EFFECT OF DIETARY SUPPLEMENTATION OF BLACK CUMIN (*Nigella sativa*) SEED ON THE PERFORMANCE OF BROILER CHICKEN DURING DIFFERENT SEASONS IN NAGALAND

Thesis

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CERTIFICATE – I

This is to certify that the thesis entitled **"Effect of dietary supplementation of black cumin (*Nigella sativa)* seed on the performance of broiler chicken during different seasons in Nagaland"** submitted to Nagaland University in partial fulfilment of the requirements for the award of degree of **Doctor of Philosophy** in **Livestock Production and Management** is the record of research work carried out by Miss **NaoremSushma Devi,** Registration No. **Ph.D./LPM/00047** 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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CERTIFICATE – II

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

This is to certify that the thesis entitled **"Effect of dietary supplementation of black cumin (*Nigella sativa)* seed on the performance of broiler chicken during differentseasons in Nagaland"** submitted by Miss **Naorem Sushma Devi,** Admission No. Ph-211/16 Registration No. **Ph.D/LPM/00047**to the NAGALAND UNIVERSITY in partial fulfilment of the requirements for the award of degree of **Doctor of Philosophy** in **Livestock Production and Management** has been examined by the Advisory Board and External Examiner on …….

The performance of the student has been found **Satisfactory/Unsatisfactory.**

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DECLARATION

I, **Naorem Sushma Devi** 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.

This is submitted to SASRD, Nagaland University for the degree of Doctor of Philosophy in Livestock Production and Management.

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Dated:
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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
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

CONTENTS

ABSTRACT

The present research work entitled "Effect of dietary supplementation of black cumin (*Nigella sativa*) seed on the performance of broilers during different seasons in Nagaland" was conducted with the aim to find out the effect of black cumin seed feeding on the growth, feed efficiency, blood profile and economics of broiler production during three seasons *viz*; summer, monsoon and winter. A total of 120 Cobb-400 strain of broilers were reared in each season by subjecting them to four dietary treatments of black cumin seed powder with T_1 (control), T_2 (1%), T_3 (2%) and T_4 (3%) having five replications per treatment with 30 birds each. The trial was conducted for 42 days in each season. During summer season the supplementation of black cumin seed powder at higher rate of 2% (T_3) and 3% (T_4) had shown positive impact on growth, feed conversion efficiency, performance index and carcass weight per bird during the summer season. During summer season, the average final body weight, gain in weight, feed intake, feed efficiency, performance index dressing percentage and carcass traits were unaffected by black cumin seed but it had significant ($P<0.05$) effect on Hb, RBC, WBC, PCV, LDL, HDL and Cholesterol. In monsoon season, feed intake and feed conversion efficiency was significantly ($P<0.05$) higher in treatment group T_3 (2%) and the poorest in T_2 (1%). Black cumin seed had significant ($P<0.05$) effect on WBC, RBC, PCV and HDL. During winter season, the average final body weight, gain in weight, feed intake, feed efficiency, performance index dressing percentage and carcass traits were unaffected by black cumin seed but it had significant ($P<0.05$) effect on Hb, WBC, PCV, LDL, HDL and Cholesterol. Feed efficiency and performance index was best at 2 per cent and 1 per cent black cumin seed, respectively. Irrespective of the groups and seasons, mortality was zero per cent and hence, liveability percentage was recorded to be 100 per cent. The dressing percentage, carcass yield and organ weight was found to be best in treatment groups as compared to control in all the seasons. Regardless of the groups, the overall growth performance, feed intake, feed conversion efficiency and blood biochemical profile were affected by different seasons. Effect of season on overall growth and feed parameters was observed to be significantly ($P<0.05$) higher during summer followed by winter and the least was in monsoon season. The best feed efficiency and performance index was observed during the winter season followed by monsoon and the least was in summer. The body weight and gain in weight was observed to be in similar trend which was found to be significantly ($P<0.05$) higher during summer season followed by winter and the least in monsoon season due to effect of season on overall growth and feed parameters. The haematological and biochemical parameters were found to have positive effect in the treatment groups as compared to control group. However, the control group had the highest net profit return as compared to the treatment groups at which positive effect of black cumin seed was not achieved in terms of economics. Hence, it was concluded that black cumin seed as herbal feed additive helps in the improvement of health condition of the birds.

CHAPTER-1

INTRODUCTION

India is a country with majority population being farmers and one of the countries with top most population of livestock. In the recent years, an increase in trend has been noticed in the poultry industry among the livestock category in terms of employment and production. Poultry industry is an alternate livelihood which makes lesser dependence on monsoon and makes working conditions continuous and healthy which resulted in a success story. It made a quantum leap to emerge as a dynamic industry from a backyard venture. Over the last 3 decades, there have been significant developments in the poultry industry with each decade focusing on different sectors. The 70's saw a spurt in egg production; the 80's an acceleration of broiler production; the nineties advances in poultry integration, automation and feed production. In the current decade broiler industry is poised to exploit value added products and explore global trade (Sridharan and Sravanan, 2013).

Among the Indian livestock based vocations, poultry farming occupies a pivotal position due to its enormous potential to bring about rapid economic growth with low investment. The Indian poultry sector with 7.3 per cent growth in poultry population, has witnessed one of the fastest annual growth of about 6 per cent in eggs, 10 per cent in meat production and 8.35 per cent in broiler production over the last decade amongst all animal based sectors. Poultry sector provides employment to over five million people in the Country (Pawariya and Jheeba, 2015). Poultry farming in India has transformed from a mere tool of supplementary income and nutritious food for the family to the major commercial activity generating the required revenue. Changing food habits,

rising income of the middle class Indian, presence of private players, rising market demand of the Indian poultry produce in the export market are some of the contributing factors to the growth of the industry (Malarvizhi and Geetha, 2015).

According to 20th livestock census report poultry has increased by 16.81 per cent and the total poultry is 851.81 million during 2019. Over 45.79 per cent increase in backyard poultry and total backyard poultry is 317.07 million in 2019. The commercial poultry has increased by 4.5 per cent and the total commercial poultry is 534.74 million. The total poultry population in urban areas has increased by 26.5 per cent during 2019. Commercial poultry in the urban areas has increased by 17.95 per cent whereas in rural areas the percentage increase is 3.95 per cent (20th Livestock census).

The poultry industry in India has made a remarkable growth ever since its inception and is presently emerging as a sunrise sector with a growth rate of 8.51 and 7.52 per cent in egg and broiler production, respectively (BAHS, 2019), as against 2.9 per cent for agricultural crops (Economic Survey, 2019–2020). Estimates from the All India Poultry Breeders Association indicates that poultry contributes for USD 17.31 billion of total India's gross value and satisfies the hungers of 50 million people through direct and indirect employment. Within the poultry sector, broiler and layer segment constitutes about 65.3 and 34.7 per cent with the monthly turnover of 400 million chicks and 8,400 million eggs, respectively (ICRA, 2020). Around 1 million farmers are engaged in poultry farming activities with 85 per cent of them having less than 2 ha of land or the landless. With the annual production of 851.8 million birds, poultry in India has emerged as the most dynamic and diversified subsector. India is the third largest egg producing and fourth largest broiler producing country in the world with an estimated production of 103.3 billion eggs and 4.1 million tons of broiler meat

(BAHS, 2019). Poultry production in India has taken a quantum leap in the last four decades, emerging from use of unscientific farming practices to commercial production systems with state-of-the-art technological interventions. The annual per capita availability of eggs had also increased to 74 per person per year as per the Basic Animal Husbandry Statistics (Ministry of Fisheries, Animal Husbandry & Dairying, 2019). Chicken meat consumption in India is around 3 kg /person / year compared to most of the countries at around 10-11 kg/ person/ annum. However, it is far below the recommended level of consumption of 180 eggs and 10.8 kg poultry meat per person per annum by Indian Council Medical Research. This transformation has involved sizeable expansions and investments in breeding, hatching, rearing and processing.

Feed represents the major part of cost in poultry production. Efforts have been made since the beginning of the poultry industry to increase the efficiency of feed utilization and to minimize the cost per unit of production. As a result, feed additives were being in use in broiler rations to reduce feed cost, enhance broiler performance and improve the quality of the product. Feed additives are non nutritive substances used in poultry feed including antibiotic, enzyme, antioxidant, pellet-binder, antifungal, colored pigment and flavouring agent. Feed additive are important materials that can improve the efficiency of feed utilization and animal performance. Recently, there is an increased consumers concern over drug residues in meat, resistance in bacteria, environmental contamination and general health. Hence, poultry scientists today are challenged to find out new alternatives particularly to the synthetic growth promoters. The possibility of using new natural alternative additives instead of antibiotics and hormone in animal diets has been extensively researched for the past three decades. Consequently, there is considerable research interest in the possible use of natural products such as essential oils and extracts of edible and medicinal plants, herbs and spices for the development of new additives in animal and

poultry feeding. An EU-wide ban on the use of antibiotics as growth promoters in animal feed entered into effect on January 1, 2006; thus, all the antibiotics used at sub-therapeutic doses for growth promotion were withdrawn (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. The positive effects of herbal products on broilers had been reported by many studies. It is conceivable that herbal agents could serve as safer alternatives as growth promoters due to their suitability and preference, lower cost of production, reduced risks toxicity and minimum health hazards. Interestingly recent biological trials of certain herbal formulations as growth promoters have shown encouraging results and some of the reports have demonstrated improvement with respect to weight gain, feed efficiency, lowered mortality, increased immunity and increased liveability in poultry birds. Herbs and spices stimulate feed intake by the secretion of endogenous enzymes, antibacterial effect and antioxidant potential (Lee *et al.*, 2015), resulting in enhanced absorption of nutrients from the gut. Such natural feed additives have been reported to exert a wide range of beneficial effects on the production performance in broilers with respect to weight gain, feed conversion and meat quality (Aji *et al.*, 2011). Also these herbal growth promoters have shown to exert therapeutic effects against liver damage due to feed contaminants like aflatoxin (Ghosh, 1992). Various herbal products possess beneficial properties which might make them useful as alternatives to antimicrobial growth promoters. As alternative remedies some researchers found plants, containing various secondary metabolites, (Ceylan *et al.*, 2003). The primary mode of action of photobiotic as potential growth promoters is attributed to their ability to inhibit the growth of harmful intestinal microflora in gastrointestinal tract (Lopez *et al.*, 2005) and by stimulating the function of

digestive organs (Jang *et al*., 2004). Some studies have indicated that various plants extracts can improve feed conversion ratio, improve carcass quality, decrease the market age of broiler and reduce their rearing cost (Muhammed *et al.,* 2009). Various herbal products are being used as growth promoters in the poultry rations one of which is black cumin seed.

Black cumin (*Nigella sativa*) is a tiny dark colored seed resembling fennel and anise seeds. It is also known as mangrail in Hindi, kalonji in Urdu, karinjeerakam in Malayalam, kalanjire in Marathi and habbasouda in Arabic. It has a strong and distinct pungent taste and aroma. Traditionally used as a medicine, it is also a favourite for seasoning purpose. The nigella seeds are used in culinary dishes, its extract is used in medicines. Black cumin seed has been selected among different phytogenic feed additives for this research due to its availability at all market and stable price throughout the year. Black cumin seeds contain 94.29 per cent dry matter (DM), 23.80 per cent crude protein (CP), 42.08 per cent ether extract (EE), 7.71 per cent crude fibre (CF), 5.10 per cent crude ash (CA), 0.36 per cent calcium (Ca), 0.65 per cent total phosphorus (P), 0.28 per cent sodium (Na), 0.25 per cent, magnesium (Mg), 0.79 per cent potassium (K), 34.19 mg/100g iron (Fe), 5.63 mg/100g zinc (Zn), and 0.87mg/100g copper (Cu) (Ayaşan, 2011). The active components of black cumin seeds are the volatile oils thymoquinoline and dithymo quinoline, both of which have antitumor properties (Zahoor *et al*., 2004). The black cumin seed have been reported to have many biological properties including antiparasitic, antidiabetic (Meral *et al*., 2001), antidiarrheal (Gilani *et al*., 2001) and diuretic effects (Zaoui *et al*., 2000). A few studies revealed that black cumin seed also have an antibacterial activity (Mouhajir *et al*., 1999; Nair *et al*., 2005).

Nutrient utilization and black cumin seed

Utilization of nutrients may increase due to supplementation of BCS, (Saleh, 2014) and (Kumar *et al*., 2017). Yatoo *et al*. (2012) reported higher dry matter (DM) digestion compared with the control when the diet was supplemented with 1 per cent BCS or 0.5 per cent each of fenugreek and BCS in combination. Saleh (2014) reported that digestion of DM and crude protein (CP) increased significantly when birds were fed diets with BCS oil at 1 ml/kg compared with control and avilamycin diet, while crude fat digestion was not affected. Kumar *et al*. (2017) found that nutrient utilization of CP, ether extract (EE) and non-starch carbohydrate increased in broiler chickens due to supplementation of BCS at 0.5 to 2 per cent in the diets. These benefits may be attributable to enhanced enzymes activity caused by the essential oils in BCS. Any stimulating effect of essential oils on digestive system (Wenk, 2003) can result in better utilization of nutrients and performance of birds. BCS possesses antibacterial and antifungal properties (Hanafy and Hatem, 1991) which can result in increased nutrient availability for the bird.

Black cumin seed (*Nigella sativa*) and bird's immunity

Black cumin bears an excellent potential as an alternative to antibiotics and vaccines to improve immunity and to reduce mortality in poultry. Mortality was decreased from 16.67 to 4.17 per cent by supplementation of layer diet with 1.5 per cent black cumin (Akhtar *et al*., 2003). Al-Jabre *et al.* (2003) found that volatile oils in *Nigella sativa* exhibit 67 constituents capable of inducing beneficial and pharmacological effects against bacteria such as *Staphylococcus* and *E.coli*. Active components of black seed possessing antibacterial, antioxidant, and anti-inflammatory activities induced positive effects on the

immunity and organs involved (Saleh, 2014). Cumin benefits include nigella seed powder which stimulates and improves appetite. It also has detoxifying actions that improve liver's ability and functioning. *Nigella sativa* seeds contain compounds that help in resolving autoimmune disorders. Black cumin side effects can be avoided if it is taken in moderation and limited proportion.

Mangrail (*Nigella sativa* L.) also known as black cumin or black seed grown in Asian and Mediterranean countries, is one of the alternatives that could be used as feed additives. The black seed or black cumin is an excellent herb with many benefits and uses, especially when it comes to maintaining a strong and healthy immune system. *Nigella sativa* seeds dietary supplementation has revealed some of its positive effect on broiler chicks' performance (Guler *et al.,* 2006; Abu-Dieyeh and Abu-Darwish, 2008), weight gain, feed conversion ratio (Al-Harthi, 2004 and Khan *et al.,* 2012), feed intake, internal organ weight percentages, thigh and breast weight percentages (Durrani *et al.,* 2007), as well as dressing weight percentage (Halle *et al.,* 1999 and Durrani *et al.,* 2007). Moreover, the effects of NS feed supplementation on growth performance and carcass measurements of broiler chicks have been explored in some studies.

Mangrail has been reported to be rich in fat (35.5%) and protein (22.7%) its seeds possess digestive and appetite stimulant (Gilani *et al*., 2004) and antibacterial agents (El-Kamali *et al*., 1998). Additionally, it has hepatoprotective (Janbaz *et al*., 2003) and antioxidant properties (Mansour *et al*., 2002). Phytogenic compounds of plant origins and their extracts have beneficial effects in the activities of poultry, e.g. on digestive and immune systems, also helps in anti-inflammatory, anti-oxidative and anti-microbial activities (Nasir and Grashorn, 2010).

The seeds of mangrail appear to be a multipurpose growth promoter and may be promising in improving broiler performance (Al-Beitawi *et al*., 2009).The addition of black cumin seed in the food of broiler chicks improved their immunity, feed conversion efficacy (Ahmed *et al*., 1995; Youssef *et al*., 1998). The addition of black cumin seed (BCS) instead of bacitracin to broiler diets had increased antibody titer against Newcastle disease and IBD (Al-Beitawi *et al*., 2009). Jamroz and Kamel, (2002) reported a stimulating effect of black seed on digestive system, resulting in better absorption and performance. Addition of *Nigella sativa* in feed increased bile flow rate results in increased emulsification that activates the pancreatic lipases which then aid in fat digestion and absorption of fat- soluble vitamins (Crossland, 1980). Extract of black seeds might have more diverse effects in growth performances and serum metabolites due to presence of a variety of active substances which can be observed in activities of different heart and liver related serum enzymes and in blood biochemistry (Nasir and Grashon, 2010). Osman (2002) found that supplementing broiler chicks diet with black cumin oil significantly ($P<0.05$) enhanced body weight gain and feed conversion ratio, and decreased feed consumption. The favourable effects of *Nigella sativa* on performance are thought to be due to high nutritive value as well as pharmacologically active substances present in the seeds. Black seeds contain mixture a of essential fatty acids, particularly oleic, linoleic and linolenic acids that cannot be synthesized in the body.

North-eastern region of India is inhabited by various tribal communities who are mostly non-vegetarians and hence there is a huge demand for meat and eggs of poultry. Requirement of poultry eggs and meat of the region is mostly being met by procuring them from outside the region. About 82 percent of the population resides in rural areas of the region and they are depending on the agriculture and allied sectors like backyard poultry for their livelihood. By and

large, all the farmers practice age old traditional system of poultry farming with little or no inputs. High cost of concentrate feeds, diseases and lack of technical knowhow and lack of finances are some of the constraints faced by the farmers. Considering the benefits of mangrail and its possible use as an alternative to antibiotic growth promoters, the present study entitled "Effect of dietary supplementation of black cumin (*Nigella sativa*) on the performance of broilers during different seasons in Nagaland" was conceived with the following objectives:

OBJECTIVES:

1. To study the dietary supplementation of black cumin *(Nigella sativa)* seed on the productive traits of broilers in three different seasons.
2. To study the dietary supplementation of black cumin *(Nigella sativa)* seed on the edible organs and carcass yield of broilers in three different seasons.
3. To study the dietary supplementation of black cumin *(Nigella sativa)* seed on the blood profile of broilers in three different seasons.
4. To find out the dietary supplementation of black cumin *(Nigella sativa)* seed on economics of broiler production in three different seasons.

CHAPTER-2

REVIEW OF LITERATURE

Black cumin seed 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. Black cumin seed and its composition:

The black cumin seed are considered to be a good source of protein, crude fat, crude fibre and macro minerals. BCS contain a yellowish volatile oil (0.5- 1.6 per cent), a fixed oil (28-42 per cent), proteins (23 to 37 per cent), ash (4.41 to 4.86 per cent), total carbohydrate (33 to 40 per cent) and different phytochemicals (Ramadan, 2007; Cheikh- Rouhou et al., 2007). The major unsaturated fatty acids are linoleic acid (49.2-50.3 per cent), followed by oleic acid (23.7-25.0 per cent), while the main saturated fatty acid is palmitic acid (17.2-18.4 per cent) (Cheikh-Rouhou *et al.,* 2007). The active constituents of black cumin seed include volatile oil consisting of carvone, an unsaturated ketone, terpene or d-limonene also called carvene, α-pinene, p-cymene and nigellone (Ramadan, 2007). Pharmacologically active constituents of the volatile oil are thymoquinone, dithymoquinone, thymohydroquinone and thymol (Ghosheh et al., 1999).

Effects of black cumin seed powder on

2.2. Body weight and body weight gain

El-Sheikh *et al*. (1998); Akhtar *et al*., 2003; Majeed *et al*. (2010) showed that adding black cumin seed to the diet significantly decreased the chickens' body weight gain.

Halle *et al*. (1999) found controversial effects of adding black cumin essential oil (0.1 or 1 g/kg) or oilseed (10 or 50g/kg) on broiler performance.

Abdel-Mageed (2002) found that substitution of soybean meal by *Nigella sativa* meal at 3.0 per cent in broiler diets significantly increased body weight and body weight gain.

El-Ghammry *et al*. (2002) and Hassan *et al.* (2004) reported an increased body weight by incorporating grounded *Nigella sativa*seed in broiler feed.

Akhtar *et al.* (2003) and El-Sheikh *et al*. (1998) found that the inclusion of black cumin seeds into the diet significantly decreased body weight of chickens.

El-Bagir *et al.* (2006) reported that dietary addition of black cumin at the level of 1 or 3 per cent significantly increased the final body weight of early laying hens.

Guler *et al*. (2006); Durrani *et al*. (2007) and Al-Beitawi and El-Ghousein (2008) found improved average daily weight gain and better feed conversion ratio (FCR) in broilers fed with 1 per cent *Nigella sativa*seed in broiler diet.

Khadr and Abdel-Fattah (2006) showed that broiler chicken diet supplemented with black seed at the 2 per cent level improved broiler performance in terms of gain in body weight.

Salman *et al*. (2007) stated that *Nigella sativa* seeds were rich in the unsaturated fatty acids such as oleic, linoleic and linolenic acids which were

considered essential for growth and also rich in essential amino acids, carotene, calcium, iron, sodium and potassium which serve as essential cofactors in various enzyme functions.

Aydin *et al*. (2008) showed that supplementing layer hen diets with 1, 2, and per cent black cumin seed had no effects on body weight gain and feed conversion ratio.

Al-Beitawi and El-Ghousein (2008) showed that administration of black cumin in broiler chickens increased live weight and weight gain.

Sogut *et al*.(2008) reported that a low level of black cumin (3 per cent) tended to improve broilers' performance compared to a high level (7 per cent).

Ziad and Mohammad (2008) found that supplementation of black cumin with the levels of 1-1.5 per cent in the diet increased weight gain but with increasing the level of black cumin resulted in significantly decreased in weight gain.

Bolukbasi *et al*. (2009) stated that in 27 weeks old laying hens, fed diets supplemented with 1, 2, and 3 per cent black cumin seeds, had no significant effects on body weight and FCR.

Hermes *et al.* (2009) reported that the reduced weight gain due to *Nigella sativa*meal was attributed to high fibre contents of the meal. Heat stressed broilers fed black cumin oil (0.5, 1 per cent), seeds (1, 2 per cent) or meal (10, 20 per cent) in feed showed better results than the control group. They found significant improvement regarding FCR, crude protein conversion (CPC), calorie conversion ratio (CCR) and feed consumption of the birds.

Abbas and Ahmed (2010) found that broiler chicks fed diet having 1 and 2 per cent black seeds showed a significant decreased in feed consumption, body weight gain and live body weight whereas non-significant results were obtained regarding FCR.

Nasir and Grashorn (2010) found no significant effect on body weight gain, average daily weight gain and FCR by the addition of 1 per cent *Nigella sativa*seed.

Isalam *et al*. (2011) found that hens supplemented with *Nigella sativa* diets with 0, 1.5, 3.5 and 4.5 per cent of seed powder had no significant ($P>0.05$) effects on body weight, feed intake of hens. However, they found that there was significant ($P<0.05$) decrease in serum triglycerides (about 70 per cent) and egg cholesterol (about 43 per cent) contents. They suggested that *Nigella sativa*seed could be a potential alternative to synthetic feed additives to formulate low cost and environment-friendly diet for the laying hens.

Bhardwaj *et al*. (2012) stated that supplementation of herbal product containing *Nigella sativa* in broiler ration at 0.5 per cent improved body weight gain and FCR in broilers.

Khan *et al.* (2012) found that the level of black cumin seed had significant ($P<0.05$) effect on days 28 and 42. At both ages, birds fed diets supplemented with 2.5 or 5.0 per cent black cumin seed had significantly greater body weight gain than those fed with the 1.25 per cent black cumin seed diet and the negative control. They found that there was no significant ($P>0.05$) difference between body weight gain in birds fed diets with black cumin seed or antibiotic (positive control) at any age.

Sogut *et al*. (2012) reported that a low level of black cumin seed (3 per cent) tended to improve broilers' performance compared to a high level (7 per cent).

Khan *et al.* (2012) stated that supplementation of black cumin seed to the diets had variable effects on chicken performance and indicated in their study that birds fed diets supplemented with 2.5 or 5.0 per cent black cumin seed diet.

Ahmad *et al.* (2013) stated that the average daily weight gain (g/bird/d) was significantly (P<0.05) increased only for birds received 2.5 per cent BCS compared to control birds. There was no significant (P>0.05) difference between body weight gain in birds fed diets with different black cumin seed.

Ali *et al.* (2014) observed that no significant effect of feeding black cumin added with vitamin C on body weight gain of broilers.

Al-Mufarrej (2014) found no significant effect on body weight, body weight gain and feed intake in broilers fed black cumin at the level of 0.7 per cent, 1.4 per cent, 2.1 per cent or 2.8 per cent.

Dwivedi *et al.* (2015) found lower body weight gain in birds on diet supplemented with 1.0 per cent mangrail seed powder mixture and no significance difference in body weight gain in birds whose diet was supplemented with 0.5 per cent black cumin seed powder mixture, however, improved the overall performance of broiler chicken.

2.3. Feed intake and feed conversion efficiency

Rathee *et al*. (1982) stated that the positive effect of *Nigella sativa* seeds might be due to its protective action against hepatotoxity which led to higher utilization of nutrients in the feed.

Al-Homidan *et al.* (2002) reported that that feed efficiency was improved by incorporating black seeds in the broiler rations.

Ashayerizadeh *et al.* (2009) mentioned birds that received 2.5 per cent and 3.5 per cent black cumin seed in the diet increased significantly average daily feed intake comparing to bird in control groups or bird getting 1.5per cent black cumin seed.

