) in T_4 (0.75%) and the highest in T_2 (0.25%). However, the variation between the garlic treated groups and the control was found to be non-significant. The values for HDL was found to be significantly (P<0.05) higher in garlic treated groups as compared to the control.

The results of the present study was in agreement with the findings of researchers such as Issa and Omar (2012) who reported decreased (P<0.05)

LDL and increased HDL levels as compared to control birds due to garlic powder supplementation at the rate of 0, 2 and 0.4 per cent and Samanthi *et al*. (2015) who also observed higher HDL level and lower LDL level in birds fed with 2 kg garlic per ton of feed followed by those fed with 1 kg garlic per ton of feed.

The values for glucose, triglycerides and cholesterol were observed to be better in garlic treated groups, however, statistically there was no significant difference. Similar to the present findings, Horton *et al*. (1991) reported that when broilers were fed with garlic based diet cholesterol was reduced while plasma triglycerides and plasma glucose were found to be non- significant due to garlic. Brzoska *et al*. (2015) had also reported non-significant variation in the content of glucose, triglycerides, total cholesterol or high density lipoprotein (HDL) in the blood serum of birds fed with liquid garlic extract at the rate of 0,1,1.5, 2,25 $mlkg^{-1}$.

Hence, addition of garlic powder had positive effect on haematological and blood lipid profile which could be due to the organo sulfur volatile compounds present in garlic which contributes to the effective bioactive properties of garlic (Mikaili *et al*., 2013).

4.1.9 Economics

The effect of dietary garlic on the economics of broiler production in different treatment groups are presented in table 4.1.9.

Table 4.1.9: Economics of broiler production in different treatment groups (Rs/bird)

Sl. No.	ITEMS	Treatment Groups			
		T_1	T_2	T_3	T_4
1.	Cost of broiler	40.00	40.00	40.00	40.00
2.	Cost of feed	123.52	126.40	124.48	128.03
3.	Cost of garlic powder	-	1.93	3.89	6.001
4.	Cost of medicine	4.78	4.78	4.78	4.78
5.	Cost of labour	12.60	12.60	12.60	12.60
6.	Miscellaneous	3.5	3.5	3.5	3.5
7.	Cost of production	184.4	189.21	189.25	194.911
8.	Average Weight of broiler (Kg)	2.189	2.262	2.269	2.314
9.	Average weight gain (Kg)	2.188	2.213	2.218	2.263
10.	Cost of production per Kg weight (Rs)	84.239	83.647	83.407	84.231
11.	Sale of broiler @Rs.130 per Kg live weight (Rs)	284.57	294.06	294.97	300.82
12.	Sale of gunny bags @Rs.20/bag(Rs)	1.10	1.13	1.11	1.14
13.	Total receipt (Rs)/bird	285.67	295.19	296.08	301.96
14.	Profit per bird(Rs)	101.27	105.98	106.83	107.05
15.	Net profit per Kg gain (Rs)	46.284	47.881	48.165	47.304

Average cost of production per bird for T_1, T_2, T_3 and T_4 was 184.40, 189.21, 189.25 and 194.911rupees per bird, respectively. Corresponding values for average cost of production per kg live weight of bird was 84.239, 83.647, 83.407 and 84.231 rupees, respectively.

Net profit per bird was 101.27, 105.98, 106.83 and 107.05 rupees, respectively for T_1, T_2, T_3 and T_4 groups while the corresponding values for net profit per kg gain in weight was 46.284, 47.881, 48.165 and 47.304 rupees, respectively.

From the results, it was found that the total cost of production per broiler was highest at 0.75 per cent garlic and the least was in control which was evidently due to higher feed intake and cost incurred due to addition of garlic. Least cost of production per kg live weight of broiler was observed in T_3 (0.5% garlic) i.e. Rs. 83.407 and the highest in control groups.

Comparatively higher net profit per bird and per kg gain in weight was observed in garlic treated groups due to higher body weight and better feed efficiency and the group fed with 0.50 per cent garlic had the highest net profit per kg gain in weight. Similar findings had been reported by Singh *et al.* (2015) who observed increased returns due to garlic supplementation and advocated its use for better profitability.

From the overall results obtained in present study, it could be concluded that supplementation of garlic powder at higher rate of 0.50 and 0.75 per cent had shown positive impact on growth, feed conversion efficiency, performance index, carcass weight and overall net profit per bird during the summer season. Further, addition of garlic had positive effect on the blood parameters.

4.2 Monsoon Season

4.2.1 Body weight

The observation on variation in body weight during monsoon season from day old to 42 days of age are presented in table 4.2.1. The mean body weight of different experimental groups at weekly interval up to the end of six weeks has been graphically plotted in Fig 4.2.1.The statistical analysis of the average body weight at sixth week of age is given in Appendix 2 (Body weight).

Table 4.2.1: Body weight (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks							Mean
	0th	1st	2nd	3rd	4th	5th	6th	
T_1	42.87	155.00	369.93	659.03	1183.33	1763.37	2269.83±71.76	378.31
T_2	42.33	152.17	355.73	627.00	1057.86	1681.43	2188.93±44.17	364.82
T_3	45.10	159.30	373.43	654.40	1156.73	1691.40	2281.87±51.44	380.31
T_4	44.33	185.9	458.93	752.23	1200.53	2002.57	2297.93±31.81	382.99

The average body weight of the day-old chicks was recorded as 42.87, 42.33, 45.10, and 44.33 g per bird, respectively for T_1, T_2, T_3 and T_4. The corresponding body weight in different treatment groups recorded at the end of the 6th week was 2269.83 ± 71.76, 2188.93 ± 44.17, 2281.87 ± 51.44 and 2297.93 ± 31.81 g per bird. The overall mean body weight was 378.31, 364.82, 380.31 and 382.99 g/bird/week for T_1, T_2, T_3 and T_4, respectively. Analysis of variance showed that there was no difference in the average body weight obtained by birds that received garlic based diet and the control group under the prevailing agro-climatic condition and the body weight was observed to be uniform. These findings were in agreement with the earlier findings of Issa and Omar (2012) who observed non- significant difference in body weight when broilers were fed with diet supplemented with garlic at 0.2 and 0.4 per cent. On the contrary, Hamodi and Al-Hamdany (2006) and Fayed *et al*. (2011) observed significant increase in body weight due to dietary supplementation of garlic. Variation in results might be due to strain differences, type of feed and its formulation, agro-climatic differences, difference in levels of garlic and other experimental conditions.

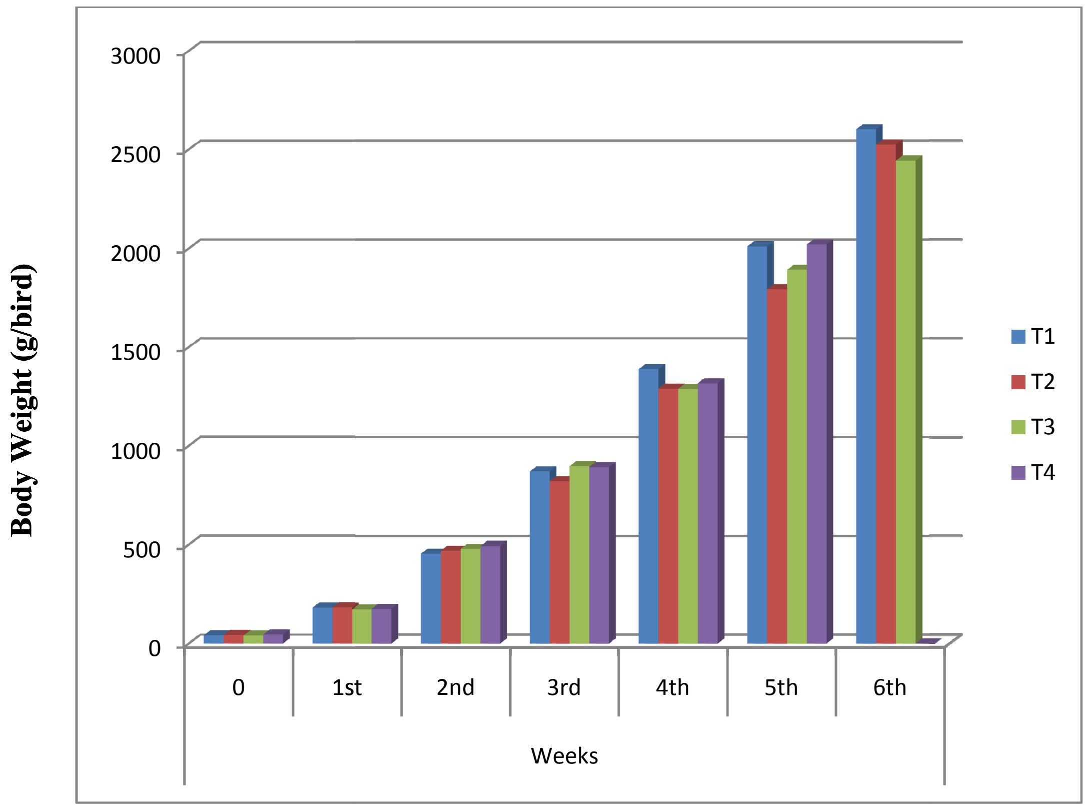


Fig 4.2.1 Body weight (g/bird) of broiler birds in different treatment groups

4.2.2 Gain in body weight

The weekly gain in body weight and total gain in weight in different treatment groups are given in table 4.2.2 and their mean statistical analysis are presented in Appendix 2(Body weight gain). The pattern of growth and total average gain in weight during experimental period are plotted graphically in Fig 4.2.2.

Table 4.2.2: Gain in body weight (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks						Total gain in body weight	Mean
	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}		
T_1	112.13	214.93	289.1	524.3	580.04	506.46	2226.96±71.76	371.16
T_2	109.84	203.57	271.27	430.86	623.57	507.00	2146.11±44.17	357.69
T_3	114.20	214.13	280.97	502.33	534.67	590.47	2236.76±51.44	372.79
T_4	141.57	273.03	293.30	448.30	802.04	295.36	2253.60±31.81	375.60

The average gain in weight for the treatment groups T_1, T_2, T_3 and T_4 was in the range of 112.13 to 580.04, 109.84 to 623.57, 114.20 to 590.47 and 141.57 to 802.04 g per bird, respectively. The corresponding values for the overall total body weight gain was 2226.96 ± 71.76, 2146.11 ± 44.17, 2236.76 ± 51.44 and 2253.60 ± 31.81 g/bird/week. The overall mean gain in body weight for the respective groups T_1, T_2, T_3 and T_4 was 371.16, 357.69, 372.79 and 375.60

Analysis of variance had revealed that the gain in weight was unaffected by garlic. Similar findings were also reported by Jimoh *et al*. (2013) and Fadlalla *et al* (2010) who had also observed non-significant difference in body weight gain of broilers when diet was supplementation with garlic. However in contradiction, Sultan *et al*. (2009) and Ibrahim (2011) found

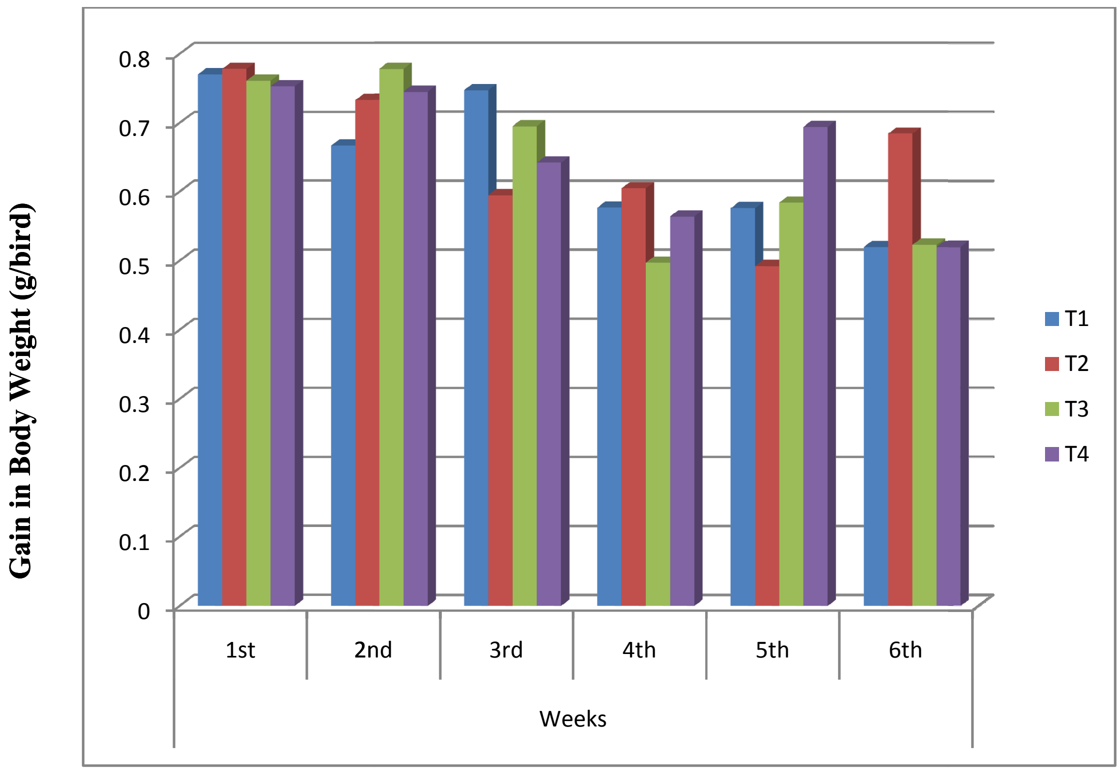


Fig 4.2.2 Gain in body weight (g/bird) of broiler birds in different treatment groups

significant increase ($P<0.05$) in body weight gain in broiler birds when fed with garlic supplemented feed. The variation in the result might be due to several factors such as strain differences, difference in levels of garlic and feed composition, agro-climatic differences etc.

4.2.3 Feed Intake

The average weekly feed intake and total feed intake of different experimental groups upto six weeks of age and their mean during the trial period are presented in table 4.2.3 and the statistical analysis for total feed consumption has been shown in Appendix 2. The pattern of feed consumption has been graphically illustrated in Fig. 4.2.3.

Table 4.2.3: Feed intake (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks						Total	Mean
	1st	2nd	3rd	4th	5th	6th		
T1	155.72	380.84	467.33	662.33	1021.13	1259.20	3946.55a±1.20	657.76
T2	139.63	305.83	420.17	587.27	955.27	1242.63	3650.80b±27.23	608.47
T3	149.50	305.33	412.77	605.73	972.30	1242.27	3687.90b±55.47	614.65
T4	172.47	368.73	479.30	633.37	923.467	1202.93	3780.27ab±56.95	630.05

a,b
Means bearing different superscripts within the column differ significantly ($P<0.05$)

Total feed intake during the entire trial period for T_1, T_2,T_3 and T_4 groups was 3946.55 ± 1.20, 3650.80 ± 27.23, 3687.90 ± 55.47and 3780.27 ± 56.95 g per bird, respectively. Feed intake was significantly ($P<0.05$) higher in control group i.e. T_1 followed by T_4, T_3 and the least in T_2. However, the difference between T_1 and T_4 and the groups T_2, T_3 and T_4 was found to be non-significant. The reduced feed intake in garlic supplemented group might be due to the associated flavour and lower palatability. Similar to the present finding,

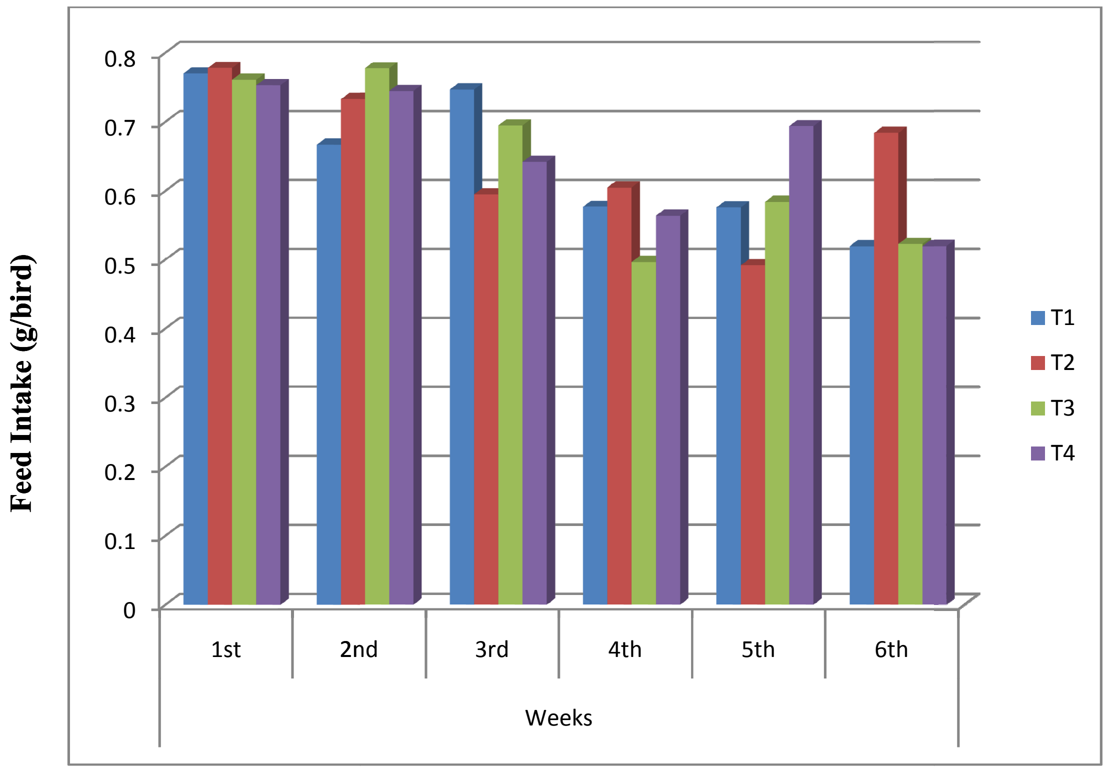


Fig 4.2.3 Feed intake (g/bird) of broiler birds in different treatment groups

Banuree *et al*. (2009); Jimoh *et al*. (2013); Eid and Iraqi (2014) and Samanthi *et al*. (2014) had also observed higher cumulative feed intake in birds that received zero garlic than those fed with garlic supplemented diet Conversely, the findings of the present study disagree with those reported by Javandel *et al*. (2008) and Issa and Omar (2012) who observed no significant effect of garlic on feed intake in broiler birds.

