EFFECT OF GARLIC (*Allium sativum*) POWDER AND NEEM (*Azadirachta indica*) SEED CAKE ON CHOLESTEROL CONTENT IN BROILER CHICKEN

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Thesis submitted in partial fulfillment of the requirement for the degree of

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DECLARATION

I hereby declare that this thesis, entitled **"EFFECT OF GARLIC (*Allium sativum*) POWDER AND NEEM *(Azadirachta indica)* SEED CAKE ON CHOLESTEROL CONTENT IN BROILER CHICKEN"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Mannuthy,
02.09.06

LONKAR VIJAYSINH DHANSING

CERTIFICATE

Certified that this thesis, entitled **"EFFECT OF GARLIC (*Allium sativum*) POWDER AND NEEM (*Azadirachta indica*) SEED CAKE ON CHOLESTEROL CONTENT IN BROILER CHICKEN"** is a record of research work done independently by **Dr. Lonkar Vijaysinh Dhansing**, under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of **Dr. Lonkar Vijaysinh Dhansing,** a candidate for the degree of **Master of Veterinary Science in Poultry Science,** agree that this thesis entitled **"EFFECT OF GARLIC (*Allium sativum*) POWDER AND NEEM (*Azadirachta indica*) SEED CAKE ON CHOLESTEROL CONTENT IN BROILER CHICKEN"** may be submitted by **Dr. Lonkar Vijaysinh Dhansing,** in partial fulfillment of the requirement for the degree.

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Dedicated To
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Introduction

1. INTRODUCTION

Poultry industry in India is emerging as the most dynamic and fast expanding component in the Animal Husbandry sector. Chicken meat production in the country has increased from 1.08 million metric tonnes in the year 2000 to 1.60 million metric tonnes during 2004 (FAO, 2005). Although India has made a quantum jump in broiler meat production, it contributes only about 2.39 per cent of the world's total poultry meat production (Narahari and Kumararaj, 2006). It implies that there is tremendous scope and opportunity for the Indian broiler industry to gain in the near future.

At present broiler chicken is the cheapest meat source in India and has been preferred by majority of our population. Further, the consumption of poultry meat is not a taboo unlike that of beef and pork. On the other hand, cholesterol content of poultry meat and products has become a primary area of consumer concern due to increased awareness of link between higher dietary cholesterol intake and incidence of cardiovascular diseases (CVD). Cardiovascular affliction is considered the world's number one peril in public health accounting for more than twenty five per cent of all deaths in the world (Gyarfas, 1992). The Global Burden of Diseases (GBD) study reported the estimated mortality from CVD in India was 1.6 million in the year 2000 (Gupta, 2005). It has been predicted that by 2020 there would be a 111 per cent increase in cardiovascular deaths in India. Coronary heart disease is believed to have a non-pharmacological remedy by way of physical exercise, low salt intake and cessation of smoking, while hypercholesterolemia is still difficult and costly to be controlled.

Gyarfas (1992) postulated that the most practical and least expensive way of overcoming the cardiovascular disease is of resorting to non-pharmacological procedures. Thus, attempts were made to reduce serum cholesterol or lipids in mammals by administrating non-pharmacological dietary hypocholesterolemic

agents such as garlic, onion, neem and ginger with varying degrees of efficacy (Kendler, 1987; Lata *et al.*, 1991).

Garlic (*Allium sativum*) has been prescribed as a folk medicine from the time of the ancient Greeks. Although garlic has long been used in infectious conditions, its antimicrobial and immunomodulatory properties endow its potential role in cardiovascular diseases. Garlic is recommended primarily for its ability to lower cholesterol and blood pressure in the attempts to reduce the risk of dying from cardiovascular diseases. Allicin (di-allyl thiosulfinate, a volatile organic compound containing sulphur), the active ingredient of garlic, has been shown to reduce total serum cholesterol (Asaf *et al.*, 1983 and Mathew *et al.*, 2004).

Neem (*Azadirachta indica*) is highly useful traditional medicinal plant in India. During the last five decades considerable progress has been achieved in determining the biological activity and medicinal applications of neem. It is now considered as a valuable source of unique natural products for development of medicines against various diseases. It has been reported that neem is prescribed as immunostimulant, anticancer and antiatherogenic agent (Biswas *et al.*, 2002).

Because of the clinical significance of consumption of poultry meat and products in inducing hypercholesterolemia as a risk factor, the role of non-pharmacological agents such as garlic and neem in reducing the cholesterol in poultry meat is worth investigation. Hence the present study was undertaken with the following objectives.

1. To assess the effect of garlic powder and neem seed cake and their combination on the performance of broiler chicken and
2. To assess the effect of garlic powder and neem seed cake and their combination on meat and serum total cholesterol of broiler chicken.

Review of Literature

2. REVIEW OF LITERATURE

Garlic and neem preparations have been used in the past in complementary medicine for many conditions. There were extensive studies carried out in many species of animals and man using garlic and neem to assess its effect for the reduction of blood and meat cholesterol. However, works related to its supplementation in poultry rations on the performance and biochemical parameters of chicken appeared to be scanty. Moreover, there were no reports on studies regarding the effect of combination of garlic and neem on blood and meat cholesterol in avian as well as other species. Therefore, literatures related to effect of garlic and neem on other species have also been reviewed.

2.1. BODY WEIGHT AND BODY WEIGHT GAIN

2.1.1. Effect of garlic on body weight and weight gain

Asaf *et al.* (1983) studied the effect of garlic in White Leghorn pullets reared from eight weeks of age fed with 79.3 g of water-soluble fraction of garlic and 3.8 g of garlic paste for 24 days and reported that water-soluble fraction of garlic and garlic paste increased body weight of White Leghorn pullets by 52 and 40 per cent respectively.

Horton *et al.* (1991) studied the effect of garlic (*Allium sativum*) on performance, carcass composition and blood chemistry changes on 96 broiler chickens from day-old to 35 days of age. The birds were supplemented with 0, 100, 1000 and 10000 mg of dried garlic/kg starter diet. It was observed that garlic supplementation at 100 and 1000 mg/kg starter diet increased average daily weight gain during the first 21 days, while after 21 days there was no significant difference in body weight gain of birds supplemented with garlic up to the end of experiment.

Konjufca *et al.* (1997) studied the effect of garlic powder on the performance of 72 male broiler chickens. The garlic powder was supplemented at 0, 1.5, 3 and 4.5 per cent from day-old to 21 days of age. They found that garlic supplementation had no effect on body weight.

Gaikwad (2005) studied the effect of garlic (*Allium sativum*) on performance of 350 broiler chickens (Ven cob) for a period of five weeks by supplementing 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 per cent in the diet and reported that garlic supplementation at 1.0 per cent level recorded highest body weight while lowest was with 3.0 per cent supplementation at the end of five weeks of age.

Sarica *et al.* (2005) compared the effects of an antibiotic growth promoter (flavomycin) and two herbal natural feed additives (garlic and thyme) with and without a xylanase-based enzyme complex in wheat-based diets on growth performance of broiler chicken. A total of 112 day-old male broiler chicks were randomly assigned to eight groups containing 14 chicks each and raised from day-old to 42 days of age. The control group received the wheat-soybean meal basal diet. In the treatment groups the basal diet was supplemented with an antibiotic, thyme, garlic, an enzyme, the antibiotic plus the enzyme, thyme plus the enzyme or garlic plus the enzyme. They found that during 42 days of age there was no significant difference in body weight of the birds fed with garlic when compared to that of broilers fed with control diet.

2.1.2. Effect of neem on body weight and weight gain

Reddy and Rao (1988) studied utilization of undecorticated expeller processed or solvent extracted neem cake by replacing ground nut cake on 240 broiler chicken from day old to four weeks of age. The neem cake was supplemented at 10, 20, 30 and 40 per cent by replacing groundnut cake in the starter diet. The rations were

made isocaloric and isonitrogenous. There was more reduction in body weight of birds supplemented with 40 per cent undecorticated expeller processed or solvent extracted neem cake followed by 30, 20 and 10 per cent undecorticated expeller processed or solvent extracted neem cake.

Reddy *et al.* (1988) studied the utilization of neem oil and potassium hydroxide (KOH) treated neem oil in broiler chicken from day-old to four weeks of age. The birds were supplemented with 6 per cent neem oil and 6 per cent KOH treated neem oil. They found that supplementation of neem oil and KOH treated neem oil in the diet of broiler chicken did not improve body weight.

Chakravarthy and Prasad (1991) studied the effect of neem leaf extract and neem cake extract on the performance of 48 broiler chicks. One hundred gram neem leaf extract and 100 g neem cake extract were administered through drinking water starting from one week to six weeks of age and found that neem cake extract administered group had better growth rate and improved weight gain due to antibacterial effect.

Nemade and Kukde (1993) investigated the effect of neem leaf extract on the performance of broiler chickens from second to six weeks of age and found that administration of 0.25 per cent neem leaf extract through drinking water significantly increased weight gain.

Nagalakshmi (1993) studied the effect of processed neem seed kernel cake (NSKC) in broiler chicken by supplementation of 1 and 2 per cent alkali treated neem seed kernel cake (ATNSKC) and 1.5 and 2.5 per cent urea treated neem seed kernel cake (UANSKC) for a period of 6 weeks. She reported lowered body weight of birds fed with 1 per cent ATNSKC and 2.5 per cent UANSKC.

Gowda *et al.* (1998) studied the effect of Neem Kernel Meal (NKM) in the diet of White Leghorn layers. Neem Kernel Meal was incorporated into a standard layer diet at 0, 100, 150 and 200 g per kg replacing parts of the soybean meal and deoiled rice bran. Each diet was offered to 18 White Leghorn layers of 25 weeks of age in individual cages for a period of 12 weeks. It was found that supplementation of neem kernel meal at 150 and 200 g per kg diet reduced weight gain significantly while at the level of 100 g per kg diet, the weight gain did not differ significantly when compared to control diet.

Lather *et al.* (2002) investigated the effect of neem seed cake on body weight of 120 broiler chickens from 28 to 56 days of age. The birds were supplemented with 0, 5, 10 and 15 per cent neem seed cake in the diets. There was significant decrease in body weight of birds fed with 5, 10 and 15 per cent neem seed cake when compared to control birds. The decline in body weight was more severe in group fed with 15 per cent neem seed cake than 5 and 10 per cent neem seed cake fed groups.

Sarag *et al.* (2003) investigated the effect of supplementation of neem oil to the diet of broiler chicken on their performance. One hundred and eighty broiler chicks were randomly divided into four treatments with three replications of 15 chicks each and reared up to six weeks of age. Four levels of neem oil viz., 0.0, 0.25, 0.50 and 0.75 per cent were added to the basal diet. The authors observed that the live weight was significantly higher in 0.25 per cent neem oil fed groups than in other groups. They suggested that neem oil at 0.25 per cent improved the broiler performance in terms of live weight.

Sridhar *et al.* (2003) observed the clinical signs and hematological changes in 50 straight run broiler chickens following neem (*Azadirachta indica*) leaf extract

administration for a period of six weeks. Ten per cent aqueous neem leaf extract was given to birds for six weeks starting from seventh day of age. There was no significant difference in body weight of birds by administration of 10 per cent aqueous neem leaf extract through drinking water.

Sharma *et al.* (2004) studied growth of broilers fed varying levels of neem seed cake. A total of 204 day-old broiler chicks were divided into four groups which were fed 0, 25, 50 and 75 per cent neem seed cake and soybean meal three times a day until eight weeks of age. It was observed that the inclusion of neem seed cake into the diets of broilers resulted in a significant reduction in live weight gain.

Virmani *et al.* (2005) studied the effect of neem seed cake on broiler chickens for a period of six weeks starting from day-old age. The authors reported that supplementation of 5, 10 and 15 per cent neem seed cake in the diet of broiler chicken significantly decreased the body weight.

Uko and Kamalu (2006) reported reduction in weight gain in male chicks fed with 75, 150 and 225 g of unextracted neem seed kernel and 75 g raw neem seed kernel per kg diet offered as mash for 35 days starting from day old age.

2.2. FEED INTAKE

2.2.1. Effect of garlic on feed intake

Horton *et al.* (1991) studied the effect of garlic (*Allium sativum*) on performance, carcass composition and blood chemistry changes in 96 broiler chickens from day old to 35 days of age. Broiler chickens were supplemented with 0, 100, 1000 and 10000 mg of dried garlic/kg starter diet. It was found that supplementation of garlic in the diet did not improve feed intake.

Girish Kumar (1997) studied the effect of feeding onion and garlic on lipid profile in Japanese quails and reported that there was no significant difference in feed consumption during fourth week of age while at fifth and sixth week of age feed intake was found to be improved in onion and garlic fed groups in both sexes.

Gaikwad (2005) conducted an experiment in broiler chickens for a period of five weeks by supplementing garlic at 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 per cent levels in the diet and reported that garlic supplementation at 0.5 and 2.5 per cent levels recorded highest feed consumption as compared to 1.0, 1.5 and 3.0 per cent garlic supplementation.

Sarica *et al.* (2005) compared the effects of an antibiotic growth promoter (flavomycin) and two herbal natural feed additives (garlic and thyme) with and without a xylanase-based enzyme complex in wheat-based diets, on growth performance of broiler chickens. It was revealed that during the 42 days of age there was no significant difference in feed intake of the birds fed with garlic when compared to birds fed with control diet.

2.2.2. Effect of neem on feed intake

Chakravarthy and Prasad (1991) studied the effect of neem leaf extract and neem cake extract on the performance of broiler chicks by administration of 100 g neem leaf extract and 100 g neem cake extract through drinking water from one to six weeks of age and found that neem cake extract fed group showed improved feed intake.

Nemade and Kukde (1993) studied the effect of neem leaf extract on the performance of broiler chicken from second to six weeks of age and found that

administration of 0.25 per cent neem leaf extract through drinking water significantly increased feed consumption.

Elangovan *et al.* (1996) studied the effect of dietary neem kernel meal on nutrient retension and reported that 10 per cent level of neem kernel meal in layer mash replacing a part of the soybean meal and rice bran did not cause any effect on feed consumption.

Gowda *et al.* (1998) studied the effect of Neem Kernel Meal (NKM) in the diet of White Leghorn layers. The NKM was incorporated into a standard layer diet at 0, 100, 150 and 200 g per kg replacing parts of the soybean meal and deoiled rice bran. Each diet was offered to 18 White Leghorn layers of 25 weeks of age in individual cages for a period of 12 weeks. It was found that supplementation of NKM at 150 and 200 g per kg diet significantly reduced average feed consumption.

Nagalakshmi *et al.* (1998) compared the relative efficacy of alkali treated and urea treated neem seed kernel cake in broiler diet by incorporation of 2 per cent alkali treated neem kernel cake and 2.5 per cent urea treated neem seed kernel cake for a period of six weeks. It was found that birds in both groups consumed similar quantity of feed when compared to reference diet.

Sarag *et al.* (2003) investigated the effect of supplementation of neem oil at the rate of 0.0, 0.25, 0.50 and 0.75 per cent to the diet of broiler chickens on their performance up to six weeks of age. It was observed that feed consumption was significantly higher in 0.25 per cent neem oil supplemented group than in other groups. It was also concluded that the supplementation of neem oil at low level improved the feed consumption than that of high level supplementation of the same in broiler diet.

Sharma *et al.* (2004) found that the inclusion of neem seed cake into the diets of broilers resulted in a significant reduction in feed intake. This reduction in feed intake might be due to the antinutritional effects of triterpenoids in *Azadirachta indica.*

Uko and Kamalu (2006) reported decreased feed intake in male chicks fed with 75, 150 and 225 g of unextracted neem seed kernel per kg diet offered as mash for 35 days starting from day-old age.

2.3. FEED EFFICIENCY

2.3.1. Effect of garlic on feed efficiency

Horton *et al.* (1991) studied the effect of garlic (*Allium sativum*) on performance, carcass composition and blood chemistry changes in broiler chickens from day-old to 35 days of age. The birds were supplemented with 0, 100, 1000 and 10000 mg of dried garlic/kg starter diet and reported that there was no significant difference in feed efficiency of birds supplemented with garlic.

Galal *et al.* (1997) assessed the use of garlic in broiler chickens. Three hundred day-old Arbor-Acre chicks were divided into five equal groups with six replicates to study the effect of incorporating freshly minced garlic at 1 per cent and dried garlic at 1, 2 and 3 per cent in broiler diet and found that garlic had no effect on feed conversion.

Konjufca *et al.* (1997) studied the effect of garlic powder on the performance of 72 male broiler chickens. The garlic powder was supplemented at 0, 1.5, 3 and 4.5 per cent from day-old to 21 days of age and found that garlic supplementation had no effect on feed conversion ratio.

Gaikwad (2005) studied the supplementation of garlic (*Allium sativum*) on performance of 350 broiler chickens (Ven cob) for a period of five weeks by supplementing 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 per cent in the diet and reported that garlic supplementation at 0.5 per cent level recorded lowest feed efficiency and 1.0 and 1.5 supplementation recorded highest at the end of five weeks.