Osman (2002) found that supplementing broiler chicks diet with black cumin oil significantly (P<0.05) enhanced body weight gain (BWG) and feed conversion ratio (FCR), and decreased feed consumption.

Gilani *et al.* (2004) stated that black cumin as feed additives stimulates the activity of digestive system, enhances the diet palatability and appetite which results in the increased amount of feed intake.

Denli *et al.* (2004) that supplementation with black cumin seed extract did not significantly affect feed intake of quail.

Durrani *et al.* (2007) and Abdel-Hady *et al*. (2009) reported that black cumin seed had a significant effect on feed conversion ratio.

Guler *et al.* (2006) reported no significant change in dietary intake of broiler by consuming feed containing black cumin and antibiotics; however, there was significant change in FCR of broilers containing black cumin and antibiotics.

Khadr *et al*. (2006) showed that broiler chicken diet supplemented with black seed at the 2 per cent level improved the feed conversion efficiency.

Durrani *et al.* (2007) found that diets with 4% grounded black cumin resulted in less feed intake but better feed efficiency as compared to control diet.

Gonzalez-Alvarado *et al*. (2007) found that the black cumin high oils and an increased nutrient digestibility are likely to be responsible for the improvement of BWG and FCR as they increased the digesta retention time in the gizzard.

Al-Beitawi and Ghousein (2008) showed that administration of black cumin in broiler chickens increased feed consumption.

Aydin *et al*. (2008) showed the different phenomenons in laying hens that supplementing layer hen diets with 1, 2, and 3per cent black cumin had no effects on body weight gain and feed conversion ratio.

Abbas and Ahmed (2010) reported poor feed efficiency was observed in broiler chicks fed diet supplemented with 1 and 2 per cent black seeds.

Abbas and Ahmed (2010) who reported that birds offered a diet supplemented with 1 or 2 per cent black cumin showed significantly ($P<0.05$) lower BWG and unaffected FCR.

Bolukbasi *et al*. (2009) reported that feed intake remained unaltered by feeding diet having 1, 2 and 3 per cent black cumin seed and 1, 2 and 3 ml/kg *Nigella sativa* oil in 27 weeks old laying hens

Lymia *et al.* (2010) showed that body weight and FCR were not affected in broiler fed on black cumin added ration.

Majeed *et al.* (2010) and Saeid *et al.* (2013) who reported that diets containing BCS at different level (0.25 – 0.75 per cent) did not significantly influence the FCR at the whole experimental period.

Toghyani *et al.* (2010); Zaid *et al*. (2008) and Abu- Dieyeh *et al*. (2008) found that feed conversion ratio improved by feeding 4g/kg black seed, 1.5 per cent black cumin seeds and 1.5 per cent powdered *Nigella sativa* in four week old broilers.

Khan *et al.* (2012) found that feed conversion ratio (weight gain/feed intake) was significantly influenced by the treatments used at both days 28 and 42. At both ages, the feed efficiency significantly improved ($P<0.05$) in broilers fed diets with 2.5 or 5 per cent black cumin seed compared to the 1.25 per cent BCS diet and the controls (both negative and positive).

Sogut *et al.* (2012) reported that Supplementation of ground black seeds to the broilers chicks diet resulted in a significant ($P< 0.01$) decreased feed intake.

Massuod *et al*. (2014) found that supplementation of 2 percent black cumin in broiler ration helped in increasing feed intake, however, decreased feed conversion was observed.

Sonia *et al*. (2014) found no change in growth of birds by feeding of black cumin seed at 1.5 per cent level.

Dwivedi *et al.* (2015) found lowest feed intake and FCR on broilers supplemented with 0.5 per cent mangrail seed powder mixture and also values of EER, PER and performance index was found to be higher on broilers supplemented with 0.5 per cent mangrail seed powder mixture.

Jahan *et al*. (2015) reported that supplementation of black cumin seed as a natural growth promoter at 1.5 per cent level in the broiler diet helps in improving feed conversion ratio.

2.4. Haematological/ Biochemical characteristics

Saxena and Vyas (1986) reported that essential oil of black cumin seeds inhibited the growth of *E.coli*, *Bacillus subtilis* and *Streptococcus feacalis*.

Khodary *et al*. (1996) found that the decrease in plasma cholesterol level may be attributed to the high content unsaturated fatty acids of black cumin which may stimulate the cholesterol excretion into the intestine and the oxidation.

Brunton (1999) suggested that reduction in serum cholesterol may be attributed to the lowering effect of thymoquinone and monosaturated fatty acids on the synthesis of cholesterol by hepatocytes or the fractional re-absorption from the small intestine. Moreover, black cumin also contain an appreciable amount of sterols, especially β-sitosterol, that has the ability to inhibit the absorption of dietary cholesterol.

Mandour *et al*. (1998) reported a decrease in plasma HDL concentration resulted from feeding chicken with 0.50 per cent of black cumin.

Osman and El-Barody (1999) stated that addition of black cumin seed in the feed to broiler chicks improved their immunity.

El-Dakhakhny *et al.* (2000) stated that the decrease in the serum cholesterol and triglycerides by diet supplementation of *Nigella sativa* seeds might be due to the association of cholerectic activity of the seed powder.

Badari *et al.* (2002) reported decrease in serum triglycerides and cholesterol level with addition of *Nigella sativa* seeds in broiler diet.

Zaoui *et al*. (2002) who showed significantly increased haemoglobin and haematocrit in rats fed black cumin oils.

Akhtar *et al.* (2003) reported that feeding *Nigella sativa* powdered seeds resulted in lower serum cholesterol level, while serum high density lipoprotein (HDL) level was increased.

El-Bagir *et al.* (2006) observed that addition of 1 or 3 per cent black cumin in the diets of 68 weeks old layers resulted in a dependent decrease of serum phospholipids and cholesterol whereas a general decline in serum lipids. The addition of 3 per cent black cumin reduced the serum cholesterol and serum phospholipids by 23 and 30 per cent respectively.

Khadr and Abdel-Fattah (2006) showed that broiler chicken diet supplemented with black seed at the 2 per cent level elevates antibody titre, increased oxidative stability of meat, modulate the cholesterol profile in the serum which can be reflected in the meat and make an advantage for human diets, and economically did not adversely affect the total costs of the diet.

Mahmood (2006) reported that black cumin had an anti-stress activity in chicken and demonstrated negative correlation between Heterophyl or Lymphocyte ratio and feed intake.

Al-Jawfi *et al*. (2008) also stated that black cumin oil significantly enhanced the immune system through increased lymphocyte production, and inhibited development of advanced dysplastic changes after tropical application of DMBA (7,12-Dimethylbenz(a) anthracene) in hamsters to induce immune-suppression however the total immunoglobulin levels were significantly higher than those of the control group when fed with BCS supplementation.

Al-Beitawi *et al.* (2009) found feeding of 3 per cent crushed and non-crushed *Nigella sativa* seeds reduced plasma cholesterol and increased the

plasma high density lipoprotein (HDL) concentrations compared to 1.5, 2 and 2.5 per cent crushed *Nigella sativa* seeds.

Al-Beitawi *et al.*(2009) reported that replacing the bacitracin with crushed black cumin at the level of 2 per cent in broiler diets significantly reduced serum cholesterol.

Ebaid *et al*. (2011) reported that the improvement of erythrocyte count and the increase in haemoglobin concentration after the administration of black cumin oil may be explained by an increased number of cells in bone marrow that reached advanced developmental stages and the accelerating effect of black cumin oil on the cellular respiratory mechanism. Thus, protein formation needed cellular events, such as mitosis generated in mitochondria, which have enzymes involved in the biosynthesis of heam the most important component in erthyropoiesis.

Isalam *et al.* (2011) revealed that there was significant decrease ($P<0.01$) in the contents of HDL and cholesterol in blood serum of laying hens supplemented with *Nigella sativa* seed (1.5 to 4.5 per cent) compared with control but these differences were not statistically significant.

Ismail (2011) showed that low levels of black cumin seed corresponded to a reduction in total Coliform bacteria counts in the caecal intestine of broilers.

Khalaji *et al.*(2011) reported that 1 per cent black cumin in broiler diets did not decrease significantly the total serum cholesterol. Black cumin reduced cholesterol only when provided at higher doses.

Richard (2011) found that an active substance of black cumin content phytosterol, have the ability to compete with cholesterol absorption in the intestine and finally resulted in reducing the absorption of cholesterol.

Bhardwaj *et al*. (2012) observed that supplementation of herbal product improved hemato-biochemical level in the chicken.

Khan *et al*. (2012) found significant reduction of caecal *Coliform* and *E.coli* population in chicks fed with a diet containing black cumin seed.

Sohail (2012) reported that supplementation of black cumin at 4 and 5 per cent levels significantly decreased serum LDL cholesterol.

Ali *et al.* (2014) stated that supplementation of black cumin at 0.5 to 0.75 per cent tended to results lower blood LDL, although statistically it did not differ significantly. The results suggest that active substance especially phytosterol of black cumin has the minor ability to lowering LDL (bad lipoprotein) in the blood of the chicken. The chicken with slightly low blood lipoprotein indicated thatthose birds were able to produce healthy productivity. No significant effect of feeding black cumin in reducing LDL may be due to different effectiveness of active substance which is also closely related to the condition of the individual broiler. They also found that blood HDL level was significantly ($P<0.05$) affected due to black cumin treatment. HDL decreased by feeding 0.50 per cent black cumin. They further stated that the dietary supplementation of *Nigella sativa* seed at 1 per cent level have resulted in lowest Heterophyl or Lymphocyte ratio which could be responsible for an anti stress factors activities.

Khan *et al.* (2013) found no significant difference ($P>0.05$) was observed between controls (positive and negative) and low level of BCS groups. This decrease in serum cholesterol levels of broilers fed BCS diets probably suggests a general decrease in lipid mobilisation.

Sonia *et al.* (2014) found that birds fed with 3 per cent black cumin had lowest liver and serum cholesterol of 4.63 mg/g of liver and 166.26 mg/dl of total serum cholesterol and highest HDL (high density lipoprotein) value of 41.83 mg/dl as compared to control group.

Siddiqui *et al.* (2015) recommended that black seed fixed oil could have favorable impact on serum lipid profile by decreasing total cholesterol and triglycerides, while elevating the HDL-cholesterol.

Singh and Kumar (2018) studied black cumin in broilers and found that 1 per cent and 1.5 per cent black cumin cause an increase in serum total protein and decrease in total cholesterol.

Talebi *et al.* (2021) reported that supplementation of *Nigella sativa* seed at 1-2 per cent level in broilers diet have resulted in the increase of Heterophyl or Lymphocyte ratio but decrease in WBC count and lymphocytes.

2.5. Dressing percentage and Carcass characteristics

Abdel-Malak *et al*. (1995) stated that feeding of broiler chicks with rations containing different level of *Nigella sativa* seeds had significant effect on relative weight of liver and heart.

El-Ghammry *et al*. (2002) found that broiler chicks fed rations containing low levels (0.2 and 0.4 per cent) of crushed BCS revealed a significant decrease in dressing percentage.

Guler *et al*. (2006) reported higher carcass yield in birds supplemented with 1% black cumin seed and also found significant difference in carcass traits of the birds supplementing with black cumin seed at the rate of 0.5 per cent, 1 per cent, 2 per cent and 3 per cent, respectively.

Guler *et al.* (2006) and Toghyani *et al.* (2010) reported an increased carcass yield, liver, abdominal fat, breast, thigh, wings and neck weights in broilers by feeding diet having 1 per cent black cumin. However, non-significant values were obtained regarding heart weight.

Durrani *et al*. (2007) reported that the addition of 4 per cent black cumin to broiler diet resulted in an increased weight of thigh and breast, in turn resulting in an increased dressing percentage.

Al-Beitawi and El-Ghousein (2008) and Ismail (2011) assumed that supplementing diets with different levels of crushed or uncrushed black cumin did not affect any of the carcass characteristic parameters.

Al Beitawi and El-Ghousein (2008) reported inclusion of different levels (1.5 per cent, 2.0 per cent, 2.5 per cent and 3.0 per cent) of black cumin seed in broiler ration did not significantly affect carcass traits (dressing percentage, breast and leg meat percentage).

Al-Beitawi *et al.* (2009) and Ismail (2011) found no improvement in carcass characteristics by feeding different levels of crushed as well as uncrushed *Nigella sativa*seed in broilers, however, breast percentage significantly increased.

Hermes *et al.* (2009) found no significant effect on giblet and abdominal fat percentage in broilers.

Abbas and Ahmed (2010) stated that broilers fed with diet containing 1 per cent whole grounded black cumin resulted in a significant decrease of dressing percentage compared to the control, however, there was no significant effects regarding liver, gizzard, heart, and abdominal fat percentage by supplementation of whole *Nigella sativa*seeds.

Toghyani *et al*. (2010) found that addition of crushed and uncrushed black cumin seed at the rate of 1.5 per cent, 2.0 per cent, 2.5 per cent and 3.0 per cent in broiler diet did not have any positive effect on carcass traits.

Ismail (2011) found that dietary BCS increased ($P<0.05$) the carcass weight as compared to the control group. However, no significant effects of dietary BCS or BCSE were observed on the dressing percentage, edible inner organs, abdominal fat, full gut weight, gut length and the total coliform bacteria counts of broilers.

Jahan *et al*. (2015) reported that supplementation of black cumin seed as a natural growth promoter at 1.5 per cent level in the broiler diet helps to increase carcass yield.

2.6. Mortality / Liveability

Khan *et al.* (2012) found no significant (P>0.05) effect of the dietary levels of BCS on mortality was observed at any time and the mortality of the birds was in the expected range.

Yalcin *et al.* (2012) noted that adding BCS at the level of 1.5 per cent into layer hen diet for 18 weeks did not affect mortality rate.

Jahan *et al*. (2015) reported that supplementation of black cumin seed at 1.5 per cent level in the broiler diet have positive effect on the survivability of birds.

2.7. Economics

Ihsan (2003) reported that the broilers fed diets with black cumin seed meal, fetched more profit than the rations without supplementation of this herbal growth promoter. Increase in the profit margin of the birds fed rations containing herbal growth promoters may be attributed to the better efficiency of feed utilization, which resulted in more growth and better feed conversion which ultimately leading to higher profit margin in the broilers reared on black cumin seed meal diets.

Ahmad (2005) reported that supplementation of black cumin seed meal at the level 0.5 per cent was more beneficial and profitable in broiler production than 1.0 per cent level.

Khadr and Abdel-Fattah (2006) who had observed higher economical returns from the broiler bird reared on diet supplemented with black cumin seed at different levels as compared to control diet.

Jahan *et al*. (2015) found that cost of feed and total production cost per broiler and per kg broiler was increased in broilers supplemented with 1.5 per cent black cumin seed meal as compared to control. They further observed an increase in cost of feed with the increase in supplementation of black cumin seed at different levels.

CHAPTER-3

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 black cumin seed 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 black cumin seed *viz*. 0, 1, 2 and 3 per cent (on dry matter basis) which was added in the basal diet.

3.2.3. Black Cumin Seed Powder Preparation:

Good quality Black cumin (*Nigella sativa*) was purchased from local market for preparation of black cumin powder. The purchased black cumin was then sundried again to remove the excess moisture. The dried black cumin 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 potassium permanganate for 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

Plate-I

Brooding and Rearing of Experimental Birds

Dried black cumin seed

Day - old chicks

Brooding in Battery Brooder

Birds in rearing cage

Weighing of birds

Vaccination

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 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 Randomized Block Design (RBD). 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 black cumin seed powder 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 black cumin seed powder as mentioned in the table below:

Table 3.1: Details of dietary supplementation of black cumin seed powder.

Experimental Group	Level of black cumin seed supplementation
T_1	Basal diet
T_2	Basal diet + Black cumin seed powder at the rate of 1 per cent
T_3	Basal diet + Black cumin seed powder at the rate of 2 per cent
T_4	Basal diet + Black cumin seed powder at the rate of 3 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:

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

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

Performance Index (PI) was calculated by adopting the formula of Bird (1955):

$$\text{PI} = \frac{\text{Average body weight (g) x \% livability}}{\text{Cumulative FCE x No. of days}} \div 100$$

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:

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

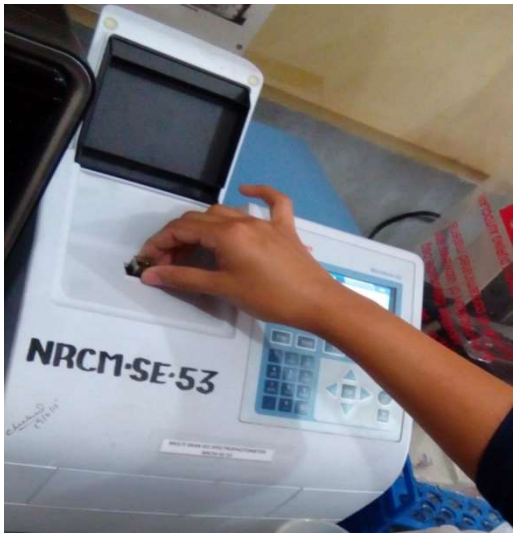
Plate-2

Carcass, Haematological and Biochemical evaluation

Collection of blood samples

Dressed birds with organs

Haematological/Biochemical analysis in the laboratory



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 Neubauer Haemacytometer 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.
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 infectious diseases and foreign invaders. The number of WBCs was counted by using an improved Neubauer Haemacytometer as per the method described by Sastry (1985).

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 as described by Sahli (1909) 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), 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.

The serum was separated from whole blood sample by using pipette and transferred into a clean plastic screw-cap vial and neatly labelled. Total plasma cholesterol concentration was estimated by following the method as described by Richmond (1973) and expressed in mg/dl.

Table 3.6.7.1. Composition of the reagent in the cholesterol standard kit

Reagent 1 (R1)	**2 x 25 ml**
Good's buffer (pH 6.7)	50 mmol/l
Phenol	5 mmol/l
4AA	0.3 mmol/l
Cholesterol esterase	> 200 U/l
Cholesterol oxidase	> 50 U/l
Peroxidase	> 3 kU/l

Plate-3


Cholesterol


HDL


Hb Estimation


DIATEK
LDL-DIRECT
R1 : 30 ml
DIATEK
LDL-DIRECT
R2 : 10 ml
LDL

Cholesterol Standard: 200 mg/dl

Procedure

1. The test tubes were marked as per the sample numbers with one test tube marked as S (standard).
2. 1ml 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. Cholesterol concentration was estimated as per the method described by Richmond (1973). 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 high density lipoprotein (HDL)

The serum was separated from whole blood sample by using pipette and transferred into a clean plastic screw-cap vial and neatly labelled. High density lipoprotein concentration was estimated as per the method described by Izawa *et al.* (1997) and was expressed in mg/dl.

Table 3.6.7.2. Composition of the reagents in the HDL standard kit:

Reagent 1 (R1)	**60mL**
TODB	1 mmol/l
Ascorbate oxidase	3.0 U/ml
PVS	2 mg/l
PEGME	0.2%
$MgCl_2$	2 mmol/l
Buffer (pH 6.5)	10 mmol/l
Reagent 2 (R2)	**20 mL**
Cholesterol esterase	4 U/ml
Cholesterol oxidase	10 U/ml
Peroxidase	30 U/ml
4-aminoantipyrine	2.5 mmol/l
Detergent	0.5%
Buffer (pH 6.5)	10 mm0l/l

Calibrator: reconstitute with 1.0 ml Distilled water.

Calibrator concentration: HDL:1.62 mmol/l or 62.79 mg/dl

LDL: 3.16 mmol/l or 122.48 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 caliberator 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. HDL concentration was estimated as per the method described by Izawa *et al.* (1997). The values obtained were calculated as per the following formula and expressed in mg/dl:

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

3.6.7.3. Determination of low density lipoprotein (LDL)

The serum was separated from whole blood sample by using pipette and transferred into a clean plastic screw-cap vial and neatly labelled. Low density lipoprotein concentration was estimated as per the method described by Weiland and Seidel (1983) and was expressed in mg/dl.

Table 3.6.7.3. Composition of the reagents in the LDL standard kit:

Reagent 1 (R1)	**30 mL**
Cholesterol esterase	5 kU
Cholesterol oxidase	5 kU
Peroxidase	20 kU
4-aminoantipyrine	0.5 g/l
$MgCl_2$	2 mmol/l
Detergent	0.5 g/l
Preservative	0.5g/l
Goods buffer	10 mmol/l
Reagent 2 (R2)	**10 ml**
TODB	2 mmol/l
Detergent	1%
Preservative	0.5g/l
Goods buffer	10mmol/l

Calibrator: reconstitute with 1.0ml Distilled water.

Calibrator concentration: HDL:1.54 mmol/l or 59.69 mg/dl

LDL: 3.10 mmol/l or 120.16 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. 450µl of reagent (R1) was taken in all the test tubes except S.
3. In the test tube marked for standard 6 µl of the caliberator 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. LDL concentration was estimated as per the method described by Weiland and Seidel (1983). 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 black cumin powder

The economics of feeding diet supplemented with black cumin 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 obtained were subjected to statistical analysis in order to draw a valid interpretation and to see the effect of different treatments on various parameters using Randomized Block Design and Split Plot Design Method as described by Snedecor and Cochran (1998) and the significance of the result was evaluated using Analysis of Variance (ANOVA) in Microsoft excel.

CHAPTER-4

RESULTS AND DISCUSSION

The 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, 1, 2 and 3 per cent of black cumin seed 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 recorded and analyzed statistically. The findings thus obtained are presented in this chapter with appropriate headings supported by suitable tables and illustrated by graphs in order to give a quick visual access to the salient findings. The results obtained are also discussed in the light of the findings of earlier research works.

4.1 Summer Season

4.1.1 Body weight

Observation on variation in body weight from day- old to six weeks of age in different treatment 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							Mean
	0	1st	2nd	3rd	4th	5th	6th	
T_1	45.83	156.63	438.00	847.66	1445.30	2160.86	2898.33±80.50	483.05
T_2	46.50	148.20	441.20	860.09	1404.26	2097.43	2811.00±78.08	468.50
T_3	47.56	157.26	447.73	891.16	1454.50	2253.33	2909.66±80.82	484.94
T_4	45.50	160.30	465.93	931.00	1521.13	2224.60	2948.66±81.91	491.44

As per Table 4.1.1, body weight at day-old was 45.83, 46.50, 47.56 and 45.50 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 6th week was 2898.33±80.50, 2811.00±78.08, 2909.66±80.82 and 2948.66±81.91 g per bird, respectively. Numerically, body weight was observed to be higher in black cumin seed 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 black cumin seed 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 Isalam *et al.* (2011) who reported that dietary supplementation of *Nigella sativa* seed powder in hens at the rate of 0, 1.5, 3.5 and 4.5 percent for 10 weeks had no significant effects on body weight. On the contrary, El-Bagir *et al.* (2006) reported that supplementation of BCS at the rate of 2.5 and 5% had

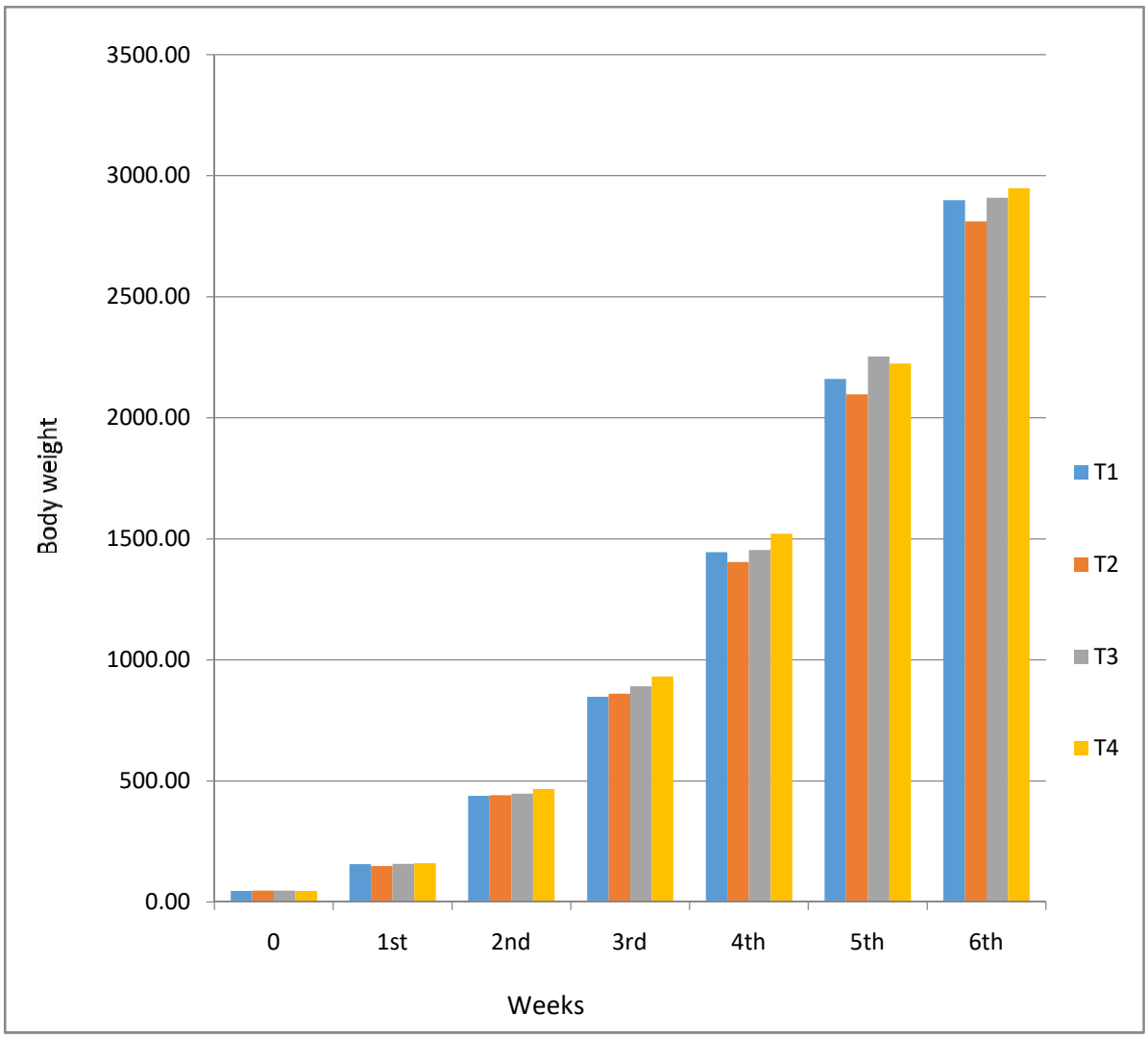


Figure 4.1.1. Body weight (g/bird/week) of broiler birds in different treatment groups.

significantly increased the final body weight of hens. Similarly, Sogut *et al.* (2012) reported that a low level of BCS (3 per cent) tended to improve broilers' performance compared to a high level (7 per cent). Variation in results might be due to factors like strain differences, differences in experimental conditions, type of feed, difference in levels of supplementation of black cumin seed and seasons, etc.