4.2.4 Feed Conversion Efficiency

Average weekly feed conversion efficiency and the mean feed efficiency of the different experimental groups up to six weeks of age are depicted in table 4.2.4 and their mean statistical analysis are shown in Appendix 2 (Feed Conversion Efficiency). The graph representing the average weekly feed conversion efficiency in various groups upto six weeks of age are plotted in Fig 4.2.4

Table 4.2.4: Feed conversion efficiency of broiler birds in different treatment groups

Treatment	Weeks						Mean
	1st	2nd	3rd	4th	5th	6th	
T_1	0.720	0.513	0.551	0.702	0.512	0.400	$0.565^{c} \pm 0.012$
T_2	0.743	0.524	0.604	0.714	0.531	0.402	$0.586^{ab} \pm 0.014$
T_3	0.764	0.515	0.621	0.723	0.550	0.475	$0.608^{a} \pm 0.012$
T_4	0.798	0.612	0.678	0.725	0.529	0.246	$0.598^{ab} \pm 0.010$

a,b,c

Means bearing different superscripts within the column differed significantly (P<0.05)

The mean feed conversion efficiency of broiler birds in different groups at the end of sixth week was recorded as 0.565 ± 0.012, 0.586 ± 0.014, 0.608 ±

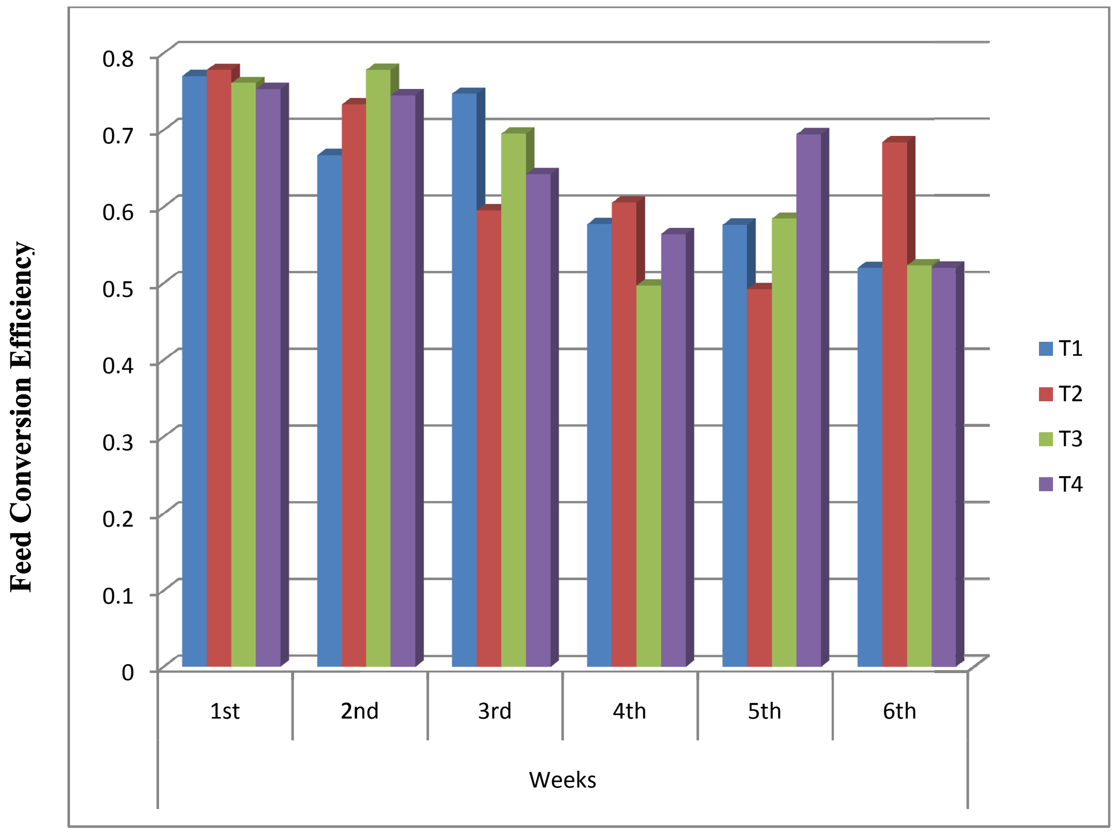


Fig 4.2.4 Feed conversion efficiency of broiler birds in different treatment groups

0.012 and 0.598 ± 0.010 for T_1, T_2, T_3 and T_4, respectively. Analysis of variance revealed that there was significant effect of garlic on feed conversion efficiency which was found to be better in garlic supplemented group. The values for feed conversion efficiency was significantly ($P<0.05$) lowest in T_1 followed by T_2, T_4 and the highest was in T_3. Hence, the result showed positive effect of garlic on feed conversion efficiency. The findings for the present study was in line with the observations of Fadlalla *et al*. (2010) and Eid and Iraqi (2014) who observed better ($P<0.05$) feed conversion efficiency in broiler birds due to incorporation of garlic in diet in the range of 0.02 to 0.3 per cent.

However, results of the present study disagree with the findings of Banuree *et al.* (2009); Issa and Omar (2012) and Saeid *et al*. (2013) who had reported non- significant effects of garlic supplementation on feed conversion efficiency in broiler birds. The differences in the findings might be due to difference in levels of garlic and feed formulation, type of feed, system of agro-climatic differences etc.

4.2.5 Mortality/Liveability and Performance Index

The average mortality, liveability percentage and performance index (PI) from day old to six weeks of age for the different treatment groups are shown in table 4.2.5 and their mean statistical analysis are shown in Appendix 2 (Performance Index).

Table 4.2.5: Mortality and liveability (per cent) and performance index of broiler birds in different treatment groups

Groups	Mortality (per cent)	Liveability (per cent)	Performance Index
T_1	0.00	100	282.29 ± 12.48
T_2	0.00	100	283.76 ± 12.59
T_3	0.00	100	301.66 ± 11.33
T_4	0.00	100	304.83 ± 7.58

Irrespective of all the groups, the mortality percentage of broiler birds from day old to six weeks of age was zero per cent. Hence, liveability per cent was recorded to be 100 per cent in all the groups which might be due to the favourable climatic condition, good quality feed and proper management practices.

The performance index was observed to be better in garlic treated groups which increased linearly with the increase in the level of garlic. However, statistically there was no significant effect of garlic on the performance index.

4.2.6 Carcass characteristics of broiler bird in different treatment groups

The average dressing percentage, carcass yield and organ weight in different treatment groups are presented in table 4.2.6 and their mean statistical analysis are shown in Appendix 2 (Dressing Percentage).

Table 4.2.6: Carcass characteristics of broiler birds in different treatment groups

Group	Dressing per cent	Carcass Weight (g)	Organ Weight (g)			
			Heart	Liver	Gizzard	Spleen
T_1	73.60	2623.75	12.84	51.09	40.68	3.91
T_2	74.93	2740.75	13.40	58.03	49.58	5.05
T_3	74.40	2453.75	11.62	50.06	44.05	4.62
T_4	74.31	2526.50	13.10	50.74	43.60	5.79

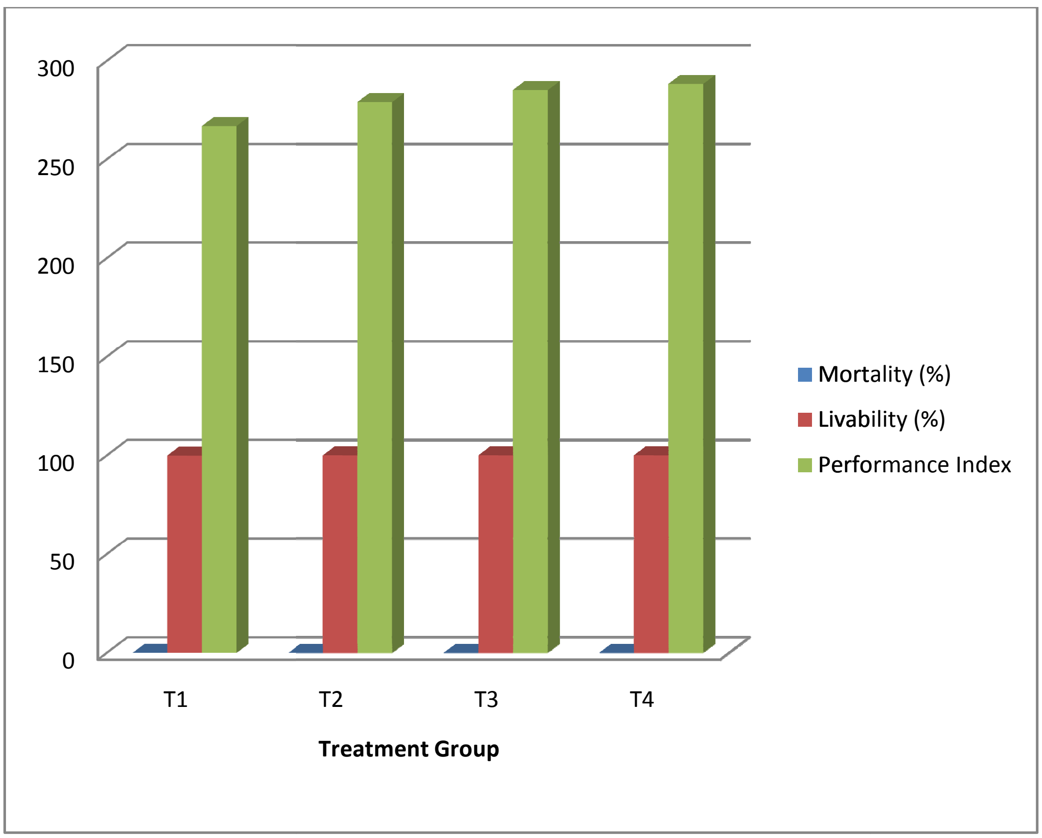


Fig 4.2.5 Mortality and liveability (per cent) and performance index of broiler birds in different treatment groups

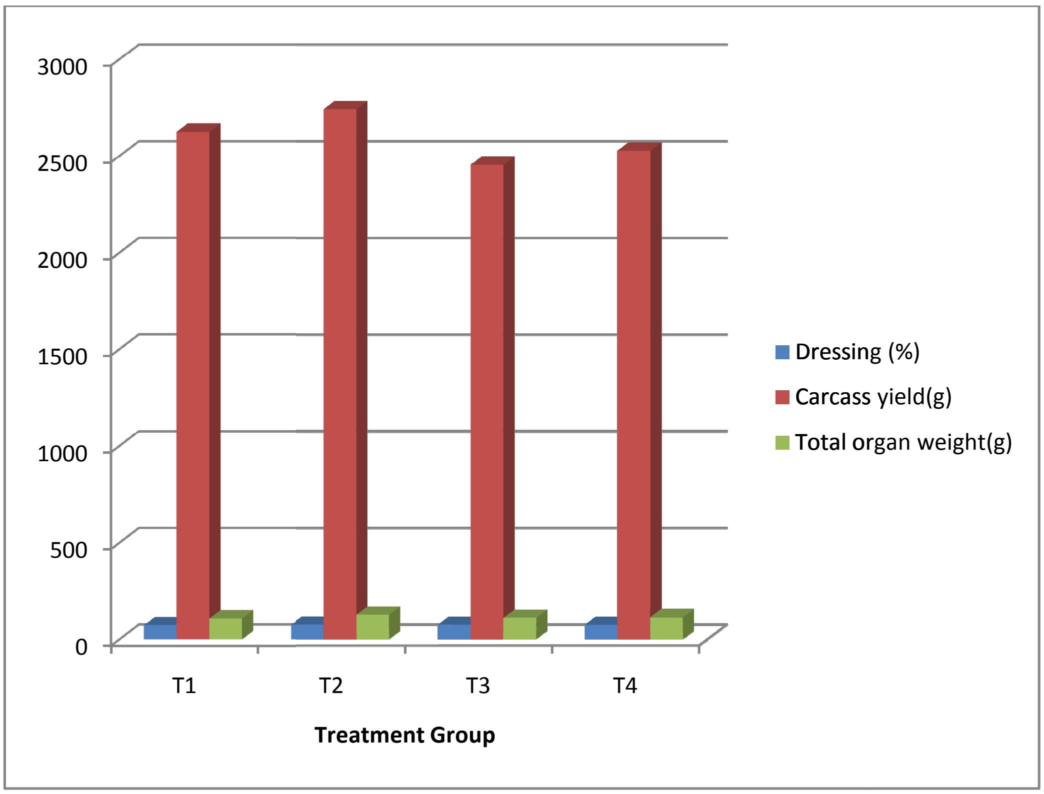


Fig 4.2.6 Carcass characteristics of broiler birds in different treatment groups

As per table 4.2.6, dressing percentage and the carcass yield and organ weights of broilers was unaffected by dietary garlic supplementation which was similar to the findings of Mahmood *et al.* (2009) and Samanthi *et al*. (2015) who had also reported non-significant effect of garlic and stated that basal feed containing garlic powder failed to produce positive effects on dressing percentage and carcass traits. On the contrary, researchers such as Fayed *et al.* (2011) observed a significant difference in average dressing percentages at 0, 0.5 and 1.0 kg/ton of feed; Ahmed El-Amin (2011) found that spleen weight decreased significantly (P□0.05) at 3 and 5 per cent garlic powder and Brzoska *et al.* (2015) reported higher dressing percentage at 2.25 ml kg^{-1}liquid garlic extract and significant (P□0.01) increase in liver weight at the level of 1.50 ml kg^{-1}. Variation in the present findings might be attributed to the difference in growth performance in response to the level of garlic, difference in experimental conditions and breed/strain differences.

4.2.7 Haematological parameters

The haematological parameters in different treatment groups are presented in table 4.2.7 and the statistical analysis is shown in Appendix 2.

Table 4.2.7: Haematological parameters of broilers birds in different treatment groups

Treatment	Haemoglobin (g/dl)	Total White blood cells ($10^3/mm^3$)	Total Red blood cells ($10^6/mm^3$)	Packed cells volume (per cent)	Differential white blood cells count (per cent)				
					Monocytes	Basophils	Heterophils	Eosinophils	Lymphocytes
T_1	10.49 ±0.17	13.3^c ±1.20	2.67^b ±0.08	34.04 ±0.56	0	0	48	2	49
T_2	11.00 ±0.49	20.0^b ±1.15	3.07^{ab} ±0.12	35.72 ±1.62	0	0	40	1	58
T_3	10.63 ±0.21	22.3^b ±1.45	2.70^{ab} ±0.15	34.49 ±0.74	0	0	46	1	52
T_4	10.69 ±0.26	32.3^a ±1.45	2.93^a ±0.03	34.73 ±0.88	0	0	35	1	63

a,b,c

Means bearing different superscripts within the column differ significantly ($P<0.05$)

The values for haemoglobin (g/dl) were 10.49 ± 0.17, 11.00 ± 0.49, 10.63 ± 0.21 and 10.69 ± 0.26 at 0, 0.25, 0.50 and 0.75 per cent garlic, respectively. The corresponding values for total white blood cells ($10^3/mm^3$) was13.3 ± 1.20, 20.0 ± 1.15, 22.3 ± 1.45 and 32.3 ± 1.45. Similarly, the total red blood cells ($10^6/mm^3$) at the above levels of garlic was 2.67 ± 0.08, 3.07 ± 0.12, 2.70 ± 0.15 and 2.93 ± 0.03, respectively. The packed cells volume recorded for the treatment groups T_1, T_2, T_3 and T_4 was 34.04 ± 0.56, 35.72 ± 1.62, 34.49 ± 0.74 and 34.73 ± 0.88 per cent, respectively.

The hematological parameter haemoglobin and PCV did not show significant difference between the treatment and control groups of broilers which was in line with the findings of Ahmed El Amin (2011) and Ahmed (2012) who reported non-significant effect of garlic on haemoglobin and PCV, respectively.

Statistical analysis had indicated that supplementation of garlic had significant ($P<0.05$) effect on total white blood cells and total red blood cells count. The garlic treated group had higher total WBC as compared to the control. The group T_4 had higher ($P<0.05$) total white blood cell followed by T_3, T_2 and the least was in control group T_1. However, there was no variation between the group T_2 and T_3. Higher values for WBC is indicative of positive effect of garlic as reported by Jamroz *et al*. (2003); Kung-chi *et al.* (2006) and Mikaili *et al*. (2013).

The results were in line with the findings of Birrenkott *et al.*(2000) who reported that including garlic in the laying hens resulted in increased total white blood cells reflecting good immune response; Ademola *et al*. (2004) who reported increase in total white blood cells by 18.70 per cent due to garlic supplementation at the rate of 10.30 per cent and Fadlalla *et al*. (2010) who also reported higher WBC values due to garlic supplementation .

The values for RBC was observed to be higher in the garlic treated group which was in agreement with the findings of Toghyani *et al*. (2011); Ahmed (2012) who reported significant (P<0.05) increase in red blood cells count in birds fed with garlic as compared to control group. Higher RBC values in the blood due to garlic is indicative of improved oxygen carrying capacity of the cells leading to more availability of nutrients to the birds consequently affecting their well-being (Oleforuh-Okoleh *et al*., 2015). Conversely, the present study disagree with Varmaghany *et al*. (2015) who observed that red blood cell count decreased linearly (P<0.005) with increasing garlic bulb levels in the diet under standard temperature conditions and Prasad *et al*. (2009) who reported that RBC was insignificantly lower in garlic treated groups.

Irrespective of the treatment, the values for monocytes and basophils was observed to be nil while the mean values for heterophils, eosinophilsand lymphocytes was observed to be 48, 40, 46 35 ; 2, 1, 1, 1 and 49, 58, 52 and 63 per cent for $T_{1,}$ T_2, T_3 and $T_{4,}$ respectively. Slight rise in lymphocyte was observed in garlic supplemented groups which may be due to immuno-stimulatory effects of garlic.

Statistically, differential white blood cells count was unaffected by garlic supplementation which was in agreement with Ahmed El Amin (2011) who had reported that there was no significant difference (P>0.05) on the differential count of white blood cells including basophils, neutrophils, eosinophils, monocytes and lymphocytes between the different treatments. The values were within the normal range reported by Maxwell *et al*. (1990); Prasad *et al*. (2009) and Nambol *et al*. (2016).

Present findings disagree with Onyimonyi *et al.* (2012); Elagib *et al.* (2013) and El-Fahim *et al*. (2014) who reported that garlic supplementation had no significant (P>0.05) effect on blood haematology. The variations in the findings could be attributed to differences in experimental conditions, feed, age, sex, seasons, environment and hormonal influence as also reported by Jones (2015).

4.2.8 Biochemical studies

The biochemical constituents of blood in different groups are presented in table 4.2.8. and the statistical analysis has been shown in Appendix 2.

Table 4.2.8: Biochemical constituents (mg/dl) of blood of broiler birds in different treatment groups

Treatment	LDL	HDL	Glucose	Triglycerides	Cholesterol
T_1	39.21±11.86	297.122±18.45	133.79±4.18	158.87^{a}±14.19	149.50±9.18
T_2	56.27±17.36	245.34±67.49	131.61±3.89	77.72^{c}±13.73	138.53±46.67
T_3	67.09±17.31	326.65±33.16	119.25±16.67	123.72^{ab}±9.04	173.42±22.59
T_4	67.34±05.24	331.55±27.22	143.00±1.78	86.46^{bc}±13.05	147.19±41.46

a,b,c

Means bearing different superscripts within the column differ significantly ($P<0.05$)

The mean values for LDL and HDL for the treatment groups T_1, T_2, T_3 and $T_4$was 39.21 ± 11.86, 56.27 ± 17.36, 67.09 ± 17.31, 67.34 ± 05.24 mg/dl; 297.122 ± 18.45, 245.34 ± 67.49, 326.65 ± 33.16 and 331.55 ± 27.22 mg/dl, respectively.