Sarica *et al.* (2005) compared the effects of an antibiotic growth promoter (flavomycin) and two herbal natural feed additives (garlic and thyme) with and without a xylanase-based enzyme complex in wheat-based diets on growth performance of broiler chickens. They observed that during the 42 days growth period there was no significant difference in feed conversion ratio of the birds fed with garlic when compared to birds fed with control diet.

2.3.2. Effect of neem on feed efficiency

Reddy and Rao (1988) studied utilization of undecorticated expeller processed or solvent extracted neem cake by replacing groundnut cake on 240 broiler chickens from day-old to four week of age. The rations were made isocaloric and isonitrogenous. The undecorticated expeller processed or solvent extracted neem cake was supplemented at 10, 20, 30 and 40 per cent in the starter diet. It was reported that undecorticated expeller processed or solvent extracted neem cake at 30 and 40 per cent level decreased the feed efficiency while at 10 and 20 per cent level of inclusion did not show significant difference in feed efficiency when compared to reference diet.

Chakravarthy and Prasad (1991) investigated the effect of neem leaf extract and neem cake extract on the performance of broiler chicks by administration of 100 g neem leaf extract and 100 g neem cake extract through drinking water starting from

one to six weeks of age and found that neem cake extract fed group showed higher feed conversion efficiency due to antibacterial effect.

Nagalakshmi (1993) studied the effect of processed neem seed kernel cake (NSKC) in broiler chicken by supplementation of 1 and 2 per cent alkali treated neem seed kernel cake (ATNSKC) and 1.5 and 2.5 per cent urea treated neem seed kernel cake (UANSKC) for a period of 6 weeks. She reported a higher feed efficiency in birds fed with 2.5 per cent UANSKC when compared to other treated groups at fourth week of age.

Nemade and Kukde (1993) studied the effect of neem leaf extract on the performance of broiler chicken from second to six weeks of age and found that administration of 0.25 per cent neem leaf extract through drinking water significantly improved feed efficiency in broiler chicken

Nagalakshmi *et al.* (1998) compared the relative efficacy of alkali treated and urea treated neem seed kernel cake in broiler diet by incorporation of 2 per cent alkali treated neem kernel cake and 2.5 per cent urea treated neem seed kernel cake for a period of six weeks. They found that feed efficiency of birds in both groups was similar when compared to reference diet.

Sarag *et al.* (2003) investigated the effect of supplementation of neem oil on the performance of broiler chicken up to six weeks of age. Four levels of neem oil viz., 0.0, 0.25, 0.50 and 0.75 per cent were added to basal diet. Poor feed efficiency was recorded in 0.75 per cent neem oil fed group while better feed efficiency was recorded in 0.25 per cent neem oil fed group. It was suggested that neem oil at 0.25 per cent in the diet improved the broiler performance in terms of feed efficiency.

Virmani *et al.* (2005) studied the effect of neem seed cake on feed efficiency of broiler chicken for a period of 6 weeks by supplementation of 5, 10 and 15 per cent neem seed cake in starter and finisher ration and found non significant decline in the feed efficiency of birds fed with neem seed cake when compared with control group.

Uko and Kamalu (2006) studied the effect of feeding of 75, 150 and 225 g of unextracted neem seed kernel and 75 g of raw neem seed kernel per kg diet offered as mash for 35 days starting from day-old age and reported increased feed efficiency of male broiler chicken fed with 225 g of unextracted neem seed kernel and 75 g raw neem seed kernel.

2.4. PROCESSING YIELDS AND LOSSES

2.4.1. Effect of garlic on processing yields and losses

Rejikumar and Narayanankutty (1992) studied the processing yields, losses and meat to bone ratio in eight week old broiler chicken and reported 72.76, 27.24, 3.42 per cent ready-to-cook yield, total loss and feather loss respectively.

Galal *et al.* (1997) conducted an experiment using garlic in diet of broiler chickens. Three hundred day-old Arbor-Acre chicks were divided into five equal groups with six replicates to study the carcass traits by incorporating freshly minced garlic at 1 per cent and dried garlic at 1, 2 and 3 per cent in broiler diet. It was found that garlic had no significant effect on carcass traits.

Gaikwad (2005) studied the supplementation of garlic (*Allium sativum*) on performance of broiler chickens for a period of five weeks by supplementing 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 per cent in the diet and found that edible carcass yield percentage was higher in group received 1.0 per cent garlic followed by groups

supplemented with 2.0, 3.0, 2.5, 0.5 and 1.5 per cent of garlic as compared to control group. He also reported that different levels of garlic supplementation had significant effect on liver weight percentage while gizzard and heart weight percentages at different levels were statistically non-significant.

Sarica *et al.* (2005) compared the effects of an antibiotic growth promoter (flavomycin) and two herbal natural feed additives (garlic and thyme) with and without a xylanase-based enzyme complex in wheat-based diets on carcass parameters of broiler chickens and reported that there was no significant difference in carcass yield of birds fed with thyme, garlic, enzyme and garlic plus enzyme.

2.4.2. Effect of neem on processing yields and losses

Nagalakshmi (1993) studied the effect of processed neem seed kernel cake (NSKC) in broiler chicken by supplementation of 1 and 2 per cent alkali treated neem seed kernel cake (ATNSKC) and 1.5 and 2.5 per cent urea treated neem seed kernel cake (UANSKC) for a period of 6 weeks. The author found lower dressing per cent in birds fed with 1 per cent ATNSKC and 2.5 per cent UANSKC as compared to 2 per cent ATNSKC and 1.5 per cent UANSKC.

Nemade and Kukde (1993) studied the effect of neem leaf extract on the performance of broiler chicken from second to six weeks of age and found that administration of 0.25 per cent neem leaf extract through drinking water significantly increased dressed weight and edible meat weight. There was no significant difference in liver, gizzard and heart weight and liver, gizzard, heart to live weight ratio.

Nagalakshmi *et al.* (1998) studied the processing yields and losses of broiler chicken by incorporation of 2 per cent alkali treated neem kernel cake and 2.5 per

cent urea treated neem seed kernel cake in diet for a period of six weeks. The per cent dressed, giblet, edible and inedible weight of birds fed with 2 per cent alkali treated neem kernel cake was 63.97, 6.01, 69.98 and 30.02 respectively. The corresponding values with 2.5 per cent urea treated neem seed kernel cake fed birds were 64.89, 5.88, 70.78 and 29.22 per cent respectively, while in birds fed with reference diet the values were 65.98, 5.84, 71.82 and 28.18 per cent respectively. The results indicated that per cent dressed, giblet, edible and inedible weight of birds fed with urea treated neem seed kernel cake was similar to birds fed with reference diet. While, per cent dressed and inedible weight was significantly lowered and giblet and edible weight was unchanged in birds fed with alkali treated neem seed kernel cake as compared to birds fed with reference diet.

Uko and Kamalu (2006) reported decrease in eviscerated carcass weight and increase in carcass yield in male chicks fed with 75, 150 and 225 g of unextracted neem seed kernel per kg diet for a period of 35 days starting from day-old age.

2.5. SERUM TOTAL CHOLESTEROL AND PROTEIN

2.5.1. Effect of garlic on serum total cholesterol and protein

Sturkey (1976) reported the total plasma or serum protein value as 4.0 and 5.24 for adult male and female chicken respectively and it could be affected by the state of dehydration, haemorrhage and level of protein nutrition.

Chang and Johnson (1980) investigated the effect of garlic on lipid synthesis in male Wistar rats by dietary inclusion of 5 g garlic powder/100 g of basal diet for a period of 18 days and indicated that garlic had an inhibitory effect on hepatic lipogenesis and serum total lipid.

Asaf *et al.* (1983) studied the effect of garlic on lipid metabolism in White Leghorn pullets and found that garlic oil and odour components and odourless water soluble components of garlic lowered the serum total cholesterol level by 20-25 per cent.

The principle behind the pharmacological action of garlic was that the sulphur containing compounds can remove thiol groups and also oxidize NADPH (Augusti, 1990). NADPH is necessary for cholesterol and fatty acid synthesis. Under these circumstances if the active ingredient of garlic bring about oxidation of NADPH then there is inhibition of either cholesterol or fatty acid synthesis resulting in hypolipaedemic and hypocholesterolemic action of garlic.

Horton *et al.* (1991) investigated the effect of garlic (*Allium sativum*) on blood chemistry changes in broiler chicken fed with 100, 1000 and 10000 mg/kg dried garlic in starter diet for a period of 35 days and found that serum total cholesterol and high density lipoprotein (HDL) cholesterol were lower in 10000 mg/kg dried garlic fed group.

Lata *et al.* (1991) studied the beneficial effects of garlic (*Allium sativum*), onion (*Allium cepa*) and guggulu (*Commiphora mukul*) on experimental hyperlipidemia and atherosclerosis by oral administration of petroleum ether extracts of *Allium sativum* (equivalent to 1 g/kg of dry garlic), *Allium cepa* (equivalent to 2 g/kg of dry onion) and *Commiphora mukul* (200mg/kg) in albino rats for a period of 5 days and observed significant fall in serum cholesterol and serum triglycerides.

Jafri and Iqbal (1993) evaluated the effect of garlic on blood lipids of rats (*Rattus norvegicus*). The raw garlic was fed at the rate of 0.5 and 1 per cent of the feed for a period of 90 days. They found that total serum cholesterol, total serum lipids and

low-density lipoprotein (LDL) cholesterol in the blood of the rats significantly decreased due to garlic feeding at both the levels. They concluded that feeding garlic to rats decreased blood cholesterol level.

Warshafsky *et al.* (1993) studied the effect of garlic on total serum cholesterol and revealed nine per cent decrease in serum total cholesterol in hypercholesterolemic patients.

Allicin from garlic significantly decreased cholesterol biosynthesis in rat hepatocytes and HepG2 cells by inhibiting HMG-CoA reductase and late steps of the mevalonate (MVA) pathway that leads to the accumulation of the precursor lanosterol (Gebhardt *et al.*, 1994)

Mini and Kumar (1995) studied the hypolipidaemic effect of *Allium sativum* in New Zealand White adult male rabbits by administration of aqueous extract of *Allium sativum* bulb (10 mg per kg body weight) for 75 days and observed significant decrease in plasma cholesterol by 79.08 per cent and plasma triglycerides by 75.76 per cent.

Merat and Fallahzadeh (1996) studied the effect of garlic powder on blood lipids and HMG-CoA reductase activity in male rats fed with 2.5 per cent garlic powder for 10 days and reported significant reduction in serum total cholesterol, triglycerides and HMG-CoA reductase enzyme. They also investigated the effect of garlic on blood lipids and HMG-CoA reductase activity in male human before and after one month of garlic powder consumption (one 400 mg garlic tablet, three times daily) and reported that levels of total cholesterol, HDL cholesterol and triglycerides in serum were significantly decreased after garlic consumption by 10.7, 11.5 and 14.2 per cent respectively.

Galal *et al.* (1997) conducted an experiment on the use of garlic in the diet of broiler chickens by incorporating freshly minced garlic at 1 per cent and dried garlic at 1, 2 and 3 per cent on the blood serum cholesterol. They found that garlic had a significant effect on lowering the level of serum cholesterol. They also reported that the reduction is positively related to the level of garlic in the diet.

Ahmed and Sharma (1997) observed the chemical effect of garlic and ginger in albino rats for a period of 4 weeks by supplementing 2 per cent garlic, 0.5 per cent ginger and their combination. They reported significant decrease in serum total cholesterol in rats whereas, increased serum HDL cholesterol and decreased VLDL cholesterol in garlic and ginger combinely treated rats.

Girish Kumar (1997) investigated the effect of feeding of one per cent onion and one per cent garlic on lipid profile in 180 Japanese quails and reported that onion and garlic supplementation significantly decreased the plasma free cholesterol.
Jain *et al.* (1997) studied the action of garlic on hyperlipidemia of experimentally induced immune complex disease in rabbits by oral administration of 75 mg per kg body weight garlic oil for a period of 4 weeks and revealed that serum total lipids, total cholesterol and beta lipoprotein cholesterol reduced significantly.

Konjufca *et al.* (1997) found that supplementation of 1.5 per cent garlic in male broiler chicken from day-old to 21 days of age decreased the activity of 3-hydroxy-3 methyl-glutaryl coenzyme A reductase (HMG – CoA), cholesterol 7 hydroxylase and thereby reduced cholesterol bio synthesis. The reduced cholesterol biosynthesis apparently resulted in less cholesterol being present in serum. They also revealed significant increase in serum HDL cholesterol.

Yeh and Liu (1998) investigated the cholesterol lowering effect of garlic extract and organosulphur compounds of garlic in rats and reported that supplementation of 2 g of aged garlic for a period of four weeks reduced plasma concentration of total cholesterol by 15 per cent and suggested that hydrophilic and hydrophobic compounds of garlic are inhibitory to cholesterol synthesis. Water soluble compounds like S-ethylcystein and S-propylcystein inhibited cholesterol synthesis by 40-60 per cent. Lipid soluble Sulphur compounds (diallyl sulfide, diallyl disulfide, diallyl trisulfide, dipropyl sulfide) at low concentration (0.05-0.5 mol /L) inhibited cholesterol synthesis by 10-15 per cent.

Effraim *et al.* (2000) studied the effect of crude garlic extract on nicotinic induced hyperglycemic and hyperlipidemic Wistar rats and reported that oral administration of 30 per cent crude garlic extract per kilogram body weight significantly reduced serum total cholesterol and triglycerides.

Matsuura (2001) investigated the cholesterol lowering effect of steroid saponin fractions from garlic with rat model of experimental hyperlipidemia induced by feeding 0.5 per cent cholesterol enriched diet for 16 weeks. The results indicated that saponin fractions from garlic lowered plasma total and LDL cholesterol concentrations without changing HDL cholesterol levels.

Slowing *et al.* (2001) studied the effect of garlic extract and its fractions on cholesterol plasma levels and vascular reactivity in cholesterol fed rats for a period of 16 weeks and reported significant reduction in plasma total cholesterol and VLDL cholesterol in rats. They concluded that garlic fractions could prevent diet induced hypercholesterolemia and vascular alterations in the endothelium-dependant relaxation associated with atherosclerosis.

Premkumar *et al.* (2002) opined that supplementation of 0.5 per cent garlic did not reduce serum total cholesterol but supplementation of 1 per cent level significantly decreased the serum total cholesterol by 12.8, 15.3 and 12.4 per cent in broiler chicken at fifth, sixth and seventh week of age respectively.

Ajoene is a garlic compound which was shown to inhibit cholesterol biosynthesis in rats by affecting 3-hydroxy-3-methyl-glutaryl coenzyme A (HMG-CoA) reductase and late enzymatic steps of the mevalonate (MVA) pathway (Ferri *et al.*, 2003).

Kamal and Daoud (2003) conducted a study to investigate the effect of adding fresh onion and/or garlic to duck ration on the blood constituents. Day-old 140 Muscovy ducks were divided into seven treatment groups and studied for 12 weeks. Addition of 10 kg onion + 10 kg garlic per tonne of feed and 20 kg onion + 20 kg garlic per tonne of feed led to a significant decrease in serum cholesterol, total lipids, triglycerides and low- density lipoprotein (LDL). No significant changes in the levels of serum high-density lipoprotein (HDL) were observed.

Mathew *et al.* (2004) investigated the cholesterol lowering effect of organosulphur compounds from garlic in rats and reported that antiatherogenic effect of organosulphur compounds could be attributed to such a reaction that inhibit HMG-CoA reductase and other lipogenic enzymes.

Mottaghitalab and Taraz (2004) studied the effect of supplementation of 0.5, 1 and 1.5 per cent garlic powder in Aryan breed hens for 10 weeks production period starting from 40 weeks of age. The results showed that dietary inclusion of 0.5, 1 and 1.5 per cent garlic powder significantly reduced serum total cholesterol levels by 14.2, 21.9 and 12.0 per cent respectively.

2.5.2. Effect of neem on serum total cholesterol and protein

Bopanna *et al.* (1997) reported that neem (*Azadirachta indica*) kernel powder administration (500 mg/kg) in diabetic rabbits resulted in marked fall of serum LDL cholesterol, VLDL cholesterol, intestine HMG-CoA reductase enzyme and increased HDL cholesterol ratio.

Sadekar *et al.* (2001) reported that the administration of 20 g dried neem leaves powder per calf per day for seven days significantly decreased serum total proteins and increased serum total bilirubin.

Ali Hussain (2002) studied the effect of oral administration of fresh leaves of neem (*Azadirachta indica*) at the rate of 250mg/ kg body weight for a period of 16 weeks in streptozotocin induced diabetic rats and observed significant fall in serum total cholesterol, LDL cholesterol and increased HDL cholesterol.

Annongu *et al.* (2003) revealed that inclusion of 30 per cent alkali treated neem kernel meal in the diet of swine did not affect serum total protein and albumin levels, while inclusion of 20 and 30 per cent inclusion of raw neem seed kernel meal in the diet of swine significantly lowered the serum total protein and albumin levels.