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	Mean
	1st	2nd	3rd	4th	5th	6th		
T_1	110.80	281.36	409.66	597.63	715.56	737.46	2852.47±79.15	475.49
T_2	101.70	293.00	419.73	543.36	693.16	713.23	2764.18±76.78	460.70
T_3	109.70	290.46	444.16	563.33	798.83	656.13	2862.61±79.51	477.10
T_4	114.80	305.63	466.00	590.13	703.46	724.06	2904.08±80.67	484.01

From the data given in Table 4.1.2, the gain in body weight ranged from 110.80 to 737.46, 101.70 to 713.23, 109.70 to 656.13 and 114.80 to 724.06 g/bird/week for the groups T_1, T_2, T_3 and T_4, respectively. The corresponding overall total body weight gain was 2849.61±79.15, 2764.18±76.78, 2862.61±79.51 and 2904.08±80.67 g/bird/week.

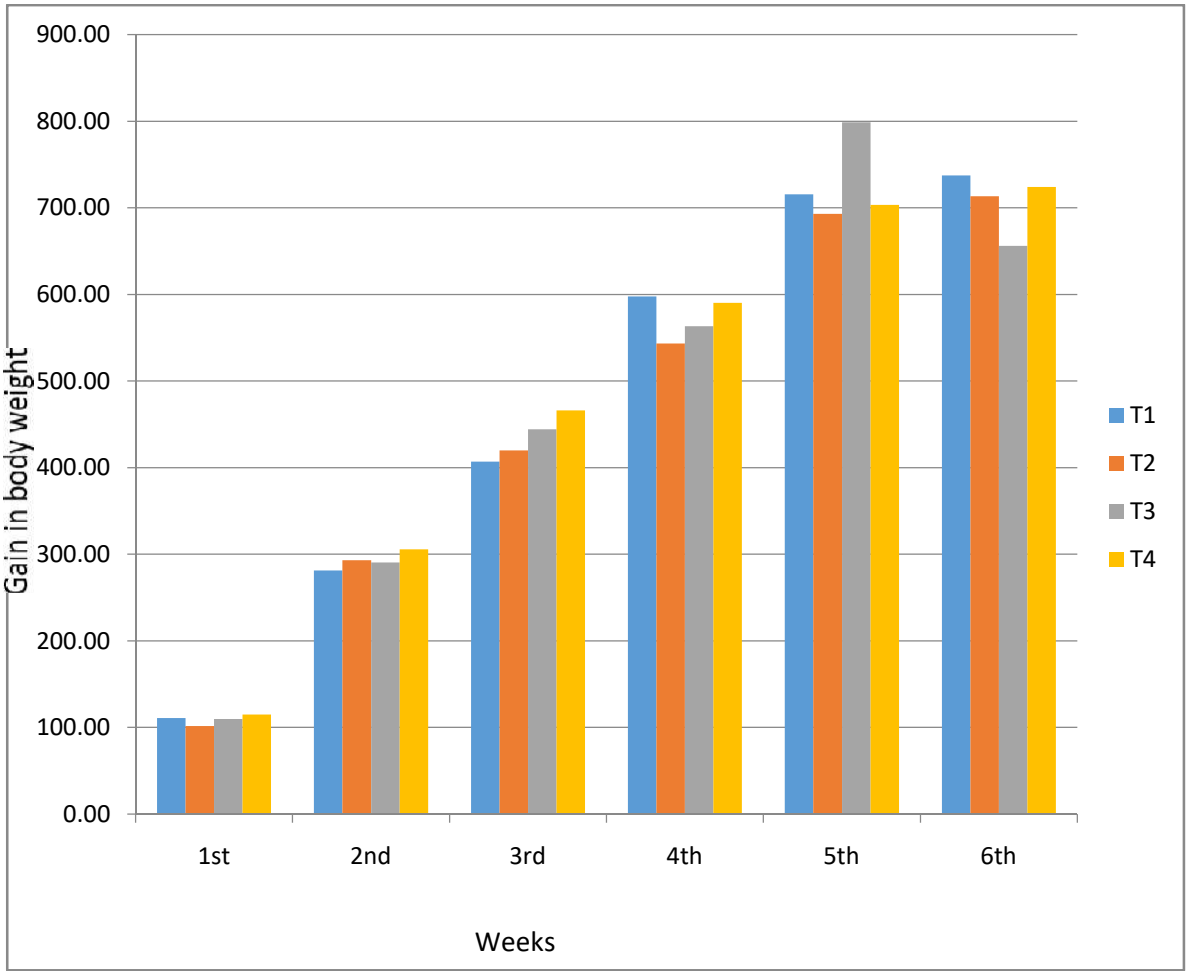


Figure 4.1.2. Gain in body weight (g/bird/week) of broiler birds in different treatment groups.

Statistical analysis had revealed that there was no significant difference in weight gain due to black cumin seed supplementation probably due to the level of black cumin seed used which was not sufficient enough to cause a significant effect on weight gain. Similar findings were reported by Ali *et al*. (2014) who observed that no significant effect of feeding black cumin on body weight gain of broilers. Similarly, Dwivedi *et al.* (2015) also found lower body weight gain in birds on diet supplemented with 1.0 per cent black cumin seed powder mixture and no significance difference in body weight gain in birds whose diet was supplemented with 0.5 per cent black cumin seed powder mixture. On the contrary, Bhardwaj *et al*. (2012) and Khadr and Abdel-Fattah (2006) stated that supplementation of herbal product containing *Nigella sativa* in broiler ration at 0.5 per cent and 2 per cent level improved broiler performance ($P<0.05$) in terms of gain in body weight. Variation in the findings might be due to differences in experimental conditions, type of feed and its composition, level of black cumin seed, 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	Mean
	1st	2nd	3rd	4th	5th	6th		
T_1	145.83	390.23	688.43	761.20	1204.26	1277.36	4467.31±124.09	744.55
T_2	138.40	350.93	678.50	780.63	1234.23	1313.36	4496.05±124.89	749.34
T_3	132.90	352.93	684.70	820.83	1295.90	1325.86	4613.12±128.14	768.85
T_4	134.86	349.70	679.73	869.73	1263.33	1315.20	4612.55±128.13	768.76

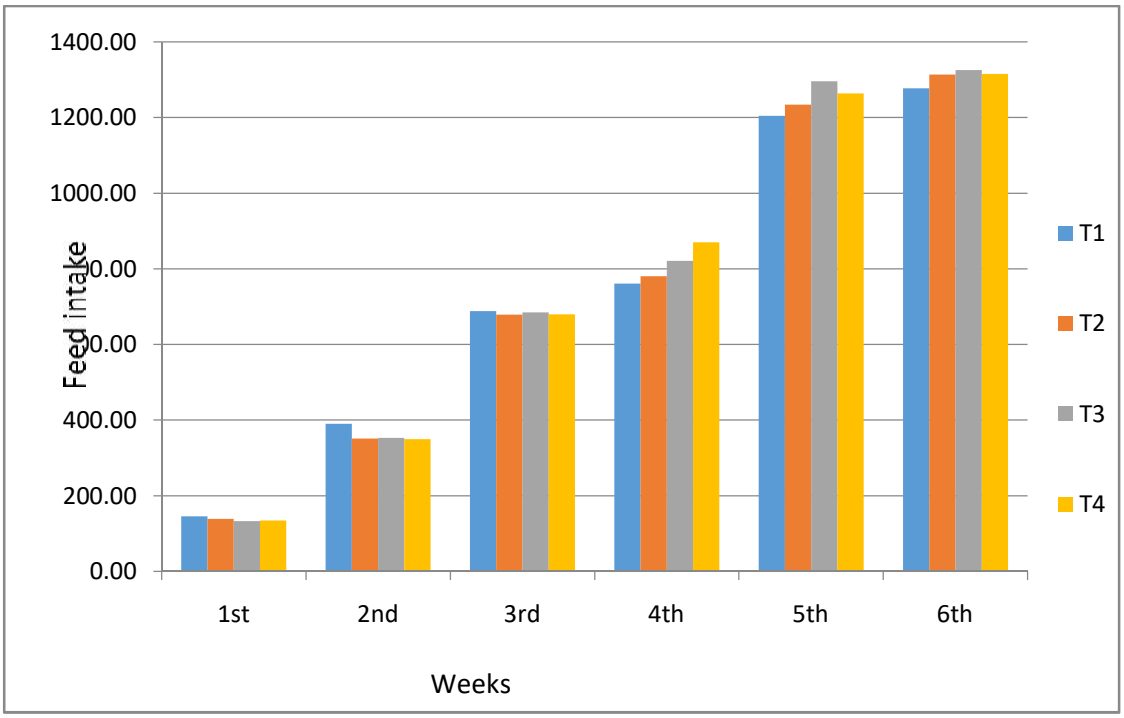


Figure 4.1.3. Feed intake (g/bird/week) of broiler birds in different treatment groups.

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 4467.31±124.09, 4496.05±124.89, 4613.12±128.14 and 4612.55±128.13 g per bird, respectively. Numerically, feed intake was higher in birds fed with black cumin seed based diet. However, statistically it was revealed that there was no significant difference between the control and the birds fed with black cumin seed treated feed.

Hence, it can be concluded that feed consumption of the birds was unaffected within the given level of with black cumin seed supplementation. The result corroborated with the findings of Guler *et al*. (2006) who reported no significant change (P>0.05) in dietary intake of broiler by consuming feed containing black cumin and antibiotics**.** However, these findings were contrary to the observations of Khadr and Abdel-Fattah (2006) and Al-Beitawi and Ghousein (2008) who observed that broiler chicken supplemented with black cumin seed at the 2 per cent level in the diet improved (P<0.05) the feed consumption. Also, Massuod *et al*. (2014) found increased in feed intake with the supplementation of 2 per cent black cumin seed in broiler ration.Thedifferences in the results could be due to the differences in experimental conditions such as feed, strains of bird used, level of black cumin seed, agro-climatic differences, seasons etc.

4.1.4 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 4.1.4 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	0.931	0.890	0.812	0.526	0.557	0.440	0.693±0.116
T_2	0.933	0.795	0.788	0.555	0.588	0.467	0.688±0.115
T_3	0.845	0.788	0.768	0.564	0.575	0.455	0.666±0.111
T_4	0.841	0.750	0.730	0.571	0.567	0.446	0.651±0.109

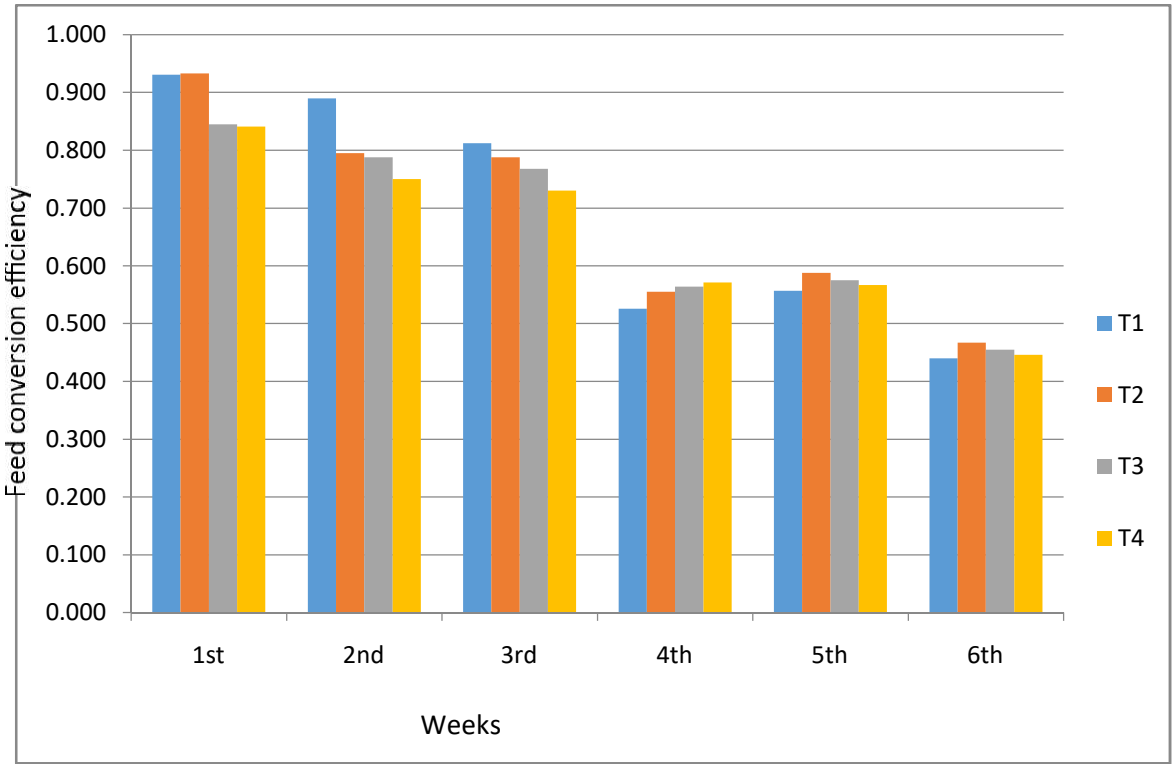


Figure 4.1.4. Feed conversion efficiency of broiler birds in different treatment groups.

As per the data given in Table 4.1.4, the average feed conversion efficiency was in the range of 0.931 to 0.440, 0.933 to 0.467, 0.845 to 0.455 and 0.841 to 0.446 for 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 0.693±0.116, 0.688±0.115, 0.666±0.111 and 0.651±0.109. Numerically highest feed conversion efficiency was observed to in the control groups. However, statistical analysis revealed that there was no significant difference ($P>0.05$) in feed efficiency. This may be probably due to the level of black cumin seed used in the present study which might not have been sufficient enough to cause any significant effect. The result of the present study corroborated with the findings of Abbas and Ahmed (2010) who found that poor feed efficiency was observed in broiler chicks fed diet supplemented with 1 and 2 per cent black cumin seeds. On the contrary, Massuod *et al*. (2014) found that supplementation of 2 per cent black cumin seed in broiler ration helped in increasing feed intake, however, decreased feed conversion. The different results in the findings of the present study might be due to be to type/strain of birds used, difference in levels of black cumin seed, agro-climatic differences, seasons, etc.

4.1.5Mortality/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. 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

Treatment	Mortality (per cent)	Liveability (per cent)	Performance Index
T_1	0.00	100	166.20
T_2	0.00	100	162.37
T_3	0.00	100	173.63
T_4	0.00	100	180.01

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

The performance index at 0, 1, 2, and 3 per cent black cumin seed was 166.20, 162.37, 173.63 and 180.01, respectively. The values for performance index was observed to be higher in groups fed with black cumin seed based diet. Numerically, the higher value of performance index was found in T_4 followed by T_3, T_1 and the least in T_2 group. Similar to the present findings, Singh andKumar (2018) found that inclusion of black cumin seed powder at the rate of 0.5, 1.0 and 1.5 per cent resulted in highest broiler performance efficiency index (BPEI) and 100 per cent liveability. Variation in the results might be due to difference in the levels of black cumin seed used in the diet, differences in the species of the broiler birds and agro-climatic of the experimental site.

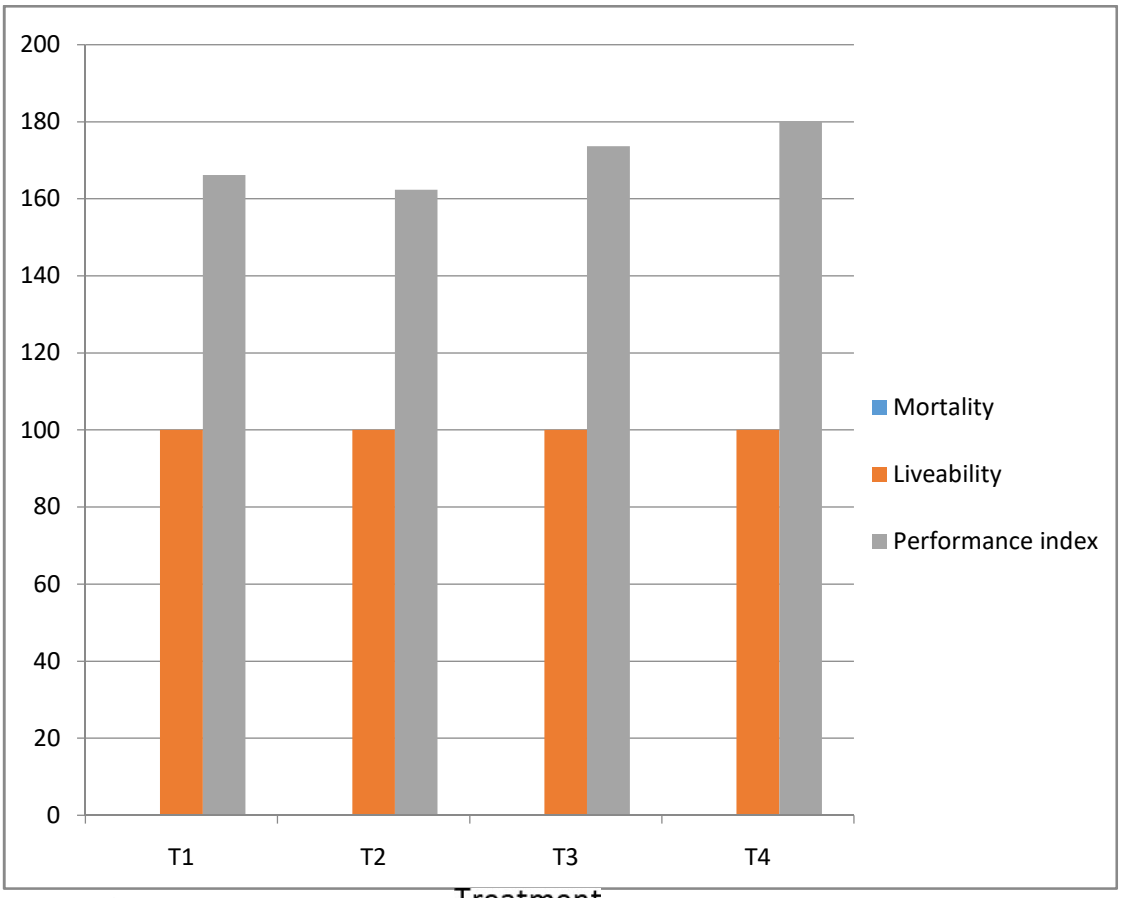


Figure 4.1.5. Mortality and Liveability and Performance index of broiler birds in different treatment groups.

4.1.6. Dressing percentage, Carcass yield and Organ weight

At the end of 6th week of age three birds from each treatment groups were taken for the study of carcass characteristics. The average dressing percentage, carcass yield and organ weight in different groups are presented in Table 4.1.6.

Table 4.1.6 Carcass characteristic of broiler birds in different treatment groups

Treatment	Dressing per cent	Carcass Weight (g)	Organ Weight (g)			
			Heart	Liver	Gizzard	Spleen
T_1	86.06	2220.00	12.97	60.62	45.60	3.08
T_2	85.08	2250.00	14.15	62.22	46.60	3.12
T_3	85.60	2250.00	13.55	63.30	55.12	3.75
T_4	86.61	2420.00	16.05	73.62	55.55	4.30

From the table 4.1.6, it was observed that the average dressing percentage of broiler birds at the end of sixth week was 86.06, 85.08, 85.60 and 86.61 in T_1, T_2, T_3 and T_4 groups, respectively. The weight of heart, liver, gizzard and spleen was included for calculating dressing percentage. Variation in the values can be noted in the different treatment groups. The highest dressing percentage was recorded in T_4 group followed by T_3 and T_2, and the least in T_1 group, respectively. The average carcass weight of broiler birds was recorded as 2220.00, 2250.00, 2250.00, 2420.00 g/bird for T_1, T_2, T_3 and T_4 groups, respectively. The average weight of carcass was highest in T_4, T_3 and T_2 group and lowest in T_1 group.

The average heart weight was recorded as 12.97, 14.15, 13.55, 16.05 g/bird for T_1, T_2, T_3, and T_4 groups, respectively. The heart weight was highest in T_4 group followed by T_3, T_2 and the lowest in T_1 group.

The average liver weight was 60.62, 62.22, 63.30, 73.62 g/bird for T_1, T_2, T_3 and T_4 groups, respectively. The liver weight was highest in T_4 group followed by T_3, T_2 and the lowest in T_1 group.

The average gizzard weight was 45.60, 46.60, 55.12, 55.55 g/bird for T_1, T_2, T_3 and T_4 groups, respectively. The value of gizzard weight was highest in T_4 group followed by T_3, T_2 and the lowest in T_1 group.

The average spleen weight was 3.08, 3.12, 3.75, 4.30 g/bird for T_1, T_2, T_3 and T_4 groups, respectively. The spleen weight was highest in T_4 group followed by T_3, T_2 and the lowest in T_1 group.

From the result, it was observed that the value for dressing percentage was better in black cumin seed supplemented group as compared to control group, the values did not follow the linear trend; however, the value was numerically the highest at the higher level of black cumin seed supplementation. The average weight of heart, liver, gizzard and spleen was more in black cumin seed supplemented group as compared to control group and also the value was numerically the highest at the higher level of black cumin seed supplementation. Similar to the present findings researcher such as Guler *et al*. (2006) and Toghyani *et al*. (2010) reported that broilers fed with 1 per cent black cumin seed in the diet had an increased carcass yield, liver, abdominal fat, breast, thigh, wing and neck weights as compared to control group. Variation in the results might be due to different levels of black cumin seed used in the diet, species differences of the broiler birds and agro-climatic of the experimental site.

4.1.7 Haematological parameters

The haematological parameters as influenced by incorporation of black cumin seed 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	10.80^{b}±0.35	19.66^{d}±0.65	2.23^{c}±0.07	33.66^{a}±1.12	0	0	33.33^{b}±1.13	1.66±0.05	69±2.30
T_2	11.91^{a}±0.39	23.33^{c}±0.74	2.33^{c}±0.07	35.33^{a}±1.17	0	0	39.00^{a}±1.30	1.06±0.02	70±2.33
T_3	10.12^{b}±0.33	28.56^{b}±0.95	2.90^{b}±0.08	35.23^{b}±1.16	0	0	34.33^{b}±1.14	1.66±0.05	68±2.26
T_4	10.23^{b}±0.34	30.60^{a}±1.02	3.16^{a}±0.09	31.23^{c}±1.16	0	0	35.00^{b}±1.16	1.33±0.04	67.66±2.25

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

The mean value for haemoglobin (g/dl) was 10.51±0.35, 11.60±0.38, 9.98±0.33 and 9.73±0.32g/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 19.33±0.64, 21.40±0.71, 26.76±0.89and 20.66±0.68, respectively. Similarly, the corresponding values for total red blood cells (10^6/mm^3) for the groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 2.23±0.07, 2.33±0.07, 2.90±0.08 and 3.16±0.09, respectively. The packed cells volume recorded for the treatment groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 33.66±1.12, 35.33±1.17, 35.23±1.16 and 31.23±1.16, respectively. The value for heterophils was 33.33±1.13, 39.00±1.30, 34.33±1.14 and 35.00±1.16 for $T_{1,}$ $T_{2,}$ T_3 and T_4, respectively. The corresponding values for eosinophils was 1.66±0.05, 1.06±0.02, 1.66±0.05 and 1.33±0.04, respectively. Similarly, the values for lymphocytes for $T_{1,}$ $T_{2,}$ T_3 and T_4 was 69±2.30, 70±2.33, 68±2.26 and 67.66±2.25, respectively. However, monocytes and basophils was recorded as nil for all the groups. There was significant effect on haematological parameters due to inclusion of black cumin seed in broiler feed. A similar finding was reported by Bhardwaj *et al*. (2012) who observed that supplementation of herbal product improved hemato-biochemical level in the chicken. Also, Khan *et al.* (2012) reported that the birds fed diets containing high levels of BCS (2.5% or 5.0%) had higher ($P<0.05$) haematological values than birds fed 1.25% BCS diets, antibiotic or the unsupplemented diet.