Similarly, the mean values for glucose was recorded as 133.79 ± 4.18, 131.61 ± 3.89, 119.25 ± 16.67 and 143.00 ± 01.78 mg/dl for T_1, T_2, T_3 and T_4 groups, respectively.

The mean values for triglycerides (mg/dl) and cholesterol (mg/dl) at 0, 0.25, 0.50 and 0.75 per cent was observed to be 158.87 ± 14.19, 77.72 ± 13.73, 123.72 ± 9.04 and 86.46 ± 13.05; 149.50 ± 9.18, 138.53 ± 46.67, 173.42 ± 22.59 and 147.19 ± 41.46, respectively.

From the perusal of table 4.2.8, it was observed that there was no significant difference in LDL, HDL, glucose and cholesterol due to garlic supplementation. However, addition of garlic powder had positive effect on the triglycerides. The highest amount of triglycerides (158.87 ± 14.19 mg/dl) was observed in control group. Lowering of triglycerides could be due to the organo sulfur volatile compounds which contributes to the effective bioactive properties of garlic (Mikaili *et al*.,2013)

4.2.9 Economics

The effect of dietary garlic on the economics of broiler production in different treatment groups are presented in table 4.2.9.

Table 4.2.9: Economics of broiler production in different treatment groups (Rs/bird)

Sl.No.	ITEMS	Treatment Groups			
		T_1	T_2	T_3	T_4
1.	Cost of broiler	40.00	40.00	40.00	40.00
2.	Cost of feed	126.272	116.8	117.98	120.96
3.	Cost of garlic powder	-	1.825	3.687	5.67
4.	Cost of medicine	4.78	4.78	4.78	4.78
5.	Cost of labour	12.60	12.60	12.60	12.60
6.	Miscellaneous cost	3.50	3.50	3.50	3.50
7.	Cost of production	187.152	179.505	182.547	187.51
8.	Average Weight of broiler (Kg)/bird	2.269	2.188	2.281	2.297
9.	Average weight gain (Kg)	2.226	2.146	2.235	2.252
10.	Cost of production per Kg weight (Rs)	82.48	82.04	80.02	81.63
11.	Sale of broiler @Rs.130 per Kg live weight (Rs)	294.97	284.44	296.953	298.61
12.	Sale of gunny bags @Rs.10/bag(Rs)	1.13	1.04	1.05	1.08
13.	Total receipt (Rs)/bird	296.10	285.48	298.003	299.69
14.	Profit per bird(Rs)	108.948	105.975	115.456	112.18
15.	Net profit per Kg weight gain(Rs)	48.94	49.38	51.66	49.80

From the data given in table 4.2.9, the total cost of production per broiler and per kg live weight was highest in T_4 (187.51/-) and T_1 (82.48/-), respectively. The net profit per bird was highest in T_3 and the net profit per kg weight gain of broiler was observed to be maximum in garlic supplemented group as compared to the control.

Highest net profit per bird and net profit per kg weight gain was recorded in T_3. Similar to the present findings, Hossain *et al.* (2014) had also reported significantly higher profitability per broiler and benefit cost ratio in garlic supplemented group and advocated its use for better profitability.

Based on the above findings, it was concluded that in terms of weight gain, feed efficiency, performance index and net profit, broilers supplemented with garlic at the rate of 0.5 per cent (T_3) and 0.75 per cent (T_4) performed better as compared to the other treatment groups during the monsoon season. Moreover, the haematological and biochemical values were improved due to garlic supplementation

4.3 Winter season

4.3.1 Body Weight

The observation on variation in body weight from day old to six week of age and their mean in different treatments groups during winter season are presented in table 4.3.1. The average body weight of different experimental groups at weekly interval has been graphically plotted in Fig 4.3.1.The statistical analysis of the average body weight at sixth week of age is given in Appendix 3 (Body Weight).

Table 4.3.1: Body weight (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks							Mean
	0	1st	2nd	3rd	4th	5th	6th	
T_1	41.967	181.133	454.746	871.011	1388.655	2010.030	2602.832^{a} ±39.70	433.81
T_2	43.133	182.530	469.946	822.410	1291.379	1792.103	2524.70^{ab} ±58.91	420.78
T_3	41.000	171.500	479.413	897.743	1290.000	1890.266	2443.998^{b} ±15.62	407.33
T_4	45.967	176.000	493.233	892.611	1318.333	2019.379	2566.098^{ab} ±60.49	427.68

a,b,c, Means bearing different superscripts within the column differ significantly (P<0.05)

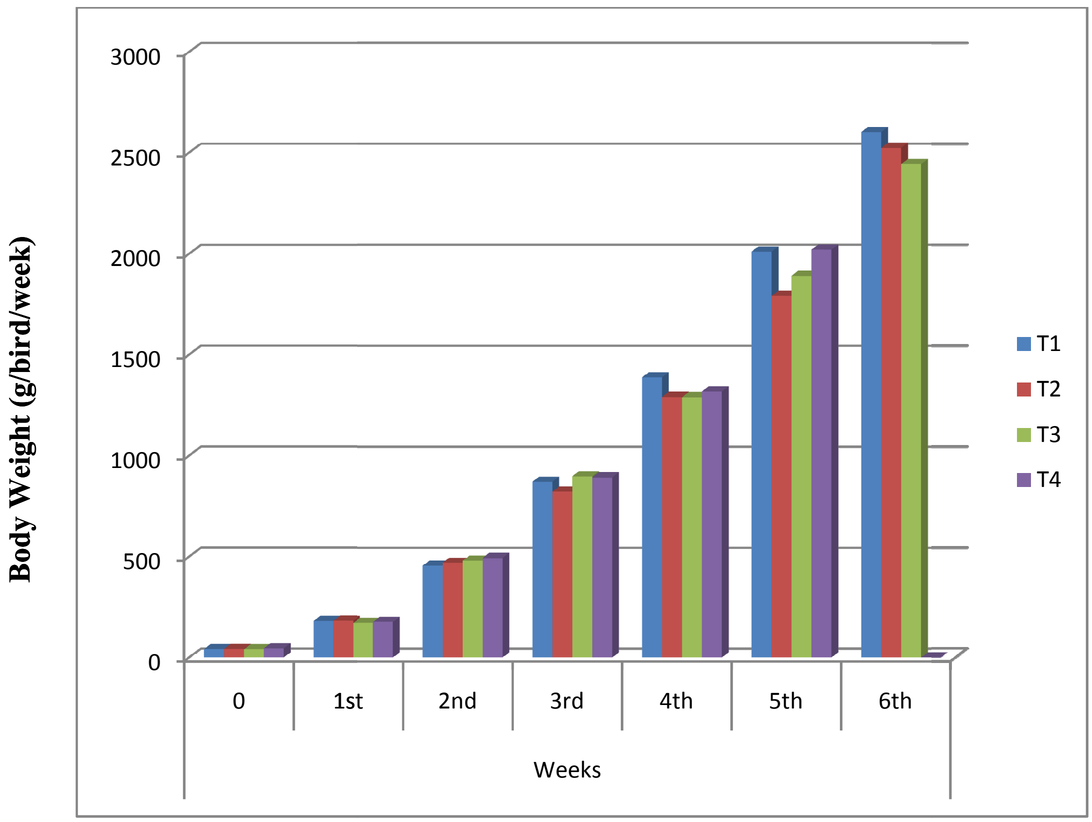


Fig 4.3.1 Body weight (g/bird) of broiler birds in different treatment groups

The average body weight of the day-old chicks for control group (T_1) and different treatment groups i.e. T_2, T_3 and T_4 was recorded as 41.967, 43.133, 41.000 and 45.967 g per bird, respectively. The corresponding final body weight recorded at the end of the 6th week was 2602.832 ± 39.70, 2524.70 ± 58.91, 2443.998 ± 15.62 and 2566.098 ± 60.49 g per bird, respectively. The overall mean body weight of the respective groups was 433.81, 420.78, 407.33 and 427.68 g/bird/week. The positive influence of garlic on the body weight could not be observed as the mean body weight was observed to be lower in garlic treated groups. Body weight was higher for the control group T_1 followed by T_4, T_2 and the least was in T_3. However, the variation in the body weight was found to be non-significant among the treatment groups T_1, T_2, T_4 and between T_2 and T_4 and among the garlic treated groups. Similar findings was also reported by Ademola *et al.* (2009) where garlic at 1.5 and 2 per cent significantly ($P<0.01$) decreased the final live weights of the chickens relative to the control. Conversely, Sultan *et al*. (2009); Ibrahim (2011) and Fayed *et al*. (2011) reported significant increase in body weight due to dietary supplementation of garlic. Variation in results might be due to strains differences, agro-climatic differences, difference in levels and form of garlic and seasons etc.

4.3.2 Gain in body weight

The weekly gain in body weight and total gain in weight in different treatment groups along with their mean are given in table 4.3.2 and their mean statistical analysis are presented in Appendix 3 (Gain in Body Weight). The pattern of growth and total average gain in weight during experimental period is plotted graphically in Fig 4.3.2.

Table 4.3.2: Gain in body weight (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks						Total weight gain	Mean
	1st	2nd	3rd	4th	5th	6th		
T_1	139.166	273.613	416.265	517.664	621.375	592.802	$2560.866^{a} \pm 39.70$	426.81
T_2	139.397	287.416	352.464	468.969	500.724	732.563	$2481.532^{ab} \pm 58.90$	412.59
T_3	130.500	307.913	418.33	392.257	600.266	553.732	$2402.997^{b} \pm 15.60$	400.50
T_4	130.03	317.233	399.378	425.722	701.046	546.719	$2485.931^{ab} \pm 22.60$	414.32

a,b Means bearing different superscripts within the column differ significantly (P<0.05)

The average gain in body weight from first to sixth week of age for the groups T_1, T_2, T_3 and T_4 was in the range of 139.166 to 621.375, 139.397 to 732.563, 130.500 to 600.266 and 130.03 to 701.046 g/bird/week, respectively. The corresponding overall total body weight gain was 2560.866 ± 39.70, 2481.532 ± 58.90, 2402.997 ± 15.60, 2485.931 ± 22.60 g per bird per week. The overall mean gain in body weight for the respective groups was 426.81, 412.59, 400.50 and 414.32.

The perusal of table 4.3.2 revealed that there was significant difference in overall gain in weight. Lower body weight gain was observed in garlic supplemented groups. Higher (P<0.050) weight gain was recorded in control group followed by T_4, T_2 and the least was in T_3. However, there was non-significant difference among the groups T_1, T_2, T_4 and among the garlic treated groups. The results of the present study was contradictory to the findings of Suriya *et al.* (2012) and Samanthi *et al.* (2015) who observed significantly higher weight gain in garlic treated birds. Variations in the findings could be due to factors such as differences in feed and its composition, level of garlic used, seasons and other experimental conditions.

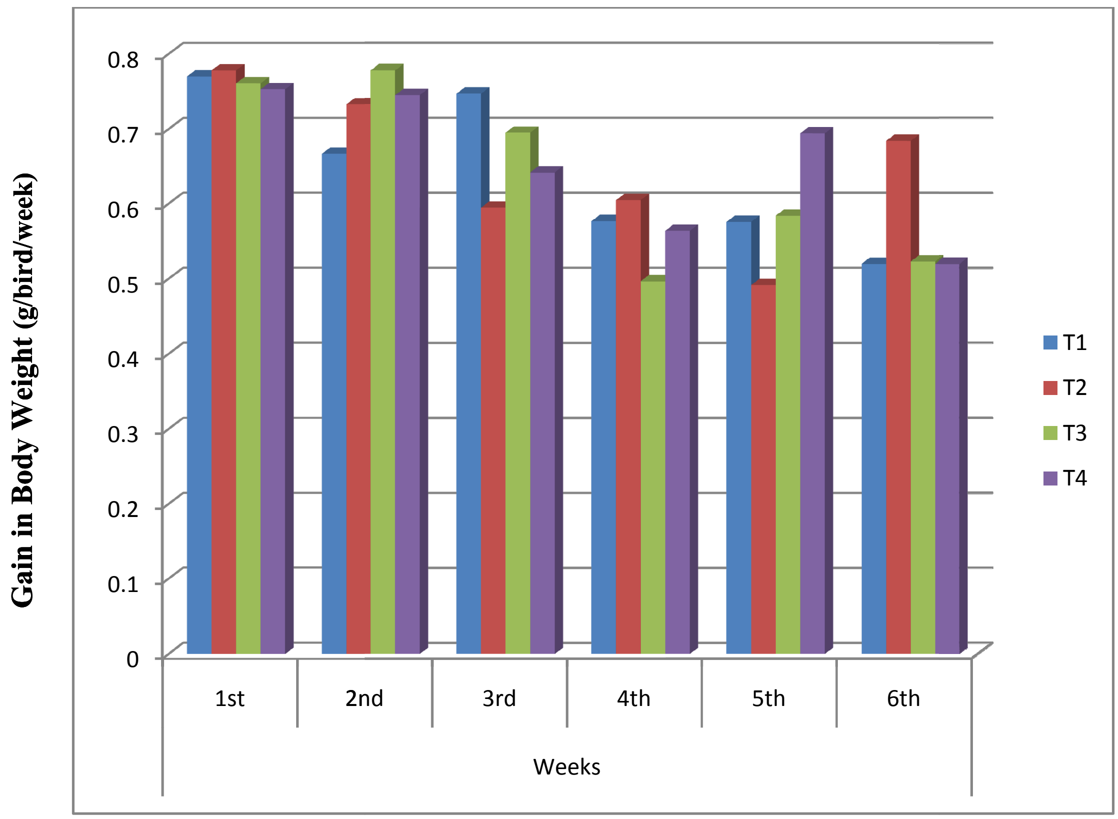


Fig 4.3.2 Gain in body weight (g/bird) of broiler birds in different treatment groups

4.3.3 Feed Intake

The weekly feed intake and total feed intake along with their mean values in different experimental groups are presented in table 4.3.3 and the statistical analysis of total feed consumption has been shown in Appendix 3 (Feed Intake). The pattern of feed consumption has been graphically illustrated in Fig 4.3.3.

Table 4.3.3: Feed intake (g/bird/week) of broiler birds in different treatment groups

Treatment	Weeks							Mean
	1st	2nd	3rd	4th	5th	6th	Total	
T_1	180.830	409.930	557.066	897.100	1078.133	1141.066	4264.125[a] ±47.40	710.69
T_2	179.190	392.260	592.366	775.433	1017.400	1071.366	4028.015[b] ±33.90	671.34
T_3	171.530	395.766	601.923	789.900	1027.633	1059.300	4046.052[b] ±32.00	674.34
T_4	172.660	425.733	621.692	754.933	1009.930	1050.433	4035.381[b] ±37.90	672.56

a,b, Means bearing different superscripts within the column differ significantly (P<0.05)

The total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 4264.125 ± 47.40, 4028.015 ± 33.90, 4046.052 ± 32.00 and 4035.381 ± 37.90 g per bird, respectively. The overall mean feed intake for the respective groups was 710.69, 671.34, 674.34 and 672.56. The statistical analysis had revealed significant effect of garlic on feed intake which was found to be significantly (P<0.05) garlic treated groups as compared to the control groups. However, the difference in feed intake among the garlic supplemented groups was found to be non- significant.

The result corroborated with the earlier findings of Hamodi and Al-Hamdany (2006); Banuree *et al*. (2009) and Jimoh *et al*. (2013) who observed

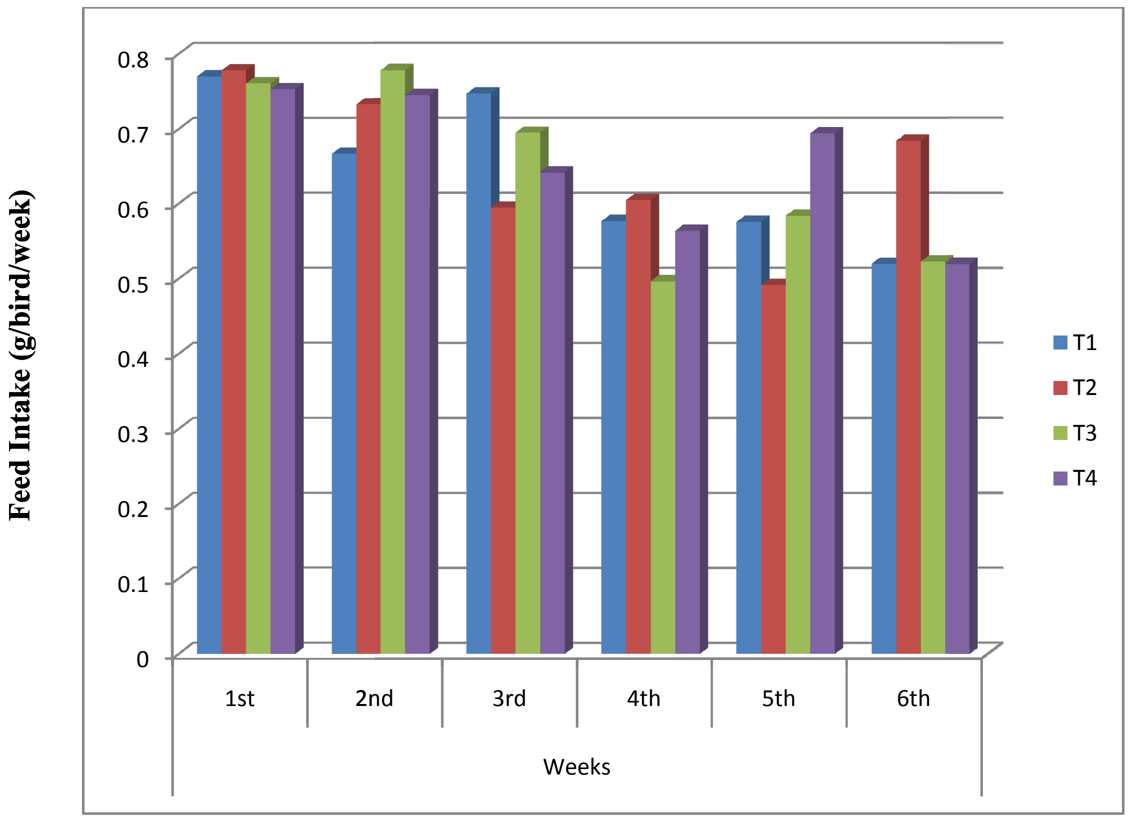


Fig 4.3.3 Feed intake (g/bird) of broiler birds in different treatment groups

decreased in feed consumption due to supplementation of garlic in broiler diet. On the contrary, Saeid *et al.* (2013) reported that addition of garlic powder and black seed plant premix to the diet resulted in higher feed intake as compared to that of control group. Issa and Omar (2012) also observed difference in broiler feed intake due to dietary supplementation of garlic. Variation in results might be due to differences in strain of broiler used, agro-climatic differences, difference in levels of garlic, type of feed and seasons etc.