Eshrat (2003) studied the effect of water extract of *A. indica* and *A. augusta* in diabetic rats by administration of combination (1:1) of water extracted dried powder of roots and leaves (200 mg/kg body weight) respectively once a day for 8 weeks and observed improvement in serum lipid profile. There was reduction in serum total cholesterol and LDL cholesterol without fall in HDL cholesterol.

Sathyan (2004) studied the hypoglycemic effect of *Azadirachta indica* (Neem), *Ocimum sanctum* (Tulsi) and *Tinospora cordifolia* (Chittamruthu) and their combination in diabetic rats. Diabetes was induced one week before starting the experiment. On the seventh day the diabetic rats were administered ethanolic extract of dried powered neem leaves at a dose of 200 mg per kg body weight orally from day seven to day 37. He found that there was significant reduction in the serum cholesterol level and serum triglycerides level. He also reported that antihyperlipidemic effect might be due to down regulation of NADPH, acting as cofactor in fat metabolism. Another mechanism of action might be decreased synthesis or increased excretion of lipids through intestinal tract.

Virmani *et al.* (2005) investigated the effect of neem seed cake on blood biochemical constituents of 96 broiler chicken by supplementation of 5, 10 and 15 per cent neem seed cake for a period of six weeks starting from day-old age and reported that there was non significant decline in serum cholesterol on neem seed cake supplementation.

Uko and Kamalu (2006) observed significantly decreased plasma total cholesterol and triglycerides in male chicks fed with 75 g of raw neem seed kernel per kg diet offered as mash for a period of 35 days starting from day-old age as compared to supplementation of 75, 150 and 225 g of unextracted neem seed kernel per kg diet offered as mash. They also studied the protein quality and toxicity of full-fat neem seed kernel and found that there was no significant difference in plasma total proteins in male chicks fed with 75, 150 and 225 g of unextracted neem seed kernel and 75 g of raw neem seed kernel offered as mash for 35 days starting from day-old age.

2.6. MEAT TOTAL CHOLESTEROL AND PROTEIN

2.6.1. Effect of garlic on meat total cholesterol and protein

Keshri *et al.* (1989) studied the proximate composition of poultry meat and mentioned that white meat of broiler chicken contained 23.29 per cent protein, whereas red meat contained only 19.70 per cent. They also revealed that per cent protein in breast and thigh meat varied with age.

Horton *et al.* (1991) investigated the effect of garlic (*Allium sativum*) on performance and carcass composition of broiler chicken and reported that feeding of 100, 1000 and 10000 mg/kg dried garlic in starter diet for a period of 35 days had no effect on breast muscle and abdominal fat content.

Khalid *et al.* (1995) reported the beneficial effects of *Allium sativum Linn* in experimental cholesterol atherosclerosis in chicken. Chickens with experimentally induced atherosclerosis were administered garlic orally twice weekly for 12 weeks. At the end of the trial the birds were killed and their dorsal aorta was examined for atherosclerotic lesions. Administration of garlic led to significant decrease in plasma levels of triglycerides, total cholesterol and LDL and VLDL cholesterol. The aortic damage was also significantly lower in the garlic-administered group compared with the model group fed on cholesterol enriched feed alone. In addition, the aqueous extract of garlic inhibited platelet aggregation in vitro. It was concluded that administration of garlic provided a significant protection against hyperlipidemia and possibly thrombus formation and may protect against cardio-vascular anomalies.

Girish Kumar (1997) investigated the effect of feeding one per cent onion and one per cent garlic on lipid profile in 180 Japanese Quails and reported that although

the trend of decreased cholesterol level in the liver and muscle was observed, the results were statistically non significant indicating the hypocholesterolemic effect of onion and garlic is to be questionable biological significance.

Konjufca *et al.* (1997) found that supplementation of 1.5 per cent garlic in male broiler chicken fed from day-old to 21 days of age decreased the activity of 3-hydroxy-3 methyl-glutaryl coenzyme A reductase (HMG – CoA), cholesterol 7 hydroxylase and thereby reduced cholesterol bio synthesis. The reduced cholesterol biosynthesis apparently resulted in less cholesterol being deposited in breast and thigh meat.

Simeonovova (1999) reported that breast muscle of broiler chicken contained approximately 22 per cent, while thigh muscle contained 17.20 per cent normal protein on fresh basis.

Premkumar *et al.* (2002) indicated that supplementation of 0.5 per cent garlic reduced breast meat cholesterol by 4.9, 8.8 and 3.3 per cent while 1 per cent garlic supplementation reduced the breast meat cholesterol by 11.9, 15.1 and 11.0 per cent and thigh meat cholesterol by 9.3, 7.9 and 9.4 per cent in broilers at fifth, sixth and seventh week of age, respectively.

Suchy *et al.* (2002) studied the chemical composition of breast and thigh muscles in three hybrid broiler chicken (Ross 308, Cobb and Hybro) and reported that protein in breast muscle of chickens was 22.5 per cent on 42^{nd} day and 22.7 per cent on 52^{nd} day, while thigh muscle contained 18.3 per cent on 42^{nd} day and 19.1 per cent protein on 52^{nd} day on fresh weight basis and concluded that breast muscle contained 3.6-4.2 per cent more protein than thigh muscle.

Kamal and Daoud (2003) conducted a study to investigate the effect of adding fresh onion and/or garlic to duck ration on the tissue constituents. One hundred and forty day-old Muscovy ducklings were divided into seven treatment groups and studied for 12 weeks. Addition of 10 kg onion + 10 kg garlic per tonne and 20 kg onion + 20 kg garlic per tonne of feed led to a significant reduction in the breast and thigh muscles cholesterol.

2.6.2. Effect of neem on meat total cholesterol and protein

Bloch (1991) reported that the cholesterol concentration was much higher in thigh muscle than in breast muscle. The cholesterol was usually associated with adipose tissue, which was more abundant in thigh than in breast muscle. Also, thigh muscles have a much greater content of slow-twitch fibers than breast muscles. Slow-twitch fibers have many more mitochondria, their mitochondria were bigger and the metabolic rate much faster in comparison to fast-twitch fibers. Slow-twitch sarcoplasmic reticulums were found to contain two to three times as much cholesterol as fast-twitch sarcoplasmic reticulum in rabbits. The higher cholesterol concentration reduces membrane fluidity, lowers Ca+-ATPase activity and regulates contraction and relaxation rates.

Nagalakshmi *et al.* (1998) studied the chemical composition of meat of broiler chicken by supplementation of 2 per cent alkali treated neem kernel cake (ATNSKC) and 2.5 per cent urea treated neem seed kernel cake (UATNSKC) in the diet for a period of six weeks. They found that protein content in meat of birds fed with alkali and urea treated neem seed kernel cake did not differ significantly when compared to birds fed with reference diet.

Gupta *et al.* (2001) studied the alterations in tissue biochemical parameters after daily oral administration of neem seed kernel extract (1 g/kg body weight) in rats for a period of 60 days and found that there was significant increase in lipid per oxidation in brain, liver and kidney.

2.7. LIVABILITY

2.7.1. Effect of garlic on livability

Shi *et al.* (1999) conducted trial on the use of garlic as feed additive for meat chickens by supplementation of garlic at 0.2, 1.0 and 2.0 per cent in the diet for a period of six weeks and reported that garlic decreased mortality.

Soliman *et al.* (1999) evaluated the effect of using fresh garlic and fat on broiler performance and immunity on 288 unsexed one-week-old Arbor Acres broiler chickens. The chicks were supplemented with fresh garlic at 0, 3 and 6 per cent with 2.5 and 5 per cent poultry fat. The results of the experiment demonstrated the synergistic effect of using 3 per cent fresh garlic and low poultry fat in broiler diets, leading to best performance parameters and increased immunity and viability of birds.

Gaikwad (2005) studied the effect of garlic (*Allium sativum*) on performance of broiler chickens for a period of five weeks by supplementing 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 per cent in the diet and found that the mortality percentage at 1.0 and 1.5 per cent level was zero, while in other groups it was within the limit. It was concluded that garlic supplementation at various levels had no ill effect on health of birds and these levels of inclusion were well tolerated by the birds. However, use of garlic at 1.0 or 1.5 per cent was more useful for improvement in the livability of birds.

2.7.2 Effect of neem on livability

Reddy and Rao (1988) evaluated utilization of undecorticated expeller processed or solvent extracted neem cake in broiler chickens from day-old to four week of age and reported that mortality was highest at 20 per cent level and lowest at 10 per cent level of inclusion.

Chakravarthy and Prasad (1991) studied the effect of neem leaf extract and neem cake extract on the performance of broiler chicks by administration of 100 g neem leaf extract and neem cake extract through drinking water starting from one week to six weeks of age and found that administration of neem leaf extract cause lowered mortality in broiler chicks.

Sridhar *et al.* (2003) reported that administration of 10 per cent aqueous neem leaf extract through drinking water for a period of six weeks starting from seven day old did not reveal any deleterious effect on livability of broiler chicken.

Uko and Kamalu (2006) reported that there was no deleterious effect on livability in male chicks fed with 75, 150 and 225 g of unextracted neem seed kernel and 75 g raw neem seed kernel per kg diet offered as mash for 35 days starting from day old age.

2.8. ECONOMICS

2.8.1. Effect of garlic on economics

Gaikwad (2005) studied the performance of broiler chickens for a period of five weeks by supplementing 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 per cent garlic (*Allium sativum*) in the diet and found that the birds supplemented with 1.0 per cent garlic

gained higher profit per kg live weight and inclusion beyond 1.5 per cent had no additional benefit in terms of profit realized.

2.8.2 Effect of neem on economics

Nagalakshmi *et al.* (1998) compared the relative efficacy of alkali treated and urea treated neem seed kernel cake in broiler diet by incorporation of 2 per cent alkali treated neem kernel cake and 2.5 per cent urea treated neem seed kernel cake for a period of six weeks. They reported that feed cost per unit body gain was lower in urea treated neem seed kernel cake than on alkali treated neem kernel cake. While the feed cost per unit meat production was lower in alkali treated neem kernel cake when compared with urea treated neem seed kernel cake diet.

Materials and Methods

3. MATERIALS AND METHODS

An experiment was conducted at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to study the effect of dietary supplementation of garlic (*Allium sativum*) powder and neem (*Azadirachta indica*) seed cake on the performance and meat and serum cholesterol content in broiler chicken. The study was conducted for a period of six weeks during January and February 2005.

Two-hundred and ten, day-old straight run commercial broiler chicks (Ven cob) procured from Venkateshwara Hatcheries Ltd., Palakkad, Kerala formed the experimental subjects. The chicks were wing banded, vaccinated against Ranikhet disease and weighed individually. The birds were allotted randomly to seven treatment groups with three replicates of ten birds each as detailed below.

Treatment	Number of replications	Number of birds in each replicate	Type of diet	Garlic powder (per cent)	Neem seed cake (per cent)
T1	3	10	Control diet (CD)	00	00
T2	3	10	CD with garlic powder	0.5	00
T3	3	10	CD with garlic powder	1.0	00
T4	3	10	CD with neem seed cake	00	1.0
T5	3	10	CD with neem seed cake	00	2.0
T6	3	10	CD with garlic powder & neem seed cake	0.5	1.0
T7	3	10	CD with garlic powder & Neem seed cake	1.0	2.0

The allotment of chicks to the different treatment groups and replicates was made in such a way that the weight of chicks within a group as well as between groups was reasonably similar. The chicks were reared under deep litter system of management. The experimental shed was cleaned and disinfected one week prior to the commencement of the experiment. Litter material was spread to a thickness of 6 cm in each pen. A floor space of 925 sq cm per chick was allotted. Feeders, waterers and other equipment were cleaned, disinfected and sun dried before use.

The chicks were brooded till they attained four weeks of age. There after light was provided during night hours to enhance feed intake. Standard managemental procedures were followed during the course of the experiment. Chicks were immunized against Ranikhet Disease and Infectious Bursal Disease. The birds were provided with feed and water *ad libitum* throughout the experimental period.

Broiler starter diet was fed up to four weeks of age and then switched over to broiler finisher diet till the end of six weeks of age. Both the rations were formulated as per BIS (1992) specification of nutrients for broiler chicken.

The garlic was supplemented in the experimental ration as garlic powder supplied by Vagad Market (A.P.M.C. Market-1, Mudibazar, Vashi, New Bombey-703) and neem was supplemented as neem seed cake procured from Mannuthy market, which was sun dried and ground before use in the experimental ration.

The ingredient composition of the seven different starter and finisher rations is presented in Tables 1 and 2 respectively. The rations were made isocaloric and isonitrogenous. The proximate analysis of the feed ingredients and rations were carried out according to procedure described by AOAC (1990). The chemical composition of the starter and finisher rations is presented in Tables 3 and 4 respectively.

The performance of birds was recorded for a period of six weeks. The following parameters were studied during the course of the experiment.

Table 1. Per cent ingredient composition of experimental starter rations

Ingredient	Control diet	Experimental diet					
	T1	T2	T3	T4	T5	T6	T7
Yellow maize	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Rice polish	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Wheat bran	4.0	3.5	3.0	3.0	2.0	2.5	1.0
Soybean meal	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Gingelly oil cake	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Unsalted dried fish	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Garlic powder	00	0.5	1.0	00	00	0.5	1.0
Neem seed cake	00	00	00	1.0	2.0	1.0	2.0
Mineral mixture[1]	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100
Added per 100 kg feed							
Vitamin mixture[2], g	10	10	10	10	10	10	10
DL Methionine, g	100	100	100	100	100	100	100
L Lysine	140	140	140	140	140	140	140
Choline chloride[3], g	120	120	120	120	120	120	120
Coccidiostat[4], g	50	50	50	50	50	50	50
Toxin binder[5], g	250	250	250	250	250	250	250
B.Complex powder[6], g	50	50	50	50	50	50	50

Note:

[1] Mineral mixture composition

Calcium 32%, Phosphorus 6%, Magnesium 1000 ppm, Cobalt 60 ppm, Zinc 2600 ppm, Iron 0.1%, Iodine 100 ppm, Copper 100 ppm, Manganese 2700 ppm.

[2] Vitamin mixture, INDOMIX A, B_2, D_3, K powder (Nicholas Primal India Ltd., Mumbai) containing Vit. A 82,500 IU, Vit. B_2 50 mg, Vit. D_3 1200 IU, Vit. K 10 mg per g

[3] Bio choline (Indian Herbs Research and Supply Co.Ltd., U.P.) containing choline chloride 50%.

[4] Elancoban 220 (Elanco Animal Health, Eli Lilly and Co., Indiana Polis, USA) containing Monensin sodium 10%.

[5] UTPP-5 powder (Tetragon Chemic Pvt. Ltd., Bangalore) containing Treated alumino silicates, Propionates, Formates, Acetates.

[6] Meriplex-FDS (Wockhardt Ltd., Wockhardt Towers, Bandra Kurla Complex, Mumbai-400 051) containing Vit.B_1 8 mg, Vit.B_6 16 mg, Vit.B_{12} 80 mg , Vit.E 80 mg, Niacin 120 mg, Folic acid 8 mg, Pantothenate 80 mg per g

Table 2. Per cent ingredient composition of experimental finisher rations

Ingredient	Control diet	Experimental diet					
	T1	T2	T3	T4	T5	T6	T7
Yellow maize	58.0	58.0	58.0	58.0	58.0	58.0	58.0
Rice polish	7.0	7.0	7.0	7.0	6.0	6.5	5.0
Wheat bran	1.0	0.5	00	00	00	00	00
Soybean meal	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Gingelly oil cake	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Unsalted dried fish	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Garlic powder	00	0.5	1.0	00	00	0.5	1.0
Neem seed cake	00	00	00	1.0	2.0	1.0	2.0
Mineral mixture[1]	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100
Added per 100 kg feed							
Vitamin mixture[2], g	10	10	10	10	10	10	10
DL Methionine, g	50	50	50	50	50	50	50
L Lysine	100	100	100	100	100	100	100
Choline chloride[3], g	120	120	120	120	120	120	120
Coccidiostat[4], g	50	50	50	50	50	50	50
Toxin binder[5], g	250	250	250	250	250	250	250
B.Complex powder[6], g	50	50	50	50	50	50	50

Note:

[1] Mineral mixture composition

Calcium 32%, Phosphorus 6%, Magnesium 1000 ppm, Cobalt 60 ppm, Zinc 2600 ppm, Iron 0.1%, Iodine 100 ppm, Copper 100 ppm, Manganese 2700 ppm.

[2] Vitamin mixture, INDOMIX A, B_2, D_3, K powder (Nicholas Primal India Ltd., Mumbai) containing Vit. A 82,500 IU, Vit. B_2 50 mg, Vit. D_3 1200 IU, Vit. K 10 mg per g

[3]Bio choline (Indian Herbs Research and Supply Co.Ltd., U.P.) containing choline chloride 50%.