4.1.8 Biochemical studies

The biochemical studies in terms of average low density lipoprotein, high density lipoprotein 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. 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	Cholesterol
T_1	68.11^{c}±2.27	61.10^{b}±2.03	112.71^{a}±3.73
T_2	89.86^{a}±2.99	70.53^{a}±2.35	87.54^{ab}±2.91
T_3	84.86^{ab}±2.82	72.15^{a}±2.40	86.22^{ab}±2.87
T_4	75.29^{bc}±2.51	68.97^{a}±2.29	61.97^{b}±2.06

^{a,b,c} 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 black cumin seed on LDL, HDL and Cholesterol among the treatment groups. The mean value for low density lipoprotein (mg/dl) was 68.11±2.27, 89.86±2.99, 84.86±2.82 and 75.29±2.51 for T_1, T_2, T_3 and T_4, respectively. The values for LDL was observed to be significantly (P<0.05) higher in T_2 followed by T_3, T_4 and the least was in T_1. However, the variation between the groups fed with 2 and 3 per cent black cumin seed powder was found to be non-significant. The results of the present study was in agreement with the findings of researchers such as Sohail (2012) who found that serum LDL cholesterol was significantly decreased with supplementation of black cumin seed at 4 and 5 per cent levels. Ali *et al*. (2014) also suggested that phytosterol present in black cumin seed acts as active substance and helps in lowering Low Density Lipoprotein (bad lipoprotein) in the blood of the chicken to produce healthy productivity.

The mean values for high density lipoprotein (mg/dl) was 61.10±2.03, 70.53±2.35, 72.15±2.40 and 68.97±2.29 for T_1, T_2, T_3 and T_4, respectively and the values was found to be significantly (P<0.05) higher in black cumin seed treated groups as compared to the control group. The value for HDL was observed to be highest in T_3 group followed by T_2, T_3 and the least was in T_1.

However, the variation between T_3, T_4 and T_2 group was observed to be non-significant.

The results of the present study was in agreement with the findings of researchers such as Ali *et al*. (2014) who observed improved levels of blood HDL in birds that are fed with the combination of vitamin C 500 ppm and 0.75 per cent black cumin seed and Sonia *et al.* (2014) who found highest HDL (high density lipoprotein) value in birds fed with 3 per cent black cumin as compared to control group.

The mean values for Cholesterol (mg/dl) was 112.71±3.73, 87.54±2.91, 86.22±2.87 and 61.97±2.06 for T_1, T_2, T_3 and T_4, respectively. Numerically, the values for Cholesterol was observed to be highest in T_1 group followed by T_2, T_3 and the least was in T_4. Statistically, Cholesterol was found to be significantly ($P<0.05$) higher in control group as compared to the black cumin treated groups which is in agreement with the findings of Khodary *et al*. (1996) who observed decreased plasma cholesterol level in broiler chickens which may be attributed to the high content of unsaturated fatty acids contained in *Nigella sativa* seeds that results in stimulation of the cholesterol excretion into the intestine. Similarly, Al-Beitawi *et al*. (2009) also reported decreased serum levels of total cholesterol with the supplementation of *Nigella sativa* seed in the diet of broiler chickens.

Hence, addition of black cumin seed had positive effect on haematological and biochemical profile which could be due to rich in nutritional and phytochemicals values as it contains almost 40 per cent fixed oils, 1.4 per cent volatile oils and around 15 amino acids, proteins, calcium, iron, sodium, and potassium (Nasir *et al*., 2005) which are responsible for efficacy of black cumin seed as herbal additive.

4.1.9 Economics

The effect of dietary black cumin seed 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	41.00	41.00	41.00	41.00
2.	Cost of feed	169.75	170.85	175.30	175.27
3.	Cost of black cumin seed	-	19.33	39.63	59.50
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	20.00	20.00	20.00	20.00
7.	Cost of production	248.13	268.56	293.31	313.15
8.	Average Weight of broiler (Kg)	2.899	2.811	2.909	2.948
9.	Cost of production per Kg weight (Rs)	85.59	95.54	100.83	106.22
10.	Sale of broiler @Rs.130 per Kg live weight (Rs)	376.87	365.43	378.17	383.24
11.	Sale of gunny bags @Rs.20/bag(Rs)	1.33	1.33	1.33	1.33
12.	Total receipt (Rs)/bird	378.23	366.79	379.53	384.60
13.	Profit per bird(Rs)	130.10	115.632	121.896	125.018
14.	Net profit per Kg weight gain (Rs)	44.88	34.94	29.63	24.24
15.	Benefit cost ratio	1.52	1.36	1.29	1.22

Average cost of production per bird for T_1, T_2, T_3 and T_4 was 248.13, 268.56, 293.31 and 313.15 rupees per bird, respectively. Corresponding values

for average cost of production per kg live weight of bird was 85.59, 95.54, 100.83 and 106.22 rupees, respectively.

Profit per bird was 130.10, 98.23, 86.22 and 71.45 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 44.88, 34.94, 29.63 and 24.24 rupees, respectively.

From the results, it was found that the total cost of production per broiler was comparable in all the groups, however the cost of production per kg live weight was lowest (Rs. 85.59) in T_1 followed by T_2, T_3 and the highest (Rs. 106.22) in T_4 group. The net profit per kg live weight of broiler was highest (Rs. 44.88) in T_1 and the lowest (Rs. 24.24) in T_4 group.

From the results, it was found that the values of total cost of production or net profit (Rs. Per bird or Rs. Per kg live weight of bird) were comparable in all the treatment groups and they did not differ significantly. The values of net profit followed decreasing trend with increased level of black cumin seed supplementation in the diet of broiler birds. The findings of the present study were contrary to the observation of Khadr and Abdel-Fattah (2006) who had observed higher economical returns from the broiler bird reared on diet supplemented with black cumin seed at different levels as compared to control diet.

Variation in the observation might be due to differences in the level of supplementation of black cumin seed, species of broiler birds, agro-climatic conditions etc.

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	42.67	184.23	424.93	788.07	1305.13	1892.97	2427.50±67.43	404.58
T_2	43.50	197.53	405.66	784.63	1299.93	1862.70	2391.90±66.44	398.65
T_3	41.73	185.23	454.50	816.50	1372.33	1968.63	2532.57±70.35	422.09
T_4	43.17	207.80	421.50	740.43	1229.23	1830.37	2407.60±66.88	401.27

The average body weight of the day-old chicks was recorded as 42.67, 43.50, 41.73, and 43.17g 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 trial period was 2427.50±67.43, 2391.90±66.44, 2532.57±70.35 and 2407.60±66.88 g per bird. The overall mean body weight for T_1, T_2, T_3 and T_4 was 404.58, 398.65, 422.09 and 401.27g/bird/week, respectively. Numerically, highest body weight was recorded in T_3 group (2 per cent black cumin seed supplementation) but analysis of variance showed that there was no difference in the average body weight obtained by birds that received black cumin seed based diet and the control group under the prevailing agro-climatic condition. The result indicated that supplementation of black cumin seed 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 Isalam *et al.* (2011) who reported that dietary supplementation of *Nigella sativa* seed

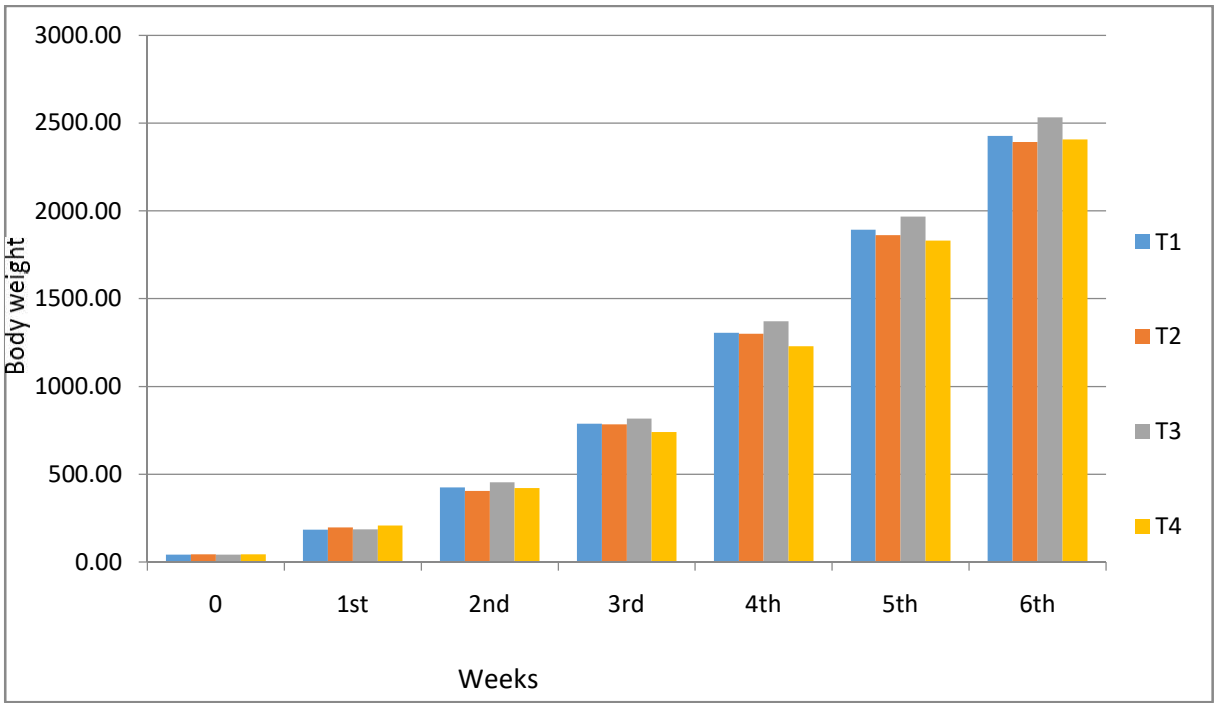


Figure 4.2.1. Body weight (g/bird/week) of broiler birds in different treatment groups.

powder in hens at the rate of 0, 1.5, 3.5 and 4.5 percent for 10 weeks had no significant effects on body weight. On the contrary, El-Bagir *et al.* (2006) reported that supplementation of BCS at the rate of 2.5 and 5 per cent had significantly increased the final bodyweight of hens. Similarly, Sogut *et al*. (2012) reported that a low level of BCS (3 per cent) tended to improve broilers' performance compared to a high level (7 per cent). Variation in results might be due to factors like strain differences, differences in experimental conditions, type of feed, difference in levels of supplementation of black cumin seed and seasons, etc.

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	Mean
	1st	2nd	3rd	4th	5th	6th		
T_1	141.57	240.70	363.13	517.07	587.83	534.53	2384.83±66.25	397.47
T_2	154.03	208.13	378.97	515.30	562.77	529.20	2348.40±65.23	391.40
T_3	143.50	269.27	362.00	555.83	596.30	563.93	2490.83±69.19	415.14
T_4	164.63	213.70	318.93	558.80	601.13	531.13	2388.33±66.34	398.06

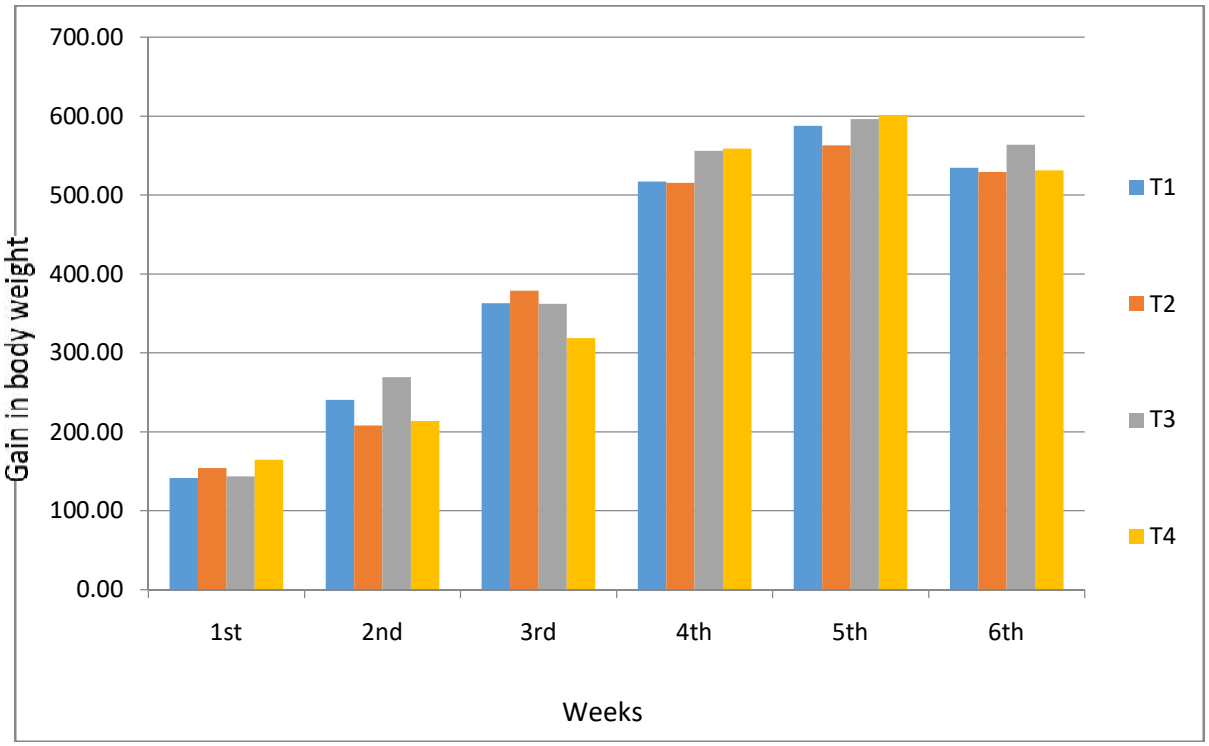


Figure 4.2.2. Gainin body weight (g/bird/week) of broiler birds in different treatment groups.

The average gain in weight for the treatment groups T_1, T_2, T_3 and T_4 was in the range of 141.57 to 534.53, 154.03 to 529.20, 143.50 to 563.93 and 164.63 to 531.13 g per bird, respectively. The corresponding values for the overall total body weight gain was 2384.83±66.25, 2348.40±65.23, 2490.83±69.19 and 2388.33±66.34 g/bird/week. The overall mean gain in body weight was 397.47, 391.40, 415.14 and 398.06 for the respective groups T_1, T_2, T_3 and T_4. Statistical analysis showed that supplementation of black cumin seed 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 Isalam *et al.* (2011) who reported that dietary supplementation of *Nigella sativa* seed powder in hens at the rate of 0, 1.5, 3.5 and 4.5 per cent for 10 weeks had no significant effects on body weight. Variation in results might be due to factors like difference in the strain of birds and experimental conditions, type of feed, difference in levels of supplementation of black cumin seed and seasons, 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		
T_1	177.93	326.50	465.10	714.90	939.67	1034.97	3659.07^{ab}±101.64	609.84
T_2	106.30	320.27	478.10	745.00	924.77	1067.43	3641.87^{a}±101.16	606.98
T_3	125.10	349.37	518.10	784.33	981.60	1127.30	3885.80^{c}±107.94	647.63
T_4	112.37	338.23	514.47	695.20	957.90	1093.37	3711.53^{b}±103.09	618.59

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

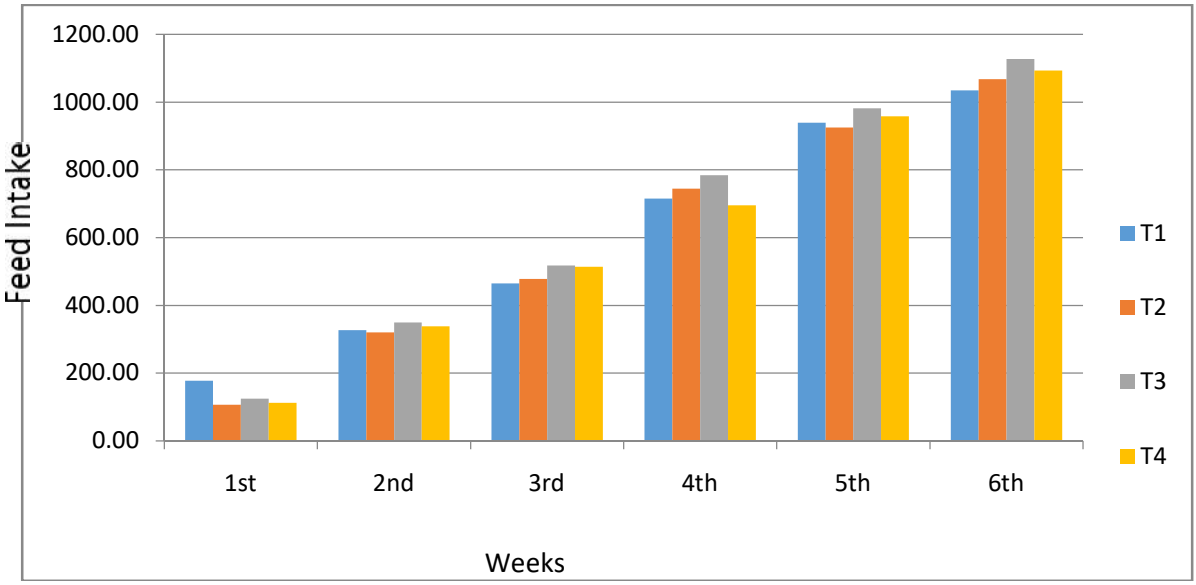


Figure 4.2.3. Feed intake (g/bird/week) of broiler birds in different treatment groups.

The total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 3659.07±101.64, 3641.87±101.16, 3885.80±107.94 and 3711.53±103.09 g per bird, respectively. The value of feed intake was numerically higher in birds fed with 2 per cent black cumin seed in the diet. From statistical analysis, it was observed that feed intake was significantly ($P<0.05$) higher in treatment group i.e. T_3 followed by T_4 andT_1 and the least in T_2. However, the difference between T_1 and T_2 and T_1 and T_4 was found to be non- significantand the groups T_2 and T_4 and T_2 and T_3 was found to be significantly different. The results were in agreement with the findings of Massuod *et al*. (2014) who found increased feed intake in birds with the supplementation of 2 per cent black cumin seed in broiler ration. Conversely, the present study disagree with the findings of Guler *et al*. (2006) who reported that broilers fed with feed containing black cumin and antibiotics showed no significant change in dietary feed intake. The differences in the results could be due to the differences in experimental conditions such as feed, strains of bird used, level of black cumin seed, agro-climatic differences, seasons etc.

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	0.640	0.768	0.590	0.547	0.496	0.426	0.578^{ab}±0.096
T_2	0.538	0.789	0.609	0.573	0.496	0.446	0.575^{a}±0.096
T_3	0.675	0.768	0.634	0.571	0.498	0.445	0.599^{b}±0.099
T_4	0.540	0.802	0.694	0.565	0.523	0.454	0.596^{b}±0.010

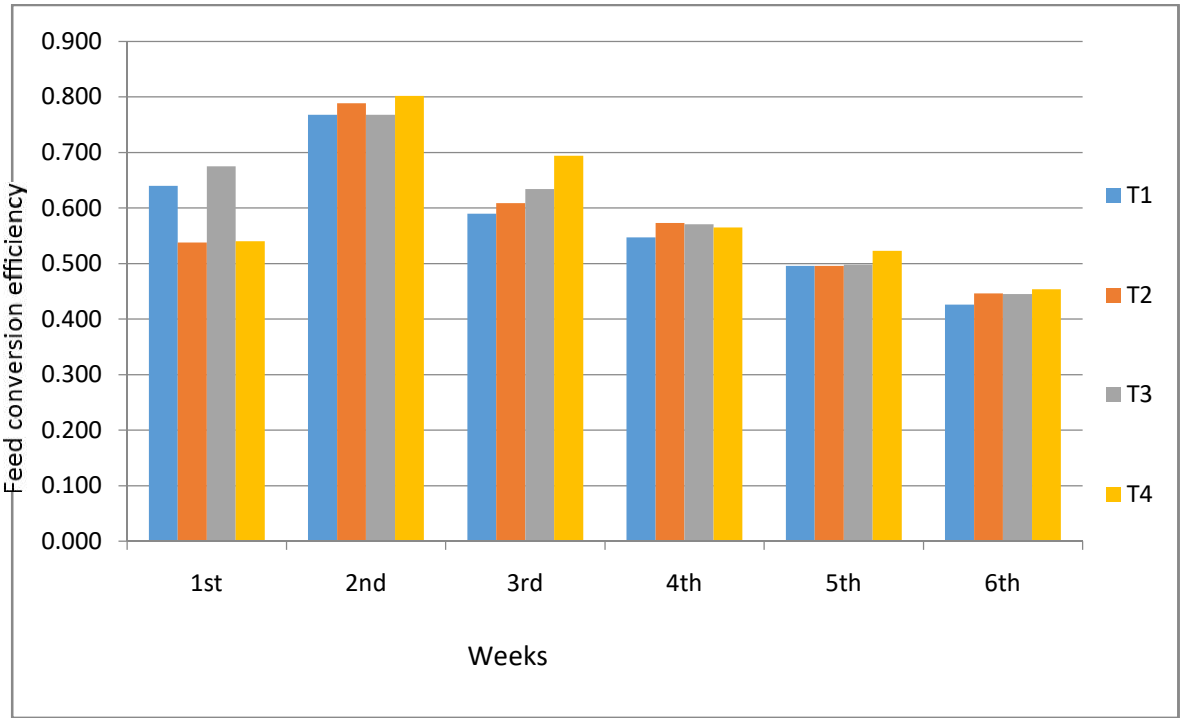


Figure 4.2.4. Feed conversion efficiency of broiler birds in different treatment groups.

[a,b] 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 0.578±0.096, 0.575±0.096, 0.599±0.099 and 0.596±0.010 for T_1, T_2, T_3 and T_4, respectively. Statistical analysis showed that there was significant effect of black cumin seed on feed conversion efficiency which was found to be better in black cumin seed supplemented group. The values for feed conversion efficiency was significantly ($P<0.05$) highest in T_3 followed by T_4, T_1 and the lowest was in T_2. Hence, the result showed positive effect of black cumin seed on feed conversion efficiency. This result were in line with the observations of Al-Homidan *et al*. (2002) who reported that feed efficiency was improved by incorporating black cumin seeds in the broiler rations. The differences in the findings might be due to difference in levels of black cumin seed 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) for the different treatment groups are shown in Table 4.2.5. The graph representing the performance index in various groups upto six weeks of age are plotted in Fig 4.2.5.

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

Treatment	Mortality (per cent)	Liveability (per cent)	Performance Index
T_1	0.00	100	166.66
T_2	0.00	100	165.07
T_3	0.00	100	167.77
T_4	0.00	100	160.30

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

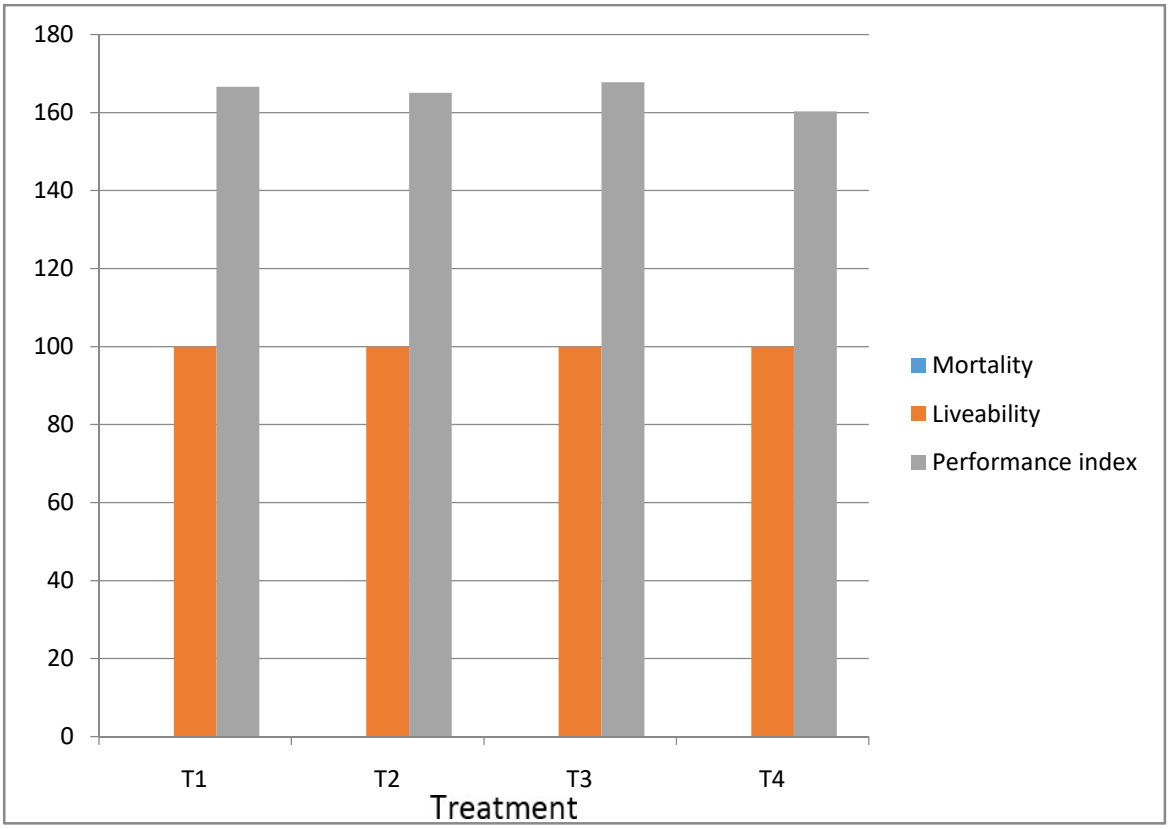


Figure 4.2.5. Mortality and Liveability and Performance index of broiler birds in different treatment groups.

which might be attributed to favourable climatic condition, good quality feed and proper management practices. It was also indicative that supplementation of black cumin seed did not have adverse effect on the survivability of the birds.