4.3.4 Feed Conversion Efficiency

The weekly feed conversion efficiency and mean feed efficiency of the different experimental groups up to six weeks of age are depicted in table 4.3.4 and their mean statistical analysis are shown in Appendix 3 (Feed Conversion Efficiency). The graph representing the average weekly feed conversion efficiency in various groups upto six weeks of age are plotted in Fig 4.3.4.

Table 4.3.4: Feed conversion efficiency of broiler birds in different treatment groups

Treatment	Weeks						
	1st	2nd	3rd	4th	5th	6th	Mean
T_1	0.770	0.667	0.747	0.577	0.576	0.520	0.643^{ab}±0.059
T_2	0.778	0.733	0.595	0.605	0.492	0.684	0.648^{a}±0.018
T_3	0.761	0.778	0.695	0.497	0.584	0.523	0.640^{b}±0.004
T_4	0.753	0.745	0.642	0.564	0.694	0.520	0.653^{ab}±0.004

a, b

Means bearing different superscripts within the column differ significantly ($P<0.05$)

The mean feed conversion efficiency of broiler birds in different groups at the end of sixth week was recorded as 0.520, 0.684, 0.523 and 0.520 for T_1, T_2, T_3 and T_4, respectively whereas the corresponding overall mean FCE was 0.643 ± 0.059, 0.648 ± 0.018, 0.640 ± 0.004 and 0.653 ± 0.004. The statistical

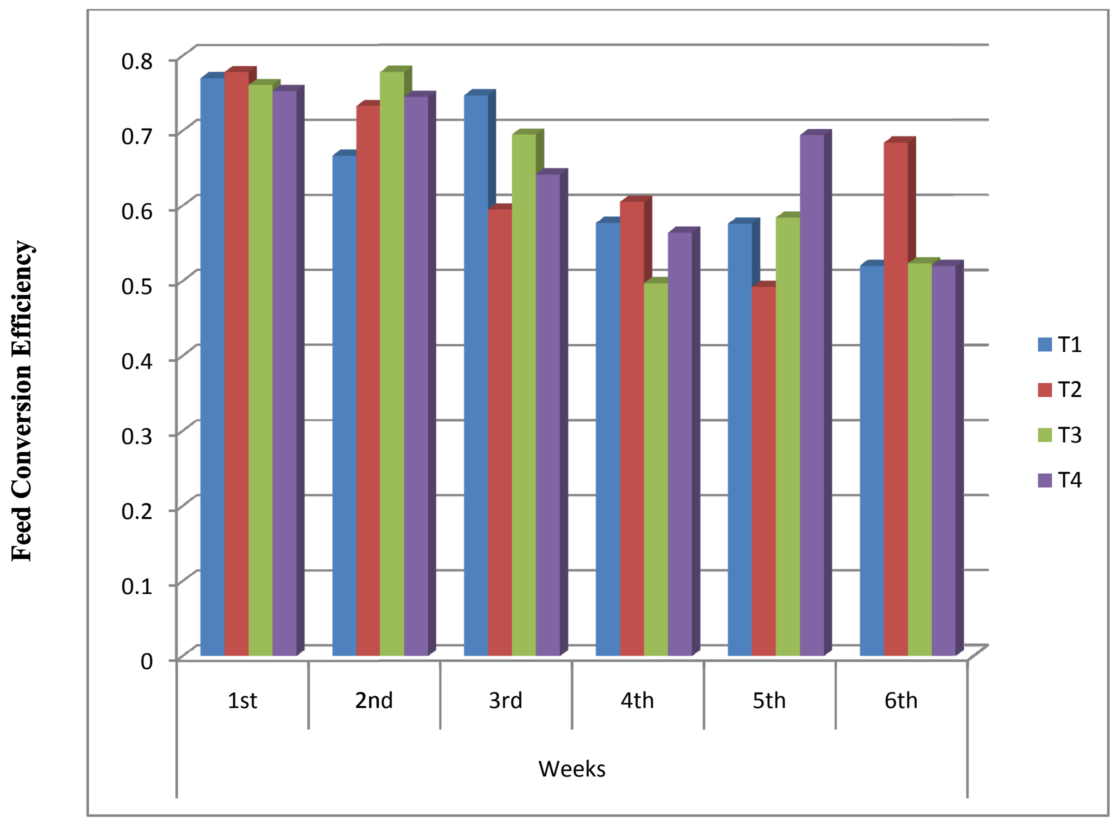


Fig 4.3.4 Feed conversion efficiency of broiler birds in different treatment groups

analysis had revealed significant effect of garlic on FCE. The values for feed conversion efficiency was higher in T_4 followed by T_2, T_1 and the lowest was in T_3. However, the difference between the groups T_1, T_2 and T_4 and the groups T_1 ,T_3 ,T_4 was found to be non- significant.

These results were in agreement with the earlier findings of Onu (2010); Suriya *et al*. (2012); Al-Kassie *et al*. (2013) and Borgohain *et al*. (2017) who observed significant improvement in feed conversion efficiency due to supplementation of garlic in broiler diet. On the contrary, Ayenie *et al*. (2008) and Amouzmehr *et al*. (2013) observed no variation in feed conversion efficiency due to dietary supplementation of garlic.

Variation in results might be due to type of feed and its composition, agro-climatic differences, difference in levels of garlic and seasons etc.

4.3.5 Mortality/Liveability and Performance Index

The average mortality, liveability percentage and performance index (PI) from day old to six weeks of age for the different treatment groups are shown in table 4.3.5 and their mean statistical analysis are shown in Appendix 3(Performance Index). The graph representing the performance index in various groups upto six weeks of age are plotted in Fig 4.3.5.

Table 4.3.5. Mortality and liveability (per cent) and performance index of broiler birds in different treatment groups

Groups	Mortality (per cent)	Liveability (per cent)	Performance Index
T_1	0.00	100	$366.882^{ab} \pm 8.423$
T_2	0.00	100	$371.456^{a} \pm 17.212$
T_3	0.00	100	$337.502^{b} \pm 4.504$
T_4	0.00	100	$363.624^{ab} \pm 6.509$

a, b

Means bearing different superscripts within the column differ significantly (P<0.05)

Irrespective of the treatment, the mortality percentage of broiler birds from day old to six weeks of age was zero per cent. Hence, liveability per cent was recorded as 100 per cent in all the groups which might be attributed to favourable climatic condition, good quality feed and proper management practices.

The performance index for T_1, T_2, T_3 and T_4 groups were recorded as 366.882 ± 8.423, 371.456 ± 17.212, 337.502 ± 4.504 and 363.624 ± 6.509, respectively. The statistical analysis had revealed significant ($P<0.05$) variation in performance index among the treatment groups. The performance index of broiler birds was observed to be highest in T_2 (371.456) and the lowest was in T_3 (337.502 ± 4.504).

The result was in harmony with the findings of Patel *et al*. (2014) who observed better performance index due to supplementation of garlic in broiler diet and El-katcha *et al*. (2016) reported that allicin supplementation at the rate of 25, 50 or 75 and 100 mg per Kg diet had improved the performance index (139.37 ± 3.02, 155.58 ± 3.88, 147.94 ± 4.07, respectively) when compared with control (125.59 ± 3.79).

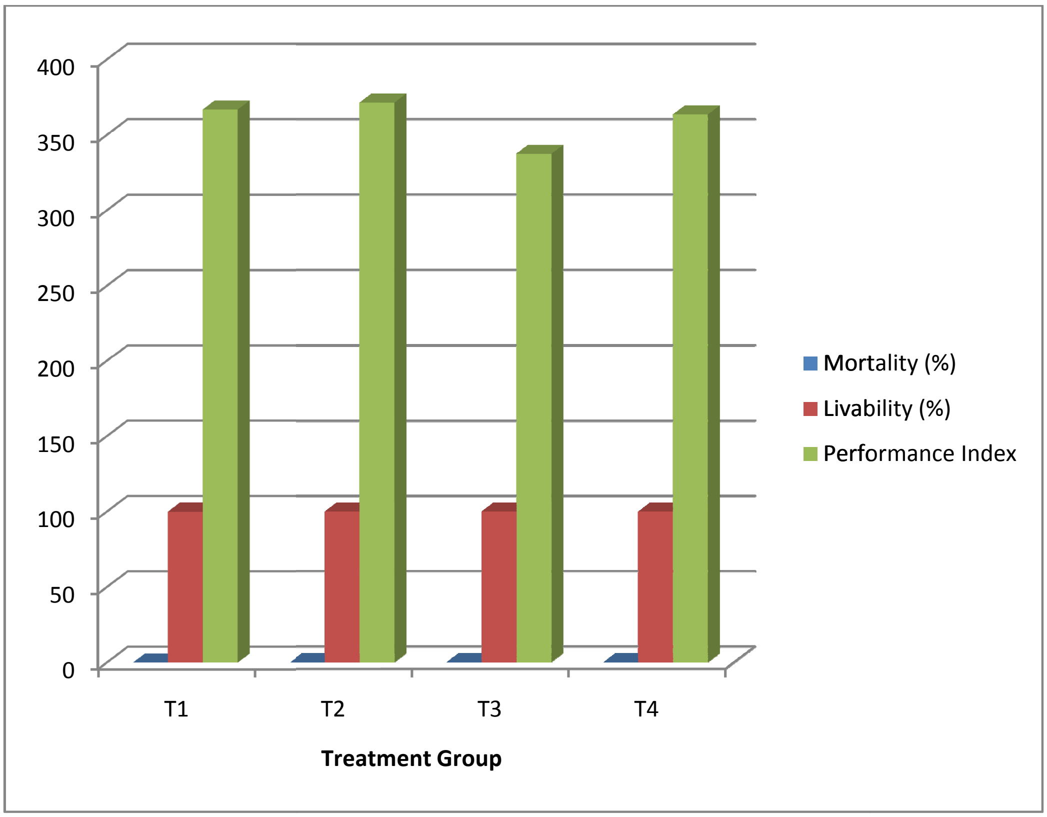


Fig 4.3.5 Mortality and liveability (per cent) and performance index of broiler birds in different treatment groups.

4.3.6 Carcass characteristics of broiler in different treatment groups

The carcass characteristics in terms of dressing percentage, carcass yield and organ weights in different treatment groups are presented in table 4.3.6 and their mean statistical analysis are shown in Appendix 3 (Dressing Percentage). The graph representing the dressing percentage in various groups are plotted in Fig 4.3.6.

Table 4.3.6: Carcass characteristics of broiler birds in different treatment groups

Group	Dressing per cent	Carcass Weight (g)	Organ Weight (g)			
			Heart	Liver	Gizzard	Spleen
T_1	82.810	2295.500	12.471	51.680	42.620	3.190
T_2	83.927	2303.250	13.711	48.670	39.100	2.980
T_3	85.300	2357.250	15.341	54.280	40.210	3.227
T_4	85.412	2508.200	15.529	54.810	45.710	3.270

As evident from table 4.3.6, the values for dressing per cent, carcass weight and heart weight were observed to be better in garlic treated groups however, statistically there was no significant effect which was in line with the findings of Mahmood *et al.* (2009) and Samanthi *et al*. (2015). On the other hand, researchers such as Hamodi and Al-Hamdany (2006) reported higher ($P<0.05$) dressing percentage and the relative carcass weight with the dietary inclusion of 0.4 per cent garlic powder; Ashayerizadeh *et al.* (2009) revealed that inclusion of garlic at the rate of 1 kg/ton of feed in broiler resulted in increased carcass percentage as compared to the control and Brzoska *et al.* (2015) reported that higher dressing percentage with garlic extract as compared to the control group.

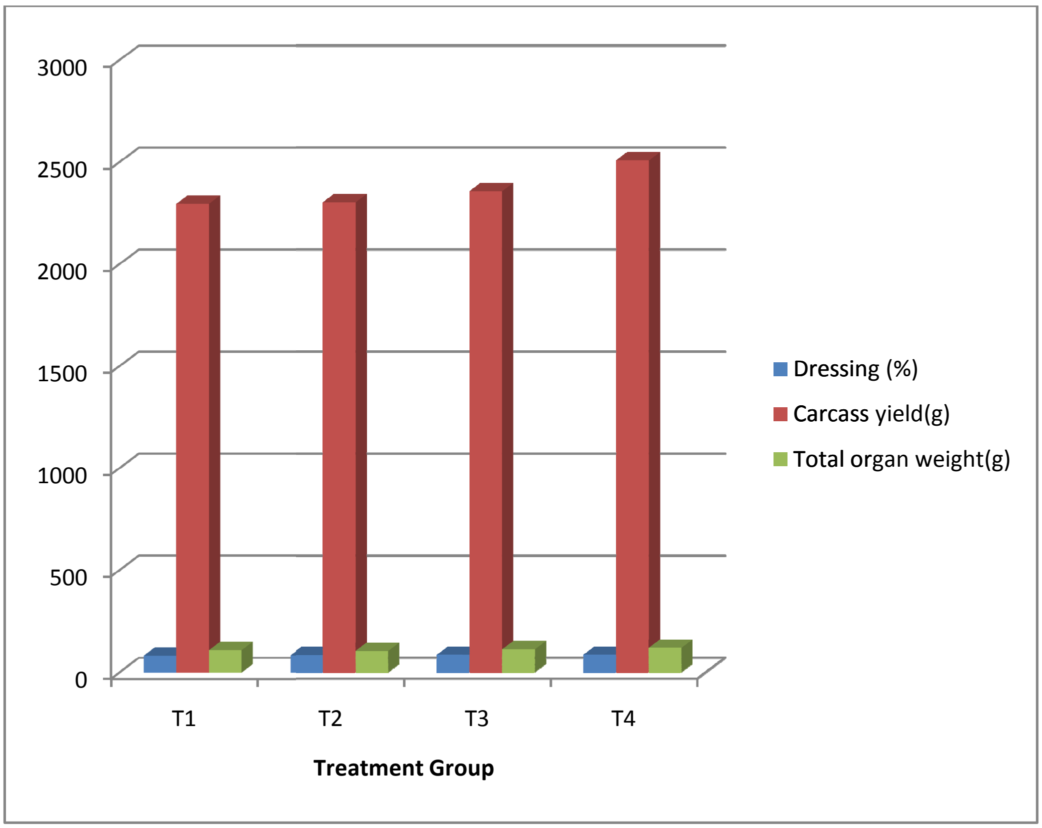


Fig 4.3.6 Carcass characteristics of broiler birds in different treatment groups

Variation in the present findings might be attributed to the difference in growth performance in response to the level of garlic, difference in experimental conditions and breed/strain differences etc.

4.3.7 Haematological parameters

The values for the haematological parameters observed in different treatment groups at six weeks of age are presented in table 4.3.7 and the statistical analysis has been shown in Appendix 3 (Haematological / biochemical parameters).

Table 4.3.7: Haematological parameters of broiler birds in different treatment groups

Treatment	Haemoglobin g/dl	Total White blood cells $10^3/mm^3$	Total Red blood cells $10^6/mm^3$	Packed cells volume (PCV)	Differential white blood cells count(per cent)				
					Monocytes	Basophils	Heterophils	Eosinophils	Lymphocytes
T_1	10.817^{bc}±0.19	8.733^{c}±2.8	2.6^{b}±0.05	35.126^{bc}±0.63	0	0	57.60^{b} ±1.30	0.33±0.33	42.00^{a}±1.50
T_2	10.087^{c}±0.26	10.1^{c} ±4.5	2.46^{b} ±0.03	32.72^{c} ±0.88	0	0	62.00^{b} ±20.00	0.33±0.33	37.66^{a}±1.80
T_3	11.627^{a}±0.27	19.6^{b} ±1.2	2.66^{b} ±0.08	37.79^{a} ±0.89	0	0	63.60^{ab}±4.10	0.33±0.33	36.00^{ab}±40
T_4	11.45^{ab}±0.18	27.3^{a} ±1.4	3.06^{a}±0.06	37.22^{ab} ±0.6	0	0	71.30^{a}±1.30	0.33±0.33	28.30^{b}±1.20

a,b,c,

Means bearing different superscripts within the column differ significantly ($P<0.05$)

The mean values for haemoglobin was 10.817 ± 0.19, 10.087 ± 0.26, 11.627 ± 0.27 and 11.45 ± 0.18 g/dl for $T_{1,}$ T_2, T_3 and $T_{4,}$ respectively. The corresponding values for total white blood cells ($10^3/mm^3$) was 8.733 ± 2.80, 10.10 ± 4.50, 19.60 ± 1.20 and 27.3 ± 1.40. Similarly, the total red blood cells ($10^6/mm^3$) for the groups $T_{1,}$ T_2, T_3 and T_4 was 2.6 ± 0.05, 2.46 ± 0.03, 2.66 ± 0.08 and 3.06 ± 0.06, respectively while the packed cells volume recorded for the respective groups was 35.126 ± 0.63, 32.72 ± 0.88, 37.79 ± 0.89 and 37.22 ± 0.6 per cent.

The mean values for monocytes and basophils was recorded as nil in all the treatment groups while the values for heterophils was 57.60 ± 1.30,62.00 ±20,63.60± 4.10 and 71.30 ± 1.30 per cent for $T_{1,}$ T_2, T_3 and T_4, respectively. Irrespective of the groups, the mean values for eosinophils were 0.33 ± 0.33. Lymphocytes count was 42.00 ± 1.5, 37.66 ± 1.8, 36.00 ± 4.00, 28.30 ± 1.20 per cent for $T_{1,}$ T_2, T_3 and T_4, respectively.

As per the statistical analysis, supplementation of garlic had resulted in significant difference in haemoglobin, total white blood cells, total red blood cells, packed cells volume, heterophils and lymphocytes.

Values for haemoglobin was significantly higher for groups fed with 0.5 per cent (T_3) garlic and the least was at 0.25 per cent garlic supplementation.

White blood cells count was significantly higher for the groups fed with 0.75 per cent garlic powder in comparison to the control group.

Red blood cells count was significantly highest at 0.75 per cent garlic supplementation and the least was at 0.50 per cent.

Values for packed cells volume was recorded to be significantly higher for group fed with diet supplemented with 0.5 per cent garlic powder and the least was at 0.25 per cent garlic supplementation.

Mean values for Heterophils was observed to be significantly higher for the group provided with 0.75 per cent garlic powder and the least was in control group.

Lymphocytes count was observed to be lower in garlic treated group. Significantly higher value was recorded in control group as compared to all the garlic treated groups. Hence, except for lymphocytes, positive effect of garlic on the haematology of the garlic treated groups was observed.