[4] Elancoban 220 (Elanco Animal Health, Eli Lilly and Co., Indiana Polis, USA) containing Monensin sodium 10%.

[5] UTPP-5 powder (Tetragon Chemic Pvt. Ltd., Bangalore) containing Treated alumino silicates, Propionates, Formates, Acetates.

[6] Meriplex-FDS (Wockhardt Ltd., Wockhardt Towers, Bandra Kurla Complex, Mumbai-400 051) containing Vit.B_1 8 mg, Vit.B_6 16 mg, Vit.B_{12} 80 mg , Vit.E 80 mg, Niacin 120 mg, Folic acid 8 mg, Pantothenate 80 mg per g

Table 3. Per cent chemical composition of experimental starter rations (on dry matter basis)

Sl. No.	Nutrient	Experimental ration						
		T1	T2	T3	T4	T5	T6	T7
1	Dry matter	88.63	88.98	88.06	88.93	88.48	89.02	88.33
2	Crude protein	23.07	23.05	23.03	23.04	23.00	23.02	23.17
3	Ether extract	3.08	3.08	3.07	3.13	3.17	3.12	3.05
4	Crude fibre	5.43	5.26	5.08	5.28	5.12	5.10	4.37
5	NFE	59.71	60.76	60.76	59.93	60.25	60.78	60.77
6	Total ash	8.71	7.85	8.06	8.62	8.46	7.98	8.64
7	Acid insoluble ash	2.98	3.16	2.89	3.01	3.00	3.09	3.04
Calculated values								
1	ME Kcal/kg	2806	2799	2803	2804	2807	2808	2801
2	Lysine	1.51	1.51	1.52	1.52	1.51	1.51	1.51
3	Methionine	0.54	0.54	0.54	0.54	0.54	0.53	0.53
4	Calcium	1.24	1.22	1.26	1.22	1.23	1.22	1.24
5	Total phosphorus	0.46	0.49	0.46	0.47	0.48	0.47	0.43

Table 4. Per cent chemical composition of experimental finisher rations (on dry matter basis)

Sl. No.	Nutrient	Experimental ration						
		T1	T2	T3	T4	T5	T6	T7
1	Dry matter	88.07	88.37	88.93	87.91	88.04	88.24	88.30
2	Crude protein	20.16	20.12	20.27	20.24	20.28	20.27	20.26
3	Ether extract	3.78	3.79	3.79	3.91	3.88	3.38	3.72
4	Crude fibre	3.78	3.91	3.92	4.14	4.29	4.10	4.21
5	NFE	63.26	63.64	63.06	62.73	62.48	63.24	63.14
6	Total ash	9.02	8.54	8.96	8.98	9.07	9.01	8.67
7	Acid insoluble ash	3.96	4.08	4.46	4.17	3.84	4.05	4.11
Calculated values								
1	ME Kcal/kg	2909	2909	2910	2921	2904	2907	2906
2	Lysine	1.19	1.19	1.19	1.19	1.19	1.99	1.19
3	Methionine	0.39	0.39	0.39	0.39	0.39	0.39	0.39
4	Calcium	1.22	1.21	1.23	1.22	1.21	1.22	1.23
5	Total phosphorus	0.33	0.30	0.35	0.37	0.31	0.34	0.31

3.1. METEOROLOGICAL PARAMETERS

The wet and dry bulb thermometer readings were taken at forenoon and afternoon daily. The maximum and minimum temperatures were recorded at forenoon on all days throughout the experimental period. From these data weekly mean maximum and minimum temperatures and relative humidity were arrived at.

3.2. BODY WEIGHT AND WEIGHT GAIN

The body weight of individual bird was recorded replicate wise at weekly interval and from these data the average weekly body weight and weight gain per bird were calculated for various treatment groups.

3.3. FEED INTAKE

Feed intake of birds was recorded replicate wise at weekly interval. From these data the average feed intake per bird per week was calculated for various treatment groups.

3.4. FEED EFFICIENCY

Feed efficiency (kg of feed per kg weight gain) was calculated in each replicate based on the data on body weight gain and feed intake.

3.5. PROCESSING YIELDS AND LOSSES

Two birds from each replicate were slaughtered both at the end of fourth and sixth week of age, totally six birds per treatment group at a time in order to study the serum and muscle biochemical characteristics and the processing yields and losses. The processing yields and losses were found out only at sixth week of age (BIS, 1973).

3.6. SERUM TOTAL CHOLESTEROL AND SERUM TOTAL PROTEIN

At the time of slaughter both at the end of fourth and sixth week of age, blood samples of two birds from each replicate were collected from the jugular vein in a clean dry labelled glass tube and was kept in slanted position at room temperature to facilitate the separation of serum.

The serum total cholesterol was estimated colorimetrically by Ferric chloride method utilizing the kit supplied by Nice Chemicals Pvt. Ltd., Cochin – 682 024, India.

The serum total protein was estimated colorimetrically by Biuret method utilizing the kit supplied by Beacon Diagnostics Pvt. Ltd., 424, New GIDC, Kabilpore, Navasari – 396 424, India.

3.7. MEAT TOTAL CHOLESTEROL AND CRUDE PROTEIN

At the time of slaughter both at the end of fourth and sixth week of age samples from breast and thigh muscles were collected. The breast and thigh muscle samples were preserved at – 18° C under deep freeze. The lipid was extracted by the method suggested by Folch *et al.* (1957) from breast and thigh muscles. The total cholesterol was estimated from extracted lipid by One step method of Wybenga *et al.* (1970) utilizing the kit supplied by Qualigens Fine Chemicals, Dr. Annie Besant Road, Worli, Mumbai – 400 025, India.

The breast and thigh muscle crude protein was estimated according to the procedure described by AOAC (1990).

3.8. LIVABILITY

The mortality of birds from different treatment groups was recorded and the livability was worked out. Post mortem examination was conducted in each case to find out the cause of death.

3.9. ECONOMICS

Cost of feed for different dietary treatments was calculated based on the cost of ingredients including cost of garlic powder and neem seed cake. Cost of feed per kg live weight for different dietary treatments was calculated based on body weight attained and recurring expenditure at six weeks of age.

3.10. STATISTICAL ANALYSIS

Data collected on various parameters were statistically analyzed as per methods described by Snedecor and Cochran (1994).

Results

4. RESULTS

The results of the experiment conducted to study the dietary supplementation of garlic (*Allium sativum*) powder and neem (*Azadirachta indica*) seed cake on the performance and cholesterol content of meat and serum in broiler chicken are presented in this chapter.

4.1 METEOROLOGICAL PARAMETERS

The data pertaining to microclimate viz., the mean maximum and minimum temperatures (°C) and per cent relative humidity inside the experimental house during the study period that is, January 2005 to February 2005 are presented in Table.5. During the course of the experiment the mean maximum temperature ranged from 33.00 to 36.00 °C, while the mean minimum temperature ranged from 22.14 to 25.00 °C. The per cent relative humidity varied from 63.00 to 74.33 in the forenoon and 41.00 to 48.50 in the afternoon.

4.2 BODY WEIGHT

The data on mean body weight of broiler chicken at weekly interval as influenced by supplementation of garlic powder (GP) and neem seed cake (NSC) is given in Table 6 and graphically represented in Fig.1. The day old body weight of chicks among different groups viz, T1, T2, T3, T4, T5, T6 and T7 were 45.05, 42.94, 44.18, 43.74, 44.10, 44.76 and 44.32 g respectively with an overall mean of 44.03 g. The statistical analysis of the data on day old body weight of chicks did not reveal any significant difference between the treatment groups.

The statistical analysis of the data on mean body weight at the end of first week of age revealed significant ($P \leq 0.05$) differences among the treatments. The birds fed with control diet had significantly ($P \leq 0.05$) higher body weight (147.68 g) and was statistically comparable to T2, T3 and T6. The birds fed with 1 per cent

Table 5. Mean weekly meteorological data in the experimental house during the period from January to February 2005

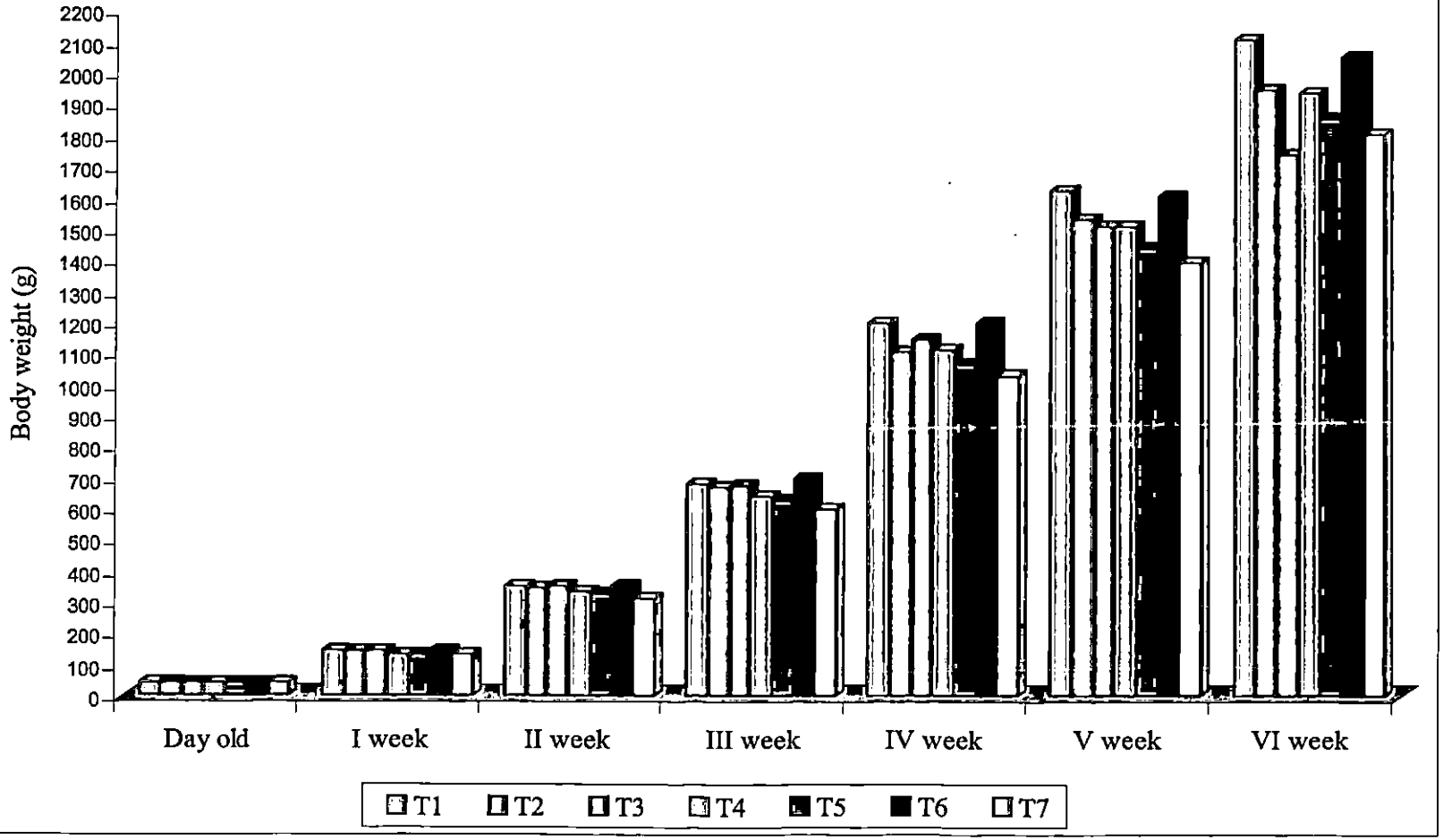
Age in week	Temperature (°C)		Relative humidity (%)	
	Maximum	Minimum	Forenoon	Afternoon
1	33.00	22.14	70.60	45.66
2	34.25	23.85	63.00	47.17
3	34.50	24.71	68.50	44.00
4	34.60	23.80	63.50	47.68
5	35.20	24.20	67.00	48.50
6	36.00	25.00	74.33	41.00
Overall mean ± SE	34.56 ± 1.00	23.95 ± 1.00	67.82 ± 1.43	45.60 ± 0.92

Table 6.Weekly mean body weight (g) of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Age in weeks						
	0 n=30	1 n=30	2 n=30	3 n=30	4 n=30	5 n=24	6 n=24
T1 GP=0.0% NSC=0.0%	45.05 ± 0.84	147.68^{b} ± 1.42	353.38^{d} ± 3.35	682.00^{c} ± 7.59	1202.00^{d} ± 19.69	1626.67^{d} ± 32.90	2113.33^{d} ± 43.48
T2 GP=0.5% NSC=0.0%	42.94 ± 0.62	144.87^{b} ± 2.63	348.69^{cd} ± 5.21	673.23^{c} ± 9.70	1109.00^{bc} ± 12.46	1536.99^{c} ± 17.92	1951.67^{c} ± 35.41
T3 GP=1.0% NSC=0.0%	44.18 ± 0.72	145.87^{b} ± 1.83	352.61^{d} ± 3.11	677.56^{c} ± 9.00	1148.33^{c} ± 12.60	1514.17^{bc} ± 22.87	1742.00^{a} ± 21.56
T4 GP=0.0% NSC=1.0%	43.74 ± 0.69	134.86^{a} ± 2.22	336.06^{bc} ± 5.17	643.33^{b} ± 11.56	1113.40^{bc} ± 19.67	1513.33^{bc} ± 27.62	1938.58^{c} ± 33.05
T5 GP=0.0% NSC=2.0%	44.10 ± 0.60	134.50^{a} ± 2.43	331.74^{b} ± 4.83	630.17^{ab} ± 11.50	1066.00^{ab} ± 14.03	1445.62^{ab} ± 24.72	1857.08^{bc} ± 34.28
T6 GP=0.5% NSC=1.0%	44.76 ± 0.63	143.92^{b} ± 1.92	351.39^{d} ± 4.26	701.50^{c} ± 9.69	1202.00^{d} ± 18.04	1609.79^{d} ± 31.97	2052.29^{d} ± 45.07
T7 GP=1.0% NSC=2.0%	44.32 ± 0.54	133.54^{a} ± 2.13	311.12^{a} ± 6.42	603.67^{a} ± 10.33	1030.83^{a} ± 15.86	1398.67^{a} ± 19.23	1806.67^{ab} ± 45.07
Overall mean ± SE	44.03 ± 0.25	140.75 ± 0.88	340.71 ± 2.03	658.78 ± 4.32	1124.51 ± 7.35	1520.74 ± 11.25	1923.09 ± 16.39

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

Fig. 1 Weekly mean body weight of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets



NSC (T4), 2 per cent NSC (T5) and 1 per cent GP and 2 per cent NSC (T7) had significantly ($P \leq 0.05$) lower body weight than the birds maintained on the control diet (T1). The data on the mean body weight recorded at the end of second week of age also revealed significant ($P \leq 0.05$) differences among the treatments. The control group T1 and treatments T2, T3 and T6 had significantly ($P \leq 0.05$) higher body weight than the birds in treatments T4, T5 and T7. Similar to the first week body weight, second week body weight of the birds fed with 0.5 per cent GP (T2), 1 per cent GP (T3) and 0.5 per cent GP and 1 per cent NSC (T6) did not differ significantly when compared to birds fed with control diet (T1).

Statistical analysis of data on mean body weight recorded at the end of third week of age also revealed significant ($P \leq 0.05$) differences among the treatments. The body weight of control group was significantly ($P \leq 0.05$) higher and was comparable to T2, T3 and T6 groups whereas, T4, T5 and T7 recorded significantly ($P \leq 0.05$) lower body weights.

The mean body weight recorded at the end of fourth week of age for treatments T1, T2, T3, T4, T5, T6 and T7 were 1202.00, 1109.00, 1148.33, 1113.40, 1066.00, 1202.00 and 1030.83 g respectively with an overall mean of 1124.51 g. Statistical analysis of this data revealed significant ($P \leq 0.05$) differences among the treatments. The birds fed with control diet (T1) and those with a combination of 0.5 per cent GP and 1 per cent NSC (T6) showed significantly ($P \leq 0.05$) higher body weight. The body weight of birds in all other treatments was significantly ($P \leq 0.05$) lower and the body weight of birds in the group T7 was the lowest (1030.83g). However, there was no significant difference between T7 and T5. Similarly, T2, T4 and T5 formed a homogenous group. The body weight of T2, T3 and T4 was also statistically similar. Among the treatments T2, T3, T4, T5 and T7 the higher body weight was recorded in treatment T3 (1148.33 g) followed by the treatments T4, T2, T5 and T7.

The overall mean body weight at the end of fifth week was 1520.74 g. The data on mean body weight at fifth week of age also exhibited significant ($P \leq 0.05$) differences among the treatments. The highest body weight was noted with the control group (1626.67g), followed by T6, T2, T3, T4, T5 and T7 in the decreasing order. However, as in the previous weeks the body weight of control birds was statistically similar to T6. The body weight of T5 and T7 were significantly ($P \leq 0.05$) lower than the other groups and were comparable. The body weight of T2, T3 and T4 were intermediatary and formed a homogenous group. Likewise, T3, T4 and T5 also formed a homogenous group.