The performance index at 0, 1, 2, and 3 per cent black cumin seed was 166.66, 165.07, 167.77 and 160.30, respectively. The values for performance index was observed to be higher in T_3 groups fed with 2 per cent black cumin seed based diet followed by T_1, T_2 and the least in T_4 group. Similar to the present findings, Singh and Kumar (2018) found that inclusion of black cumin seed powder at the rate of 0.5, 1.0 and 1.5 per cent resulted in highest broiler performance efficiency index (BPEI) and 100 per cent liveability. Variation in the results might be due to difference in the levels of black cumin seed used in the diet, differences in the species of the broiler birds and agro-climatic of the experimental site.

4.2.6 Dressing percentage, Carcass yield and Organ weight

At the end of 6th week of age three birds from each treatment groups were taken for the study of carcass characteristics. The average dressing percentage, carcass yield and organ weight in different groups are presented in Table 4.2.6.

Table 4.2.6 Carcass characteristic of broiler birds in different treatment groups

Treatment	Dressing per cent	Carcass Weight (g)	Organ Weight (g)			
			Heart	Liver	Gizzard	Spleen
T_1	84.08	1963.50	11.35	41.27	40.95	2.37
T_2	84.89	2013.25	13.30	48.30	45.07	3.12
T_3	84.41	2007.75	13.82	46.47	44.95	4.30
T_4	84.32	2000.00	11.55	57.85	55.55	3.75

From the table 4.2.6, it was observed that the average dressing percentage of broiler birds at the end of sixth week was 84.08, 84.89, 84.41 and 84.32 in T_1, T_2, T_3 and T_4 groups, respectively. The weight of heart, liver, gizzard and spleen was included for calculating dressing percentage. Variation in the values can be noted in the different

treatment groups. The highest dressing percentage was recorded in T_2 group followed by T_3 and T_4, and the least in T_1 group, respectively.

The average carcass weight of broiler birds was recorded as 1963.50, 2013.25, 2007.75 and 2000.00 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The average weight of carcass was highest in T_2, T_3 and T_4 group and lowest in T_1 group.

The average heart weight was recorded as 11.35, 13.30, 13.82 and 11.55 g per bird for T_1, T_2, T_3, and T_4 groups, respectively. The heart weight was highest in T_3 group followed by T_2, T_4 and the lowest in T_1 group.

The average liver weight was 41.27, 48.30, 46.47 and 57.85 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The liver weight was highest in T_4 group followed by T_2, T_3 and the lowest in T_1 group.

The average gizzard weight was 40.95, 45.07, 44.95 and 55.55 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The value of gizzard weight was highest in T_4 group followed by T_2, T_3 and the lowest in T_1 group.

The average spleen weight was 2.37, 3.12, 4.30 and 3.75 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The spleen weight was highest in T_3 group followed by T_4, T_2 and the lowest in T_1 group.

From the result, it was observed that the value for dressing percentage was better in black cumin seed supplemented group as compared to control group, the values did not follow the linear trend; however, the value was numerically the highest at the higher level of black cumin seed supplementation. The result of the present study corroborated with the findings of Guler *et al*. (2006) and Toghyani *et al*. (2010) who reported that carcass

yield, liver, abdominal fat, breast, thigh, wing and neck weights in broilers was increased in broilers chicken fed 1 per cent black cumin seed in the diet. Conversely, Al-Beitawi *et al*. (2009) and Ismail *et al*. (2011) found that carcass characteristics of broiler birds was not increased by feeding different levels of crushed as well as uncrushed *Nigella sativa* seed in broilers, however, breast percentage was found to be increased significantly.Variation in the results might be due to different levels use of

black cumin seed in the diet, species differences of the broiler birds and agro-climatic of the experimental site.

4.2.7 Haematological parameters

The haematological parameters as influenced by incorporation of black cumin seed are presented in Table 4.2.7. The statistical analysis has been shown in Appendix 2 **(**Haematological/biochemical parameters).

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	9.44±0.30	30.37^{a}±1.02	3.20^{a}±0.10	32.66^{a}±1.08	0	0	40.00^{b}±1.33	1.66^{b}±0.05	58.66^{c}±1.95
T_2	9.64±0.31	29.66^{b}±0.98	3.10^{a}±0.10	31.00^{b}±1.03	0	0	34.33^{c}±1.14	1.00^{c}±0.01	70.00^{a}±2.33
T_3	9.78±0.32	25.06^{c}±0.83	2.83^{b}±0.09	30.33^{b}±1.01	0	0	34.66^{c}±1.15	2.33^{a}±0.07	68.33^{b}±2.27
T_4	10.11±0.33	29.00^{b}±0.96	3.10^{a}±0.10	32.00^{a}±1.06	0	0	47.00^{a}±1.56	2.00^{ab}±0.06	53.66^{d}±1.78

^{a,b,c,d} Means bearing different superscripts within the column differ significantly ($P<0.05$)

The mean values for haemoglobin (g/dl) was 9.44±0.30, 9.64±0.31, 9.78±0.32 and 10.11±0.33 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 30.37±1.02, 29.66±0.98, 25.06±0.83 and 29.00±0.96, respectively. Similarly, the corresponding values for total red blood cells ($10^6/mm^3$) for the groups T_1, T_2, T_3 and T_4 was 3.20±0.10, 3.10±0.10, 2.83±0.09 and 3.10±0.30, respectively. The packed cells volume recorded for the treatment groups T_1, T_2, T_3 and T_4 was 32.66±1.08, 31.00±1.03, 30.33±1.01 and 32.00±1.06, respectively. The value for heterophils was 40.00±1.33, 34.33±1.14, 34.66±1.15 and 47.00±1.56 for T_1, T_2, T_3 and T_4, respectively. The corresponding values for eosinophils was 1.66±0.05, 1.00±0.01, 2.33±0.07 and 2.00±0.06, respectively. Similarly, the values for lymphocytes for T_1, T_2, T_3 and T_4 was 58.66±1.95, 70.00±2.33, 68.33±2.27 and 53.66±1.78, respectively. However, monocytes and basophils was recorded as nil for all the groups.

There was significant effect on haematological parameters due to inclusion of black cumin seed in broiler feed. Similar findings were reported by Bhardwaj *et al.* (2012) who observed that supplementation of herbal product improved hemato-biochemical level in the chicken. Similarly, Khan *et al.* (2012) reported that the birds that were fed with diets containing high levels of BCS (2.5 per cent or 5.0 per cent) had higher ($P<0.05$) haematological values than birds fed with 1.25 per cent BCS diets, antibiotic or the unsupplemented diet.

The hematological parameter haemoglobin did not show significant difference between the treatment and control groups of broilers which was in line with the findings of Haqa *et al.* (2010) and Hassan (2021) who reported that haemoglobin concentration of broiler chickens were not affected with the supplementation of *Nigella sativa* seed in the diet.

Irrespective of the treatment, the values for monocytes and basophils was observed to be nil. Slight rise in lymphocyte was observed in black cumin seed supplemented groups which may be due to immuno-stimulatory effects of black cumin

seed. Similarly, Ali *et al.* (2014) also stated that the dietary supplementation of *Nigella sativa* seed at 1 per cent level have resulted in lowest Heterophyl or Lymphocyte ratio which could be responsible for an anti stress factors activities. On the contrary, Talebi *et al.* (2021) reported that supplementation of *Nigella sativa* seed at 1-2 per cent level have resulted in the increase of Heterophyl or Lymphocyte ratio but decrease in WBC count.

4.2.8 Biochemical studies

The biochemical studies in terms of average low density lipoprotein, high density lipoprotein and cholesterol of broiler birds in different treatment groups upto six weeks of age during the trial period are presented in Table 4.2.8 and the statistical analysis has been shown in Appendix 1 (Haematological / biochemical parameters).

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

Treatment	LDL	HDL	Cholesterol
T_1	91.51±3.05	60.67^{c}±2.02	110.77±3.69
T_2	95.12±3.17	62.96^{bc}±2.09	107.10±3.56
T_3	97.60±3.25	71.25^{ab}±2.37	114.28±3.80
T_4	92.64±3.08	76.88^{a}±2.56	117.65±3.92

^{a,b,c} Means bearing different superscripts within the column differed significantly ($P<0.05$)

The mean values for LDL was recorded as 91.51±3.05, 95.12±3.17, 97.60±3.25 and 92.64±3.08 mg/dl for the treatment groups T_1, T_2, T_3 and T_4 groups, respectively. The corresponding values for HDL was, 60.67±2.02, 62.96±2.09, 71.25±2.37 and 76.88±2.56 mg/dl, respectively. Similarly, the corresponding

values for Cholesterol for the groups T_1, T_2, T_3 and T_4 was 110.77±3.69, 107.10±3.56, 114.28±3.80 and 117.65±3.92 mg/dl, respectively.

From the perusal of table, there was no significant difference in LDL and cholesterol due to black cumin seed supplementation. However, addition of black cumin seed powder had positive effect on HDL. The highest amount of HDL (76.88 mg/dl) was observed in T_4 group and was found to be highly significant ($P<0.05$). The result of the present finding are in line with the findings of Ali *et al*. (2014) and Sonia *et al.* (2014) who observed improved levels of HDL in birds that are fed with black cumin seed in the diet.

4.2.9 Economics

The effect of dietary black cumin seed 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	41.00	41.00	41.00	41.00
2.	Cost of feed	136.76	138.36	147.63	141.02
3.	Cost of black cumin seed	-	15.65	33.41	47.87
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	20.00	20.00	20.00	20.00
7.	Cost of production	215.14	232.40	259.20	267.27
8.	Average Weight of broiler (Kg)	2.427	2.391	2.532	2.407
9.	Cost of production per Kg weight (Rs)	88.64	97.20	102.37	111.04
10.	Sale of broiler @Rs.130 per Kg live weight (Rs)	315.51	310.83	329.16	312.91
11.	Sale of gunny bags @Rs.20/bag(Rs)	1.333	1.333	1.333	1.333
12.	Total receipt (Rs)/bird	316.87	312.19	330.52	314.27
13.	Profit per bird(Rs)	101.73	79.80	71.32	47.00
14.	Net profit per Kg weight gain (Rs)	41.92	33.37	28.17	19.52
15.	Benefit cost ratio	1.47	1.34	1.27	1.17

Average cost of production per bird for T_1, T_2, T_3 and T_4 was 215.142, 232.39, 259.20 and 267.27 rupees per bird, respectively. Corresponding values for average cost of production per kg live weight of bird was 88.64, 97.20, 102.37 and 111.04 rupees, respectively.

Profit per bird was 101.73, 79.80, 71.32 and 47.00 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 41.92, 33.37, 28.17 and 19.52 rupees, respectively.

From the results, it was found that the total cost of production per broiler was comparable in all the groups, however the cost of production per kg live weight was lowest (Rs. 88.64) in T_1 followed by T_2, T_3 and the highest (Rs. 111.04) in T_4 group. The net profit per kg live weight of broiler was highest (Rs. 41.92) in T_1 and the lowest (Rs. 19.52) in T_4 group.

From the results, it was found that the values of total cost of production or net profit (Rs. Per bird or Rs. Per kg live weight of bird) were comparable in all the treatment groups. The value of net profit was highest in control group and lowest in treatment group supplemented with 3 per cent level of black cumin seed in the diet of broiler birds. The findings of the present study were contrary to the observation of Khadr and Abdel-Fattah (2006) who had observed higher economical returns from the broiler bird reared on diet supplemented with black cumin seed at different levels as compared to control diet.

Variation in the observation might be due to differences in the level of supplementation of black cumin seed, species of broiler birds, agro-climatic conditions etc.

Based on the above findings, it was concluded that in terms of body weight, body weight gain, feed efficiency and performance index, broilers supplemented with black cumin seed at the rate of 2 per cent (T_3) performed better as compared to the other treatment groups during the monsoon season. Moreover, the haematological and biochemical values were improved due to black cumin seed supplementation.

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	46.33	202.47	436.83	877.30	1348.60	2147.33	2667.77±74.11	444.63
T_2	43.83	196.60	425.67	844.97	1329.30	2152.47	2689.63±74.71	448.27
T_3	45.30	185.80	433.50	876.87	1356.43	2147.47	2714.47±75.40	452.41
T_4	43.57	192.30	433.53	888.23	1363.77	2177.13	2704.17±75.12	450.69

The average body weight of the day-old chicks was recorded as 42.67, 43.50, 41.73, and 43.17 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 2667.77±74.11, 2689.63±74.71, 2714.47±75.40 and 2704.17±75.12 g per bird. The overall mean body weight was 444.63, 448.27, 452.41 and 450.69 g/bird/week for T_1, T_2, T_3 and T_4, respectively. Numerically highest body weight was recorded in T_3 group (2 per cent black cumin seed supplementation) but analysis of variance showed that there was no difference in the average body weight obtained by birds that received Black cumin seed based diet and the control group under the prevailing agro-climatic

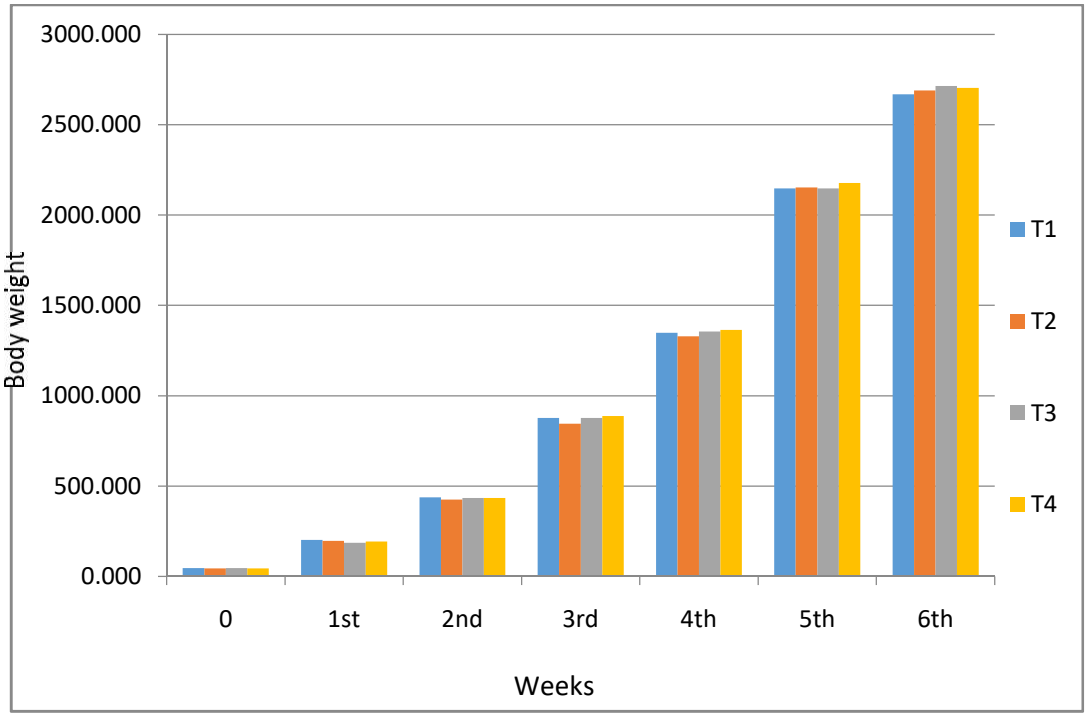


Figure 4.3.1. Body weight (g/bird/week) of broiler birds in different treatment groups.

condition. The result indicated that supplementation of black cumin seed 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 Isalam *et al.* (2011) who reported that dietary supplementation of *Nigella sativa* seed powder in hens at the rate of 0, 1.5, 3.5 and 4.5 percent for 10 weeks had no significant effects on body weight. On the contrary, El-Bagir *et al.* (2006) reported that supplementation of BCS at the rate of 2.5 and 5% had significantly increased the final bodyweight of hens. Similarly, Sogut *et al*. (2012) reported that a low level of BCS (3 per cent) tended to improve broilers' performance compared to a high level (7 per cent). Variation in results might be due to factors like strain differences, differences in experimental conditions, type of feed, difference in levels of supplementation of black cumin seed 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 are given in Table 4.3.2 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.4.3.2.

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

Treatment	Weeks						Total	Mean
	1st	2nd	3rd	4th	5th	6th		
T_1	156.13	234.37	440.47	471.30	798.73	520.43	2621.43±72.81	436.91
T_2	152.77	229.07	419.30	484.33	823.17	537.17	2645.80±73.50	440.97
T_3	140.50	247.70	443.37	479.57	791.03	567.00	2669.17±74.14	444.86
T_4	148.73	241.23	454.70	475.53	813.37	527.03	2660.60±73.91	443.43

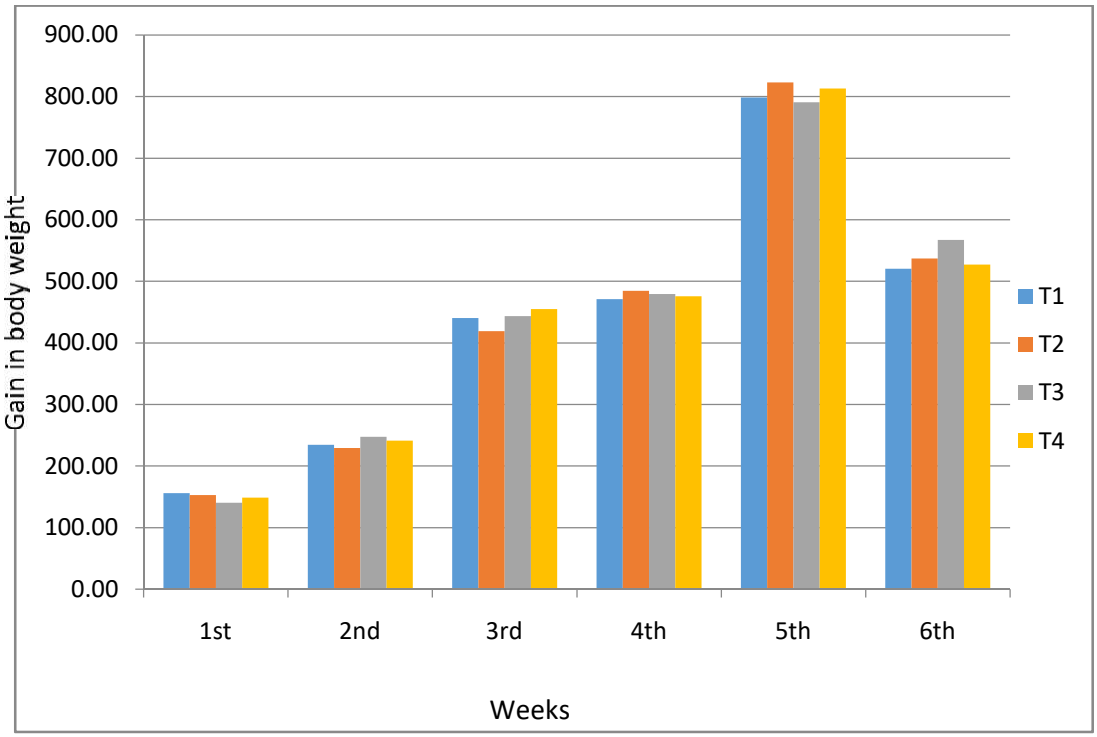


Figure 4.3.2. Gain in body weight (g/bird/week) of broiler birds in different treatment groups.

The average gain in weight for the treatment groups T_1, T_2, T_3 and T_4 was in the range of 156.13 to 520.43, 152.77 to 537.17, 140.50 to 567.00 and 148.73 to 527.03 g per bird, respectively. The corresponding values for the overall total body weight gain was 2621.43±72.81, 2645.80±73.50, 2669.17±74.14 and 2660.60±73.91 g/bird/week. The overall mean gain in body weight for the respective groups T_1, T_2, T_3 and T_4 was 436.91, 440.97, 444.86 and 443.43.Statistical analysis had revealed that there was no significant difference in weight gain due to black cumin seed supplementation probably due to the level of black cumin seed used which was not sufficient enough to cause a significant effect on weight gain. Similar findings were reported by Ali *et al*. (2014) who observed that no significant effect of feeding black cumin on body weight gain of broilers. Similarly, Dwivedi *et al.* (2015) also found lower body weight gain in birds on diet supplemented with 1.0 per cent black cumin seed powder mixture and no significant difference in body weight gain in birds whose diet was supplemented with 0.5 per cent black cumin seed powder mixture. On the contrary, Bhardwaj *et al*. (2012) and Khadr and Abdel-Fattah (2006) stated that supplementation of herbal product containing *Nigella sativa* in broiler ration at 0.5 per cent and 2 per cent level improved broiler performance ($P<0.05$) in terms of gain in body weight. Variation in the findings might be due to differences in experimental conditions, type of feed and its composition, level of black cumin seed, agro-climatic differences and seasons, etc.

4.3.3 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 4.3.3 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. 4.3.3.

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

Treatment	Weeks						Total	Mean
	1st	2nd	3rd	4th	5th	6th		
T_1	125.37	366.80	627.07	754.30	1129.40	1134.67	4137.60±114.93	689.60
T_2	136.13	340.30	594.80	739.93	1135.93	1143.10	4090.20±113.62	681.70
T_3	108.40	331.90	613.87	790.37	1141.33	1141.20	4127.07±114.64	687.84
T_4	123.90	352.97	626.97	794.03	1090.00	1161.80	4149.67±115.20	691.61

Total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 4137.60±114.93, 4090.20±113.62, 4127.07±114.64 and 4149.67±115.20 g per bird, respectively. Numerically, feed intake was higher in birds fed with black cumin seed based diet. However, statistically it was revealed that there was no significant difference between the control and the birds fed with black cumin seed treated feed. Hence, it was indicative that within the given level of black cumin seed supplementation, feed consumption of the birds was unaffected. The result were in line with the findings of Guler *et al.* (2006) who reported no significant change in dietary intake of broiler by consuming feed containing black cumin and antibiotics. However, the present study were not in line with the findings of Massuod *et al*. (2014) who found increased feed intake in birds with the supplementation of 2 per cent black cumin seed in broiler ration. The differences in the results could be due to the differences in experimental conditions such as feed, strains of bird used, level of black cumin seed, agro-climatic differences, seasons etc.

4.3.4 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 4.3.4 and their mean statistical analysis are shown in Appendix 2 (Feed Conversion Efficiency).

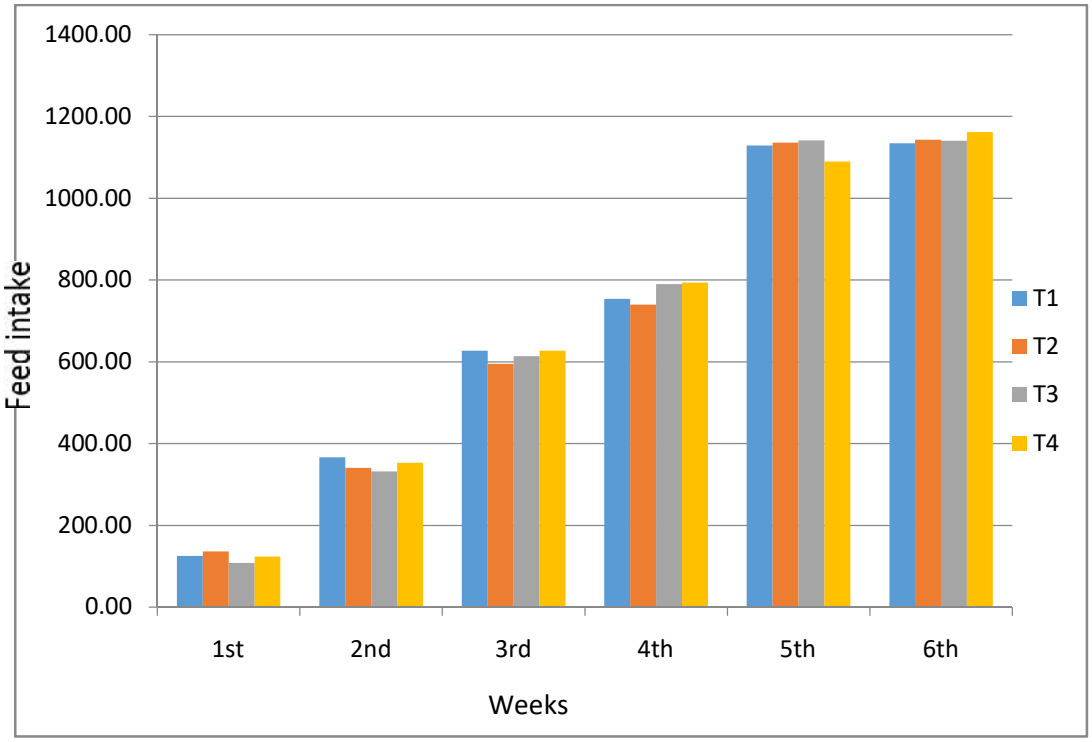


Figure 4.3.3. Feed intake (g/bird/week) of broiler birds in different treatment groups.