Similar to the present findings, Oleforuh-Okoleh *et al*. (2015) had reported significant ($P<0.01$) increase in the concentration of haemoglobin, packed cell volume, white blood cell and red blood cell when broilers were fed with diet supplemented with aqueous extract of ginger and garlic at the level of 0, 50 ml ginger extract, 50 ml of garlic extract and a mixture of ginger and garlic 25 ml each per liter of water. They were of the view that increase in the values of PCV, Hb and RBC contents of the blood of birds fed the above extract is indicative of improved oxygen carrying capacity of the cells that increases the availability of nutrients to the birds and ultimately affects their overall well-being.

Researchers including Birrenkott *et al*. (2000); Fadlalla *et al*. (2010) and Mehdi Toghyani (2010) had also observed significant increased in red blood cells and white blood cells count due to garlic supplementation. On the other hand, Ahmed El Amin (2011) had found that there was no significant difference ($P>0.05$) between the different treatments groups on the packed cell volume (PCV), total red blood cells count, total white blood cells and differential count of white blood cells at 0, 3 and 5 per cent of garlic supplementation. Elagib *et al.* (2013) had also reported that garlic supplementation at 3 and 5 per cent had no significant effect ($P>0.05$) on the blood haematology. Variation in results might be due to strains differences, agro-climatic differences, difference in levels and form of garlic used, seasons and other experimental conditions.

4.3.8 Biochemical studies

The values for biochemical constituent of blood in different treatment groups are presented in table 4.3.8 and the statistical analysis has been shown in Appendix 3 (Haematological / biochemical parameters).

Table 4.3.8: Biochemical constituents (mg/dl) of blood of broiler birds in different treatment groups

Treatment	LDL	HDL	Glucose	Triglycerides	Cholesterol
T_1	79.30±6.62	56.39±4.30	146.32±10.2	82.20±15.70	174.20±12.31
T_2	83.50±3.19	49.70±1.04	149.22±3.56	104.8±25.53	182.40±15.61
T_3	82.80±8.78	61.50±3.52	154.69±4.19	54.30±5.13	163.70±29.68
T_4	100.20±4.82	59.14±3.96	147.32±6.19	54.80±2.23	128.70±6.03

As per the data given in table 4.3.8, there was increase in LDL and HDL and slight decrease in the values for cholesterol and triglycerides at higher level of garlic supplementation when compared with the control. However, statistically, the biochemical constituent of blood was unaffected by garlic supplementation. Positive influence of garlic on the blood biochemical constituent was observed by Issa and Omar (2012); Patel *et al*. (2014) who reported that lipid profile of blood *viz*. cholesterol, triglyceride and low density lipoprotein showed significant improvement in broiler group supplemented with garlic powder over control. The difference in the observation might be due to season influence, feed composition , experimental condition etc.

4.3.9 Economics

The effect of dietary garlic on the economics of broiler production in different treatment groups are presented in table 4.3.9.

Table 4.3.9: Economics of broiler production in different treatment groups (Rs/bird)

Sl.No.	ITEMS	Treatment Groups			
		T_1	T_2	T_3	T_4
1.	Cost of broiler	40.00	40.00	40.00	40.00
2.	Cost of feed	128.128	119.712	123.168	122.72
3.	Cost of garlic powder	-	1.871	3.849	5.753
4.	Cost of medicine	4.78	4.78	4.78	4.78
5.	Cost of labour	12.60	12.60	12.60	12.60
6.	Miscellaneous cost	3.50	3.50	3.50	3.50
7.	Cost of production	189.008	182.463	187.897	189.353
8.	Average Weight of broiler (Kg)	2.600	2.500	2.440	2.560
9.	Average weight gain (Kg)	2.558	2.457	2.399	2.514
10.	Cost of production per Kg weight (Rs)	72.69	72.98	77.00	73.97
11.	Sale of broiler @Rs.130 per Kg live weight (Rs)	338.00	325.00	317.20	333.58
12.	Sale of gunny bags @Rs.20/bag(Rs)	1.21	1.15	1.16	1.15
13.	Total receipt (Rs)/bird	339.21	326.15	318.36	334.73
14.	Profit per bird(Rs)	150.202	143.687	130.463	145.377
15.	Net profit per Kg weight gain (Rs)	58.72	58.48	54.38	57.82

The average cost of production for T_1, T_2, T_3 and T_4 were 189.008, 182.463, 187.897 and 189.353 rupees per bird, respectively. The corresponding values for average cost of production per kg live weight of bird was 72.69, 72.98, 77.00 and 73.97 rupees, respectively.

The net profit per bird was 150.202, 143.687, 130.463 and 145.377 rupees, respectively for T_1, T_2, T_3 and T_4 groups and the corresponding values for net profit per kg weight gain of bird was 58.72, 58.48, 54.38 and 57.82 rupees, respectively.

From the results, it was found that the total cost of production per broiler was the least in groups fed with 0.25 per cent garlic as compared to the other groups while the least and the highest cost of production per kg live weight of broiler was recorded in groups served with 0 and 0.50 per cent garlic, respectively. The highest and the least net profit per bird was recorded in T_1 and T_3, respectively. The net profit per kg weight gain of the broiler also followed a similar trend. Lower net profit per bird and per kg gain in weight in T_3 might be due to lower weight gain and poorer feed efficiency. Hence, higher net return was obtained from the control group than from the garlic treated groups. Contrary to the present finding, Singh *et al.* (2015); Eevuri and Putturu (2013) and Fayed *et al*. (2011) reported that addition of dietary garlic in the ration resulted in economic and efficient production of broiler. Poorer performance in garlic treated groups might be due to some unidentified stress factors.

Hence, during winter season, the overall performance of broiler chicken in terms of body weight, total gain in weight, FCE, performance index and net return was better in control groups in comparison to the garlic treated groups. Dietary inclusion of garlic had favourable effect on the haematological parameters.

4.4 Effect of Season and Treatment

4.4.1 Growth and Feed Parameters

The effect of season, treatment and their interaction effect on the overall growth and feed parameters and performance index in broiler birds at

42 days of age are presented in table 4.4.1, table 4.4.2 and table 4.4.3, respectively and their statistical analysis is given in Appendix 4.

Table 4.4.1: Effect of season on overall growth and feed parameters

Season	Body weight (g/bird)	Total Gain in weight (g/bird)	Feed intake (g/bird)	Feed conversion efficiency	Performance index
S_1	2259.106^b	2208.773^b	3926.906^b	0.562^c	279.855^b
S_2	2259.642^b	2215.986^b	3766.374^c	0.589^b	293.134^b
S_3	2534.399^a	2482.831^a	4093.641^a	0.644^a	359.867^a
Sem (±)	27.459	25.007	33.437	0.005	6.088
CD(P=0.05)	106.851	97.307	130.111	0.021	23.688

a, b, c

Means bearing different superscript within the column differ significantly ($P<0.05$)

From the table 4.4.1, the average final body weight of the birds during summer (S_1), rainy (S_2) and winter (S_3) season was 2259.106, 2259.642 and 2534.399 g per bird, respectively. The corresponding values for gain in weight were 2208.773, 2215.986 and 2482.831 g per bird. Feed intake for S_1, S_2 and S_3 was recorded to be 3926.906, 3766.374 and 4093.641, respectively while the feed efficiency for the respective seasons was 0.562, 0.589 and 0.644.The overall performance index was recorded to be 279.855, 293.134 and 359.867 for S_1, S_2 and S_3, respectively.

Statistical analysis revealed significant seasonal effect on all the growth and feed parameters. Higher body weight and gain in weight was observed during winter season intermediate during monsoon and the least in summer season. However, the increase in body weight and the increase in weight gain between season S_1 and S_2 was found to be non- significant. Feed intake was significantly ($P<0.05$) higher during winter season (S_3) followed by summer (S_1) and the least in monsoon (S_2) season. The best feed efficiency and performance index was observed during the winter season followed by monsoon and the least was in summer. Hence, productive performance of broiler birds in terms of body weight, weight gain, feed efficiency and performance index was best during the winter season. Similar to the present findings Osti *et al*. (2017) had also reported effect of season on body weight and feed conversion ratio and observed that body weight at 42 days was significantly (P□0.05) higher during winter season as compared to the summer season; Rahman *et al.* (2003) had reported highest weight gain during winter season, lowest in rainy and intermediate in summer season. The present findings disagree with Thirumalesh *et al*. (2012) who had reported that there was no significant difference between summer, rainy and winter season in weight gain and feed intake. Variations in the findings could be due to various factors such as the difference in location, system of housing, temperature range, type/strain of birds, feed composition etc.

Table 4.4.2: Effect of treatment on overall growth and feed parameters

Treatment	Body weight (g/bird)	Total gain in weight (g/bird)	Feed intake (g/bird)	Feed conversion efficiency	Performance index
T_1	2353.99	2308.84	4024.37^{a}	0.59	305.38
T_2	2325.50	2280.72	3877.55^{b}	0.60	311.41
T_3	2331.82	2286.15	3874.81^{b}	0.60	309.17
T_4	2392.89	2334.40	3939.17^{ab}	0.60	317.85
Sem (±)	27.018	25.651	33.893	0.006	5.743
CD(P=0.05)	89.374	84.851	112.114	0.020	18.996

a, b

Means bearing similar superscript within the column do not differ significantly ($P>0.05$)

Table 4.4.2 reveal the treatment effect on the overall body weight, total gain in weight, feed intake, feed efficiency and performance. As evident, statistical analysis had revealed that garlic supplementation had significant effect on feed intake of broilers however, body weight, gain in weight, feed efficiency and performance index were unaffected by garlic treatment.

Feed intake was maximum in control group and lower in garlic treated groups with the least at 0.50 per cent garlic supplementation. The feed intake among the garlic treated groups was found to be similar. Lower feed intake in garlic supplemented group might be due to the associated flavour and lower palatability.

Table 4.4.3: Interaction effect of season x treatment on overall growth and feed parameters

SxT	Body weight (g/bird)	Total gain in weight (g/bird)	Feed intake (g/bird)	Feed conversion efficiency (gain: feed)	Performance index
S_1T_1	2189.30	2138.70	3862.47^{bc}	0.55	266.96
S_1T_2	2262.90	2214.02	3952.83^{bc}	0.56	279.02
S_1T_3	2269.60	2218.69	3890.47^{bc}	0.57	285.18
S_1T_4	2314.63	2263.68	4001.86^{b}	0.57	288.27
S_2T_1	2269.84	2226.97	3946.53^{bc}	0.56	282.29
S_2T_2	2188.93	2146.60	3650.80^{d}	0.59	283.76
S_2T_3	2281.87	2236.77	3687.90^{d}	0.61	304.83
S_2T_4	2297.93	2253.60	3780.27^{cd}	0.60	301.66
S_3T_1	2602.83	2560.87	4264.12^{a}	0.64	366.88
S_3T_2	2524.67	2481.53	4029.01^{b}	0.66	371.46
S_3T_3	2444.00	2403.00	4046.05^{b}	0.62	337.50
S_3T_4	2566.10	2485.93	4035.38^{b}	0.65	363.63
Sem (±)	46.797	44.428	58.704	0.010	9.946
CD(P=0.05)	154.801	146.966	194.188	0.034	32.902

a,b,c,d

Means bearing same superscript in the column do not differ significantly ($P<0.05$)

From table 4.4.3, numerically, the highest and the lowest body weight per bird due to the interaction effect of season and treatment was observed in

S_3T_1 (2602.83 g) and S_2T_2 (2188.93 g), respectively while the corresponding values for the total gain in weight was observed in S_3T_1 (2560.87 g) and S_1T_1**(**2138.70 g). The overall feed intake per bird was highest during winter season in control group S_3T_1 and the least in garlic treated groups during monsoon season. The overall FCE value was maximum (0.66) during winter season at 0.25 per cent level of garlic (S_3T_2) and the least (0.55) was in summer in control group S_1T_1. Similarly, the best and the poorest performance index was recorded in S_3T_2 (371.46) and S_1T_1 (266.96). Statistical analysis had revealed that season x garlic (interaction effect) had significant effect on the overall feed intake of broilers. The groups reared during winter with different levels of garlic supplementation had the highest feed intake. However, the least feed intake was observed in garlic treated groups during monsoon season while the other parameters were unaffected by garlic.

4.4.4 Mortality/Liveability and Performance index

The average mortality, liveability performance index during different seasons are shown in table 4.4.4.

Table 4.4.4: Mortality and liveability (per cent) and performance index of broiler birds during the different three seasons

Parameters	Summer	Monsoon	Winter
Mortality (per cent)	0	0	0
Liveability (per cent)	100	100	100
Performance index	279.858	293.135	359.851

Irrespective of the treatment groups, the mortality percentage was zero per cent while liveability was recorded as 100 per cent which could be due to good management practices, good quality feed, suitable strain and favourable agro-climatic condition. The best performance index was observed during winter season (359.851) followed by monsoon (293.135) and summer season (279.858).

4.4.5 Carcass characteristics

The average dressing percentage, carcass yield and organ weight in different seasons are presented in table 4.4.5.

Table 4.4.5: Carcass characteristics of broiler birds during different seasons

Parameters	**Summer**	**Monsoon**	**Winter**
Dressing per cent	73.25	74.31	84.362
Carcass weight g/bird	2453.75	2586.188	2366.00
Organ weight (g)			
Heart	17.045	12.74	14.263
Liver	90.803	52.48	52.36
Gizzard	45.375	44.477	41.91
Spleen	7.875	4.842	3.166

The average dressing percentage of broiler birds at the end of sixth week during summer, monsoon and winter was 73.25, 74.31 and 84.362 per cent, respectively. Hence, dressing percentage was observed to be higher during winter season followed by monsoon season and the least in summer group. Conversely, Thirumalesh *et al*. (2012) had reported higher dressing percentage during rainy season as compared to summer and winter seasons.

The average carcass yield was observed to be higher during monsoon season followed by summer and the least in winter season. With respect to the organs weight (heart, liver, gizzard and spleen), the values were observed to be higher during summer season followed by monsoon and least was during winter.

4.4.6 Haematological / biochemical studies

4.4.6 Haematological studies

The effect of season, treatment and their interaction effect on the haematology and biochemical constituents of blood are presented in table 4.4.6, table 4.4.7 and table 4.4.8, respectively and their statistical analysis are given in Appendix 4.

Table 4.4.6: Effect of season on haematological / biochemical parameters

Season	Hb (g/dl)	WBC (10^3 /mm^3)	RBC (10^6 / mm^3)	PCV (per cent)	LDL (mg/dl)	HDL (mg/dl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)	Glucose (mg/ dl)
S1	9.916^c	24.12^a	2.788^{ab}	32.156^c	69.308^b	165.078^b	139.823	102.502	132.87^b
S2	10.700^b	22.00^b	2.842^a	34.744^b	63.978^b	300.166^a	152.160	111.696	131.92^b
S3	10.990^a	16.40^c	2.700^b	35.718^a	86.462^a	56.704^c	162.309	74.062	149.48^a
Sem (±)	0.070	0.489	0.026	0.173	1.837	11.453	8.490	13.852	3.110
CD(P=0.05)	0.271	1.903	0.100	0.671	7.150	44.565	33.038	53.901	12.101

a, b, c

Means bearing different superscript within the column differ significantly ($P<0.05$)

The perusal of table 4.4.6 had revealed significant seasonal effect on Hb, WBC, RBC, PCV, LDL, HDL and glucose. The overall mean values for haemoglobin (g/dl) was significantly higher during winter season and the least was in summer.

The overall WBC (10^3 /mm^3) values for summer, monsoon and winter season was 24.12, 22.00 and 16.40, respectively which was significantly higher during the summer season followed by monsoon and the least in winter.

The mean RBC ($10^6/mm^3$) was significantly ($P<0.05$) higher (2.842) during monsoon followed by summer and the least (2.700) in winter season. Hence, there was significant difference between seasons S_2 and S_3 however, difference between summer season (S_1) with monsoon (S_2) and winter (S_3) was found to be non-significant. The overall mean PCV (per cent) during summer, monsoon and winter season was 32.156, 34.744 and 35.718, respectively which was observed to be significantly higher in winter followed by monsoon and the least was in summer season.

The overall low density lipoprotein (LDL) was 69.308, 63.978 and 86.462 mg/dl, respectively. Highest ($P<0.05$) LDL value was observed in winter followed by summer and the least was in monsoon season. However, the difference between season S_1 and S_2 was found to be non- significant.

The overall high density lipoprotein (HDL) during summer, monsoon and winter season was 165.078, 300.166 and 56.704 mg/dl, respectively which was significantly higher in monsoon season followed by summer and the least in winter season.

The values for cholesterol (mg/dl) were 139.823, 152.160 and 162.309 during summer, monsoon and winter season, respectively. The corresponding values for triglycerides (mg/dl) was 102.502, 111.696 and 74.062.The perusal of table 4.4.6 revealed that cholesterol and triglycerides were unaffected by season.

The value for glucose (mg/ dl) was 132.87, 131.92 and 149.48 during summer, monsoon and winter season, respectively. Higher ($P<0.05$) glucose level was observed during winter followed by summer and the least during monsoon season. However, the difference between S_1 and S_2 was found to be non- significant.

Table 4.4.7: Effect of treatment on haematological / biochemical parameters

Treatment	WBC (10^3 /mm^3)	RBC (10^6 /mm^3)	Hb (g/dl)	PCV (per cent)	LDL (mg/dl)	HDL (mg/dl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)	Glucose (mg/dl)
T_1	13.35^d	2.61^c	10.43	33.84	66.12^b	150.96^{bc}	156.58	113.81^a	139.82
T_2	17.45^c	2.81^b	10.34	33.54	74.05^a	140.05^c	153.08	102.58^a	138.44
T_3	22.06^b	2.68^c	10.75	34.90	75.30^a	210.20^a	160.12	94.24^{ab}	135.15
T_4	30.56^a	3.01^a	10.64	34.54	77.54^a	194.71^{ab}	135.94	73.72^b	138.96
Sem (±)	0.441	0.036	0.165	0.585	1.706	15.601	10.317	6.626	3.277
CD(P=0.05)	1.457	0.120	0.545	1.935	5.642	51.608	34.127	21.920	10.842

a, b, c,

Means bearing different superscript within the column differ significantly (P<0.05)

As per the table 4.4.7, dietary supplementation of garlic had significant effect on WBC, RBC, LDL, HDL and triglycerides. The values for WBC was observed to be improved in groups fed with garlic based diet as compared to the control.

The values for WBC and RBC was significantly higher in groups fed with diet containing 0.75 per cent garlic powder while the control group obtained the lowest values for these parameters. Haemoglobin and PCV was unaffected by garlic supplementation.

The values for LDL showed an increasing trend with the increase in the level of garlic with the lowest in control and the highest in T_4 (0.75%). However, the difference among the garlic treated group was found to be non-significant. While HDL was significantly higher in T_3group with the least was in group (T_2).

Cholesterol and glucose level was unaffected by dietary supplementation of garlic while the level of triglycerides was decreased significantly ($P<0.05$) with the increase in the level of garlic. The level of triglycerides was least in groups fed with highest level of garlic (0.75%) and highest in control group (T_1).