At the end of sixth week of age the mean body weights recorded were 2113.33, 1951.67, 1742.00, 1938.58, 1857.08, 2052.29 and 1806.67 g for treatments T1, T2, T3, T4, T5, T6 and T7 respectively with an overall mean of 1923.09 g. Statistical analysis of the data on body weight at this period also revealed significant ($P \leq 0.05$) differences among the treatments. The trend in body weight among the treatments was similar to previous weeks. Highest body weight was recorded with the control group T1 followed by T6, T2, T4, T5, T7 and T3 in that order. The body weight of birds in T1 and T6 were significantly ($P \leq 0.05$) higher, whereas that of T3 recorded lowest body weight. However, there was no significant difference between T3 and T7. The body weight of birds in groups T2, T4 and T5 were also comparable.

4.3 BODY WEIGHT GAIN

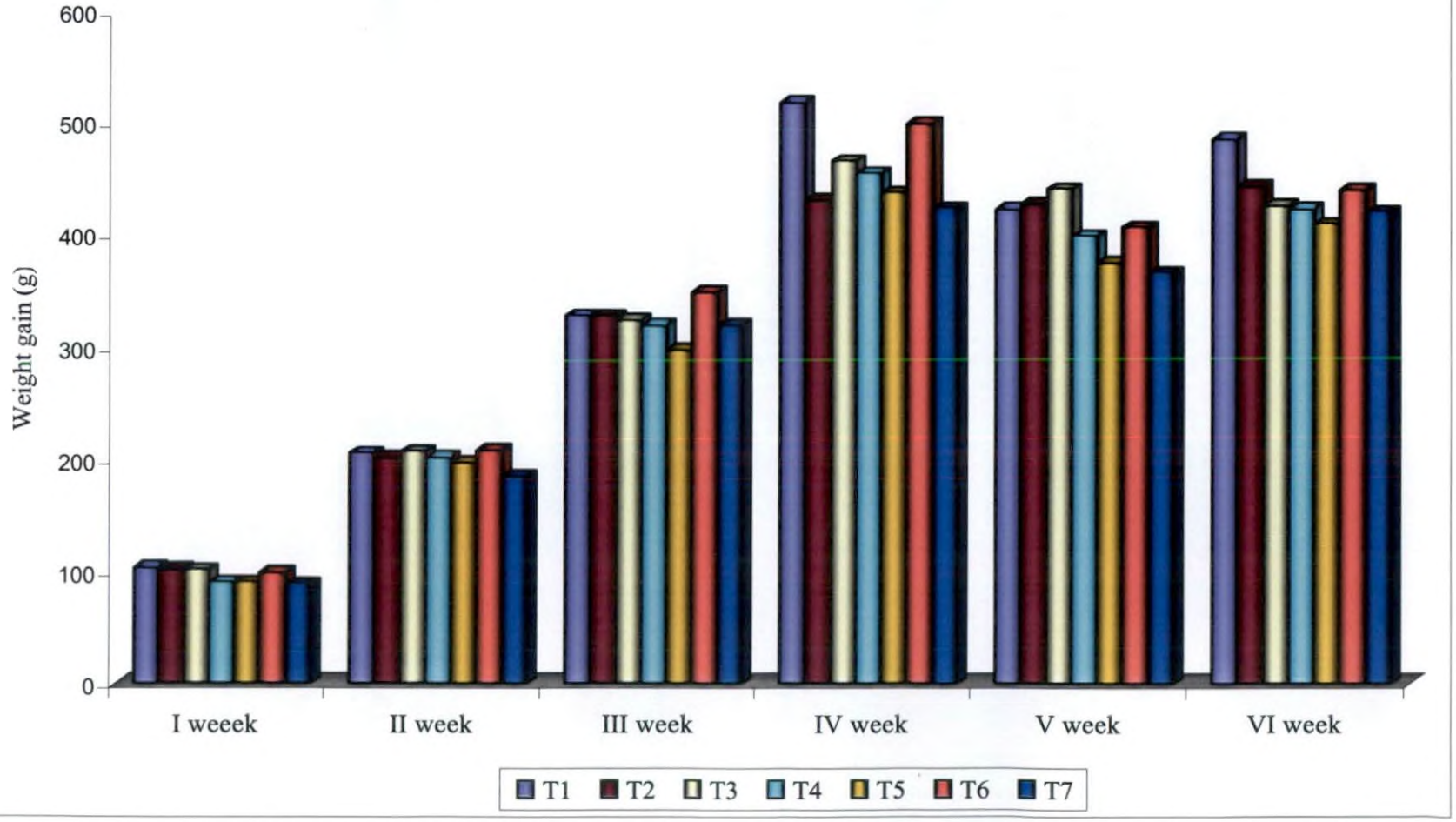
The data on mean body weight gain of broiler chicken at weekly intervals as influenced by supplementation of GP and NSC is given in Table 7 and graphically depicted in Fig. 2. Statistical analysis of the data on body weight gain at the end of first week of age revealed significant ($P \leq 0.05$) differences among the treatments. The birds fed with 1 per cent NSC (T4), 2 per cent NSC (T5) and combination of 1 per cent GP and 2 per cent NSC (T7) had significantly ($P \leq 0.05$) lower body weight

Table 7.Weekly mean body weight gain and cumulative body weight gain (g) of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Age in weeks						Cumulative body weight gain	
	1	2	3	4	5	6	0-4	0-6
T1 GP=0.0% NSC=0.0%	103.54^{a} ± 2.00	205.61^{a} ± 3.34	328.70 ± 4.65	520.00^{a} ± 1.45	424.67 ± 5.36	486.67^{a} ± 19.91	1157.86^{a} ±10.72	2069.19^{a} ± 58.39
T2 GP=0.5% NSC=0.0%	101.93^{a} ± 1.39	201.39^{a} ± 6.66	328.74 ± 4.31	433.00^{c} ± 2.73	428.99 ± 4.49	445.33^{ab} ± 2.99	1065.06^{c} ± 14.63	1939.39^{b} ± 8.61
T3 GP=1.0% NSC=0.0%	101.14^{a} ± 0.31	207.16^{a} ± 4.39	324.94 ± 6.07	467.67^{bc} ± 2.02	442.50 ± 6.17	427.88^{b} ± 12.51	1100.81^{b} ± 15.48	1937.85^{b} ± 42.93
T4 GP=0.0% NSC=1.0%	90.45^{b} ± 0.04	201.50^{a} ± 5.68	320.67 ± 8.36	456.63^{bc} ± 4.54	400.33 ± 3.63	425.24^{b} ± 2.70	1069.26^{c} ± 6.00	1904.83^{c} ± 32.15
T5 GP=0.0% NSC=2.0%	90.40^{b} ± 2.70	197.29^{ab} ± 1.89	298.20 ± 1.95	439.33^{c} ± 1.55	376.29 ± 4.91	411.67^{b} ± 18.78	1025.23^{d} ±14.15	1813.19^{d} ± 23.81
T6 GP=0.5% NSC=1.0%	98.82^{a} ± 1.88	207.77^{a} ± 1.16	349.98 ± 3.05	500.67^{ab} ± 1.20	408.20 ± 6.98	442.08^{b} ± 15.25	1157.24^{a} ± 12.82	2007.57^{b} ± 15.85
T7 GP=1.0% NSC=2.0%	88.67^{b} ± 1.88	184.81^{b} ± 4.61	320.60 ± 3.57	425.66^{c} ± 5.35	368.00 ± 10.61	422.33^{b} ± 14.55	986.35^{e} ± 7.68	1776.68^{d} ± 11.98
Overall mean ±SE	96.42 ± 1.42	200.79 ± 2.15	324.54 ± 6.28	463.28 ± 7.13	406.99 ± 8.71	437.32 ± 6.75	1080.25 ± 13.60	1921.24 ± 23.51

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

Fig. 2 Weekly mean body weight gain of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets



gain than the birds maintained on control diet (T1), 0.5 per cent GP (T2), 1 per cent GP (T3) and 0.5 per cent GP and 1 per cent NSC (T6).

The statistical analysis of the data on mean body weight gain recorded at the end of second week of age also revealed significant ($P \leq 0.05$) differences among the treatments. The birds fed with a combination of 1 per cent GP and 2 per cent NSC (T7) had significantly ($P \leq 0.05$) lower body weight gain than the birds maintained on control diet, but was statistically comparable to T5. The body weight gain of treatments T2, T3, T4, T5 and T6 was statistically similar and formed a homogenous group.

The mean body weight gain at the end of third week of age for the birds in different dietary combinations did not differ significantly.

The analysis of the data on mean body weight gain recorded at the end of fourth week of age revealed significant ($P \leq 0.05$) differences among the treatment groups. The birds maintained on 0.5 per cent GP (T2), 1 per cent GP (T3), 1 per cent NSC (T4), 2 per cent NSC (T5) and a combination of 1 per cent GP and 2 per cent NSC (T7) had significantly ($P \leq 0.05$) lower body weight gain than the birds maintained on control diet and T6. However, T3, T4 and T6 were statistically similar in their body weight.

The statistical analysis of the data on mean body weight gain at the end of fifth week of age did not reveal any significant difference among the treatments and showed homogeneity.

The mean body weight gain recorded at the end of sixth week of age for treatments T1, T2, T3, T4, T5, T6 and T7 were 486.67, 445.33, 427.88, 425.24, 411.67, 442.08 and 422.33 g respectively. Statistical analysis of the data revealed significant ($P \leq 0.05$) differences among the treatments. The birds fed with control diet (T1) had significantly ($P \leq 0.05$) higher body weight gain than all other treatments and was statistically comparable to T2. Birds fed with 0.5 per cent GP (T2) was statistically comparable to T3, T4, T5, T6 and T7.

The mean cumulative body weight gain (Table 7) of birds up to sixth week of age was 2069.19, 1939.39, 1937.85, 1904.83, 1813.19, 2007.57, 1776.68 g for treatments T1, T2, T3, T4, T5, T6 and T7, respectively with an overall mean of 1921.24 g. Statistical analysis of the data revealed significant ($P \leq 0.05$) differences among the treatments. The birds supplemented with GP and NSC and their combination had significantly ($P \leq 0.05$) lower body weight gain than the birds fed with control diet (T1).

4.4 FEED INTAKE

The data on mean feed intake at weekly intervals as influenced by dietary inclusion of garlic powder and neem seed cake is given in Table 8 and graphically represented in Fig. 3. The mean feed intake recorded during the first, second, third, fourth, fifth and sixth week of age, irrespective of the treatment effect were 132.05, 336.57, 507.64, 644.86, 744.87 and 840.72 g respectively. Statistical analysis of the mean feed intake data revealed that the dietary supplementation of garlic powder and neem seed cake significantly ($P \leq 0.05$) influenced weekly feed consumption from first to sixth week of age except fourth and fifth weeks.

The mean cumulative feed intake (Table 8, Fig. 4) of birds up to four weeks of age was 1691.50, 1621.83, 1696.00, 1592.17, 1479.00, 1722.83 and 1579.17 g for treatments T1, T2, T3, T4, T5, T6 and T7 respectively with an overall mean of 1626.07 g. Statistical analysis of the data revealed significant ($P \leq 0.05$) differences among the treatments. The birds offered a diet containing 2 per cent NSC (T5) consumed significantly ($P \leq 0.05$) less feed than the other groups. However, the groups supplemented with NSC at 1 and 2 per cent levels and those fed a combination of 1 per cent GP and 2 per cent NSC were statistically comparable.

The mean cumulative feed intake of birds up to sixth week of age was 3295.08, 3229.18, 3301.66, 3208.32, 3015.41, 3371.57 and 3057.74 g for treatments T1, T2, T3, T4, T5, T6 and T7 respectively with an overall mean of

Table 8.Weekly mean feed intake and mean cumulative feed intake (g) of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Age in weeks						Cumulative feed intake	
	1	2	3	4	5	6	0-4	0-6
T1 GP=0.0% NSC=0.0%	144.67^{a} ± 4.00	324.50^{bcd} ± 10.99	520.50^{ab} ± 10.02	700.50 ± 34.67	716.66 ± 31.75	888.58^{a} ± 23.00	1691.50^{a} ± 36.19	3295.08 ± 30.68
T2 GP=0.5% NSC=0.0%	131.33^{bc} ± 3.48	320.33^{d} ± 5.58	535.50^{a} ± 8.50	634.67 ± 51.08	755.96 ± 22.48	851.06^{ab} ± 13.71	1621.83^{a} ± 8.23	3229.18 ± 42.33
T3 GP=1.0% NSC=0.0%	137.17^{ab} ± 1.59	350.00^{ab} ± 7.40	533.67^{a} ± 8.23	641.83 ± 10.12	767.75 ± 24.83	837.91^{abc} ± 21.36	1696.00^{a} ± 13.05	3301.66 ± 56.19
T4 GP=0.0% NSC=1.0%	126.17^{c} ± 2.89	321.33^{cd} ± 7.05	491.83^{ab} ± 6.21	652.83 ± 50.69	775.08 ± 61.75	841.07^{ab} ± 8.98	1592.17^{ab} ± 54.85	3208.32 ± 42.50
T5 GP=0.0% NSC=2.0%	121.83^{c} ± 2.77	348.33^{abc} ± 12.65	458.00^{b} ± 35.30	550.83 ± 52.18	723.54 ± 11.92	812.87^{bc} ± 12.67	1479.00^{b} ± 33.07	3015.41 ± 54.06
T6 GP=0.5% NSC=1.0%	132.00^{bc} ± 4.77	337.33^{abcd} ± 1.09	548.00^{a} ± 15.82	705.50 ± 28.75	785.82 ± 28.35	864.25^{a} ± 14.30	1722.83^{a} ± 34.56	3371.57 ± 36.06
T7 GP=1.0% NSC=2.0%	131.17^{bc} ± 2.52	354.17^{a} ± 8.68	466.00^{b} ± 34.20	627.83 ± 20.93	689.25 ± 12.12	789.33^{c} ± 4.68	1579.17^{ab} ± 4.24	3057.74 ± 37.68
Overall mean ±SE	132.05 ± 1.83	336.57 ± 4.02	507.64 ± 9.85	644.86 ± 16.26	744.87 ± 18.13	840.72 ± 8.30	1626.07 ± 22.23	3211.28 ± 38.68

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

Fig. 3 Weekly mean feed intake of broiler chicken as influenced by garlic powderand neem seed cake supplementation in experimental diets