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						Mean
	1st	2nd	3rd	4th	5th	6th	
T_1	0.619	0.839	0.714	0.559	0.525	0.425	0.614±0.101
T_2	0.692	0.799	0.703	0.556	0.527	0.424	0.617±0.103
T_3	0.583	0.765	0.700	0.582	0.531	0.420	0.597±0.099
T_4	0.644	0.814	0.705	0.582	0.500	0.429	0.612±0.102

The mean feed conversion efficiency of broiler birds in different groups at the end of sixth week was recorded as 0.614±0.101, 0.617±0.103, 0.597±0.099 and 0.612±0.102 for T_1, T_2, T_3 and T_4, respectively. Numerically, the highest FCE was observed in T_2 but statistical analysis had revealed that there was non- significant ($P>0.05$) difference in feed conversion efficiency probably due to the level of black cumin seed used in the present study which might not have been sufficient enough to cause any significant effect. The result of the present study corroborated with the findings of Abbas and Ahmed (2010) who found that poor feed efficiency was observed in broiler chicks fed diet supplemented with 1 and 2 per cent black cumin seeds. On the contrary, Massuod *et al*. (2014) found that supplementation of 2 per cent black cumin seed in broiler ration helped in increasing feed intake, however, decreased feed conversion. The different results in the findings of the present study might be due to be to type/strain of birds used, difference in levels of black cumin seed, agro-climatic differences, seasons, etc.

4.3.5 Mortality/Liveability and Performance Index

The average mortality, liveability percentage and performance index (PI) for the different treatment groups are shown in Table 4.3.5. The graph representing the performance index in various groups upto six weeks of age are plotted in Fig 4.3.5.

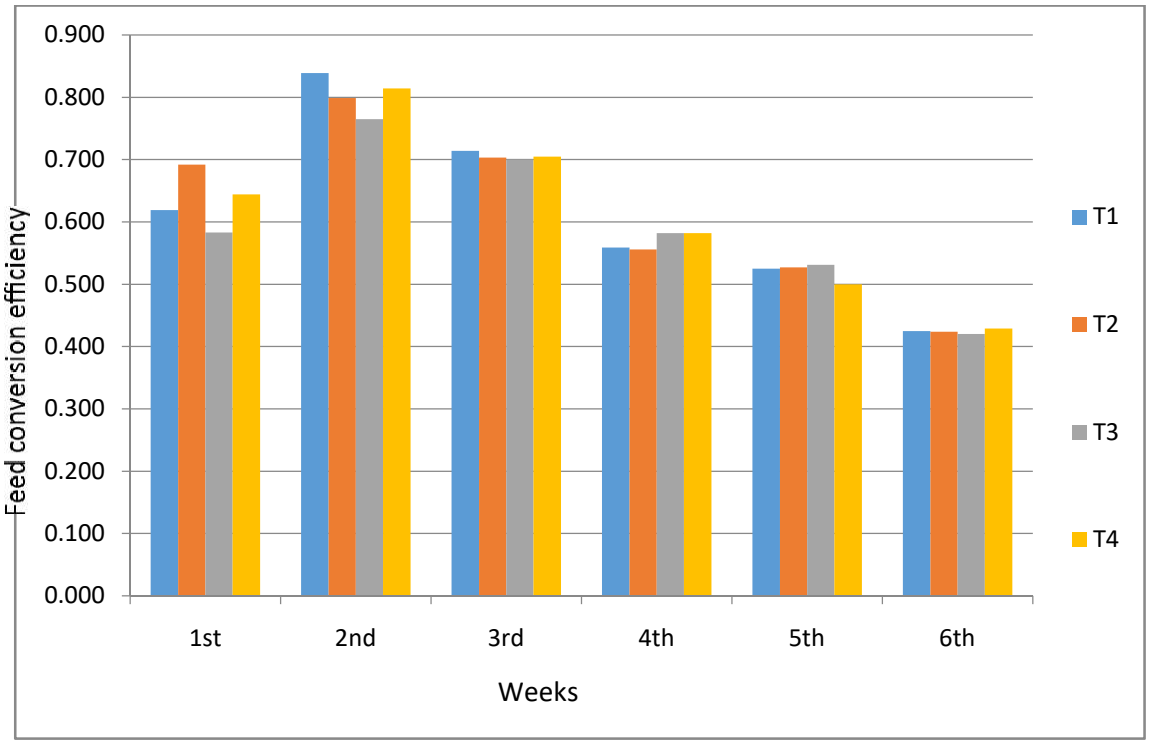


Figure 4.3.4. Feed conversion efficiency of broiler birds in different treatment groups.

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

Treatment	Mortality (per cent)	Liveability (per cent)	Performance Index
T_1	0.00	100	172.41
T_2	0.00	100	172.98
T_3	0.00	100	180.43
T_4	0.00	100	175.34

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 black cumin seed did not have adverse effect on the survivability of the birds.

The performance index at 0, 1, 2, and 3 per cent black cumin seed was 172.41, 172.98, 180.43 and 175.34, respectively. The values for performance index was observed to be higher in groups fed with black cumin seed based diet. Numerically, the higher value of performance index was found in T_3 followed by T_4, T_2 and the least in T_1 group. Similar to the present findings, Singh and Kumar (2018) reported that inclusion of black cumin seed powder at the rate of 0.5, 1.0 and 1.5 per cent resulted in highest broiler performance efficiency index (BPEI).

4.3.6 Dressing percentage, Carcass yield and Organ weight

At the end of 6^{th} week of age three birds from each treatment groups were taken for the study of carcass characteristics. The average dressing percentage, carcass yield and organ weight in different groups are presented in Table 4.3.6.

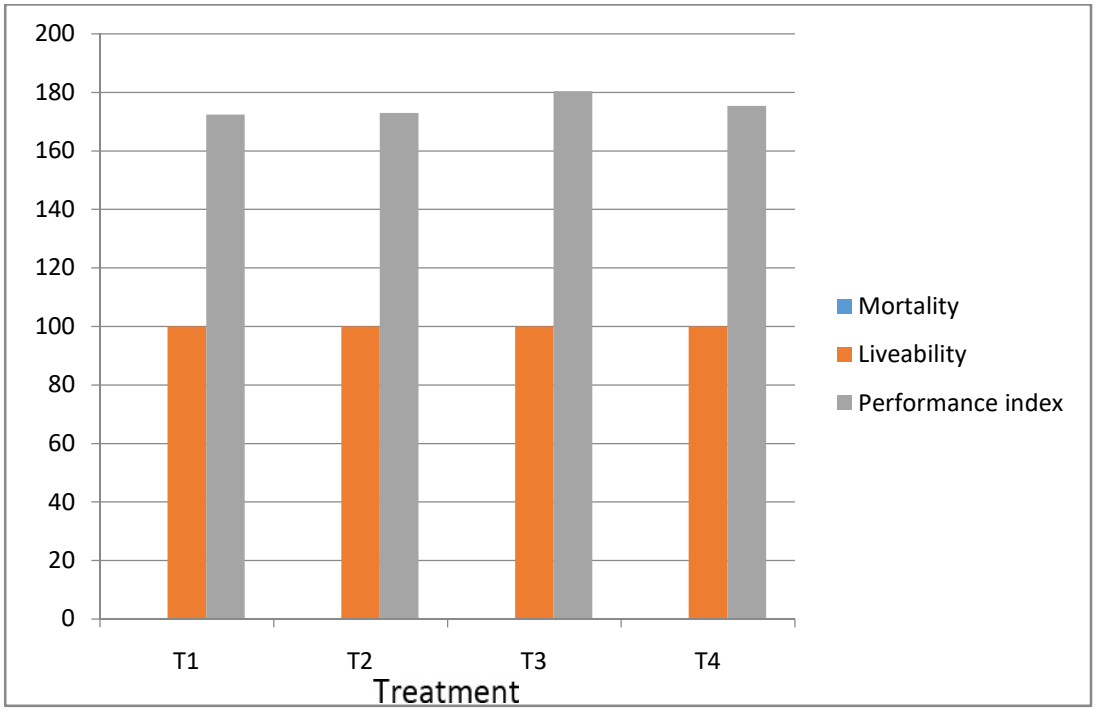


Figure 4.3.5. Mortality and Liveability and Performance index of broiler birds in different treatment groups.

Table 4.3.6 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	87.03	2107.25	14.47	51.27	40.40	2.90
T_2	88.46	2160.00	16.65	56.62	46.00	3.52
T_3	90.80	2156.50	17.20	57.00	46.82	3.12
T_4	87.50	2365.25	18.40	56.80	53.65	3.82

From the table 4.3.6, it was observed that the average dressing percentage of broiler birds at the end of sixth week was 87.03, 88.46, 90.80 and 87.50 in T_1, T_2, T_3 and T_4 groups, respectively. The weight of heart, liver, gizzard and spleen was included for calculating dressing percentage. Variation in the values can be noted in the different treatment groups. The highest dressing percentage was recorded in T_3 group followed by T_2 and T_3, and the least in T_1 group, respectively.

The average carcass weight of broiler birds was recorded as 2107.25, 2160.00, 2156.50, 2365.25 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The average weight of carcass was highest in T_4, T_2 and T_3 group and lowest in T_1 group.

The average heart weight was recorded as 14.47, 16.65, 17.20 and 18.40 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The heart weight was highest in T_4 group followed by T_3, T_2 and the lowest in T_1 group.

The average liver weight was 51.27, 56.62, 57.00 and 56.80 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The liver weight was highest in T_3 group followed by T_4, T_2 and the lowest in T_1 group.

The average gizzard weight was 40.40, 46.00, 46.82 and 53.65 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The value of gizzard weight was highest in T_4 group followed by T_3, T_2 and the lowest in T_1 group.

The average spleen weight was 2.90, 3.52, 3.12 and 3.82 g per bird for T_1, T_2, T_3 and T_4 groups, respectively. The spleen weight was highest in T_4 group followed by T_2, T_3 and the lowest in T_1 group.

From the result, it was observed that the value for dressing percentage was better in black cumin seed supplemented group as compared to control group, the values did not follow the linear trend; however, the value was numerically the highest at the higher level of black cumin seed supplementation. The result of the present study corroborated with the findings of Guler *et al*. (2006) and Toghyani et al. (2010) who reported that carcass yield, liver, abdominal fat, breast, thigh, wing and neck weights in broilers was increased in broilers chicken fed 1 per cent black cumin seed in the diet. Conversely, Al-Beitawi *et al*. (2009) and Ismail *et al*. (2011) found that carcass characteristics of broiler birds was not increased by feeding different levels of crushed as well as uncrushed *Nigella sativa* seed in broilers, however, breast percentage was found to be increased significantly.Variation in the results might be due to different levels use of black cumin seed in the diet, species differences of the broiler birds and agro-climatic of the experimental site.

4.3.7 Haematological parameters

The haematological parameters as influenced by incorporation of black cumin seed are presented in Table 4.3.7. The statistical analysis has been shown in Appendix 3 **(**Haematological/biochemical parameters).

Table 4.3.7. 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	10.51±0.35^{ab}	19.33±0.64^{c}	2.50±0.08	30.40±1.01^{a}	0	0	38.60±1.28^{a}	1±0.03^{c}	45±1.50
T_2	11.60±0.38^{a}	21.40±0.71^{b}	2.63±0.08	29.03±0.96^{b}	0	0	37.33±1.24^{bc}	3±0.10^{a}	44±1.46
T_3	9.98±0.33^{b}	26.76±0.89^{a}	2.76±0.09	29.86±0.99^{ab}	0	0	36.33±1.21^{c}	3±0.10^{a}	42±1.40
T_4	9.73±0.32^{b}	20.66±0.68^{bc}	2.76±0.09	25.93±0.86^{c}	0	0	38.33±1.27^{ab}	2±0.06^{b}	44±1.46

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

The mean values for haemoglobin (g/dl) was 10.51±0.35, 11.60±0.38, 9.98±0.33 and 9.73±0.32g/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 19.33±0.64, 21.40±0.71, 26.76±0.89and 20.66±0.68, respectively. Similarly, the corresponding values for total red blood cells (10^6/mm^3) for the groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 2.50±0.08, 2.63±0.08, 2.76±0.09 and 2.76±0.09, respectively. The packed cells volume recorded for the treatment groups $T_{1,}$ $T_{2,}$ T_3 and T_4 was 30.40±1.01, 29.03±0.96, 29.86±0.99and 25.93±0.86, respectively. The value for heterophils was 38.60±1.28, 37.33±1.24, 36.33±1.21 and 38.33±1.27for $T_{1,}$ $T_{2,}$ T_3 and T_4, respectively. The corresponding values for eosinophils was 1±0.03, 3±0.10, 3±0.10and 2±0.06, respectively. Similarly, the values for lymphocytes for $T_{1,}$ $T_{2,}$ T_3 and T_4 was 45±1.50, 44±1.46, 42±1.40 and 44±1.46, respectively. However, monocytes and basophils was recorded as nil for all the groups.

The values for haemoglobin was significantly higher for groups fed with 1% (T_2) black cumin seed followed by T_1, T_3 and the least was in T_4 (3 per cent). However, the difference between the groups T_3 and T_4, T_1 and T_2 and the groups T_1 and T_3 was found to be non- significant. The white blood cells count was significantly higher for the groups fed with 2 per cent (T_3) black cumin seed powder followed by T_4, T_2 and the least was in control (T_1). However, the difference between T_2 and T_4 and the group T_1 and T_4 was found to be non- significant.

The red blood cells count was not affected by the supplementation of black cumin seed. The values for packed cells volume was recorded to be significantly higher in control group as compared to treatment groups. However, the difference between T_1 and T_3 and the group T_2 and T_3 was found to be non- significant. Bhardwaj *et al*. (2012) observed that supplementation of herbal product improved hemato-biochemical level in the chicken. Similarly, Khan *et al.* (2012) also reported that the birds fed diets containing high levels

of BCS (2.5 per cent or 5.0 per cent) had higher (P<0.05) haematological values than birds fed 1.25 per cent BCS diets, antibiotic or the unsupplemented diet.

4.3.8 Biochemical studies

The biochemical studies in terms of average high density lipoprotein, low density lipoprotein and cholesterol of broiler birds in different treatment groups upto six weeks of age during the trial period 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 of blood (mg/dl) of broiler birds in different treatment groups

Treatment	LDL	HDL	Cholesterol
T_1	92.11±3.07^{a}	61.91±2.13	117.21±3.90^{a}
T_2	91.03±3.03^{a}	57.25±1.90	97.68±3.25^{c}
T_3	89.89±2.79^{b}	57.84±1.92	107.53±3.58^{b}
T_4	89.16±2.97^{ab}	56.91±1.89	107.19±3.57^{b}

^{a,b,c} Means bearing different superscripts within the column differed significantly (P<0.05)

From Table 4.3.8, it was observed that there was significant (P<0.05) effect of black cumin seed on LDL, HDL and cholesterol among the treatment groups. The mean value for low density lipoprotein (mg/dl) was 92.11±3.07, 91.03±3.03, 89.89±2.79 and 89.16±2.97for T_1, T_2, T_3 and T_4, respectively. The values for LDL was observed to be significantly (P<0.05) higher in T_1 followed by T_2, T_4 and the least was in T_3. However, the variation between the groups fed with 0 per cent and 1 per cent and between the groups fed with 2 and 3 per cent black cumin seed powder was found to be non- significant. The results of the present study was in agreement with the findings of researchers such Sohail *et al.* (2012) who found that serum LDL cholesterol was significantly

decreased with supplementation of black cumin seed at 4 and 5 per cent levels. Ali *et al*. (2014) also suggested that phytosterol present in black cumin seed acts as active substance and helps in lowering Low Density Lipoprotein (bad lipoprotein) in the blood of the chicken to produce healthy productivity.

The mean values for High density lipoprotein (mg/dl) was 61.91±2.13, 57.25±1.90, 57.84±1.92 and 56.91±1.89 for $T_{1,}$ $T_{2,}$ T_3 and $T_{4,}$ respectively. The value for HDL was observed to be highest in T_1 group followed by T_3, T_2 and the least was in T_4. However, the variation between the control and treatment group was found to be non- significant ($P>0.05$).

The results of the present study was in agreement with the findings of researches such as Isalam *et al.* (2011) who observed the reducing tendency of the contents of HDL in blood serum of laying hens supplemented with *Nigella sativa* seed (1.5 to 4.5 per cent) compared with control and concluded that the differences were not statistically significant. On the contrary, Sonia *et al.* (2014) found highest HDL (high density lipoprotein) value in birds fed with 3 per cent black cumin as compared to control group.

The mean values for Cholesterol (mg/dl) was 117±3.90, 97.68±3.25, 107.53±3.58 and 107.19±3.57 for $T_{1,}$ $T_{2,}$ T_3 and $T_{4,}$ respectively. Numerically, the values for Cholesterol was observed to be highest in T_1 group followed by T_3, T_4 and the least was in T_2. Statistically, Cholesterol was found to be significantly ($P<0.05$) higher in control group as compared to the black cumin treated groups which is in agreement with the findings of Khodary *et al*. (1996) who observed decreased plasma cholesterol level in broiler chickens which may be attributed to the high content of unsaturated fatty acids contained in *Nigella sativa* seeds that results in stimulation of the cholesterol excretion into the intestine. Similarly, Al-Betawi *et al*. (2009) also reported decreased serum levels of total cholesterol with the supplementation of *Nigella sativa* seed in the diet of broiler chickens.

Hence, addition of black cumin seed had positive effect on haematological and biochemical profile which could be due to rich in nutritional and phytochemicals values as it contains almost 40 per cent fixed oils, 1.4 per cent volatile oils and around 15 amino acids, proteins, calcium, iron, sodium, and potassium (Nasir *et al*., 2005) which are responsible for efficacy of black cumin seed as herbal additive.

4.3.9 Economics

The effect of dietary black cumin seed 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	41.00	41.00	41.00	41.00
2.	Cost of feed	157.20	155.42	156.82	157.66
3.	Cost of black cumin seed	-	17.58	35.17	53.52
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	20.00	20.00	20.00	20.00
7.	Cost of production	235.59	251.38	270.38	289.56
8.	Average Weight of broiler (Kg)	2.667	2.689	2.714	2.704
9.	Cost of production per Kg weight (Rs)	88.33	93.48	99.62	107.08
10.	Sale of broiler @Rs.130 per Kg live weight (Rs)	346.71	349.57	352.82	351.52
11.	Sale of gunny bags @Rs.20/bag(Rs)	1.333	1.333	1.333	1.333
12.	Total receipt (Rs)/bird	348.07	350.93	354.18	352.88
13.	Profit per bird(Rs)	112.48	99.55	83.80	36.32
14.	Net profit per Kg weight gain (Rs)	42.17	37.02	30.87	13.43
15.	Benefit cost ratio	1.47	1.39	1.30	1.21

Average cost of production per bird for T_1, T_2, T_3 and T_4 was 235.59, 251.38, 270.38 and 289.56 rupees per bird, respectively. Corresponding values

for average cost of production per kg live weight of bird was 88.33, 93.48, 99.62 and 107.08 rupees, respectively.

Profit per bird was 112.48, 99.55, 83.80 and 36.32 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 42.17, 37.02, 30.87 and 13.43 rupees, respectively.

From the results, it was found that the total cost of production per broiler was comparable in all the groups, however the cost of production per kg live weight was lowest (Rs. 88.33) in T_1 followed by T_2, T_3 and the highest (Rs. 107.08) in T_4 group. The net profit per kg live weight of broiler was highest (Rs. 42.17) in T_1 and the lowest (Rs. 13.43) in T_4 group.

From the results, it was found that the values of total cost of production or net profit (Rs. Per bird or Rs. Per kg live weight of bird) were comparable in all the treatment groups and they did not differ significantly. The value of net profit was highest in control group and lowest in treatment group supplemented with 3 per cent level of black cumin seed in the diet of broiler birds. The findings of the present study were contrary to the observation of Khadr and Abdel-Fattah(2006) who had observed higher economical returns from the broiler bird reared on diet supplemented with black cumin seed at different levels as compared to control diet.

Variation in the observation might be due to differences in the level of supplementation of black cumin seed, species of broiler birds, agro-climatic conditions etc.

Based on the above findings, it was concluded that in terms of body weight, body weight gain, performance index and dressing percentage broilers supplemented with black cumin seed at the rate of 2 per cent (T_3) performed better as compared to the other treatment groups during the winter season. Moreover, the haematological and biochemical values were improved due to black cumin seed supplementation.

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, 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 (gain: feed)	Performance index
S_1	2891.91[a]	2845.12[a]	4547.26[a]	0.674[a]	170.55[ab]
S_2	2439.88[c]	2403.10[c]	3724.56[c]	0.587[b]	164.95[b]
S_3	2694.00[b]	2649.25[b]	4126.12[b]	0.610[b]	175.29[a]
Sem (±)	21.47	10.02	15.15	0.011	2.98
CD(P=0.05)	74.307	69.32	104.87	0.028	8.571

[a, b, c] Means bearing different superscript within the column differ significantly ($P<0.05$)

From the Table 4.4.1, it was observed that the average final body weight of the birds during summer (S_1), rainy (S_2) and winter (S_3) season was 2891.91, 2439.88 and 2694.00g per bird, respectively. The corresponding values for gain in weight were 2845.12, 2403.10 and 2649.25g per bird. Feed intake for S_1, S_2 and S_3 was recorded to be 4547.26, 3724.56 and 4126.12 g per bird, respectively while the feed efficiency for the respective seasons was 0.674, 0.587 and 0.610.The overall performance index was recorded to be 170.55, 164.95and 175.29for S_1, S_2 and S_3, respectively.

Statistical analysis revealed significant seasonal effect on all the growth and feed parameters. The body weight and gain in weight was observed to be in similar trend which was found to be significantly ($P<0.05$) higher during

summer season followed by winter and the least in monsoon season. Feed intake was significantly ($P<0.05$) higher during summer season (S_1) followed by winter (S_3) and the least in monsoon (S_2) season. The best feed efficiency was observed during summer season followed by winter and the least in monsoon season. The highest performance index was observed during the winter season followed by summer and the least was in monsoon. Hence, productive performance of broiler birds in terms of body weight, weight gain and feed efficiency was best during the summer season. Similar to the present findings, Al-Habib (2016) concluded that the supplementation of black seed at the rate of 1 and 2 per cent during summer season reduce the effect of heat stress and improve the body weight, body weight gain and physiological responses of broiler chickens. Similarly, Hermes *et al*. (2011) and Hermes *et al.* (2009) suggested that supplementation of *Nigella sativa* seed in broiler diet at 1 per cent level during summer season significantly ($P<0.05$) increase the live weight, feed conversion ratio and feed consumption of broiler chickens. 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	2664.41	2618.62	4087.98	0.628	168.42
T_2	2630.84	2586.12	4076.03	0.626	166.80
T_3	2718.89	2674.20	4208.65	0.620	173.94
T_4	2686.80	2651.00	4157.91	0.619	171.87
Sem (±)	20.12	19.20	31.11	0.002	1.61

As per Table 4.4.2, the highest and lowest overall mean values for body weight as influenced by different levels of black cumin seed supplementation was observed in T_3 (2718.89 g) and T_2 (2630.84 g), respectively. Similarly, the

corresponding values for the total gain in weight per bird was observed in T_3 (2674.20 g) and T_2 (2586.12 g). Feed intake was maximum in T_3 (4208.65 g) group and lowest feed intake was observed in T_2 (4076.03 g) group. The best feed efficiency was recorded in T_1 (0.628) followed by T_2 (0.626), T_3 (0.620) and the least in T_4 (0.619) group. The highest performance index was observed in T_3 (173.94) followed by T_4 (171.87), T_1 (168.42) and the least in T_2 (166.80) group. Statistical analysis showed no significant effect on the overall body weight, total gain in weight, feed intake, feed efficiency and performance index due to black cumin seed supplementation. 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 4.4.3: 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	2898.33^{b}	2849.61^{b}	4467.31^{abc}	0.693^{a}	166.20
S_1T_2	2811.00^{c}	2764.18^{c}	4496.05^{ab}	0.688^{a}	162.36
S_1T_3	2909.66^{b}	2862.61^{b}	4613.12^{a}	0.666^{ab}	173.62
S_1T_4	2948.66^{a}	2904.08^{a}	4612.55^{a}	0.651^{ab}	180.01
S_2T_1	2727.49^{h}	2384.83^{h}	3659.06^{f}	0.578^{c}	166.65
S_2T_2	2391.89^{i}	2348.39^{j}	3641.86^{f}	0.575^{c}	165.06
S_2T_3	2532.56^{g}	2940.83^{g}	3885.79^{def}	0.599^{bc}	167.77
S_2T_4	2407.59^{i}	2388.33^{i}	3711.53^{ef}	0.596^{bc}	160.29
S_3T_1	2667.76^{f}	2621.43^{f}	4137.59^{bcd}	0.614^{bcd}	172.41
S_3T_2	2689.63^{e}	2645.80^{e}	4090.19^{cde}	0.617^{cde}	172.98
S_3T_3	2714.46^{d}	2669.16^{d}	4127.06^{bcd}	0.597^{bcd}	180.43
S_3T_4	2704.16^{de}	2660.60^{d}	4149.66^{bcd}	0.612^{bcd}	175.29
Sem (±)	0.458	0.347	9.456	0.012	1.880
CD(P=0.05)	3.176	2.413	65.644	0.070	

^{a,b,c,d,e,f,g,h,i,j} 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_1T_4 (2948.66 g) and S_2T_2 (2391.89 g), respectively while the corresponding values for the total gain in weight was observed in S_1T_4 (2904.08 g) and S_2T_2 (2348.39 g). The overall feed intake per bird was highest during summer season in control group S_1T_3 and the least in black cumin seed treated group S_2T_2 during monsoon season. The overall FCE value was maximum (0.693) during summer season at control group (S_1T_1) and the least (0.575) was in monsoon season treated with 1 per cent of black cumin seed S_2T_2. Similarly, the best and the poorest performance index was recorded in S_3T_3 (180.42) and S_2T_4 (160.29). Statistical analysis had revealed that season x black cumin seed (interaction effect) had significant effect on the overall body weight, total gain in weight, feed intake and feed efficiency of broilers. Hence, productive performance of broiler birds in terms of body weight, weight gain, feed intake and feed efficiency had significant effect due to black cumin seed supplementation.