Table 4.4.8: Interaction effect of season x treatment on haematological / biochemical parameters

SxT	WBC (10^3 /mm^3)	RBC (10^6 /mm^3)	Hb (g/dl)	PCV (per cent)	LDL	HDL	Cholesterol (mg/dl)	Triglycerides (mg/dl)	Glucose (mg/dl)
S_1T_1	18.00^{d}	2.56^{cd}	9.98	32.35	69.82^{de}	99.37	146.00	100.31^{ab}	139.35
S_1T_2	22.25^{c}	2.89^{ab}	9.92	32.18	72.35^{de}	125.11	138.23	125.20^{a}	134.47
S_1T_3	24.25^{c}	2.68^{c}	10.00	32.43	70.00^{de}	242.39	143.21	104.68^{ab}	131.51
S_1T_4	32.00^{a}	3.03^{a}	9.77	31.67	65.06^{e}	193.44	131.85	79.82^{bc}	126.18
S_2T_1	13.33^{e}	2.67^{cd}	10.49	34.04	49.21^{f}	297.12	149.50	158.88^{a}	133.80
S_2T_2	20.00^{cd}	3.07^{a}	11.00	35.72	66.27^{e}	245.34	138.53	77.73^{bc}	131.62
S_2T_3	22.33^{c}	2.70^{bc}	10.63	34.49	73.09^{cde}	326.65	173.42	123.72^{a}	119.25
S_2T_4	32.33^{a}	2.93^{a}	10.69	34.73	67.34^{e}	331.55	147.19	86.46^{abc}	143.01
S_3T_1	8.72^{f}	2.60^{cd}	10.82	35.13	79.31^{bcd}	56.40	174.23	82.23^{bc}	146.32
S_3T_2	10.10^{f}	2.47^{d}	10.09	32.73	83.52^{b}	49.70	182.49	104.81^{ab}	149.22
S_3T_3	19.61^{d}	2.67^{cd}	11.63	37.79	82.81^{bc}	61.57	163.73	54.33^{c}	154.69
S_3T_4	27.33^{b}	3.07^{a}	11.46	37.23	100.20^{a}	59.15	128.79	54.88^{c}	147.70
Sem (±)	0.763	0.063	0.070	1.013	2.954	27.022	17.869	11.477	5.67
CD (P=0.05)	2.524	0.208	0.271	3.352	9.773	89.387	59.109	37.966	18.778

a, b, c, d, e, f, g, h, i

Means bearing different superscript within the column differ significantly ($P<0.05$)

As per table 4.4.8, the values for WBC (10^3 /mm^3) was observed to be highest in group S_2T_4 (32.33) and the least was in S_3T_1 (8.72) while RBC (10^6 /mm^3) was found to be highest inS_2T_2 and S_3T_4 (3.07) and the least was in S_3T_2 (2.47).

The highest and the lowest level of haemoglobin (g/dl) was observed in S_3T_3 and S_1T_4, respectively.

The highest and the lowest PCV (per cent) level was recorded in S_3T_3 (37.79) and S_1T_4 (31.67), respectively. The corresponding values for LDL were 100.20 in $S_3T_4$and 49.21 in S_2T_1.

Higher HDL was recorded in S_2T_3 (326.65) and lowest HDL in S_3T_2 (49.70) while the corresponding values for cholesterol (mg/dl) was 182.49 in S_3T_2 and 128.79 in S_3T_4.

The highest and the lowest triglycerides (mg/dl) was observed in S_2T_1 (158.88) and S_3T_3 (54.33), respectively and the respective values for glucose (mg/dl) was observed in S_3T_3 (154.69) and S_2T_3 (119.25).

The perusal of table 4.4.8 had revealed that interaction effect of season x treatment had significant effect on the blood parameters with respect to WBC, RBC, LDL and triglycerides however, there was no significant difference in haemoglobin, packed cell volume, high density lipoprotein, cholesterol and glucose due to interaction effect of season x treatment.

Based on the above findings, it was observed that season S_1 had higher WBC values and least Hb and PCV values. Season S_2 had higher RBC, HDL and the least LDL. While season S_3 had higher Hb, PCV, and LDL and the least WBC, HDL and glucose values. Hence, season had significant influence on the blood haematology and biochemical parameters of broiler chicken. The present study was in line with what Jones (2005) who had stated that haematology varies with age, sex, seasons, environment and hormonal influence. Further the present study corroborated with the findings of

Mohamed *et al*. (2012) who had reported significant decrease in PCV, Hb and glucose due to seasonal effect.

In the treatment effect, garlic treated group had the lowest triglycerides and the highest WBC, RBC, LDL and HDL values. Garlic at 0.75 per cent (T_4) resulted in higher WBC, RBC, LDL and the lowest triglycerides values.

The interaction effect of season and treatment had significant effect on WBC, RBC, LDL and triglycerides. The interaction effect resulted in higher values for WBC, RBC and LDL and reduced triglycerides. In comparison to the values reported by Maxwell *et al*. (2012); El- Amin (2011) and wikivet (2012), almost all the values for the haematological parameters were within the range reported by these researchers and also the reference value reported by G.C. Banerjee. Meanwhile the biochemical constituents (COL, HDL, LDL, Triglycerides) was observed to be higher than the values reported by Issa and Omar (2012); Puvaca *et al*. (2014) and Broska *et al*. (2015) which might be due to the fat content of the feed, type of bird, age etc as also stated by Nambol *et al.* (2016) who also observed higher cholesterol values in broiler birds.

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Feed represents the major part of cost in poultry production. There has been a pressing need to develop ideal, safe and cost effective feed that will virtually meet all aspects of production and reproduction. As a result, numerous works have been carried out using different types of feed additives which could potentially reduce feed cost, enhance broiler performance and improve quality of the product. Due to the increased consumers concern over drug residues in meat and bacterial resistance, environmental contamination and general health, there has been a rising trend in research that is focussed on using natural products such as essential oils and extracts of edible and medicinal plants, herbs and spices to develop novel products in animal and poultry feeding. Garlic is one such herbal product which has been identified to have positive effect on the performance of broilers. Garlic contains bioactive substances that act as antibacterial, antifungal, antiparasitic, antiviral, antioxidant and antithrombotic. Garlic is also widely used in this region as a spice and in traditional medicines for human as well as for animal. Considering the benefits of garlic and its possible use as an alternative to antibiotic growth promoters, the present investigation was conceived to study the effects of garlic on the performance of broilers in terms of growth, feed efficiency, liveability, performance index, carcass traits and blood profile of broilers under the agro-climatic condition of Nagaland.

In order to carry out the present study, day old Cobb-400 strain of broilers were reared during three seasons *viz.* winter (November – February), summer (March – June) and rainy (July – October) with 120 numbers in each season. The experiment was done as per Completely Randomized Design. Birds were randomly divided into four treatment groups (T_1, T_2, T_3 and T_4) of 30 birds each with 5 replications having 6 birds in each replicate. Group T_1

served as control and the other groups *i.e.* T_2, T_3 and T_4 were fed with basal diet supplemented with garlic powder at the level of 0.25, 0.50 and 0.75 per cent, respectively.

Summer

Body weight

Average body weight in different groups recorded at the end of the 6^{th} week was 2189.50 ± 28.62, 2262.90 ± 58.15, 2269.60 ± 27.89 and 2314.63 ± 63.55 g per bird, respectively. Numerically, body weight was observed to be higher in garlic treated groups. However, statistically, there was no difference in the average body weight among the different treatment groups under the prevailing agro-climatic condition.

Body Weight gain

Total gain in weight was 2138.698 ± 28.62, 2214.020 ± 58.15, 2218.692 ± 27.89 and 2263.68 ± 3.98 g/bird/week. Statistical analysis had revealed that there was no variation in weight gain due to garlic supplementation.

Feed Consumption

Total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 3862.46 ± 53.23, 3952.83 ± 35.92, 3890. 46 ± 27.15 and 4001.86 ± 53.14 g per bird, respectively. Numerically, feed consumption was higher in birds fed with garlic based diet. However, statistically it was revealed that there was no significant difference between the control and the birds fed with garlic treated feed.

Feed conversion Efficiency (FCE)

Mean feed efficiency of broiler birds in different treatment groups at the end of the study was recorded as 0.554 ± 0.0052, 0.560 ± 0.0107, 0.570 ± 0.0092 and 0.565 ± 0.0089. Though the FCE was observed to be better in the garlic treated groups, the statistical analysis of the data had revealed that there was non- significant difference in feed efficiency.

Mortality/Liveability and Performance Index

Irrespective of the treatment, the mortality percentage of broiler birds was recorded as zero per cent.

The performance index for T_1, T_2, T_3 and T_4groups were calculated as 266.96 ± 4.93, 279.02 ± 12.06, 285.18 ± 7.87 and 288.27 ± 12.29, respectively. The values for performance index was observed to be higher in groups fed with garlic based diet however, the statistical analysis did not reveal any significant effect on this parameter.

Carcass Characteristics

Average dressing percentage of broiler birds at the end of sixth week in different groups T_1, T_2, T_3 and T_4 was 72.22, 73.57, 74.03 and 73.19 per cent, respectively and the corresponding average carcass weight of birds was 2203.50, 2638.00, 2573.00 and 2400.50 g/bird. The garlic treated groups showed higher values for dressing per cent, carcass and the organs yield though statistically there was no difference.

Haematological parameters

Haemoglobin

Haemoglobin values for$T_{1,}$ T_2, T_3 and T_4 was 9.98 ± 0.18, 9.92 ± 0.35, 9.99 ± 0.41 and 9.77 ± 0.19 g/dl, respectively. There was no significant effect of garlic on haemoglobin due to inclusion of garlic in broiler feed.

Total White Blood Cells Count

Values for total white blood cells **(**$10^3/mm^3$) was 18.0 ± 5.67, 22.3 ± 7.73, 24.3 ± 7.96 and 32.0 ± 9.44. Statistical analysis had indicated difference ($P<0.05$) in total white blood cells. The value for total WBC was maximum at 0.75 per cent garlic (T_4) and the least was in control group T_1.

Total Red Blood Cells Count

Total red blood cells ($10^6/mm^3$) for the groups $T_{1,}$ T_2, T_3 and T_4 was 2.56 ± .03, 2.89 ± 0.04, 2.68 ± 0.05 and 3.03 ± 0.06, respectively. Statistical analysis had shown significant ($P<0.05$) difference on total red blood cells between the groups fed on 0% and those fed on 0.25, 0.50 and 0.75 per cent levels of garlic powder.

Packed Cells Volume

Packed cells volume recorded for the treatment groups $T_{1,}$ T_2, T_3 and T_4 was 32.35 ± 0.62, 32.18 ± 1.15, 32.43 ± 1.35 and 31.67 ± 0.61 per cent, respectively. There was no significant effect on packed cells volume due to inclusion of garlic in broiler feed.

Differential white blood cells count

Values for heterophilsand lymphocytes was 30 ± 2.08, 27 ± 2.08, 28 ± 3.28 and 23 ± 2.03 per cent; 69 ± 2.5, 71 ± 2.96, 71 ± 3.21 and 75 ± 1.45 per cent for T_1, T_2, T_3 and T_4, respectively. Basophils and eosinophils was recorded as nil irrespective of the groups. There was no significant effect on differential white blood cells count due to inclusion of garlic in broiler feed.

Biochemical parameters

Low Density Lipoprotein

Low density lipoprotein for T_1, T_2, T_3 and T_4 was 69.82 ± 1.50, 72.35 ± 1.63, 69.99 ± 1.54 and 65.06 ± 1.09 mg/dl, respectively. Garlic supplementation had significant effect on LDL and the values was observed to be significantly ($P<0.05$) higher at 0.25 per cent level of garlic and the least was in T_4 group (0.75 per cent).

High Density Lipoprotein

The average values for high density lipoprotein for the groups T_1, T_2, T_3 and T_4, was 99.37 ± 20.80, 125.11 ± 31.98, 242.39 ± 39.20 and 193.44 ± 38.98 mg/dl, respectively and the values were found to be higher ($P<0.05$) in garlic treated groups as compared to the control.

Glucose

The average values for glucose (mg/dl) was 139.346 ± 12.18, 134.46 ± 9.11, 131.509 ± 7.27 and 126.183 ± 7.06 for T_1, T_2, T_3 and T_4, respectively. Highest glucose value of 139.346 ± 12.18 mg/dl and the least 126.183 ± 7.06 mg/dl was observed in T_1 and T_4, respectively.

Triglyceride

The mean values for triglyceride was 100.31 ± 20.84, 125.2 ± 29.45, 66.68 ± 18.15 and 79.82 ± 14.09 for T_1, T_2, T_3 and T_4 respectively. The highest and the least triglyceride value was observed at 0.25 per cent (T_2) and T_3 (0.50 per cent), respectively.

Cholesterol

The mean values for cholesterol was 146.00 ± 7.28, 138.23 ± 19.23, 143.21 ± 24.23 and 131.85 ± 24.35 for T_1, T_2, T_3 and T_4 respectively. Numerically the values for cholesterol was lower in garlic treated groups.

Economics

Total production cost per broiler was highest in T_4 followed by T_3, T_2 and T_1 which was evidently due to higher feed intake and cost incurred due to addition of garlic. The cost of production in terms of per kg live weight of broiler was lowest in T_3 *i.e.* Rs. 83.407 followed by T_2, T_4 and the highest in control group. The net profit per kg gain of broiler was highest in T_3 which was Rs. 48.165 as compared to the other treatment groups.

Monsoon Season

Body weight

Body weight in different groups recorded at the end of the 6^{th} week was 2269.83 ± 71.76, 2188.93 ± 44.17, 2281.87 ± 51.44 and 2297.93 ± 31.81 g per bird. There was no significant difference in the average body weight obtained by birds that received garlic based diet and the control group under the prevailing agro-climatic condition and the body weight was observed to be uniform.

Gain in body weight

The total body weight gain was 2226.96 ± 71.76, 2146.11 ± 44.17, 2236.76 ± 51.44 and 2253.60 ± 31.81 g/bird/week. Body weight gain was unaffected by garlic supplementation.

Feed Intake

The total feed intake during the entire trial period for T_1, $T_{2,}$ T_3 and T_4 groups was 3946.55 ± 1.20, 3650.80 ± 27.23, 3687.90 ± 55.47and 3780.27 ± 56.95 g per bird, respectively. Feed intake was higher ($P<0.05$) in control group *i.e.* T_1 followed by T_4, T_3 and the least in T_2.

Feed Conversion Efficiency

The mean feed conversion efficiency of broiler birds in different groups at the end of sixth week was recorded as 0.565 ± 0.012, 0.586 ± 0.014, 0.608 ± 0.012 and 0.598 ± 0.010 for T_1, T_2, T_3 and $T_{4,}$ respectively. Analysis of variance revealed significant effect of garlic on feed conversion efficiency which was found to be better in garlic supplemented group. The values for feed conversion efficiency was significantly ($P<0.05$) lowest in T_1 followed by T_2, T_4 and the highest was in T_3.

Mortality/Liveability and Performance Index

Irrespective of all the groups the mortality percentage of broiler birds from day old to six weeks of age was zero per cent. The performance index for T_1, T_2, T_3 and T_4 groups was calculated as 282.286 ± 12.478, 283.760 ± 12.588, 301.658 ± 11.332 and 304.83 ± 7.577, respectively. Though the values were observed to be higher in garlic treated groups, statistically there was no significant effect of garlic on performance index.

Carcass characteristics

The average dressing percentage of broiler birds at the end of sixth week in different groups T_1, T_2, T_3 and T_4 was 73.60, 74.93, 74.40 and 74.31 per cent, respectively. The average carcass weight of broiler birds in different experimental groups was 2623.75, 2740.75, 2453.75 and 2526.50 g/bird for T_1, T_2, T_3 and T_4 groups, respectively.

The average heart weight, liver, gizzard and spleen weight for T_1 , T_2, T_3 and T_4 was 12.84, 51.09, 40.68 and 3.91 g; 13.40, 58.03, 49.58 and 5.05 g; 11.62, 50.06, 44.05 g and 4.62; 13.10, 50.74, 43.60 and 5.79 g, respectively.

Statistical analysis had revealed that there was no significant effect of garlic on the dressing per cent, carcass yield and organ weight of broilers.

Haematological parameters

Haemoglobin

The values for haemoglobin (g/dl) was 10.49 ± 0.17, 11.00 ± 0.49, 10.63 ± 0.21 and 10.69 ± 0.26 for T_1, T_2, T_3 and T_4, respectively. The hematological parameter haemoglobin did not show significant different between the treatment and control groups of broilers.

Total White Blood Cells Count

The values for total white blood cells ($10^3/mm^3$) was 13.3 ± 1.20, 20.0 ± 1.15, 22.3 ± 1.45 and 32.3 ± 1.45. The group T_4 had significantly ($P<0.05$) higher total white blood cell followed by T_3, T_2 and the least was in control group T_1.

Total Red Blood Cells Count

The total red blood cells ($10^6/mm^3$) for the groups $T_{1,}$ T_2, T_3 and T_4 was 2.67 ± 0.08, 3.07 ± 0.12, 2.70 ± 0.15and 2.93 ± 0.03, respectively. The values for RBC was observed to be higher in the garlic treated group.

Packed Cells Volume

The packed cells volume recorded for the treatment groups $T_{1,}$ T_2, T_3 and T_4 was 34.04 ± 0.56, 35.72 ± 1.62, 34.49 ± 0.74 and 34.73 ± 0.88 per cent, respectively however, there was no significant difference between the garlic treated groups and the control groups for this parameter..

Differential white blood cells count

The values for monocytes and basophils was observed to be nil while the mean values for heterophils, eosinophils and lymphocytes was observed to be 48, 40, 46 35 ; 2, 1, 1, 1 and 49, 58, 52 and 63 per cent for $T_{1,}$ T_2, T_3 and $T_{4,}$ respectively. Statistically, differential white blood cells count was unaffected by garlic supplementation.

Biochemical parameters

Low Density Lipoprotein

The mean values for LDL was recorded as 39.21 ± 11.86, 56.27 ±17.36, 67.09 ± 17.31, 67.34 ± 05.24 mg/dl for the treatment groups T_1, T_2, T_3 and T_4, respectively.

High Density Lipoprotein

The values for HDL was 297.122 ± 18.45, 245.34 ± 67.49, 326.65 ± 33.16 and 331.55 ± 27.22 mg/dl.

Glucose

The mean values for glucose was recorded was 133.7 ± 4.18, 131.61 ± 3.89, 192.5 ± 16.67 and 143.00 ± 1.78 mg/dl for T_1, T_2, T_3 and T_4 groups, respectively.

Triglyceride

The mean values for triglycerides (mg/dl) was observed to be 158.87 ± 14.19, 77.72 ± 13.73, 123.72 ± 9.04 and 86.46±13.05 for T_1, T_2, T_3 and T_4, respectively. The highest amount of triglycerides (158.87 ± 14.19 mg/dl) was observed in treatment T_1.