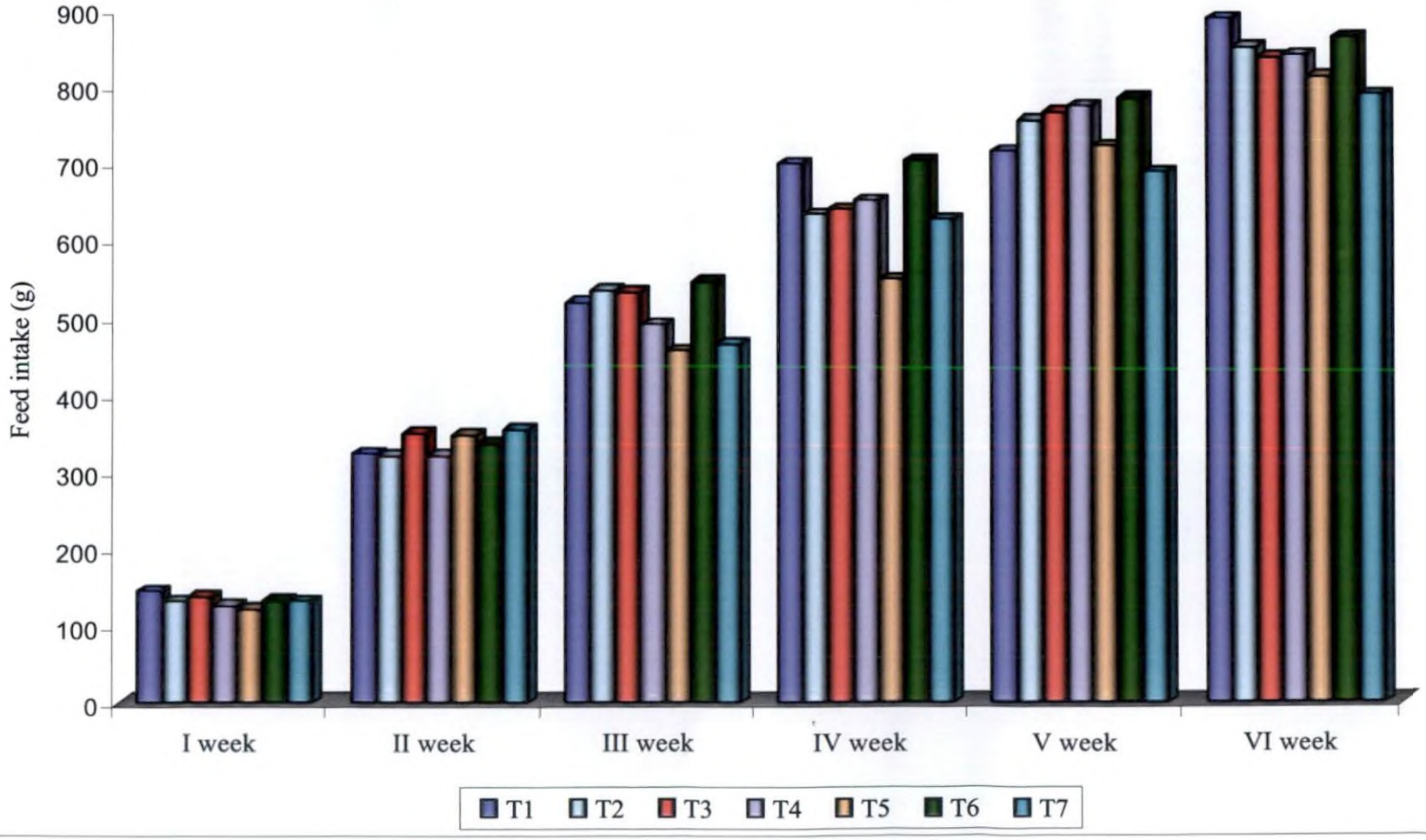
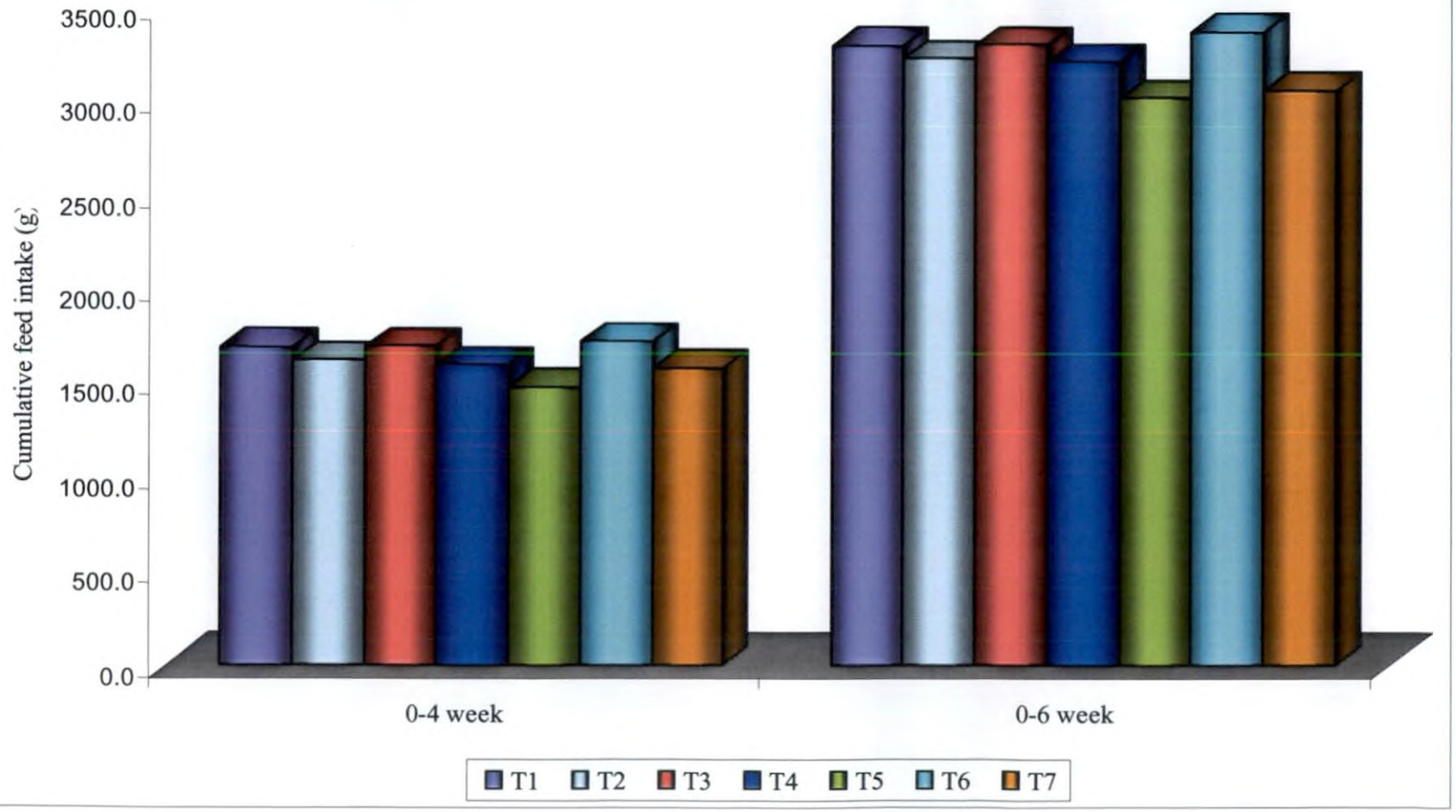


Fig. 4 Mean cumulative feed intake of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets



3211.28 g. Statistical analysis of the data did not reveal any difference between the treatments. Numerically higher cumulative feed intake (3371.57 g) was recorded in the group fed a diet supplemented with a combination of 0.5 per cent GP and 1 per cent NSC (T6), whereas the group offered the diet containing 2 per cent NSC consumed less feed (T5).

4.5 FEED EFFICIENCY

The data on weekly mean feed efficiency of birds maintained on different dietary treatments is presented in Table 9. The overall mean feed efficiency during the first, second, third, fourth, fifth and sixth week of age, without considering the treatment effects, was 1.37, 1.68, 1.61, 1.40, 1.86 and 1.93 respectively. Statistical analysis of the mean feed efficiency values showed that the different dietary combinations had an effect only during the first and second
week of age and in the remaining weeks, the values were statistically comparable among treatments.

The mean cumulative feed efficiency up to four and six weeks of age is set out in Table 9 and graphically depicted in Fig.5. The mean cumulative feed efficiency of birds up to four weeks of age calculated for the treatments T1, T2, T3, T4, T5, T6 and T7 were 1.48, 1.50, 1.55, 1.50, 1.48, 1.49 and 1.62 respectively with an overall mean of 1.52. The statistical analysis of the data on cumulative feed efficiency up to four weeks of age showed significant ($P \leq 0.05$) differences among the treatment groups. The birds fed with a combination of 1 per cent GP and 2 per cent NSC (T7) had significantly ($P \leq 0.05$) lower cumulative feed efficiency and it was statistically comparable to T3 (1 per cent GP). All other treatments were significantly ($P \leq 0.05$) superior with respect to 0 to 4 weeks cumulative feed efficiency.

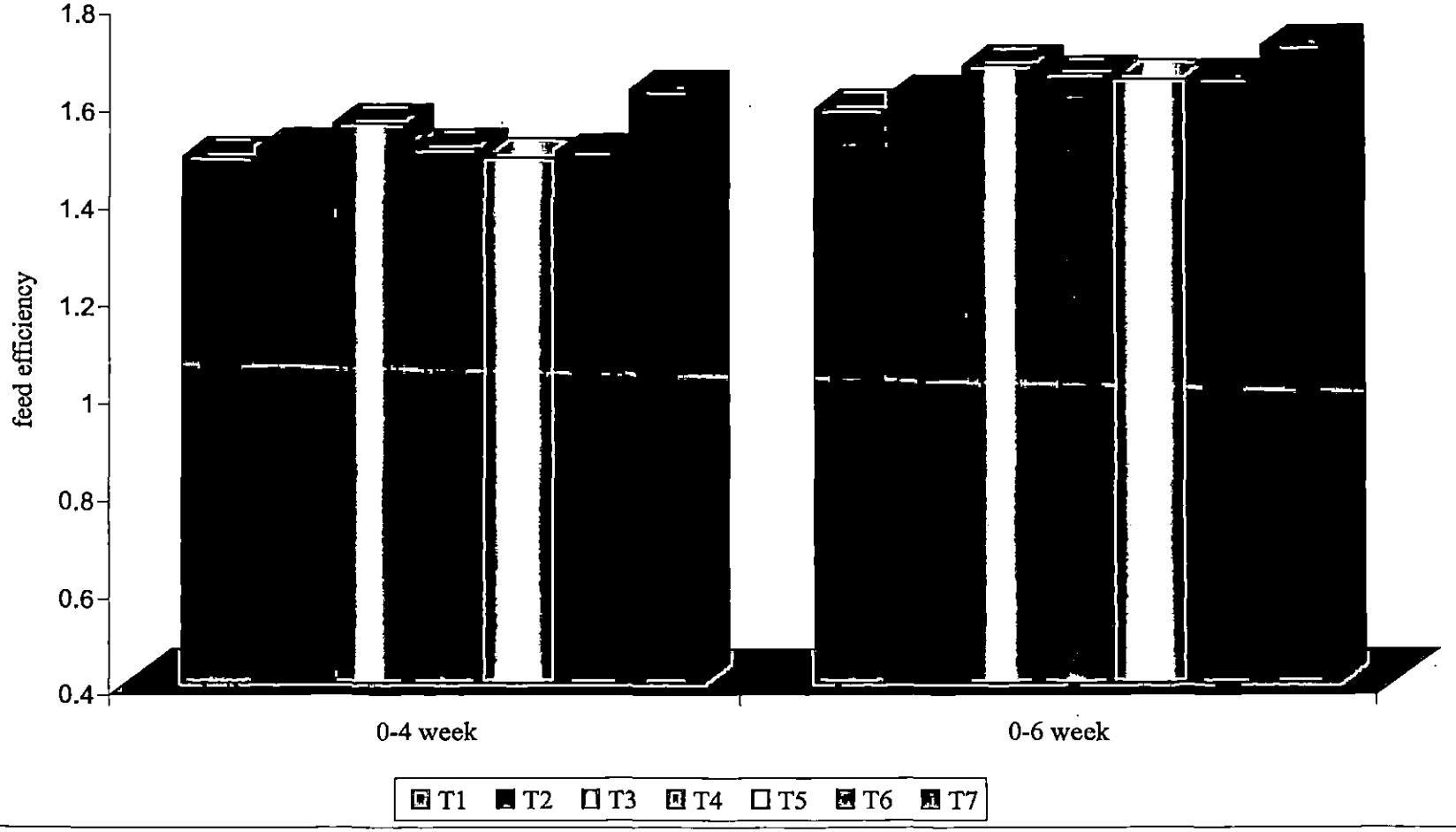
The mean cumulative feed efficiency of birds up to six weeks of age recorded for the treatments T1, T2, T3, T4, T5, T6 and T7 were 1.58, 1.61, 1.67,

Table 9.Weekly mean feed efficiency and mean cumulative feed efficiency of broiler chicken as influenced garlic powder and neem seed cake supplementation in experimental diets (kg feed / kg body wt gain)

Treatment	Age in weeks						Cumulative feed efficiency	
	1	2	3	4	5	6	0-4	0-6
T1 GP=0.0% NSC=0.0%	1.40^{ab} ± 0.05	1.58^{c} ± 0.03	1.58 ± 0.02	1.35 ± 0.03	1.72 ± 0.19	1.83 ± 0.08	1.48^{a} ± 0.02	1.58^{a} ± 0.02
T2 GP=0.5% NSC=0.0%	1.29^{c} ± 0.02	1.60^{bc} ± 0.07	1.63 ± 0.02	1.47 ± 0.14	1.77 ± 0.20	1.91 ± 0.02	1.50^{a} ± 0.05	1.61^{ab} ± 0.07
T3 GP=1.0% NSC=0.0%	1.36^{bc} ± 0.02	1.69^{bc} ± 0.05	1.76 ± 0.10	1.38 ± 0.9	1.87 ± 0.06	1.96 ± 0.01	1.55^{ab} ± 0.05	1.67^{ab} ± 0.01
T4 GP=0.0% NSC=1.0%	1.40^{abc} ± 0.02	1.60^{bc} ± 0.07	1.54 ± 0.07	1.43 ± 0.12	1.93 ± 0.01	1.98 ± 0.01	1.50^{a} ± 0.03	1.65^{ab} ± 0.02
T5 GP=0.0% NSC=2.0%	1.35^{bc} ± 0.01	1.77^{ab} ± 0.06	1.54 ± 0.12	1.46 ± 0.14	1.93 ± 0.04	1.98 ± 0.06	1.48^{a} ± 0.03	1.64^{ab} ± 0.01
T6 GP=0.5% NSC=1.0%	1.34^{bc} ± 0.02	1.62^{bc} ± 0.01	1.56 ± 0.05	1.41 ± 0.05	1.93 ± 0.02	1.95 ± 0.03	1.49^{a} ± 0.02	1.64^{ab} ±0.02
T7 GP=1.0% NSC=2.0%	1.48^{a} ± 0.01	1.92^{a} ± 0.01	1.62 ± 0.10	1.48 ± 0.03	1.87 ± 0.04	1.87 ± 0.05	1.62^{b} ± 0.02	1.71^{b} ± 0.02
Overall mean ± SE	1.37 ± 0.02	1.68 ± 0.03	1.61 ± 0.03	1.40 ± 0.04	1.86 ± 0.04	1.93 ± 0.02	1.52 ± 0.01	1.64 ± 0.01

Means bearing the different superscript within the same column differ significantly ($P \leq 0.05$)

Fig. 5 Mean cumulative feed efficiency (kg feed/kg wt gain)of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets



1.65, 1.64, 1.64 and 1.71 respectively with an overall mean of 1.64. The statistical interpretation of data on cumulative feed efficiency up to six weeks of age revealed significant ($P \leq 0.05$) differences among the treatment groups. Birds fed with the control diet had statistically superior feed efficiency. The mean cumulative feed efficiency of birds fed with a combination of 1 per cent GP and 2 per cent NSC (T7) recorded significantly ($P \leq 0.05$) inferior feed efficiency than the birds fed with control diet (T1). The cumulative feed efficiency of birds fed with 0.5 per cent GP (T2), 1 per cent GP (T3), 1 per cent NSC (T4), 2 per cent NSC (T5) and combination of 0.5 per cent GP and 1 per cent NSC (T6) did not differ significantly when compared to birds fed with standard diet (T1). Likewise, the groups T2, T3, T4, T5, T6 and T7 formed a homogenous group.

4.6 PROCESSING YIELDS AND LOSSES

The mean per cent dressed yield, eviscerated yield, giblet yield, ready-to-cook yield, blood loss, feather loss and total loss recorded in broiler chickens slaughtered at six weeks of age as influenced by dietary inclusion of GP and NSC are presented in Table 10. The statistical analysis of the data on processing yields and losses revealed that dressed yield, eviscerated yield, ready-to-cook yield, blood loss, feather loss and total loss did not differ significantly, while the giblet yield differed significantly ($P \leq 0.05$) among the treatments.

The overall mean per cent dressed yield, eviscerated yield, ready-to-cook yield, blood loss, feather loss and total loss recorded were 83.38, 66.72, 72.03, 4.86, 11.78 and 28.76 respectively.

The mean per cent giblet yield recorded for treatments T1, T2, T3, T4, T5, T6 and T7 were 5.28, 4.97, 5.46, 5.45, 5.65, 4.76 and 5.59 respectively with an overall mean of 5.31. The birds fed with combination of 0.5 per cent GP and 1 per cent NSC (T6) recorded significantly ($P \leq 0.05$) lower giblet yield. On the other

Table 10. Mean per cent processing yields and losses of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Dressed yield	Eviscerated yield	Giblet yield	Ready-to-cook yield	Blood loss	Feather loss	Total loss
T1 GP=0.0% NSC=0.0%	83.35 ± 0.17	67.80 ± 0.20	5.28^{ab} ± 0.15	73.08 ± 0.34	5.03 ± 0.04	11.62 ± 0.20	27.42 ± 0.34
T2 GP=0.5% NSC=0.0%	83.52 ± 0.37	66.37 ± 0.46	4.97^{bc} ± 0.08	71.35 ± 0.44	4.84 ± 0.11	11.92 ± 0.44	28.66 ± 0.44
T3 GP=1.0% NSC=0.0%	83.41 ± 0.27	66.99 ± 0.31	5.46^{b} ± 0.10	72.45 ± 0.29	4.59 ± 0.24	11.99 ± 0.39	27.56 ± 0.29
T4 GP=0.0% NSC=1.0%	83.63 ± 0.48	66.86 ± 0.47	5.45^{ab} ± 0.09	72.31 ± 0.49	4.83 ± 0.10	11.35 ± 0.46	27.69 ± 0.49
T5 GP=0.0% NSC=2.0%	83.38 ± 0.19	66.21 ± 0.51	5.65^{a} ± 0.26	71.85 ± 0.58	4.97 ± 0.05	11.65 ± 0.19	28.15 ± 0.58
T6 GP=0.5% NSC=1.0%	83.54 ± 0.33	66.61 ± 0.39	4.76^{c} ± 0.24	71.37 ± 0.36	4.83 ± 0.07	11.62 ± 0.36	28.63 ± 0.68
T7 GP=1.0% NSC=2.0%	82.82 ± 0.46	66.20 ± 0.44	5.59^{a} ± 0.11	71.79 ± 0.38	4.93 ± 0.03	12.26 ± 0.45	28.20 ± 0.38
Overall mean ± SE	83.38 ± 0.13	66.72 ± 0.17	5.31 ± 0.08	72.03 ± 0.17	4.86 ± 0..05	11.78 ± 0.14	28.76 ± 0.72

Means bearing the different superscript within the same column differ significantly ($P \leq 0.05$)

hand, significantly ($P \leq 0.05$) higher per cent giblet yield was recorded in T5 and T7. Other treatments showed intermediatary values.