4.4.4 Mortality/Liveability

The average mortality, liveability 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

Irrespective of the season and 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. Mahmoud *et al*. (2002) also revealed that the active ingredient (thymoquinone) in Black seed had hepato-protective effects which may result in a

sound healthy chickens with strong immune system that feed adequately with no or minimal heat stress that leads to low mortality.

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	85.83	84.42	88.44
Carcass weight g/bird	2285.00	1996.12	2197.25
Organ weight (g)			
Heart	14.18	12.50	16.68
Liver	64.94	48.47	55.42
Gizzard	50.71	46.63	46.71
Spleen	3.53	3.38	3.34

The average dressing percentage of broiler birds at the end of sixth week during summer, monsoon and winter season was 85.83, 84.42 and 88.44 per cent, respectively. Hence, dressing percentage was observed to be higher during winter season followed by summer season and the least in monsoon group.

The average carcass yield was observed to be higher during summer season followed by winter season and the least in monsoon season. With respect to the organs weight (liver, gizzard and spleen), the values were observed to be higher during summer season followed by monsoon season and the least in winter group. Al-Habib (2016) found an increase in the weight of the lymphoid organs (liver, gizzard and spleen) during summer season. Also, El-Khaiaty *et al*. (2002) reported that the increase in the weight of liver, gizzard and spleen might be as a result of the effective substance Nigellon which activated lymphoid organs for better immune response. The present findings disagreed with the result of Felver-Gant *et al.* (2012) and Ghazi *et al.* (2012) who found lower relative weight of spleen and liver in laying hens subjected to chronic heat stress.

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)
S1	10.76	25.53	2.65	33.86^{a}	79.53^{b}	68.18	87.11
S2	9.74	28.52	3.05	31.49^{ab}	94.21^{a}	67.94	112.45
S3	10.45	22.03	2.66	28.80^{b}	90.54^{ab}	58.97	107.40
Sem (±)	0.30	1.87	0.13	0.39	1.55	3.03	7.74
CD (P=0.05)				2.70	10.74		

[a, b] 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 PCV and LDL. The overall PCV (per cent) mean values for summer, monsoon and winter season was 33.86, 31.49 and 28.80, respectively which was significantly higher during summer season followed by monsoon season and the least was in winter season. Also, the overall mean values for low density lipoprotein (LDL) are 79.53, 94.21 and 90.54 for summer, monsoon and winter season, respectively which was significantly higher during monsoon season followed by winter season and the least was in summer season. However, the difference between season S_1 and S_3 and season S_2 and S_3 was found to be non- significant.

The overall mean values for haemoglobin (g/dl) for summer, monsoon and winter seasons are 10.76, 9.74 and 10.45, respectively. The perusal of Table 4.4.6 revealed that there was no significant result between the seasons due to black cumin seed supplementation.

The overall WBC (10^3 /mm^3) values for summer, monsoon and winter season was 25.53, 28.52 and 22.03, respectively. The corresponding values for RBC (10^6/mm^3)

was 2.65, 3.05 and 2.66. The perusal of Table 4.4.6 revealed that WBC (10^3 /mm^3) and RBC (10^6/mm^3) were unaffected by season.

The overall high-density lipoprotein (HDL) during summer, monsoon and winter season was 68.18, 67.94 and 58.97 mg/dl, respectively. Statistically, no significant result was observed in all the three seasons by black cumin seed supplementation.

The values for cholesterol (mg/dl) were 87.11, 112.45 and 107.40 during summer, monsoon and winter season, respectively. The perusal of Table 4.4.6 revealed that cholesterol were unaffected by season.

The results were in line with the findings of Al-Habib (2016) who showed that during summer season only the packed cell volume (PCV) differs significantly at ($P< 0.05$) between the control and the supplemented group while the haemoglobin (Hb), white blood cells (WBC) and the red blood cells (RBC) did not differ statistically at ($P>0.05$). On the contrary, Hermes *et al.* (2011) observed improved RBC, WBC, Hb and PCV due to the supplementation of *Nigella sativa* seed at 1 and 2 per cent level in broiler diet during summer season, however, reduction in the cholesterol content.

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)
T_1	23.12	2.64	10.25	32.24	83.91	67.29	113.56
T_2	24.79	2.68	11.05	31.78	92.00	63.58	97.44
T_3	26.79	2.83	9.96	31.80	90.78	67.08	102.67
T_4	26.75	3.00	10.02	29.72	85.69	62.18	95.60
Sem (±)	0.88	0.08	0.25	0.56	1.95	1.27	4.03

As per the Table 4.4.7, the values for WBC, RBC, Hb and LDL was observed to be improved in groups fed with black cumin seed based diet as compared to the control. The values for WBC and RBC was higher in groups fed with diet containing 2 and 3 per cent black cumin seed powder while the control group obtained the lowest values for WBC parameter. Haemoglobin value was found higher in treatment group containing 1 per cent black cumin seed powder.

The values for LDL was highest in T_2 (1 per cent) lowest in control (T_1). The level of PCV, HDL and cholesterol was least in groups fed with highest level of black cumin seed powder (3 per cent) and highest in control group (T_1). However, dietary supplementation of black cumin seed had no significant effect on WBC, RBC, Hb, PCV, LDL, HDL and cholesterol.

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 (mg/dl)	HDL (mg/dl)	Cholesterol (mg/dl)
S_1T_1	19.66^{g}	2.23^{f}	10.80^{bc}	33.66^{b}	68.11^{f}	61.10^{def}	112.71^{ab}
S_1T_2	23.33^{e}	2.33^{ef}	11.91^{a}	35.33^{a}	89.86^{bcd}	70.53^{b}	87.54^{c}
S_1T_3	28.56^{b}	2.90^{b}	10.12^{cde}	35.23^{a}	84.86^{cd}	72.15^{ab}	86.22^{c}
S_1T_4	30.60^{a}	3.16^{a}	10.23^{cde}	31.23^{de}	75.29^{e}	68.97^{bc}	61.97^{d}
S_2T_1	30.37^{a}	3.20^{a}	9.44^{e}	32.66^{c}	91.51^{abc}	76.88^{a}	110.10^{ab}
S_2T_2	29.66^{ab}	3.10^{a}	9.64^{de}	31.00^{e}	95.12^{ab}	62.96^{de}	107.10^{ab}
S_2T_3	25.06^{d}	2.83^{b}	9.78^{de}	30.33^{ef}	97.60^{a}	71.25^{ab}	114.28^{ab}
S_2T_4	29.00^{b}	3.10^{a}	10.11^{cde}	32.00^{cd}	92.64^{ab}	60.67^{def}	117.65^{a}
S_3T_1	19.33^{g}	2.50^{de}	10.50^{cd}	30.40^{ef}	92.11^{ab}	63.91^{cd}	117.21^{a}
S_3T_2	21.40^{ef}	2.64^{cd}	11.60^{ab}	29.03^{g}	91.03^{abc}	57.24^{ef}	97.67^{bc}
S_3T_3	26.76^{c}	2.76^{bc}	9.98^{cde}	29.86^{fg}	83.89^{d}	57.84^{ef}	107.53^{ab}
S_3T_4	20.66^{fg}	2.76^{bc}	9.73^{de}	25.93^{h}	89.15^{bcd}	56.91^{f}	107.19^{ab}
Sem (±)	0.212	0.020	1.008	0.148	1.092	0.903	2.672
CD (P=0.05)	1.351	0.177	0.963	0.948	6.962	5.754	17.034

$^{a, b, c, d, e, f, g, h}$ 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_1T_4 (30.60) and the least was in S_3T_1 (19.33) while RBC (10^6 /mm^3) was found to be highest in S_2T_1 (3.20) and the least was in S_1T_1 (2.23).

The highest and the lowest level of haemoglobin (g/dl) was observed in S_1T_2 and S_2T_1, respectively.

The highest and the lowest PCV (per cent) level was recorded in S_1T_2 (35.33) and S_3T_4 (25.93), respectively. The corresponding values for LDL (mg/dl) were 97.60 in S_2T_3 and 68.11 in S_1T_1.

Higher HDL (mg/dl) was recorded in S_2T_1 (76.88) and lowest HDL in S_3T_4 (56.91) while the corresponding values for cholesterol (mg/dl) was 117.65 in S_2T_4 and 61.97 in S_1T_4.

Based on the above findings, it was observed that season S_1 had higher WBC, Hb and PCV values and least RBC, LDL and Cholesterol values. Season S_2 had higher RBC, LDL, HDL and the least Hb. While season S_3 had lowest WBC, PCV and HDL values. Hence, season had significant influence on the blood haematology and biochemical parameters of broiler chicken.

The interaction effect of season and treatment had significant effect on the blood parameters of broiler chickens with respect to WBC, RBC, Hb, PCV, LDL, HDL and Cholesterol.

The interaction effect resulted in higher values for WBC, RBC and LDL and reduced cholesterol. The result of the haematology at the end of the experiment for PCV (24-45%), Hb (7-13g/dl) and RBC (2- 4.0 $x10^{12}$/l) values were within the normal range (Mistruka and Rawnsley, 1977). The values of HDL and LDL were low as compared to the other workers (Sonia *et al.* 2014 and Basmacioglu and Ergul, 2005). The results of total cholesterol were well in agreement with the findings of El-Dakhakhny *et al*. (2000), Islam *et al*. (2011) and Siddiqui *et al*.(2015) who observed that Black cumin oil had favourable impact on serum lipid profile by decreasing total cholesterol which could be particularly helpful to humans being very conscious of cholesterol intake.

SUMMARY

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. Black cumin seed (*Nigella sativa*) is one such herbal product which has been identified to have positive effect on the performance of broilers. Black cumin seed (*Nigella sativa*) contains bioactive substances that act as antibacterial, antifungal, antiparasitic, antiviral, antioxidant and antithrombotic. Black cumin seed (*Nigella sativa*) 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 black cumin seed (*Nigella sativa*) and its possible use as an alternative to antibiotic growth promoters, the present investigation was conceived to study the effects of black cumin seed (*Nigella sativa*) 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 Randomized Block 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 black cumin seed powder at the level of 1, 2 and 3 per cent, respectively.

Summer

Body weight

Average body weight in different groups recorded at the end of the 6^{th} week for T_1, T_2, T_3 and T_4 groups was 2898.33±80.50, 2811.00±78.08, 2909.66±80.82 and 2948.66±81.91 g per bird, respectively. Numerically, body weight was observed to be higher in black cumin seed 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 for T_1, T_2, T_3 and T_4 groups was 2849.61±79.15, 2764.18±76.78, 2862.61±79.51 and 2904.08±80.67 g/bird/week. Statistical analysis had revealed that there was no variation in weight gain due to black cumin seed supplementation.

Feed Consumption

Total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 4467.31±124.09, 4496.05±124.89, 4613.12±128.14 and 4612.55±128.13 g per bird, respectively. Numerically, feed consumption was higher in birds fed with black cumin seed based diet. However, statistically it was revealed that there was no significant difference between the control and the birds fed with black cumin seed treated feed.

Feed conversion Efficiency (FCE)

Mean feed conversion efficiency of broiler birds in different treatment groups at the end of the study was recorded as 0.693±0.116, 0.688±0.115,

0.666±0.111 and 0.651±0.109 for for T_1, T_2, T_3 and T_4 groups, respectively.Numerically highest feed conversion efficiency was observed to in the control groups. However, statistical analysis revealed that there was no 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_4 groups were calculated as 166.20, 162.37, 173.63 and 180.01, respectively. The values for performance index was observed to be higher in groups fed with black cumin seed based diet.

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 86.06, 85.08, 85.60 and 86.61 per cent, respectively and the corresponding average carcass weight of birds was 2220.00, 2250.00, 2250.00, 2420.00 g/bird. The black cumin seed treated groups showed higher values for dressing per cent, carcass and the organs yield.

Haematological parameters

Haemoglobin

The mean values for haemoglobin (g/dl) was 10.80±0.35, 11.91±0.39, 10.12±0.33 and 10.23±0.34 g/dl for T_1, T_2, T_3 and T_4, respectively. There was significant effect of black cumin seed on haemoglobin due to inclusion of black cumin seed in broiler feed.

Total White Blood Cells Count

Values for total white blood cells (10^3/mm^3) was 19.66±0.65, 23.33±0.74, 28.56±0.95 and 30.60±1.02 for T_1, T_2, T_3 and T_4, respectively. Statistical analysis had indicated significant difference ($P<0.05$) in total white blood cells. The value for total WBC was maximum at 3 per cent black cumin seed (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 2.23±0.07, 2.33±0.07, 2.90±0.08 and 3.16±0.09, 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 1%, 2% and 3% levels of black cumin seed powder.

Packed Cells Volume

Packed cells volume recorded for the treatment groups T_1, T_2, T_3 and T_4 was 33.66±1.12, 35.33±1.17, 35.23±1.16 and 31.23±1.16 per cent, respectively. There was significant effect on packed cells volume due to inclusion of black cumin seed in broiler feed.

Differential white blood cells count

Values for heterophils was 33.33±1.13, 39.00±1.30, 34.33±1.14 and 35.00±1.16 per cent for T_1, T_2, T_3 and T_4, respectively and statistical analysis showed significant difference due to inclusion of black cumin seed in broiler feed.

The values for eosinophils for T_1, T_2, T_3 and T_4 was 1.66±0.05, 1.06±0.02, 1.66±0.05 and 1.33±0.04, respectively. Similarly, the values for lymphocytes for T_1, T_2, T_3 and T_4 was 69±2.30, 70±2.33, 68±2.26 and 67.66±2.25, respectively. Monocytes and basophils was recorded as nil for all the groups. However, there was no significant effect on eosinophils and lymphocytes count due to inclusion of black cumin seed in broiler feed.

Biochemical parameters

Low Density Lipoprotein

Low density lipoprotein for T_1, T_2, T_3 and T_4 was 68.11±2.27, 89.86±2.99, 84.86±2.82 and 75.29±2.51 mg/dl, respectively. Black cumin seed supplementation had significant effect on LDL and the values was observed to be significantly ($P<0.05$) higher at T_2 (1 per cent) level of black cumin seed and the least was in T_1 group (0 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 61.10±2.03, 70.53±2.35, 72.15±2.40 and 68.97±2.29 mg/dl, respectively and the values were found to be higher ($P<0.05$) in black cumin seed treated groups as compared to the control.

Cholesterol

The mean values for cholesterol was 112.71±3.73, 87.54±2.91, 86.22±2.87 and 61.97±2.06 for T_1, T_2, T_3 and T_4, respectively. Numerically the values for cholesterol was lower in black cumin seed 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 black cumin seed. The cost of production in terms of per kg live weight of broiler was lowest in T_1 i.e. Rs.85.59 followed by T_2, T_3 and the highest in T_4 group. The net profit per kg gain of broiler was highest in T_1 which was Rs.44.88 as compared to the other treatment groups.

Monsoon Season

Body weight

Body weight in different groups recorded at the end of the 6th week for T_1, T_2, T_3 and T_4 was 2427.50±67.43, 2391.90±66.44, 2532.57±70.35 and 2407.60±66.88 g per bird, respectively. There was no significant difference in the average body weight obtained by birds that received black cumin seed based diet and the control group under the prevailing agro-climatic condition.

Gain in body weight

The total body weight gain for T_1, T_2, T_3 and T_4 was 2384.83±66.25, 2348.40±65.23, 2490.83±69.19 and 2388.33±66.34 g/bird/week, respectively. Body weight gain was unaffected by black cumin seed supplementation. Statistical analysis had revealed that there was no significant effect in weight gain due to black cumin seed supplementation.

Feed Intake

The total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 3659.07±101.64, 3641.87±101.16, 3885.80±107.94 and 3711.53±103.09 per bird, respectively. Feed intake was higher ($P<0.05$) in T_3 followed byT_4, T_2 and the least in control group i.e. T_1.

Feed Conversion Efficiency

The mean feed conversion efficiency of broiler birds in different groups at the end of sixth week was recorded as 0.578±0.096, 0.575±0.096, 0.599±0.099 and 0.596±0.010 for T_1, T_2, T_3 and T_4, respectively. Analysis of variance revealed significant effect of black cumin seed on feed conversion efficiency which was found to be better in black cumin seed supplemented

group. The values for feed conversion efficiency was significantly ($P<0.05$) lowest in T_1 followed by T_2, T_3 and the highest was in T_4.

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 166.66, 165.07, 167.77 and 160.30, respectively. The values for performance index was observed to be higher in T_3 groups fed with 2 per cent black cumin seed based diet followed by T_1, T_2 and the least in T_4 group.

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 84.08, 84.89, 84.41 and 84.32 per cent, respectively. The average carcass weight of broiler birds in different experimental groups was 1963.50, 2013.25, 2007.75 and 2000.00 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 11.35, 13.30, 13.82 and 11.55 g; 41.27, 48.30, 46.47 and 57.85g; 40.95, 45.07, 44.95 and 55.55; 2.37, 3.12, 4.30 and 3.75 g, respectively.

Haematological parameters

Haemoglobin

The values for haemoglobin (g/dl) were 9.44±0.30, 9.64±0.31, 9.78±0.32 and 10.11±0.33 for T_1, T_2, T_3 and T_4, respectively. The hematological parameter haemoglobin did not show significant difference between the treatment and control groups of broilers.

Total White Blood Cells Count

The value for total white blood cells (103/mm3) was 30.37±1.02, 29.66±0.98, 25.06±0.83 and 29.00±0.96 for $T_{1,}$ T_2, T_3 and $T_{4,}$ respectively. The group T_1 had significantly ($P<0.05$) higher total white blood cell followed by T_2, T_4 and the least was in control group T_3.

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 3.20±0.10, 3.10±0.10, 2.83±0.09 and 3.10±0.30, 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 1%, 2% and 3% levels of black cumin seed powder.

Packed Cells Volume

The packed cells volume recorded for the treatment groups $T_{1,}$ T_2, T_3 and $T_4$was 32.66±1.08, 31.00±1.03, 30.33±1.01 and 32.00±1.06 per cent, respectively. There was significant effect on packed cells volume due to inclusion of black cumin seed in broiler feed.

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 40.00±1.33, 34.33±1.14, 34.66±1.15 and 47.00±1.56; 1.66±0.05, 1.00±0.01, 2.33±0.07 and 2.00±0.06; 58.66±1.95, 70.00±2.33, 68.33±2.27 and 53.66±1.78 per cent for $T_{1,}$ T_2, T_3 and $T_{4,}$ respectively. Statistical analysis revealed that there was significant difference due to inclusion of black cumin seed in broiler feed.

Biochemical parameters

Low Density Lipoprotein

The mean values for LDL was recorded as 91.51±3.05, 95.12±3.17, 97.60±3.25 and 92.64±3.08 mg/dl for the treatment groups T_1, T_2, T_3 and T_4, respectively.

High Density Lipoprotein

The values for HDL were 60.67±2.02mg, 62.96±2.09, 71.25±2.37 and 76.88±2.56/dl for the treatment groups T_1, T_2, T_3 and T_4, respectively.

Cholesterol

The value for cholesterol (mg/dl) was recorded to be 110.77±3.69, 107.10±3.56, 114.28±3.80 and 117.65±3.92 mg/dl for T_1, T_2, T_3 and T_4 groups, respectively.

Statistically, there was no significant difference in LDL and cholesterol due to black cumin seed supplementation. However, addition of black cumin seed powder had positive effect on the blood lipid profile particularly for HDL.

Economics

The total cost of production per broiler and the cost of production per kg live weight was lowest (Rs. 88.64) in T_1 followed by T_2, T_3 and the highest (Rs. 111.04) in T_4 group. The net profit per kg live weight of broiler was highest (Rs. 41.92) in T_1 and the lowest (Rs. 19.52) in T_4 group.

Winter Season

Body weight

The final body weight recorded at the end of the 6^{th} week for T_1, T_2, T_3 and T_4 groups was 2667.77±74.11, 2689.63±74.71, 2714.47±75.40 and 2704.17±75.12 g per bird, respectively. There was no significant difference in

the average body weight obtained by birds that received black cumin seed based diet and the control group under the prevailing agro-climatic condition.

Gain in Body Weight

The overall total body weight gain for T_1, T_2, T_3 and T_4 groups was 2621.43±72.81, 2645.80±73.50, 2669.17±74.14 and 2660.60±73.91 g per bird per week, respectively. Body weight gain was unaffected by black cumin seed supplementation. Statistical analysis had revealed that there was no significant effect in weight gain due to black cumin seed supplementation.

Feed Intake

The total feed intake during the entire trial period for T_1, T_2, T_3 and T_4 groups was 4137.60±114.93, 4090.20±113.62, 4127.07±114.64 and 4149.67±115.20 g per bird, respectively. Statistically it was revealed that there was no significant difference between the control and the birds fed with black cumin seed treated feed.

Feed conversion Efficiency (FCE)

The overall mean FCE for T_1, T_2, T_3 and T_4 groups at the end of the study was recorded as 0.614±0.101, 0.617±0.103, 0.597±0.099 and 0.612±0.102. Numerically highest feed conversion efficiency was observed to in the T_2 (1 per cent) group. However, statistical analysis revealed that there was no significant difference in feed efficiency.

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 172.41, 172.98, 180.43 and 175.34,

respectively. The values for performance index was observed to be higher in T_3 groups fed with 2 per cent black cumin seed based diet followed by T_4, T_2 and the least in T_1 group.

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 87.03, 88.46, 90.80 and 87.50 per cent, respectively and the corresponding average carcass weight of birds was 2107.25, 2160.00, 2156.50, 2365.25 g/bird. The black cumin seed treated groups showed higher values for dressing per cent, carcass weight and the organs yield. The average heart weight, liver, gizzard and spleen weight for T_1, T_2, T_3 and T_4 was 14.47, 16.65, 17.20 and 18.40 g; 51.27, 56.62, 57.00 and 56.80g; 40.40, 46.00, 46.82 and 53.65; 2.90, 3.52, 3.12 and 3.82 g, respectively.

Haematological parameters:

Haemoglobin

The mean values for haemoglobin (g/dl) was 10.51±0.35, 11.60±0.38, 9.98±0.33 and 9.73±0.32g/dl for T_1, T_2, T_3 and T_4, respectively. The values for haemoglobin was significantly higher for groups fed with 2 per cent (T_2) black cumin seed followed by T_1, T_3 and the least was in T_4 (3 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 19.33±0.64, 21.40±0.71, 26.76±0.89and 20.66±0.68, respectively. The white blood cells count was significantly higher for the groups fed with 2 per cent (T_3) black cumin seed powder followed by T_2, T_4 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 2.50±0.08, 2.63±0.08, 2.76±0.09 and 2.76±0.09, respectively. The red blood cells count was not affected by the supplementation of black cumin seed.

Packed Cells Volume

The packed cells volume recorded for the respective groups was 30.40±1.01, 29.03±0.96, 29.86±0.99and 25.93±0.86 per cent. The values for packed cells volume was recorded to be significantly higher in control group i.e T_1 followed by T_3, T_2 and the least was in T_4 (3 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 38.60±1.28, 37.33±1.24, 36.33±1.21 and 38.33±1.27 per cent for T_1, T_2, T_3 and T_4, respectively. Irrespective of the groups, the mean values for eosinophils was 1±0.03, 3±0.10, 3±0.10and 2±0.06. Lymphocytes count was 45±1.50, 44±1.46, 42±1.40 and 44±1.46 for T_1, T_2, T_3 and T_4, respectively. Statistical analysis revealed that there was significant difference due to inclusion of black cumin seed in broiler feed.

Biochemical parameters

Low Density Lipoprotein

The mean value for low density lipoprotein (mg/dl) was 92.11±3.07, 91.03±3.03, 89.89±2.79 and 89.16±2.97 for T_1, T_2, T_3 and T_4, respectively. Black cumin seed supplementation had significant effect on LDL and the values was observed to be significantly ($P<0.05$) higher at T_1 (0 per cent) followed by T_2, T_3 and the least was in T_4 group (3 per cent).