Cholesterol

The values for cholesterol (mg/dl) was recorded to be 149.50 ± 9.18, 138.53 ± 46.67, 173.42 ± 22.59 and 147.19 ± 41.46.

LDL, HDL, glucose and cholesterol was unaffected due to garlic supplementation. However, addition of garlic powder had positive effect on the blood lipid profile particularly for triglycerides.

Economics

The total production cost per broiler and per kg live weight was highest in T_4 (187.51/-) and T_1 (82.48/-), respectively. The net return per bird and per kg live weight of broiler was observed to be higher in garlic supplemented group. Groups supplemented with 0.50 per cent garlic obtained highest net profit per bird and net profit per kg live weight.

Winter Season

Body weight

The final body weight recorded at the end of the 6^{th} week was 2602.832 ± 39.70, 2524.000 ± 58.91, 2443.998 ± 15.62 and 2566.098 ± 60.49 g per bird, respectively. The mean body weight was observed to be significantly higher for the control group T_1 followed by T_4, T_2 and the least was in T_3.

Gain in Body Weight

The overall total body weight gain was 2560.866 ± 39.70, 2481.532 ± 58.90, 2402.997 ± 15.60, 2485.931 ± 22.60 g per bird per week. Statistical analysis had revealed that there was significant difference in overall gain in weight. The mean gain in weight was significantly higher in group T_1 followed by T_4, T_2 and the least was in $T_{3.}$

Feed Intake

The total feed intake during the entire trial period for T_1, $T_{2,}$ T_3 and T_4 groups was 4264.125 ± 47.40, 4028.015 ± 33.90, 4046.052 ± 32.00 and 4035.381 ± 37.90 g per bird, respectively. The statistical analysis had revealed significant difference in feed intake among the treatment groups. Feed intake in control group T_1 was found to be significantly ($P<0.05$) higher as compared to the other treatment groups.

Feed conversion Efficiency (FCE)

The overall mean FCE for T_1, $T_{2,}$ T_3 and T_4 groups was 0.643 ± 0.0598, 0.648 ± 0.0185, 0.640 ± 0.00468 and 0.653 ± 0.00458. The statistical analysis had revealed significant variation among the treatment groups. The values for feed conversion efficiency were significantly higher in T_4 followed by T_2, T_1 and the lowest was in T_3.

Mortality/Liveability and Performance Index

Irrespective of the treatment, the mortality percentage of broiler birds from day old to six weeks of age was zero per cent. Liveability per cent was recorded to be 100 per cent in all the groups. The performance index for T_1, T_2, T_3 and T_4 groups were calculated as 366.882 ± 8.423, 371.456 ± 17.212, 337.502 ± 4.504 and 363.624 ± 6.509, respectively. The statistical analysis revealed had significant ($P<0.05$) variation in performance index among the treatment groups. The performance index of broiler birds was observed to be significantly highest inT_2 (371.456) and the lowest was in T_3 (337.502 ± 4.504).

Carcass Characteristics

The highest dressing percentage and carcass yield was observed in T_4 (85.412 per cent and 2508.00 g / bird, respectively). Liver, Gizzard and spleen weight was also observed to be higher in group T_4. However, statistical analysis had shown that carcass characteristics and organs weight was unaffected by garlic supplementation.

Haematological parameters:

Haemoglobin

The mean values for haemoglobin (g/dl) was 10.817 ± 0.19, 10.087 ± 0.26, 11.627 ± 0.27 and 11.45 ± 0.18 g/dl for T_1, T_2, T_3 and T_4, respectively. The values for haemoglobin was significantly higher for groups fed with 0.5 per cent (T_3) garlic followed by T_4, T_1 and the least was in T_2 (0.25 per cent).

Total White Blood Cells Count

The values for total white blood cells **(**$10^3/mm^3$) for T_1, T_2, T_3 and T_4 groups was 8.733 ± 2.80, 10.10 ± 4.50,19.60 ± 1.20 and 27.3 ± 1.40, respectively. The white blood cells count was significantly higher for the groups fed with 0.75% (T_4) garlic powder followed by T_3, T_2 and the least was in control.

Total Red Blood Cells Count

The total red blood cells ($10^6/mm^3$) for the groups T_1, T_2, T_3 and $T_4$was 2.6 ± 0.05, 2.46 ± 0.03, 2.66 ± 0.08 and 3.06 ± 0.06, respectively The red blood cells count was significantly highest in T_4 followed by T_3, T_1 and the least in T_2 group. However, the difference among the treatment groups T_1, T_2 and T_3 was found to be non- significant.

Packed Cells Volume

The packed cells volume recorded for the respective groups was 35.126 ± 0.63, 32.72 ± 0.88, 37.79 ± 0.89 and 37.22 ± 0.6 per cent. The values for packed cells volume was recorded to be significantly higher for group fed with diet supplemented with 0.50 per cent (T_3) garlic powder followed by T_4, T_1 and the least was in T_2 (0.25 per cent).

Differential white blood cells count

The mean values for monocytes and basophils was recorded as nil in all the treatment groups while the values for heterophils was 57.60 ± 1.30,62.00 ± 20,63.60 ± 4.10 and 71.30 ± 1.30 per cent for T_1, T_2, T_3 and T_4, respectively. Irrespective of the groups, the mean values for eosinophils was 0.33 ± 0.33. Lymphocytes count was 42.00 ± 1.5, 37.66 ± 1.8, 36.00 ± 4.00, 28.30 ± 1.20 for T_1, T_2, T_3 and T_4, respectively. Significantly higher value was recorded in control group T_1 followed by T_2, T_3 and the least in T_4 but the difference among T_1, T_2 and T_3 and between T_3 and T_4 was non- significant.

Biochemical parameters

Low Density Lipoprotein

The mean values for low density lipoprotein (mg/dl) was 79.30 ± 6.62, 83.50 ± 3.19, 82.80 ± 8.78 and 100.20 ± 4.82 for T_1, T_2, T_3 and T_4, respectively. Statistically there was non - significant difference among the treatment groups.

High Density Lipoprotein

The values for high density lipoprotein (mg/dl) was 56.39 ± 4.30, 49.70 ± 1.04, 61.50 ± 3.52, 59.14 ± 3.96. There was non-significant difference among the treatment groups.

Glucose

The values for glucose (mg/dl) for the treatment groups T_1, T_2, T_3 and T_4 was 146.32 ± 10.2, 149.22 ± 3.56, 154.69 ± 0.29, 147.32 ± 6.19, respectively. Glucose was unaffected by garlic supplementation.

Triglyceride

The values for triglycerides (mg/dl) was 82.20 ± 15.70, 104.80 ± 25.53, 54.30 ± 5.13, 54.80 ± 2.23, respectively. Numerically, there was slight decrease in the values for triglycerides at higher level of garlic supplementation. However, statistically there was no significant effect due to garlic supplementation.

Cholesterol

The values for Cholesterol (mg/dl) was 174.20 ± 12.31, 182.40 ± 15.61, 163.70 ± 29.68, 128.70 ± 6.03, respectively. Numerically, there was slight decrease in the level of cholesterol at higher level of garlic supplementation.

However, statistically there was no significant effect due to garlic supplementation.

Economics

The total cost of production for T_1, T_2, T_3 and T_4 were 189.008, 182.463, 187.897 and 189.353 rupees per bird, respectively. The corresponding values for average cost of production per kg live weight of bird was 72.69, 72.98, 77.00 and 73.97 rupees, respectively.

The net profit per bird was 150.202, 143.687, 130.463 and 145.377 rupees, respectively for T_1, T_2, T_3 and T_4 groups and the corresponding values for net profit per kg weight gain of bird was 58.72, 58.48, 54.38 and 57.82 rupees, respectively. The net profit per bird was highest in T_1 followed by T_4, T_2 and the least was in T_3 while the net profit per kg weight gain of the broiler was highest in T_1 (Rs. 58.72) followed by T_2, T_4 and the least was in T_3 (Rs. 53.40).

INTERACTION EFFECT

Effect of season on overall growth and feed parameters

The average final body weight of the birds during summer (S_1), rainy (S_2) and winter (S_3) season was 2259.106, 2259.642 and 2534.399 g per bird, respectively. The corresponding values for gain in weight was 2208.773, 2215.986 and 2482.831. Feed intake for S_1, S_2 and S_3 was recorded to be 3926.906, 3766.374 and 4093.641, respectively while the feed efficiency (gain/feed) for the respective seasons was 0.562, 0.589 and 0.644.The performance index was recorded to be 279.855, 293.134 and 359.867 for S_1, S_2 and S_3, respectively. Season had significant effect on all the overall growth and feed parameter. The body weight and gain in weight was found to be significantly ($P<0.05$) higher during winter season followed by monsoon and the least in summer season.

Feed intake was significantly ($P<0.05$) higher during winter season (S_3) followed by summer (S_1) and the least in monsoon (S_2) season. The best feed efficiency and performance index was observed during the winter season followed by monsoon and the least was in summer.

Effect of treatment on overall growth and feed parameters

Statistically, body weight and gain in weight was unaffected by garlic supplementation. Feed intake was significantly higher in control group T_1 followed by T_4, T_2 and the least was at 0.50 per cent (T_3) garlic supplementation. The feed conversion efficiency and the performance index was unaffected by garlic supplementation.

Interaction effect of season x treatment on overall growth and feed parameters

The highest and the lowest body weight per bird due to the interaction effect of season and treatment was observed in S_3 T_1 (2602.83 g) and S_2 T_2 (2188.93 g), respectively while the corresponding values for the total gain in weight was observed in S_3 T_1 (2560.87 g) and S_1 T_1 (2138.70 g). The overall feed intake per bird was highest during winter season in control group S_3 T_1 and the lowest was in monsoon at 0.25 per cent level of garlic (S_2 T_2). The overall FCE value was maximum (0.66) during winter season at 0.25 per cent level of garlic (S_3 T_2) and the least (0.55) was in summer in control group S_1 T_1. Interaction effect of season x treatment had significant effect only on feed intake.

Mortality/Liveability and Performance Index

Irrespective of season and the treatments, the mortality percentage was zero per cent while liveability percentage was recorded as 100 per cent. The best performance index was observed during winter season followed by monsoon and summer season.

Dressing percentage, Carcass yield and Organ weight

Dressing per cent was maximum during winter followed by monsoon and summer season. The average carcass yield was observed to be higher during monsoon season followed by summer and the least in winter season. With respect to the organs weight (heart, liver, gizzard and spleen), the values were observed to be higher during summer season followed by monsoon and least was during winter.

Effect of season on Haematological / Biochemical parameters

The overall WBC (10^3 /mm^3) values for summer, monsoon and winter season was 24.125, 22.00 and 16.440, respectively which was significantly higher during the summer season followed by monsoon and the least in winter.

The mean values for haemoglobin (g/dl) was significantly higher during winter season and the least was in summer.

The mean RBC (10^6/mm^3) was significantly ($P<0.05$) higher (2.842) during monsoon followed by summer and the least (2.700) in winter season.

The overall mean PCV (per cent) during summer, monsoon and winter season was 32.156, 34.744 and 35.718, respectively which was observed to be significantly higher in winter followed by monsoon and the least was in summer season.

The overall low density lipoprotein (LDL) was 69.308, 63.978 and 86.462 mg/dl, respectively. Highest ($P<0.05$) LDL value was observed in winter followed by summer and the least was in monsoon season. However, the difference between season S_1 and S_2 was found to be non- significant.

The overall high density lipoprotein (HDL) during summer, monsoon and winter season was 165.078, 300.166 and 56.704 mg/dl, respectively which was significantly higher in monsoon season followed by summer and the least in winter season.

The values for cholesterol (mg/dl) were 139.823, 152.160 and 162.309 during summer, monsoon and winter season, respectively.

The corresponding values for triglycerides (mg/dl) was 102.502, 111.696 and 74.062.

The value for glucose (mg/ dl) was 132.87, 131.91 and 149.48 during summer, monsoon and winter season, respectively. However, the difference between S_1 and S_2 was found to be non- significant.

Effect of treatment on Haematological / Biochemical parameters

The dietary supplementation of garlic had significant effect on WBC, RBC, LDL, HDL and triglycerides. The values for WBC was observed to be improved in groups fed with garlic based diet as compared to the control. RBC was significantly higher in groups fed with diet containing 0.75 per cent garlic powder (T_4) followed by T_2, T_3 and the least was in control group T_1. Haemoglobin and PCV was unaffected by garlic supplementation. The values for LDL showed an increasing trend with the increase in the level of garlic with the lowest in T_1 followed by T_2, T_3 and the highest in T_4. HDL was significantly higher in T_3 followed by T_4, T_1 and the least was in T_2. Cholesterol and glucose level was unaffected by dietary supplementation of garlic while the level of triglycerides was decreased significantly (P<0.05) with the increase in the level of garlic.

Interaction effect of season x treatment on Haematological / Biochemical parameters

The interaction effect of season x treatment had significant effect on the blood parameters with respect to WBC, RBC, LDL and triglycerides however, there was no significant difference in haemoglobin, packed cell volume, high density lipoprotein, cholesterol and glucose due to interaction effect of season x treatment. Hence, higher level of garlic (0.5 and 0.75 per cent) during monsoon and winter season had showed positive effect on most of the blood parameters including WBC, RBC, Hb, PCV, HDL, COL and triglycerides in broiler chicken.

Conclusion

1. During summer season, there was no significant difference in the average final body weight, gain in weight, feed intake, feed efficiency and performance index within the level of garlic supplemented (0, 0.25, 0.5 and 0.75 per cent) in the present study under the prevailing agro-climatic condition. Irrespective of the treatment, mortality was zero per cent. Hence, liveability percentage was recorded to be 100 per cent in all the groups. There was non- significant difference on dressing per cent, carcass yield and organ weight within the level of garlic used. Significantly (P<0.05) higher WBC and RBC was observed in birds treated with garlic at 0.75 per cent, intermediate at 0.25 and 0.50 per cent and the least in control group while haemoglobin, packed cells volume and differential white blood cells count were unaffected by inclusion of garlic in broiler feed. Supplementation of garlic had significant effect on LDL and HDL. The values for LDL were observed to be significantly (P<0.05) higher at 0.25 per cent garlic and the least at 0.75 per cent. HDL values were found to

be significantly ($P<0.05$) higher in garlic treated groups as compared to the control. Glucose, triglycerides and cholesterol were unaffected by garlic supplementation in broiler feed. The cost of production in terms of per kg live weight of broiler was lowest in T_3 *i.e.* Rs. 83.407 followed by T_2, T_4 and higher in control group while the net profit per kg gain of broiler was highest in T_3 (0.50 per cent) which was Rs. 48.165 and the least was in T_4 (Rs. 46.284). Hence, it is concluded that during summer season performance of broiler in terms of body weight, gain in weight, feed conversion efficiency, performance index, carcass weight was unaffected by garlic. Garlic treated groups had higher net return with the highest at 0.50 per cent garlic. Further, there was positive impact of garlic on blood profile of broiler chicken particularly for WBC, RBC, LDL and HDL.

2. During monsoon, there was no significant effect of garlic on average final body weight and body weight gain. Feed intake was significantly ($P<0.05$) higher in control group T_1. While feed conversion efficiency which was found to be better in garlic supplemented group with the best in T_3 and the poorest in T_1. Irrespective of all the groups, the mortality per cent was zero so liveability percentage was recorded to be 100 per cent in all the groups. The values for performance index was higher in garlic treated groups as compared to control. However, it was found to be non- significant. Similarly dressing percentage, carcass yield and organ weights of broilers was unaffected by garlic.The hematological parameters haemoglobin, PCV and differential white blood cells count did not show significant different between the treatment and control groups of broilers.However, supplementation of garlic had significant ($P<0.05$) effect on total white blood cells and total red blood cells count and the values were observed to be higher in the garlic treated group. Further, addition of garlic powder had positive effect on the blood lipid profile particularly for triglycerides. The total cost of production rupees per kilogram weight highest in T_1 and the least in T_3. While the highest net profit per kilogram gain in

weight of broiler was observed in T_3. Hence, during monsoon season performance of broiler in terms of gain in weight, feed conversion efficiency, performance index and net profit was better in garlic treated groups at 0.50 and 0.75 per cent as compared to the other treatment groups. Further, there was positive impact of garlic on blood profile of broiler chicken particularly for WBC, RBC and triglycerides.

3. During winter season, final body weight and gain in weight were observed to be higher in control group and lower in garlic treated group. Feed intake was also maximum in control group T_1 however, feed efficiency was best at 0.75 per cent garlic and least was at 0.50 per cent garlic supplementation. Performance index was highest at 0.25 per cent (T_2) and the least was at 0.50 per cent (T_3). Irrespective of the treatment, mortality was zero per cent. Hence, liveability percentage was recorded to be 100 per cent in all the groups. There was no significant difference on dressing per cent, carcass yield and organ weights within the level of garlic used. Garlic supplementation had significant effect on haemoglobin, WBC, RBC, PCV, heterophils and lymphocytes which was observed to be improved in garlic treated groups however, the biochemical constituents *viz*. LDL, HDL, glucose, triglycerides and cholesterol were unaffected by garlic supplementation. The total cost of production per broiler was the least in T_2 groups while the cost of production per kg live weight of broiler was lowest in T_1 *i.e*. Rs. 72.69 followed by T_2, T_4 and the highest in T_3 groups. The net profit per bird was highest in T_1 followed by T_4, T_2 and the least was in T_3 while the net profit per kg live weight of the broiler was highest in T_2 (Rs. 57.42) followed by T_4, T_1 and the least was in T_3 (Rs. 53.40). Hence, it was concluded that during winter season performance of broiler in terms of body weight, gain in weight, feed conversion efficiency, performance index and net profit was better in control group while the values for haematological parameters, except PCV and lymphocytes, increased linearly in garlic treated groups.

4. Season had significant effect on the overall growth and feed parameters. Performance of broiler in terms of body weight, weight gain, feed efficiency and performance index was best during the winter season while treatment (garlic) had significant effect only on overall feed intake which was higher in control group. Similarly, interaction of season x treatment had significant effect only on feed intake. The values for dressing percentage and carcass yield was higher in winter and monsoon, respectively while organ weights were observed to be higher during summer season. Season had significant effect on white blood cells, red blood cells, haemoglobin, packed cell volume, low density lipoprotein and glucose while treatment had significant influence on WBC, RBC, LDL, HDL and triglycerides. The interaction of season and treatment had significant effect on WBC, RBC, LDL and triglycerides. The interaction effect resulted in higher values for WBC (S_2T_4), RBC (S_2T_2 and S_3T_4) and LDL (S_2T_1) and reduced triglycerides (S_3T_3).

Future Plan:

1. Similar studies under extensive and semi intensive system of rearing can be carried out for longer duration in different genotypes of poultry under the prevailing agroclimatic condition of Nagaland in order to derive valuable information and ascertain its positive effect on the productive and reproductive aspects of birds.