4.7 WEIGHT OF BURSA OF FABRICIOUS AND SPLEEN

The average weight of bursa of fabricious and spleen of broiler chicken at six weeks of age maintained on different dietary treatments are presented in Table 11 and graphically represented in Fig. 6. The average weight of bursa of fabricious of birds recorded for the treatments T1, T2, T3, T4, T5, T6 and T7 were 4.55, 5.08, 5.22, 5.22, 5.30, 5.78 and 5.98g respectively with an overall mean of 5.30g. The statistical analysis of the data revealed significant ($P \leq 0.05$) differences between the treatments. The birds fed with a combination of 0.5 per cent GP and 1 per cent NSC (T6) and 1 per cent GP and 2 per cent NSC (T7) had significantly ($P \leq 0.05$) higher bursa of fabricious weight than the birds fed with control diet (T1). Eventhough there was numerical increase in weight of bursa of fabricious of the birds fed with 0.5 per cent GP (T2), 1 per cent GP (T3), 1 per cent NSC (T4) and 2 per cent NSC (T5) they did not differ significantly when compared to birds fed with control diet (T1). Similarly, the weights of bursa of fabricious of the birds in groups T2 and T7 were statistically comparable.

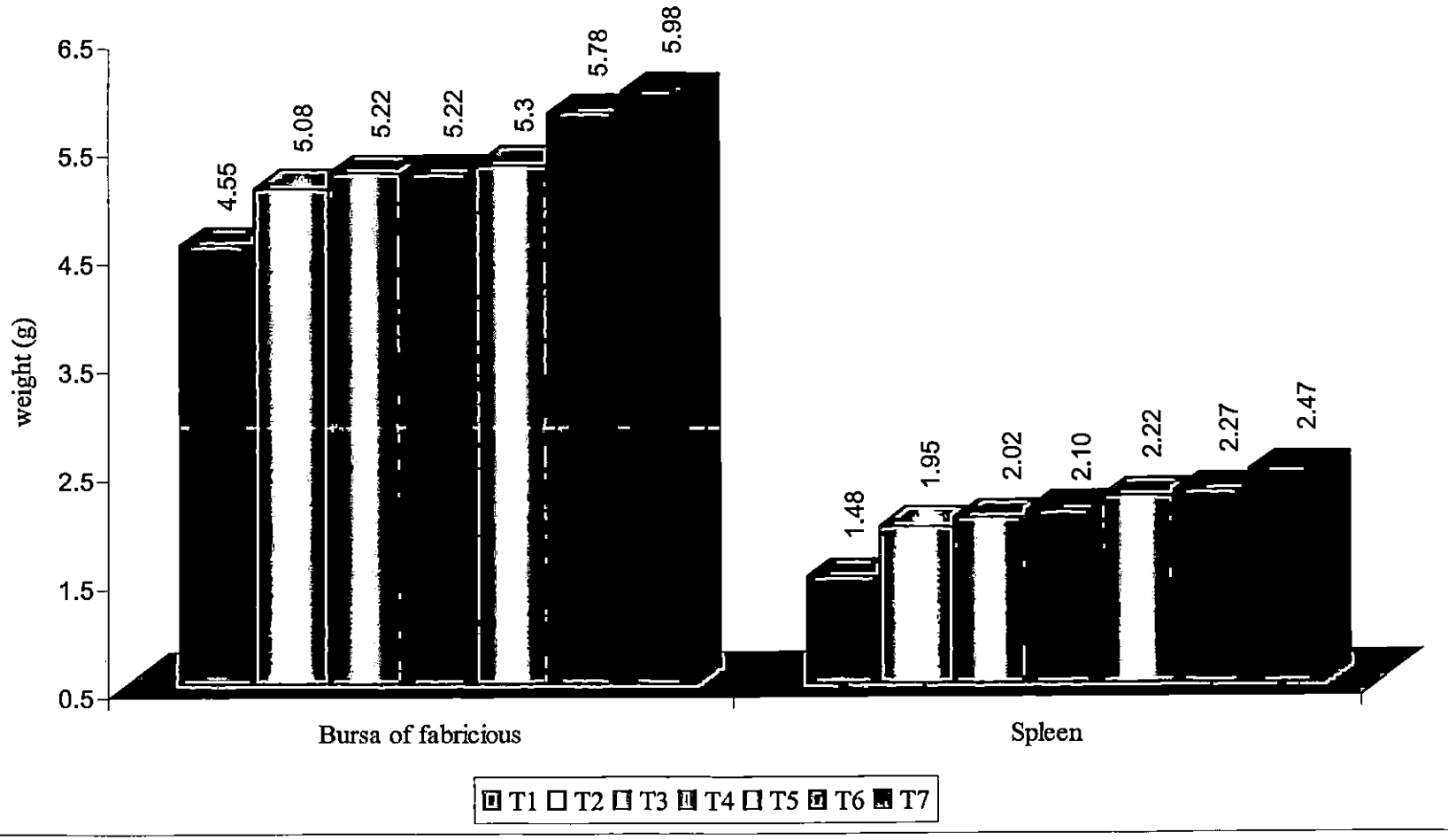
The average weight of spleen of birds recorded for the treatments T1, T2, T3, T4, T5, T6 and T7 were 1.48, 1.95, 2.02, 2.10, 2.22, 2.27 and 2.47g respectively with an overall mean of 2.07g. Analysis of this data also showed statistical differences among the treatments. The birds fed with control diet recorded significant ($P \leq 0.05$) reduction in the weight of spleen. The spleen weight of birds supplemented with different levels of GP and NSC individually and their combination was significantly ($P \leq 0.05$) more. The weight of spleen of birds in the group T2 was intermediate.

Table 11. Mean weight of bursa of fabricious and spleen (g) of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Weight of bursa of fabricious (g)	Weight of spleen (g)
T1 GP=0.0% NSC=0.0%	$4.55^{a} \pm 0.29$	$1.48^{a} \pm 0.15$
T2 GP=0.5% NSC=0.0%	$5.08^{ab} \pm 0.37$	$1.95^{ab} \pm 0.13$
T3 GP=1.0% NSC=0.0%	$5.22^{ab} \pm 0.22$	$2.02^{b} \pm 0.14$
T4 GP=0.0% NSC=1.0%	$5.22^{ab} \pm 0.28$	$2.10^{b} \pm 0.25$
T5 GP=0.0% NSC=2.0%	$5.30^{ab} \pm 0.34$	$2.22^{b} \pm 0.21$
T6 GP=0.5% NSC=1.0%	$5.78^{b} \pm 0.23$	$2.27^{b} \pm 0.09$
T7 GP=1.0% NSC=2.0%	$5.98^{b} \pm 0.12$	$2.47^{b} \pm 0.24$
Overall mean ± SE	5.30 ± 0.12	2.07 ± 0.08

Means bearing the different superscript within the same column differ significantly ($P \leq 0.05$)

Fig. 6 Weight of bursa of fabricious and spleen of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets



4.8 SERUM TOTAL CHOLESTEROL

The mean serum total cholesterol (mg per dl) estimated at fourth and sixth week of age is set out in Table 12 and graphically represented in Fig.7. The serum cholesterol levels at fourth week of age for treatments T1, T2, T3, T4, T5, T6 and T7 were 160.59, 156.18, 151.19, 158.06, 151.21, 146.49 and 141.18 mg per dl respectively. The corresponding values at sixth week of age were 181.73, 175.04, 164.86, 177.54, 170.53, 161.98 and 150.67 mg per dl. The statistical analysis of the mean serum total cholesterol values revealed significant ($P \leq 0.05$) differences among the treatments both at fourth and sixth week of age.

In both the periods, significantly ($P \leq 0.05$) higher values were observed with control group (T1). The birds fed a diet supplemented with 0.5 per cent GP (T2) and those supplemented with 1 per cent NSC (T4) were statistically similar to control group. Whereas, significantly ($P \leq 0.05$) lower serum cholesterol values were noted with the group T7 i.e. birds supplemented with a combination of 1 per cent GP and 2 per cent NSC. Serum cholesterol values of other treatments were intermediate.

4.9 SERUM TOTAL PROTEIN

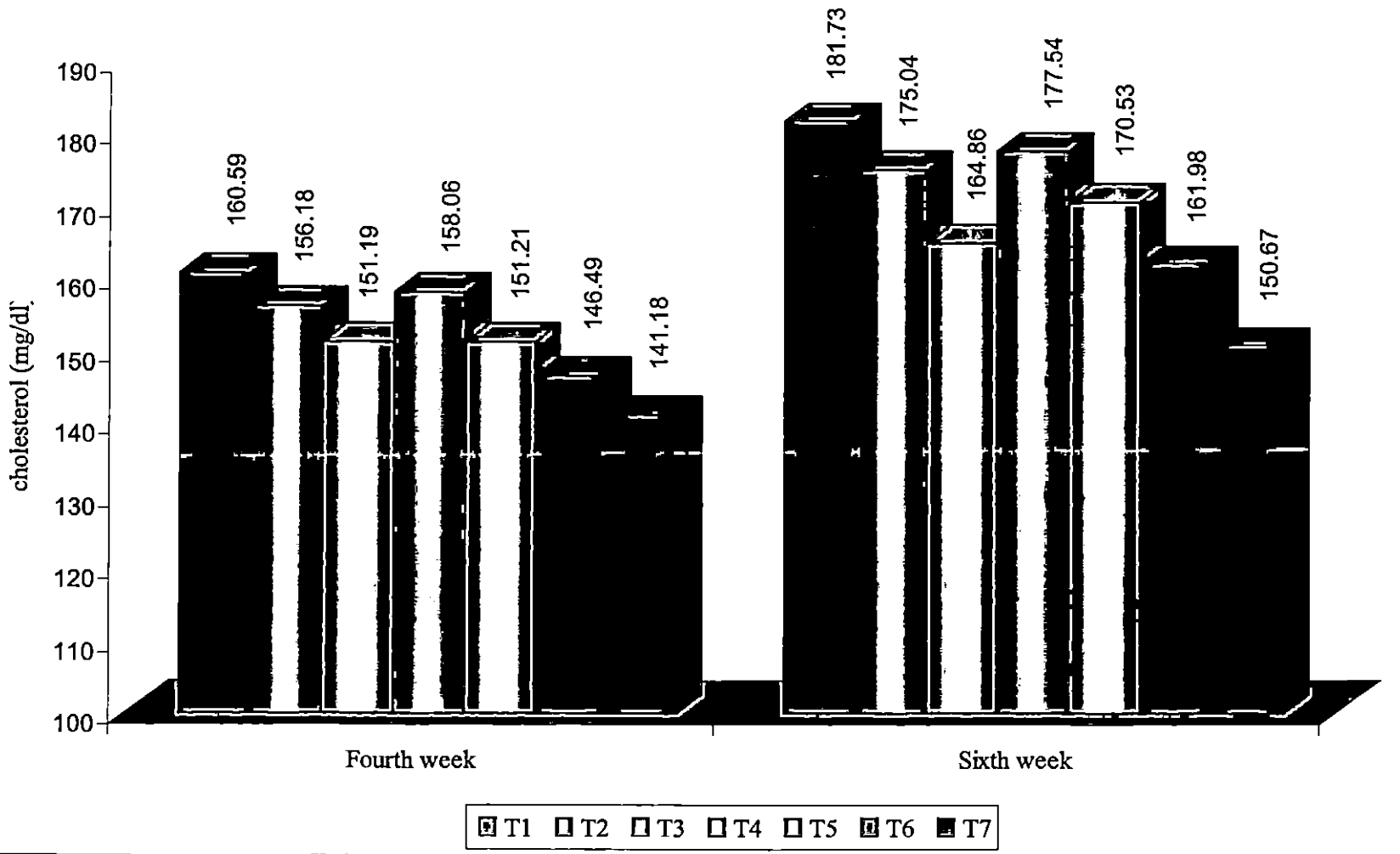
The mean serum total protein levels in broiler chickens estimated at the end of fourth and sixth week of age as influenced by different dietary treatments are presented in Table 12. The mean serum total protein levels at fourth week of age recorded for treatments T1, T2, T3, T4, T5, T6 and T7 were 4.37, 4.10, 4.23, 4.19, 4.13, 4.26 and 4.32 g per dl respectively. The corresponding values at sixth week of age were 5.20, 5.23, 5.12, 4.99, 5.12, 5.10 and 5.06 g per dl. Statistical analysis of the data on serum total protein both at fourth and sixth weeks of age did not reveal any significant difference between the treatments.

Table 12. Mean serum total cholesterol and protein of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Serum total cholesterol (mg per dl)		Serum total protein (mg per dl)	
	Fourth week	Sixth week	Fourth week	Sixth week
T1 GP=0.0% NSC=0.0%	$160.59^{a} \pm 0.87$	$181.73^{a} \pm 0.56$	4.37 ± 0.39	5.20 ± 0.44
T2 GP=0.5% NSC=0.0%	$156.18^{a} \pm 1.96$	$175.04^{a} \pm 3.01$	4.10 ± 0.17	5.23 ± 0.61
T3 GP=1.0% NSC=0.0%	$151.19^{c} \pm 1.56$	$164.86^{b} \pm 1.17$	4.23 ± 0.37	5.12 ± 0.37
T4 GP=0.0% NSC=1.0%	$158.06^{a} \pm 2.32$	$177.54^{a} \pm 1.37$	4.19 ± 0.36	4.99 ± 0.45
T5 GP=0.0% NSC=2.0%	$151.21^{c} \pm 1.20$	$170.53^{b} \pm 1.25$	4.13 ± 0.39	5.12 ± 0.46
T6 GP=0.5% NSC=1.0%	$146.49^{b} \pm 1.21$	$161.98^{b} \pm 1.77$	4.26 ± 0.60	5.10 ± 0.52
T7 GP=1.0% NSC=2.0%	$141.18^{d} \pm 0.87$	$150.67^{c} \pm 1.40$	4.32 ± 0.49	5.06 ± 0.43
Overall mean ± SE	152.13 ± 1.11	168.91 ± 1.78	4.23 ± 0.40	5.11 ± 0.45

Means bearing the different superscript within the same column differ significantly ($P \leq 0.05$)

Fig. 7 Mean serum total cholesterol of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets



4.10 BREAST MEAT TOTAL CHOLESTEROL

The mean breast meat total cholesterol estimated at fourth and sixth week of age are presented in Table 13 and graphically depicted in Fig. 8. The highest breast meat cholesterol was observed in the control group (T1) both at fourth and sixth week of age (49.09 and 54.07 mg per dl respectively), whereas the lowest values were noted with the group supplemented a combination of 1 per cent GP and 2 per cent NSC (T7) (40.14 and 42.04 mg per dl respectively). The breast meat cholesterol content of other treatments were in between the above values. Statistical analysis of data revealed significant ($P \leq 0.05$) differences among the treatments both at fourth and sixth week of age. The breast meat cholesterol content at fourth week of age was significantly ($P \leq 0.05$) higher in T1 and was different from all other groups. Similarly T7 showed significantly ($P \leq 0.05$) lower value. Statistically similar breast meat cholesterol was observed with T2, T4 and T5. Likewise, T3 and T6 also formed a homogenous group. The breast meat cholesterol level at sixth week of age was significantly ($P \leq 0.05$) higher in control group (T1) and lower in T7. The other treatments were intermediary. The maximum reduction of breast meat cholesterol was achieved in T7 followed by T6, T3, T5, T4, T2 and T1 in ascending order.