High Density Lipoprotein

The value for high density lipoprotein (mg/dl) was 61.91±2.06, 57.25±1.90, 57.84±1.92 and 56.91±1.89T_1, T_2, T_3 and T_4, respectively. There was no significance difference among the treatment groups.

Cholesterol

The values for Cholesterol (mg/dl) for T_1, T_2, T_3 and T_4 groups was 117±3.90, 97.68±3.25, 107.53±3.58 and 107.19±3.57, respectively. Statistically, Cholesterol was found to be significantly ($P<0.05$) higher in control group as compared to the black cumin treated groups.

Economics

The total cost of production for T_1, T_2, T_3 and T_4 were 235.59, 251.38, 270.38 and 289.56 rupees per bird, respectively. The corresponding values for average cost of production per kg live weight of bird was 88.33, 93.48, 99.62 and 107.08 rupees, respectively.

The net profit per bird was 112.48, 99.55, 83.80 and 36.32 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 42.17, 37.02, 30.87 and 13.43 rupees, respectively. The net profit per bird was highest in T_1 followed by T_2, T_3 and the least was in T_4. Similarly, the net profit per kg weight gain of the broiler was highest in T_1 (Rs.42.17) followed by T_2, T_3 and the least was in T_4 (Rs.13.43).

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 2891.91, 2439.88 and 2694.00 g per bird, respectively. The corresponding value for gain in weight was 2845.12, 2403.10 and 2649.25 g per bird, respectively. Feed intake for S_1, S_2 and S_3 was recorded to be 4547.26, 3724.56 and 4126.12 g per bird, respectively while the feed efficiency (gain/feed) for the respective seasons was 0.674, 0.587 and 0.610.

The performance index was recorded to be 170.55, 164.95and 175.29 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 observed to be in similar trend which was found to be significantly ($P<0.05$) higher during summer season followed by winter and the least in monsoon season. Feed intake was significantly ($P<0.05$) higher during summer season (S_1) followed by winter (S_3) and the least in monsoon (S_2) season. The best feed efficiency was observed during summer season followed by winter and the least in monsoon season. The highest performance index was observed during the winter season followed by summer and the least was in monsoon.

Effect of treatment on overall growth and feed parameters

The highest and lowest overall mean values for body weight as influenced by different levels of black cumin seed supplementation was observed in T_3 (2718.89 g) and T_2 (2630.84 g), respectively. Similarly, the corresponding values for the total gain in weight per bird was observed in T_3 (2674.20 g) and T_2 (2586.12 g). Feed intake was maximum in T_3 (4208.65 g) group and lowest feed intake was observed in T_2 (4076.03 g) group. The best feed efficiency was recorded in T_1 (0.628) followed by T_2 (0.626), T_3 (0.620) and the least in T_4 (0.619) group. The highest performance index was observed in T_3 (173.94) followed by T_4 (171.87), T_1 (168.42) and the least in T_2 (166.80) group. However, statistical analysis showed no significant effect on the overall body weight, total gain in weight, feed intake, feed efficiency and performance index due to black cumin seed 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_1T_4 (2948.66 g) and

S_2T_2(2391.89 g), respectively while the corresponding values for the total gain in weight was observed in S_1T_4 (2904.08 g) and S_2T_2 (2348.39 g). The overall feed intake per bird was highest during summer season in control group S_1T_3 and the least in black cumin seed treated group S_2T_2 during monsoon season. The overall FCE value was maximum (0.693) during summer season at control group (S_1T_1) and the least (0.575) was in monsoon season treated with 1 per cent of black cumin seed S_2T_2. Similarly, the best and the poorest performance index was recorded in S_3T_3 (180.42) and S_2T_4 (160.29). Statistical analysis had revealed that season x black cumin seed (interaction effect) had significant effect on the overall body weight, total gain in weight, feed intake and feed efficiency of broilers.

Mortality/Liveability

Irrespective of the season and treatment groups, the mortality percentage was zero per cent while liveability was recorded as 100 per cent.

Dressing percentage, Carcass yield and Organ weight

Dressing percentage was observed to be higher during winter season (88.44 per cent) followed by summer season (85.83 per cent) and the least in monsoon season (84.42 per cent).The average carcass yield was observed to be higher during winter season followed by summer season and the least in monsoon season. With respect to the organs weight (heart, liver, gizzard and spleen), the values were observed to be higher during winter season followed by summer season and the least in monsoon group.

Effect of season on Haematological / Biochemical parameters

There was significant seasonal effect on PCV and LDL. The overall PCV (per cent) mean values for summer, monsoon and winter season was 33.86, 31.49 and 28.80, respectively which was significantly higher during summer season followed by monsoon season and the least was in winter season. Also, the overall mean values for low density lipoprotein (LDL) are 79.53, 94.21 and 90.54 for summer, monsoon and winter season, respectively

which was significantly higher during monsoon season followed by winter season and the least was in summer season. However, dietary supplementation of black cumin seed had no significant effect on Hb, WBC, RBC, HDL and cholesterol.

Effect of treatment on Haematological / Biochemical parameters

The value for WBC, RBC, Hb and LDL was observed to be improved in groups fed with black cumin seed based diet as compared to the control. The values for WBC and RBC was higher in groups fed with diet containing 2 and 3 per cent black cumin seed powder while the control group obtained the lowest values for WBC parameter. Haemoglobin value was found higher in treatment group containing 1 per cent black cumin seed powder.

The values for LDL was highest in T_2 (1%) lowest in control (T_1). The level of PCV, HDL and cholesterol was least in groups fed with highest level of black cumin seed powder (3 %) and highest in control group (T_1). However, dietary supplementation of black cumin seed had no significant effect on WBC, RBC, Hb, PCV, LDL, HDL and cholesterol.

Interaction effect of season x treatment on Haematological / Biochemical parameters

The interaction effect of season x treatment had significant effect on the blood parameters of broiler chickens with respect to WBC, RBC, Haemoglobin, PCV, LDL, HDL and cholesterol. It was observed that summer seasonhad higher WBC, Hb and PCV values and least RBC, LDL and Cholesterol values. Monsoon season had higher RBC, LDL, HDL and the least Hb. While winter season had lowest WBC, PCV and HDL values. Hence, season had significant influence on the blood haematology and biochemical parameters of broiler chicken.

Conclusions

During summer season the supplementation of black cumin seed powder at higher rate of 2 percent (T_3) and 3 percent (T_4) had shown positive impact on growth, feed conversion efficiency, performance index and carcass weight per bird during the summer season.

During monsoon season it could be concluded that in terms of body weight, weight gain, feed intake, feed efficiency and performance index, broilers supplemented with black cumin seed at the rate 2% (T_3) and 3% (T_4) performed better as compared to the other treatment groups during the monsoon season.

During winter season the treatment group T_3 and T_4 with 2% and 3% percent black cumin seed powder supplementation performed the best in terms of body weight, body weight gain, feed efficiency and performance index as compared to the control.

However, the control group had the highest net profit return as compared to the treatment groups at which positive effect of black cumin seed was not achieved in terms of economics. The body weight and gain in weight was observed to be in similar trend which was found to be significantly ($P<0.05$) higher during summer season followed by winter and the least in monsoon season.

Effect of season on overall feed intake was significantly ($P<0.05$) higher during summer season (S_1) followed by winter (S_3) 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.

The body weight and gain in weight was observed to be in similar trend which was found to be significantly ($P<0.05$) higher during summer season followed by winter and the least in monsoon season due to effect of season on overall growth and feed parameters.

Black cumin seed supplementation had positive influence on the haematology and blood profile of broiler chicken due to treatment effect on Haematological / Biochemical parameters.

Future Plan:

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 agro climatic condition of Nagaland in order to derive valuable information and ascertain its positive effect on the productive and reproductive aspects of birds.

Comparative studies on the efficacy of black cumin seed and other herbal products on the health aspects of broiler and other local germplasm to popularise it at farmer's level.

Further studies using black cumin seed as an alternative to antibiotic growth promoter on other species of livestock can be beneficial.

Recommendation:

Based on the final conclusion, it can be recommended that using of good quality black cumin seed improves the health condition of the broiler chicken.

Black cumin seed can be used as an alternative to antibiotics and vaccines to improve immunity and to reduce mortality in poultry. Broiler chickens incorporated with black cumin seed supplementation helps in producing best meat quality.

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APPENDIX -1 (SUMMER SEASON)

BODY WEIGHT

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	90387.373	22596.8432	1.3865919	3.2591667	Non- Significant
Treatment	3	41451.737	13817.24577	0.8478565	3.4902948	Non- Significant
Error	12	195560.15	16296.67931			
Total	19					

CV %	4.40975
SEM (±)	57.090593

BODY WEIGHT GAIN

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	39584.085	9896.021317	1.4000213	3.2591667	Non- Significant
Treatment	3	19217.679	6405.892873	0.9062618	3.4902948	Non- Significant
Error	12	84821.752	7068.479311			
Total	19					

CV %	11.879542
SEM (±)	37.599147

FEED INTAKE

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	15689.723	3922.430643	1.2456525	3.2591667	Non- Significant
Treatment	3	6709.1445	2236.381507	0.7102112	3.4902948	Non- Significant
Error	12	37786.756	3148.896369			
Total	19					

CV %	4.2902316
SEM (±)	25.095403

FEED CONVERSION EFFICIENCY

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.0018693	0.000467325	1.3688823	3.2591667	Non- Significant
Treatment	3	0.0020668	0.000688933	2.0180145	3.4902948	Non- Significant
Error	12	0.0040967	0.000341392			
Total	19					

CV %	4.08417
SEM (±)	0.008263

HAEMATOLOGICAL/BIOCHEMICAL PARAMETERS

HAEMOGLOBIN

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	4.919366	1.229841	2.328593	3.259167	Non- Significant
Treatment	3	10.05221	3.350736	6.344314	3.490295	Significant
Error	12	6.337774	0.528148			
Total	19					

CV %	6.75119
SEM (±)	0.32501
CD	1.00145

WBC

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	6.29167	1.57292	1.53103	3.25917	Non- Significant
Treatment	3	396.482	132.161	128.641	3.49029	Significant
Error	12	12.3283	1.02736			
Total	19					

CV %	4.0076
SEM (±)	0.45329
CD	1.39673

RBC

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.03393	0.00848	0.47359	3.25917	Non- Significant
Treatment	3	3.01528	1.00509	56.1097	3.49029	Significant
Error	12	0.21496	0.01791			
Total	19					

CV %	5.03471
SEM (±)	0.05985
CD	0.18443

PCV

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	1.55167	0.38792	0.70158	3.25917	Non- Significant
Treatment	3	54.9667	18.3222	33.1374	3.49029	Significant
Error	12	6.635	0.55292			
Total	19					

CV %	2.19562
SEM (±)	0.33254
CD	1.02466

HETEROPHILS

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	13.1667	3.29167	0.75719	3.25917	Non- Significant
Treatment	3	92.6389	30.8796	7.1033	3.49029	Significant
Error	12	52.1667	4.34722			
Total	19					

CV %	5.88706
SEM (±)	0.93244
CD	2.87313

LYMPHOCYTES

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	1.16667	0.29167	0.02473	3.25917	Non- Significant
Treatment	3	16.6667	5.55556	0.47114	3.49029	Non- Significant
Error	12	141.5	11.7917			
Total	19					

CV %	5.00082
SEM (±)	1.53569

EOSINOPHILS

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.46657	0.11664	0.41171	3.25917	Non- Significant
Treatment	3	1.26691	0.4223	1.49062	3.49029	Non- Significant
Error	12	3.3997	0.28331			
Total	19					

CV %	37.1354
SEM (±)	0.23804

CHOLESTEROL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	48.0869	12.0217	0.02651	3.25917	Non- Significant
Treatment	3	6441.88	2147.29	4.73447	3.49029	Significant
Error	12	5442.54	453.545			
Total	19					

CV %	24.4478
SEM (±)	9.52413
CD	29.3468

LDL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	178.637	44.6592	0.85302	3.25917	Non- Significant
Treatment	3	1416.84	472.279	9.02085	3.49029	Significant
Error	12	628.25	52.3542			
Total	19					

CV %	9.09743
SEM (±)	3.23587
CD	9.9707

HDL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	83.3972	20.8493	2.12621	3.25917	Non- Significant
Treatment	3	360.302	120.101	12.2479	3.49029	Significant
Error	12	117.67	9.80585			
Total	19					

CV %	4.59207
SEM (±)	1.40042
CD	4.31512

APPENDIX -2 (MONSOON SEASON)

BODY WEIGHT

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	11678.18588	2919.5465	0.3631489	3.2591667	Non- Significant
Treatment	3	60440.6778	20146.893	2.505979	3.4902948	Non- Significant
Error	12	96474.35756	8039.5298			
Total	19					

CV %	3.6748942
SEM (±)	40.098703

BODY WEIGHT GAIN

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	11619.782	2904.94538	1.6812611	3.2591667	Non- Significant
Treatment	3	8019.4189	2673.13964	1.5471016	3.4902948	Non- Significant
Error	12	20734.046	1727.83712			
Total	19					

CV %	7.5411213
SEM (±)	18.589444

FEED INTAKE

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	1062.7425	265.685634	0.1320039	3.2591667	Non- Significant
Treatment	3	23236.792	7745.59726	3.8483428	3.4902948	Significant
Error	12	24152.517	2012.70978			
Total	19					

CV %	4.1493292
SEM (±)	20.063448
CD	61.821637

FEED CONVERSION EFFICIENCY

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.000473	0.00011825	0.906246	3.2591667	Non- Significant
Treatment	3	0.002149	0.00071631	5.4897177	3.4902948	Significant
Error	12	0.0015658	0.00013048			
Total	19					

CV %	2.5799955
SEM (±)	0.0051085
CD	0.0157408

HAEMATOLOGICAL/BIOCHEMICAL PARAMETERS

HAEMOGLOBIN

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.724074	0.181018	0.416117	3.259167	Non- Significant
Treatment	3	1.20981	0.40327	0.927018	3.490295	Non- Significant
Error	12	5.220224	0.435019			
Total	19					

CV %	6.770962
SEM (±)	0.294964

WBC

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	1259	314.75	3.244845	3.259167	Non- Significant
Treatment	3	1319	439.6667	4.532646	3.490295	Significant
Error	12	1164	97			
Total	19					

CV %	34.41651
SEM (±)	4.404543
CD	13.57175

RBC

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.006667	0.001667	0.142858	3.259167	Non- Significant
Treatment	3	0.370833	0.123611	10.59523	3.490295	Significant
Error	12	0.14	0.011667			
Total	19					

CV %	3.531741
SEM (±)	0.048305
CD	0.148841

PCV

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	2	0.5	1.8	3.259167	Non- Significant
Treatment	3	16.11111	5.37037	19.33333	3.490295	Significant
Error	12	3.333334	0.277778			
Total	19					

CV %	1.673163
SEM (±)	0.235702
CD	0.726271

HETEROPHILS

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	15.5	3.875	1.060837	3.259167	Non- Significant
Treatment	3	527.7778	175.9259	48.16223	3.490295	Significant
Error	12	43.83333	3.652778			
Total	19					

CV %	4.900575
SEM (±)	0.854725
CD	2.633671

LYMPHOCYTES

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.166668	0.041667	0.272729	3.259167	Non- Significant
Treatment	3	914.4444	304.8148	1995.151	3.490295	Significant
Error	12	1.833334	0.152778			
Total	19					

CV %	0.623726
SEM (±)	0.174802
CD	0.538617

EOSINOPHILS

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	1.166668	0.291667	1.235295	3.259167	Non- Significant
Treatment	3	11.52778	3.842593	16.27451	3.490295	Significant
Error	12	2.833334	0.236111			
Total	19					

CV %	30.68922
SEM (±)	0.217307
CD	0.669589

CHOLESTEROL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	366.0423	91.51056	0.642636	3.259167	Non- Significant
Treatment	3	309.5344	103.1781	0.724572	3.490295	Non- Significant
Error	12	1708.786	142.3988			
Total	19					

CV %	10.61212
SEM (±)	5.336644

LDL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	189.6104	47.4026	2.616117	3.259167	Non- Significant
Treatment	3	110.5999	36.86665	2.034645	3.490295	Non- Significant
Error	12	217.4334	18.11945			
Total	19					

CV %	4.517913
SEM (±)	1.903652

HDL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	18.40015	4.600037	0.10023	3.259167	Non- Significant
Treatment	3	842.5255	280.8418	6.119241	3.490295	Significant
Error	12	550.7386	45.89488			
Total	19					

CV %	9.970835
SEM (±)	3.029682
CD	9.335381

APPENDIX -3 (WINTER SEASON)

BODY WEIGHT

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	21519.5	5379.8738	0.537421	3.259167	Non- Significant
Treatment	3	6147.271	2049.0904	0.204693	3.490295	Non- Significant
Error	12	120126.4	10010.531			
Total	19					

CV %	3.713896
SEM (±)	44.7449

BODY WEIGHT GAIN

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	13207.47	3301.8668	0.66597	3.259167	Non- Significant
Treatment	3	6350.163	2116.7210	0.426932	3.490295	Non- Significant
Error	12	59495.81	4957.9841			
Total	19					

CV %	13.09076
SEM (±)	31.48963

FEED INTAKE

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	7867.35	1966.83755	1.491235	3.259167	Non- Significant
Treatment	3	2034.615	678.205122	0.514208	3.490295	Non- Significant
Error	12	15827.19	1318.93209			
Total	19					

CV %	3.171269
SEM (±)	16.2415

FEED CONVERSION EFFICIENCY

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.013721	0.00343	2.302169	3.259167	Non- Significant
Treatment	3	0.002853	0.000951	0.638221	3.490295	Non- Significant
Error	12	0.01788	0.00149			
Total	19					

CV %	2.476276
SEM (±)	0.017263

HAEMATOLOGICAL/BIOCHEMICAL PARAMETERS

HAEMOGLOBIN

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.339629	0.084907	0.098296	3.259167	Non- Significant
Treatment	3	10.33348	3.444493	3.987629	3.490295	Significant
Error	12	10.36554	0.863795			
Total	19					

CV %	8.886534
SEM (±)	0.415643
CD	1.280723

WBC

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	1259	314.75	3.244845	3.259167	Non- Significant
Treatment	3	1319	439.6667	4.532646	3.490295	Significant
Error	12	1164	97			
Total	19					

CV %	44.68291
SEM (±)	4.404543
CD	13.57175

RBC

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.225556	0.056389	2.465587	3.259167	Non- Significant
Treatment	3	0.244444	0.081481	3.562753	3.490295	Significant
Error	12	0.274444	0.02287			
Total	19					

CV %	5.671107
SEM (±)	0.067632
CD	0.208395

PCV

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	6.311756	1.577939	3.099885	3.259167	Non- Significant
Treatment	3	59.84861	19.94954	39.19117	3.490295	Significant
Error	12	6.108378	0.509031			
Total	19					

CV %	2.47659
SEM (±)	0.319071
CD	0.983156

HETEROPHILS

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	8.30005	2.075013	2.797764	3.259167	Non- Significant
Treatment	3	16.01667	5.338889	7.198488	3.490295	Significant
Error	12	8.900017	0.741668			
Total	19					

CV %	2.287388
SEM (±)	0.385141
CD	1.186738

LYMPHOCYTES

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	16	4	0.8	3.259167	Non- Significant
Treatment	3	23.75	7.916667	1.583333	3.490295	Non- Significant
Error	12	60	5			
Total	19					

CV %	5.111013
SEM (±)	1

EOSINOPHILS

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	0.5	0.125	1	3.259167	Non- Significant
Treatment	3	13.75	4.583333	36.66667	3.490295	Significant
Error	12	1.5	0.125			
Total	19					

CV %	15.71348
SEM (±)	0.158114
CD	0.487197

CHOLESTEROL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	153.5381	38.38451	0.961152	3.259167	Non- Significant
Treatment	3	953.9974	317.9991	7.962732	3.490295	Significant
Error	12	479.2312	39.93593			
Total	19					

CV %	5.88378
SEM (±)	2.826161
CD	8.708269

LDL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	36.81376	9.20344	0.578186	3.259167	Non- Significant
Treatment	3	199.6466	66.54888	4.180788	3.490295	Significant
Error	12	191.0134	15.91778			
Total	19					

CV %	4.480395
SEM (±)	1.784252
CD	5.497829

HDL

SOV	df	SS	MSS	F value		Inference
				F RATIO	F TABLE	
Replication	4	91.85578	22.96394	1.134031	3.259167	Non- Significant
Treatment	3	81.06392	27.02131	1.334396	3.490295	Non- Significant
Error	12	242.9982	20.24985			
Total	19					

CV %	7.694866
SEM (±)	2.012454

APPENDIX- 4

(INTERACTION OF SEASON AND TREATMENT)

Body Weight

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	0.068	0.02			
Main plot Treatment	2	2.066	1.03	127.90	4.459	Significant
Main plot Error	8	0.065	0.01			
Sub plot Treatment	3	0.060	0.02	1.91	2.866	Non-Significant
Interaction	6	0.055	0.01	0.86	2.364	Non-Significant
Error	36	0.380	0.01			
Total	59	0.068	0.02			
CV	3.846926					

Gain in body Weight

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	41174.67	10293.67			
Main plot Treatment	2	356800.94	178400.47	61.42	4.46	Significant
Main plot Error	8	23236.67	2904.58			
Sub plot Treatment	3	2334.95	778.32	0.17	2.87	Non- Significant
Interaction	6	31252.31	5208.72	1.14	2.36	Non –Significant
Error	36	165051.61	4584.77			
Total	59	619851.14				
CV	11.31					

Feed Intake

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	12778.34	3194.59			
Main plot Treatment	2	546722.26	273361.13	184.68	4.46	Significant
Main plot Error	8	11841.47	1480.18			
Sub plot Treatment	3	21305.86	7101.95	3.29	2.87	Significant
Interaction	6	10674.69	1779.11	0.82	2.36	Non-Significant
Error	36	77766.46	2160.18			
Total	59	681089.09				
CV	3.95					

Feed conversion Efficiency

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	0.00292	0.000731			
Main plot Treatment	2	0.00788	0.003939	16.61	4.46	Significant
Main plot Error	8	0.00190	0.000237			
Sub plot Treatment	3	0.00204	0.000679	3.73	2.87	Significant
Interaction	6	0.00237	0.000395	2.17	2.36	Non-Significant
Error	36	0.00655	0.000182			
Total	59	0.00292	0.000731			
CV	3.07					

WBC

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	4.29	1.07			
Main plot Treatment	2	432.33	216.16	261.09	4.46	Significant
Main plot Error	8	6.62	0.83			
Sub plot Treatment	3	139.31	46.44	39.05	2.87	Significant
Interaction	6	508.65	84.77	71.29	2.36	Significant
Error	36	42.81	1.19			
Total	59	1134.00				
CV	4.31					

RBC

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	0.10637	0.02659			
Main plot Treatment	2	2.08981	1.04491	52.32	4.46	Significant
Main plot Error	8	0.15978	0.01997			
Sub plot Treatment	3	1.23148	0.41049	23.48	2.87	Significant
Interaction	6	2.39907	0.39985	22.87	2.36	Significant
Error	36	0.62940	0.01748			
Total	59	6.61593				
CV	4.73					

HAEMOGLOBIN

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	2.50402	0.62600			
Main plot Treatment	2	11.04190	5.52095	12.69531	4.46	Significant
Main plot Error	8	3.47905	0.43488			
Sub plot Treatment	3	11.32267	3.77422	6.19755	2.87	Significant
Interaction	6	10.27282	1.71214	2.81145	2.36	Significant
Error	36	21.92353	0.60899			
Total	59	60.54400				
CV	7.56					

PCV

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	1.65	0.41			
Main plot Treatment	2	256.22	128.11	124.81	4.46	Significant
Main plot Error	8	8.21	1.03			
Sub plot Treatment	3	57.72	19.24	43.08	2.87	Significant
Interaction	6	73.21	12.20	27.32	2.36	Significant
Error	36	16.08	0.45			
Total	59	413.09				
CV	2.13					

LDL

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	127.76	31.94			
Main plot Treatment	2	2218.91	1109.45	32.01	4.46	Significant
Main plot Error	8	277.30	34.66			
Sub plot Treatment	3	570.69	190.23	6.61	2.87	Significant
Interaction	6	1156.40	192.73	6.69	2.36	Significant
Error	36	1036.70	28.80			
Total	59	5387.75				
CV	6.13					

HDL

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	119.36	29.84			
Main plot Treatment	2	1101.76	550.88	84.92	4.46	Significant
Main plot Error	8	51.90	6.49			
Sub plot Treatment	3	293.20	97.73	4.16	2.87	Significant
Interaction	6	1074.47	179.08	7.61	2.36	Significant
Error	36	846.77	23.52			
Total	59	3487.46				
CV	7.46					

CHOLESTEROL

Source of variation	Df	SS	MSS	F cal	F table	Logic
Replication	4	339.61	84.90			
Main plot Treatment	2	7195.20	3597.60	126.20	4.46	Significant
Main plot Error	8	228.06	28.51			
Sub plot Treatment	3	2931.53	977.18	4.61	2.87	Significant
Interaction	6	4773.88	795.65	3.75	2.36	Significant
Error	36	7630.55	211.96			
Total	59	23098.83				
CV	14.23					