2. Comparative studies on the efficacy of garlic and other herbal products on the health aspects of broiler and other local germplasm to popularise it at farmers level.

3. Further studies using garlic as an alternative to antibiotic growth promoter on other species of livestock can be beneficial

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APPENDICES

APPENDIX -1 (SUMMER SEASON)

BodyWeight		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	5	2189.2960
T_2	5	2262.8980
T_3	5	2269.5990
T_4	5	2314.6312
Sig.		.104
Means for groups in homogeneous subsets are displayed.		

Body Weight Gain		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	5	2138.6980
T_2	5	2214.0200
T_3	5	2218.6920
T_4	5	2263.6802
Sig.		.105
Means for groups in homogeneous subsets are displayed.		

FeedIntake		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	5	3862.4650
T_2	5	3890.4660
T_3	5	3952.8314
T_4	5	4001.8620
Sig.		.054
Means for groups in homogeneous subsets are displayed.		

FEED CONVERSION EFFICIENCY		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	5	.5538
T_2	5	.5600
T_4	5	.5650
T_3	5	.5706
Sig.		.229
Means for groups in homogeneous subsets are displayed.		

PERFORMANCE INDEX		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	5	266.9560
T_2	5	279.0150
T_3	5	285.1767
T_4	5	288.2719
Sig.		.175
Means for groups in homogeneous subsets are displayed.		

DRESSINGPERCENTAGE		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	4	72.2250
T_4	4	73.1875
T_2	4	73.5775
T_3	4	74.0275
Sig.		.387
Means for groups in homogeneous subsets are displayed.		

Haematological/Biochemical Parameters

HAEMOGLOBIN		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_4	8	9.7674
T_2	8	9.9231
T_1	8	9.9750
T_3	8	9.9970
Sig.		.627
Means for groups in homogeneous subsets are displayed.		

WBC				
Duncan				
Treatment	N	Subset for alpha = 0.05		
		1	2	3
T_1	8	1.8000E4		
T_2	8		2.2250E4	
T_3	8		2.4250E4	
T_4	8			3.2000E4
Sig.		1.000	.081	1.000
Means for groups in homogeneous subsets are displayed.				

RBC				
Duncan				
Treatment	N	Subset for alpha = 0.05		
		1	2	3
T_1	8	2.5625		
T_3	8	2.6750		
T_2	8		2.8875	
T_4	8			3.0250
Sig.		.083	1.000	1.000
Means for groups in homogeneous subsets are displayed.				

PCV		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_4	8	31.6675
T_2	8	32.1800
T_1	8	32.3512
T_3	8	32.4250
Sig.		.626
Means for groups in homogeneous subsets are displayed.		

MONOCYTES		
Duncan		
TREATMENT	N	Subset for alpha = 0.05
		1
T_3	3	.3333
T_4	3	.6667
T_1	3	1.0000
T_2	3	1.6667
Sig.		.207
Means for groups in homogeneous subsets are displayed.		

HETEROPHILS		
Duncan		
TREATMENT	N	Subset for alpha = 0.05
		1
T_4	3	23.3333
T_2	3	27.0000
T_3	3	28.6667
T_1	3	30.0000
Sig.		.105
Means for groups in homogeneous subsets are displayed.		

LYMPHOCYTES		
Duncan		
TREATMENT	N	Subset for alpha = 0.05
		1
T_1	3	69.0000
T_3	3	71.0000
T_2	3	71.3333
T_4	3	75.3333
Sig.		.147
Means for groups in homogeneous subsets are displayed.		

LDL			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_4	8	65.0611	
T_1	8	69.8245	69.8245
T_3	8	69.9979	69.9979
T_2	8		72.3481
Sig.		.120	.422
Means for groups in homogeneous subsets are displayed.			

HDL			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_1	8	99.3720	
T_2	8	125.1106	
T_4	8	193.4372	193.4372
T_3	8		242.3934
Sig.		.070	.311
Means for groups in homogeneous subsets are displayed.			

Glucose		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_4	8	126.1832
T_3	8	131.5097
T_2	8	134.4685
T_1	8	139.3467
Sig.		.362
Means for groups in homogeneous subsets are displayed.		

TRIGLYGERIDES		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_3	8	66.6776
T_4	8	79.8230
T_1	8	100.3053
T_2	8	125.2035
Sig.		.086
Means for groups in homogeneous subsets are displayed.		

CHOLESTEROL		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_4	8	131.8462
T_2	8	138.2279
T_3	8	143.2141
T_1	8	146.0029
Sig.		.653
Means for groups in homogeneous subsets are displayed.		

APPENDIX -2 (MONSOON SEASON)

Bodyweight		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_2	5	2188.9332
T_1	5	2269.8362
T_3	5	2281.8666
T_4	5	2297.9332
Sig.		.190
Means for groups in homogeneous subsets are displayed.		

Body weight gain		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_2	5	2146.6032
T_1	5	2226.9702
T_3	5	2236.7666
T_4	5	2253.6032
Sig.		.198
Means for groups in homogeneous subsets are displayed.		

Feed intake			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_2	5	3.6508E3	
T_3	5	3.6879E3	
T_4	5	3.7803E3	3.7803
T_1	5		3.9465
Sig.		.253	.128
Means for groups in homogeneous subsets are displayed.			

FEED CONVERSION EFFICIENCY			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_1	5	.5650	
T_2	5	.5860	.5860
T_4	5	.5980	.5980
T_3	5		.6080
Sig.		.084	.238
Means for groups in homogeneous subsets are displayed.			

PERFORMANCE INDEX		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	5	282.2860
T_2	5	283.7600
T_4	5	301.6580
T_3	5	304.8300
Sig.		.207
Means for groups in homogeneous subsets are displayed.		

DRESSING PERCENTAGE		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	4	73.6024
T_4	4	74.3105
T_3	4	74.4005
T_2	4	74.9260
Sig.		.263
Means for groups in homogeneous subsets are displayed.		

Haematological /Biochemical Parameters

RBC			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_1	3	2.6667	
T_3	3	2.7000	2.7000
T_4	3	2.9333	2.9333
T_2	3		3.0667
Sig.		.133	.050
Means for groups in homogeneous subsets are displayed.			

WBC				
Duncan				
Treatment	N	Subset for alpha = 0.05		
		1	2	3
T_1	3	1.3333E4		
T_2	3		2.0000E4	
T_3	3		2.2333E4	
T_4	3			3.2333E4
Sig.		1.000	.248	1.000
Means for groups in homogeneous subsets are displayed.				

HAEMOGLOBIN		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	3	10.4897
T_3	3	10.6253
T_4	3	10.6923
T_2	3	11.0003
Sig.		.309
Means for groups in homogeneous subsets are displayed.		

PACKED CELL VOLUME		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	3	34.0400
T_3	3	34.4867
T_4	3	34.7267
T_2	3	35.7218
Sig.		.312
Means for groups in homogeneous subsets are displayed.		

HETEROPHILS		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_4	3	35.6667
T_2	3	40.6667
T_3	3	46.6667
T_1	3	48.6667
Sig.		.079
Means for groups in homogeneous subsets are displayed.		

LYMPHOCYTES		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	3	49.6667
T_3	3	52.3333
T_2	3	58.0000
T_4	3	63.6667
Sig.		.072
Means for groups in homogeneous subsets are displayed.		

EOSINOPHILS		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_4	3	.6667
T_3	3	1.0000
T_2	3	1.3333
T_1	3	1.6667
Sig.		.220
Means for groups in homogeneous subsets are displayed.		

HDL		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_2	3	245.3381
T_1	3	297.1221
T_3	3	326.6480
T_4	3	331.5539
Sig.		.200
Means for groups in homogeneous subsets are displayed.		

LDL		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	3	39.2145
T_2	3	56.2696
T_3	3	67.0860
T_4	3	67.3426
Sig.		.214
Means for groups in homogeneous subsets are displayed.		

CHOLESTEROL		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_2	3	138.5278
T_4	3	147.1937
T_1	3	149.4996
T_3	3	173.4195
Sig.		.507
Means for groups in homogeneous subsets are displayed.		

TRIGLYCERIDES				
Duncan				
Treatment	N	Subset for alpha = 0.05		
		1	2	3
T_2	3	77.7286		
T_4	3	86.4602	86.4602	
T_3	3		1.2372E2	1.2372E2
T_1	3			1.5888E2
Sig.		.639	.071	.085
Means for groups in homogeneous subsets are displayed.				

GLUCOSE		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_3	3	119.2527
T_2	3	131.6156
T_1	3	133.7957
T_4	3	143.0054
Sig.		.113
Means for groups in homogeneous subsets are displayed.		

APPENDIX – 3 (WINTER SEASON)

BODY WEIGHT			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_3	5	2.4440E3	
T_2	5	2.5247E3	2.5247E3
T_4	5	2.5661E3	2.5661E3
T_1	5		2.6028E3
Sig.		.102	.284
Means for groups in homogeneous subsets are displayed.			

BODY WEIGHT GAIN			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_3	5	2.4030E3	
T_2	5	2.4815E3	2.4815E3
T_4	5	2.4859E3	2.4859E3
T_1	5		2.5609E3
Sig.		.163	.181
Means for groups in homogeneous subsets are displayed.			

FEED INTAKE			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_2	5	3.7414E3	
T_4	5	3.8354E3	
T_3	5	3.8494E3	
T_1	5		4.0045E3
Sig.		.076	1.000
Means for groups in homogeneous subsets are displayed.			

FEED CONVERSION EFFICIENCY			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
3	5	.6244	
1	5	.6396	.6396
4	5	.6482	.6482
2	5		.6638
Sig.		.139	.133
Means for groups in homogeneous subsets are displayed.			

PERFORMANCE INDEX			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_3	5	337.5020	
T_4	5	363.6240	363.6240
T_1	5	366.8820	366.8820
T_2	5		371.4560
Sig.		.074	.620
Means for groups in homogeneous subsets are displayed.			

DRESSING PERCENTAGE		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	4	82.8150
T_2	4	83.9300
T_3	4	85.3900
T_4	4	85.4150
Sig.		.309
Means for groups in homogeneous subsets are displayed.		

Haematological /Biochemical Parameters

WBC				
Duncan				
Treatment	N	Subset for alpha = 0.05		
		1	2	3
T_1	3	.3333E3		
T_2	3	1.0100E4		
T_3	3		1.9667E4	
T_4	3			2.7333E4
Sig.		.158	1.000	1.000
Means for groups in homogeneous subsets are displayed.				

RBC			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_2	3	2.4667	
T_1	3	2.6000	
T_3	3	2.6667	
T_4	3		3.0667
Sig.		.069	1.000
Means for groups in homogeneous subsets are displayed.			

PACKED CELL VOLUME				
Duncan				
Treatment	N	Subset for alpha = 0.05		
		1	2	3
T_2	3	32.7267		
T_1	3	35.1267	35.1267	
T_4	3		37.2267	37.2267
T_3	3			37.7933
Sig.		.058	.089	.615
Means for groups in homogeneous subsets are displayed.				

HAEMOGLOBIN				
Duncan				
Treatment	N	Subset for alpha = 0.05		
		1	2	3
T_2	3	10.0877		
T_1	3	10.8173	10.8173	
T_4	3		11.4557	11.4557
T_3	3			11.6279
Sig.		.058	.089	.615
Means for groups in homogeneous subsets are displayed.				

HETEROPHILS			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_1	3	57.6667	
T_2	3	62.0000	
T_3	3	63.6667	63.6667
T_4	3		71.3333
Sig.		.142	.062
Means for groups in homogeneous subsets are displayed.			

LYMPHOCYTES			
Duncan			
Treatment	N	Subset for alpha = 0.05	
		1	2
T_4	3	28.3333	
T_3	3	36.0000	36.0000
T_2	3		37.6667
T_1	3		42.0000
Sig.		.055	.130
Means for groups in homogeneous subsets are displayed.			

EOSINOPHILS		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	3	.3333
T_2	3	.3333
T_3	3	.3333
T_4	3	.3333
Sig.		1.000
Means for groups in homogeneous subsets are displayed.		

HDL		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_2	3	49.7007
T_1	3	56.3969
T_4	3	59.1498
T_3	3	61.5679
Sig.		.052
Means for groups in homogeneous subsets are displayed.		

LDL		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	3	79.3103
T_3	3	82.8130
T_2	3	83.5220
T_4	3	100.2013
Sig.		.056
Means for groups in homogeneous subsets are displayed.		

TRIGLYCERIDES		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_3	3	54.3256
T_4	3	54.8837
T_1	3	82.2326
T_2	3	104.8062
Sig.		.059
Means for groups in homogeneous subsets are displayed		

GLUCOSE		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_1	3	146.3229
T_4	3	147.6981
T_2	3	149.2227
T_3	3	154.6936
Sig.		.420
Means for groups in homogeneous subsets are displayed.		

CHOLESTEROL		
Duncan		
Treatment	N	Subset for alpha = 0.05
		1
T_4	3	128.7898
T_3	3	163.7340
T_1	3	174.2255
T_2	3	182.4866
Sig.		.085
Means for groups in homogeneous subsets are displayed.		

APPENDIX- 4

(INTERACTION OF SEASON AND TREATMENT)

Body Weight

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	59777.30	14944.32			
Main plot Treatment	2	1008514.6	504257.3	33.44	4.459	Significant
Main plot Error	8	120641.53	15080.19			
Sub plot Treatment	3	41724.042	13908.01	1.27	2.866	Non- Significant
Interaction	6	103774.69	17295.78	1.58	2.364	Non–Significant
Error	36	394190.86	10949.75			
Total	59	1728623.0				
CV	4.450823					

Gain in body Weight

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	56359.86	14089.97			
Main plot Treatment	2	975779.1	487889.5	39.01	4.459	Significant
Main plot Error	8	100052.4	12506.55			
Sub plot Treatment	3	26998.01	8999.34	0.91	2.866	Non- Significant
Interaction	6	109536.17	18256.03	1.85	2.364	Non –Significant
Error	36	355299.49	9869.43			
Total	59	1624025.0				
CV	4.314602					

Feed Intake

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	45304.11	11326.03			
Main plot Treatment	2	1071167.1	535583.5	23.95	4.459	Significant
Main plot Error	8	178883.38	22360.42			
Sub plot Treatment	3	221752.38	73917.46	4.29	2.866	Significant
Interaction	6	292421.16	48736.86	2.83	2.364	Significant
Error	36	620300.88	17230.58			
Total	59	2429829.0				
CV	3.340957					

Feed conversion Efficiency

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	0.002	0.000422			
Main plot Treatment	2	0.07	0.034630	60.58	4.459	Significant
Main plot Error	8	0.00	0.000572			
Sub plot Treatment	3	0.003	0.001059	2.02	2.866	Non –Significant
Interaction	6	0.006	0.001066	2.04	2.364	Non- Significant
Error	36	0.02	0.000524			
Total	59	0.10				
CV	3.823654					

PERFORMANCE INDEX

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	2517.714	629.43			
Main plot Treatment	2	73543.83	36771.9	49.61	4.459	Significant
Main plot Error	8	5929.39	741.17			
Sub plot Treatment	3	1231.442	410.48	0.83	2.866	Non –Significant
Interaction	6	5664.321	944.05	1.91	2.364	Non –Significant
Error	36	17807.48	494.65			
Total	59	106694.18				
CV	7.152476					

WBC

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	26.345	6.59			
Main plot Treatment	2	629.930	314.96	65.86	4.459	Significant
Main plot Error	8	38.256	4.78			
Sub plot Treatment	3	2451.932	817.31	280.74	2.866	Significant
Interaction	6	135.794	22.63	7.77	2.364	Significant
Error	36	104.805	2.91			
Total	59	3387.062				
CV	8.181459					

RBC

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	0.096	0.02			
Main plot Treatment	2	0.206	0.10	7.79	4.459	Significant
Main plot Error	8	0.106	0.01			
Sub plot Treatment	3	1.379	0.46	23.32	2.866	Significant
Interaction	6	0.820	0.14	6.94	2.364	Significant
Error	36	0.710	0.02			
Total	59	3.316				
CV	5.057073					

HAEMOGLOBIN

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	1.316	0.33			
Main plot Treatment	2	12.500	6.25	64.39	4.459	Significant
Main plot Error	8	0.777	0.10			
Sub plot Treatment	3	1.616	0.54	1.32	2.866	Non- Significant
Interaction	6	6.584	1.10	2.70	2.364	Significant
Error	36	14.637	0.41			
Total	59	37.429				
CV	6.050636					

PCV

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	3.180	0.80			
Main plot Treatment	2	135.582	67.79	113.89	4.459	Significant
Main plot Error	8	4.762	0.60			
Sub plot Treatment	3	17.549	5.85	1.14	2.866	Non- Significant
Interaction	6	71.195	11.87	2.31	2.364	Non -Significant
Error	36	184.839	5.13			
Total	59	417.108				
CV	6.624346					

LDL

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	200.195	50.05			
Main plot Treatment	2	5521.10	2760.6	40.89	4.459	Significant
Main plot Error	8	540.153	67.52			
Sub plot Treatment	3	1111.223	370.41	8.49	2.866	Significant
Interaction	6	1925.692	320.95	7.35	2.364	Significant
Error	36	1571.131	43.64			
Total	59	10869.498				
CV	9.018862					

HDL

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	8644.359	2161.09			
Main plot Treatment	2	595114.32	297557.2	113.43	4.459	Significant
Main plot Error	8	20986.026	2623.25			
Sub plot Treatment	3	51345.103	17115.03	4.69	2.866	Significant
Interaction	6	36041.039	6006.84	1.65	2.364	Non- Significant
Error	36	131434.41	3650.96			
Total	59	843565.25				
CV	34.72942					

GLUCOSE

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	430.362	1075.59			
Main plot Treatment	2	3902.14	1951.11	10.09	4.459	Significant
Main plot Error	8	1547.214	193.40			
Sub plot Treatment	3	187.667	62	0.39	2.866	Non –Significant
Interaction	6	1904.406	317.40	1.97	2.364	Non –Significant
Error	36	5800.42	161.12			
Total	59	13772.22				
CV	9.1919					

CHOLESTEROL

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	5451.355	1362.84			
Main plot Treatment	2	5072.25	2536.1	1.76	4.459	Non- Significant
Main plot Error	8	11534.11	1441.76			
Sub plot Treatment	3	5169.092	1723.03	1.08	2.866	Non –Significant
Interaction	6	7131.491	1188.58	0.74	2.364	Non –Significant
Error	36	57473.52	1596.49			
Total	59	91831.82				
CV	26.38572					

TRIGLYCERIDES

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	9277.186	2319.30			
Main plot Treatment	2	15398.053	7699.03	2.01	4.459	Non- Significant
Main plot Error	8	30699.821	3837.48			
Sub plot Treatment	3	12895.385	4298.46	6.53	2.866	Significant
Interaction	6	21954.220	3659.04	5.56	2.364	Significant
Error	36	23710.851	658.63			
Total	59	113935.517				
CV	26.70905					