4.11 THIGH MEAT TOTAL CHOLESTEROL

The mean thigh meat total cholesterol estimated at the end of fourth and sixth week of age is presented in Table 13 and graphically depicted in Fig. 9. The trend of result in this trait was comparatively similar to that of breast meat cholesterol. In both the periods thigh meat cholesterol was numerically more in control birds and less in the group T7. The values with other treatments were intermediary. Statistical analysis of the data confirmed this trend. The thigh meat cholesterol was significantly ($P \leq 0.05$) more in the control birds and significantly ($P \leq 0.05$) less in birds supplemented with a combination of 1 per cent GP and 2 per

Table 13. Mean breast and thigh meat total cholesterol of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Breast meat total cholesterol (mg per dl)		Thigh meat total cholesterol (mg per dl)	
	Fourth week	Sixth week	Fourth week	Sixth week
T1 GP=0.0% NSC=0.0%	$49.09^{a} \pm 0.45$	$54.07^{a} \pm 0.37$	$109.09^{a} \pm 0.87$	$111.09^{a} \pm 0.95$
T2 GP=0.5% NSC=0.0%	$47.01^{b} \pm 0.53$	$50.36^{b} \pm 0.66$	$103.68^{bc} \pm 1.04$	$103.57^{b} \pm 1.36$
T3 GP=1.0% NSC=0.0%	$43.55^{c} \pm 0.60$	$45.42^{cd} \pm 0.96$	$97.08^{d} \pm 0.98$	$98.97^{d} \pm 0.31$
T4 GP=0.0% NSC=1.0%	$46.42^{b} \pm 0.55$	$47.21^{c} \pm 1.24$	$105.41^{b} \pm 0.53$	$106.69^{c} \pm 0.51$
T5 GP=0.0% NSC=2.0%	$45.71^{b} \pm 0.51$	$46.97^{c} \pm 0.84$	$102.81^{b} \pm 1.05$	$105.74^{bc} \pm 0.57$
T6 GP=0.5% NSC=1.0%	$43.27^{c} \pm 0.34$	$44.20^{de} \pm 0.47$	$97.71^{d} \pm 0.66$	$98.26^{d} \pm 0.37$
T7 GP=1.0% NSC=2.0%	$40.14^{d} \pm 0.35$	$42.04^{e} \pm 0.67$	$96.17^{d} \pm 0.40$	$97.64^{d} \pm 0.63$
Overall mean ± SE	45.03 ± 0.46	47.18 ± 0.64	101.17 ± 0.76	103.14 ± 0.77

Means bearing the different superscript within the same column differ significantly ($P \leq 0.05$)

Fig. 8 Mean breast meat total cholesterol of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimrntal diets

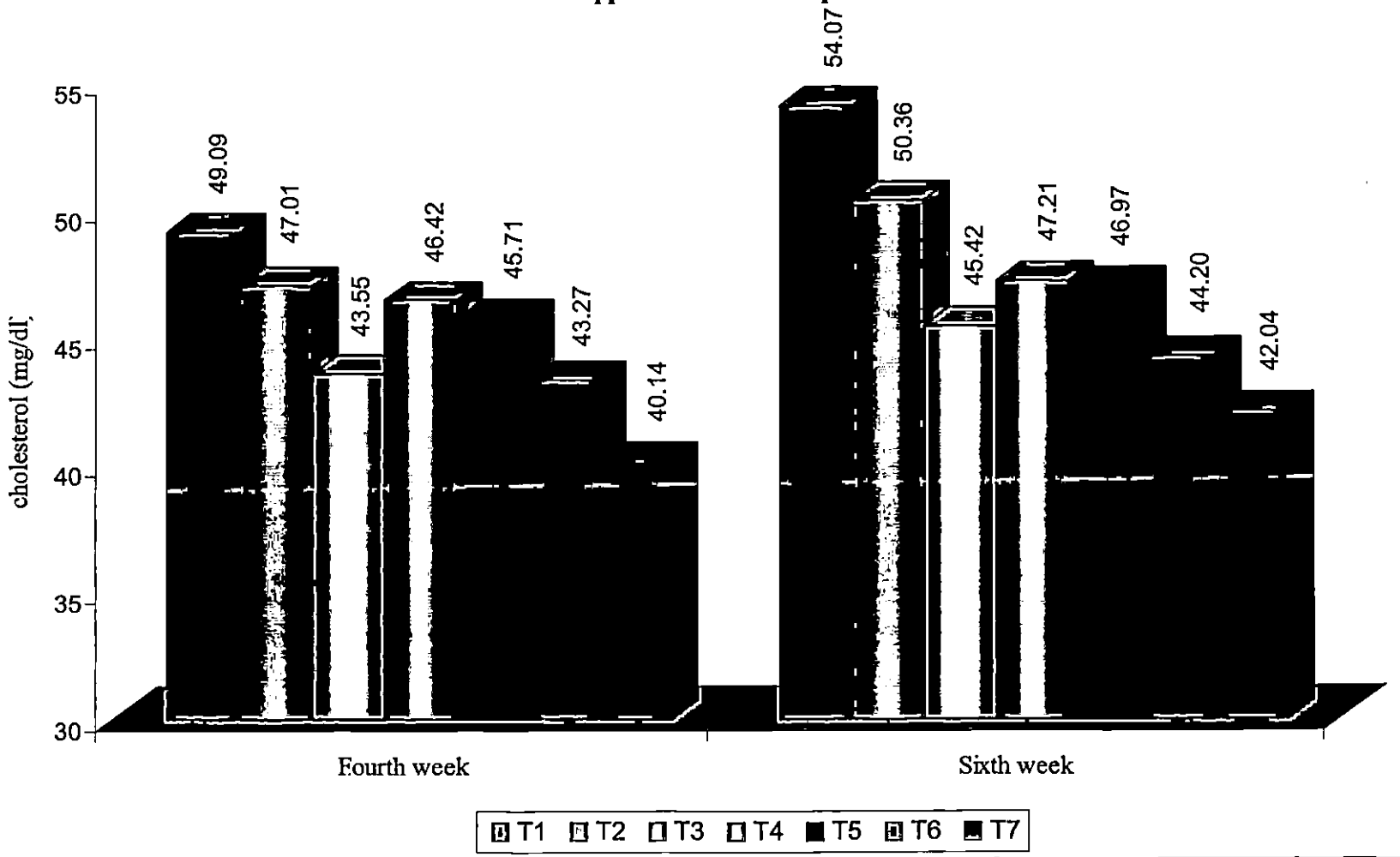
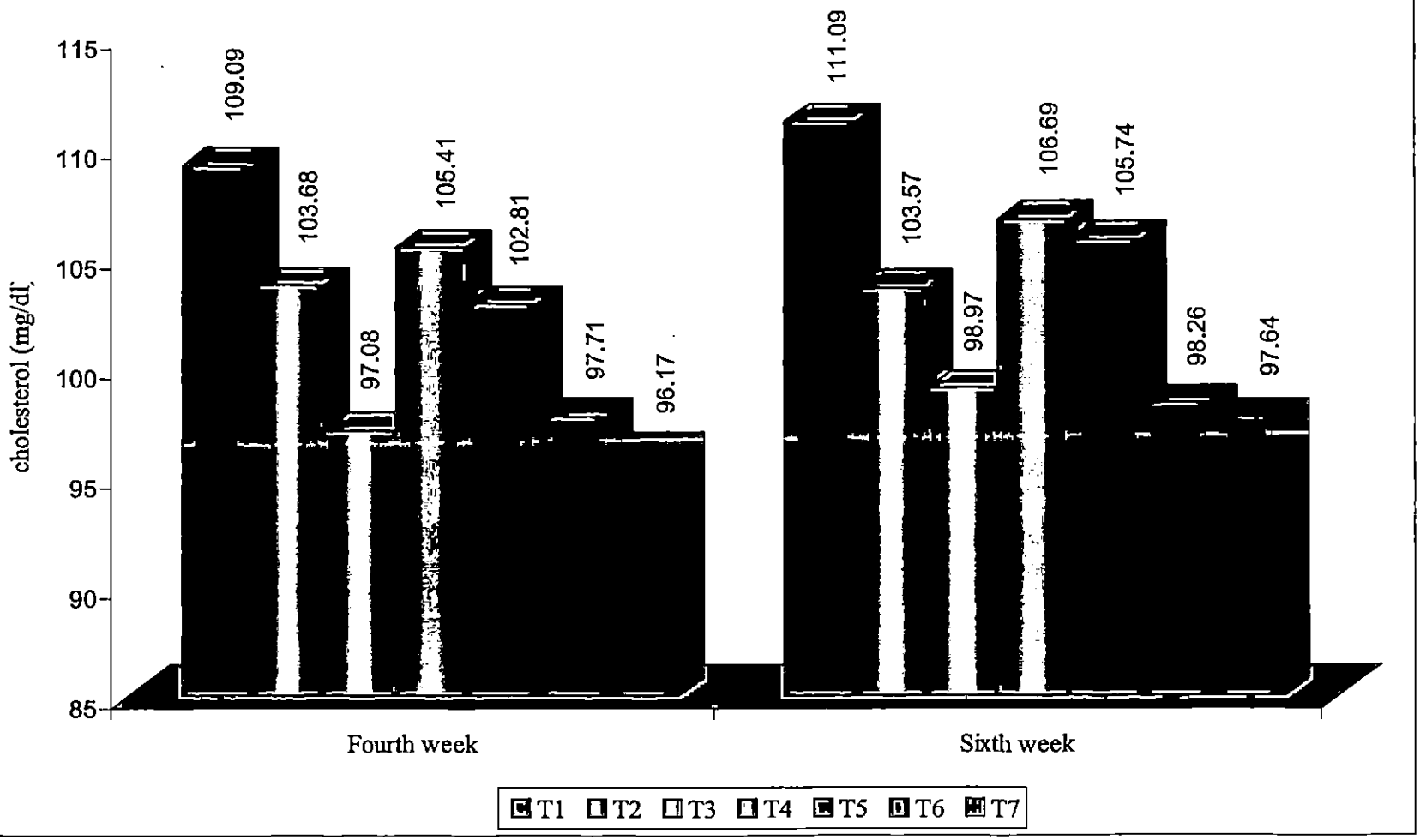


Fig. 9 Mean thigh meat total cholesterol of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets



cent NSC (T7). Supplementation of both GP and NSC either alone or in combination resulted in significant ($P \leq 0.05$) reduction of thigh meat cholesterol. The mean thigh meat cholesterol of all groups put together at the end of fourth and sixth week of age was 101.17 and 103.14 mg per dl respectively.

4.12 BREAST AND THIGH MEAT CRUDE PROTEIN

The mean per cent breast and thigh meat crude protein on fresh basis estimated at the end of fourth and sixth week of age is presented in Table 14. The breast meat crude protein at fourth week of age was 21.75, 21.18, 21.00, 20.90, 20.74, 21.54 and 20.87 per cent recorded for the treatments T1, T2, T3, T4, T5, T6 and T7 respectively with an overall mean of 21.19 per cent. The corresponding values at sixth week of age were 21.99, 21.89, 22.22, 22.09, 21.62, 22.26 and 21.49 per cent respectively with an overall mean of 21.94 per cent.

The overall mean per cent thigh meat crude protein, irrespective of dietary treatments was 18.34 and 19.01 at fourth and sixth week of age respectively. The statistical analysis of the data on breast and thigh meat crude protein at fourth and sixth week of age revealed that the magnitude of difference in mean values between the treatments was not significant.

4.13 LIVABILITY

There was no mortality in the treatment groups during the entire experimental period of six weeks and hence the livability was 100 per cent.

4.14 ECONOMICS

The costs of starter ration used in this study were 10.84, 11.05, 11.25, 10.87, 10.90, 11.15 and 11.31 rupees and that of finisher ration was 10.20, 10.72, 10.61, 10.23, 10.27, 10.44 and 10.68 rupees per kg feed for the treatments T1, T2, T3, T4, T5, T6 and T7 respectively. In order to calculate the cost of starter and

Table 14. Mean per cent breast and thigh meat crude protein (on fresh basis) of broiler chicken as influenced by garlic powder and neem seed cake supplementation in experimental diets

Treatment	Breast meat crude protein (%)		Thigh meat crude protein (%)	
	Fourth week	Sixth week	Fourth week	Sixth week
T1 GP=0.0% NSC=0.0%	21.75 ± 0.24	21.99 ± 0.47	18.38 ± 0.20	19.13 ± 0.19
T2 GP=0.5% NSC=0.0%	21.18 ± 0.24	21.89 ± 0.40	18.10 ± 0.21	19.04 ± 0.13
T3 GP=1.0% NSC=0.0%	21.00 ± 0.20	22.22 ± 0.38	18.39 ± 0.20	19.17 ± 0.13
T4 GP=0.0% NSC=1.0%	20.90 ± 0.19	22.09 ± 0.38	18.13 ± 0.18	19.11 ± 0.11
T5 GP=0.0% NSC=2.0%	20.74 ± 0.30	21.62 ± 0.34	18.37 ± 0.48	18.85 ± 0.19
T6 GP=0.5% NSC=1.0%	21.54 ± 0.54	22.26 ± 0.48	18.24 ± 0.25	19.02 ± 0.19
T7 GP=1.0% NSC=2.0%	20.87 ± 0.30	21.49 ± 0.37	18.31 ± 0.34	18.77 ± 0.30
Overall mean ± SE	21.19 ± 0.12	21.94 ± 0.15	18.34 ± 0.11	19.01 ± 0.20

finisher rations used in this experiment, the tender rate for feed ingredients in the University Poultry Farm at the time of the experiment was taken.

The economics of rearing broiler chicken by dietary inclusion of different levels of garlic powder, neem seed cake and their combinations were worked out and given in Table 15. The average cost of production and total return from a bird at sixth week of age was calculated to assess the cost benefit. The cost of production included cost of starter and finisher rations and miscellaneous cost. The miscellaneous expenditure includes vaccination, medication and litter cost. The birds are sold at the rate of Rs. 30 per kg live weight. Cost of poultry manure also accounted for the total return. The net profit per kg body weight at sixth week of age was Rs. 5.72, 3.48, 2.85, 4.08, 3.88, 4.15 and 0.85 for the treatments T1, T2, T3, T4, T5, T6 and T7 respectively. The net profit per kg body weight was more in the birds fed with the control diet. There was a reduction in net profit to a tune of 2.24, 2.87, 1.64, 1.84, 1.57 and 4.87 rupees per kg broiler chicken for the groups T2, T3, T4, T5, T6 and T7 respectively from that of control. Among the GP and NSC supplemented groups the net profit per kg body weight was more (Rs.4.15) in birds fed with a combination of 0.5 per cent GP and 1 per cent NSC (T6) followed by treatments T4, T5, T2, T3 and T7.

Table 15. Cost benefit analysis as influenced by garlic powder and neem seed cake supplementation in experimental diets

Particulars	Dietary treatments						
	T1	T2	T3	T4	T5	T6	T7
Live body weight, g	2113.33	1951.67	1942.04	1938.57	1857.29	2052.29	1806.67
Starter feed intake/bird, g	1691.50	1621.83	1696.00	1592.17	1479.00	1722.83	1579.17
Finisher feed intake/bird, g	1605.24	1607.02	1605.66	1596.15	1536.41	1650.07	1478.58
Starter feed cost/kg feed, Rs	10.84	11.05	11.25	10.87	10.90	11.15	11.31
Finisher feed cost/kg feed, Rs	10.20	10.72	10.61	10.23	10.27	10.44	10.68
Total starter feed cost, Rs.	18.34	17.92	19.08	17.31	16.12	19.21	20.26
Total finisher feed cost, Rs.	16.37	17.23	17.04	16.33	15.78	17.23	15.79
Total feed cost, Rs	34.71	35.15	36.12	33.64	31.90	36.44	36.05
Chick cost, Rs.	14.50	14.50	14.50	14.50	14.50	14.50	14.50
Miscellaneous cost, Rs.	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Total cost, Rs/bird	52.21	52.65	53.62	51.14	49.40	53.94	53.55
Return from bird sale, Rs	63.40	58.55	58.26	58.16	55.71	61.57	54.20
Return from manure sale, Rs	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Net profit per bird, Rs	12.08	6.79	5.53	7.91	7.20	8.52	1.54
Net profit/kg body weight, Rs.	**5.72**	**3.48**	**2.85**	**4.08**	**3.88**	**4.15**	**0.85**

Discussion

5. DISCUSSION

The results obtained in the study to find out the effect of dietary supplementation of garlic powder and neem seed cake on the performance and cholesterol content of meat and serum in broiler chicken are discussed in this chapter.

5.1 METEOROLOGICAL PARAMETERS

The data pertaining to microclimate inside the experimental house (Table 5) showed that the mean maximum temperature was lowest (33.00^{0}C) during the first week of the biological trial and highest during the last week. The difference in mean maximum temperature between the lowest and highest was only 3^{0}C. Similarly, the mean minimum temperature was lowest (22.14^{0}C) during the first week and highest (25.00^{0}C) during the last week of the trial. Unlike mean maximum temperature, which showed a gradual raise from first to sixth week of the experiment, the mean minimum temperature raised from first week to third week and then declined during the fourth week and again raised gradually and reached a temperature of 25.00^{0}C. Likewise, the mean per cent R.H. in the forenoon and afternoon were 67.82 and 45.90 respectively. All these indicates that climatograph of this locality fell within the hot and humid climate.

5.2 BODY WEIGHT

The data on mean body weight of broilers for different treatments recorded at weekly intervals are presented in Table 6. Statistical analysis of the data recorded significant ($P \leq 0.05$) difference between treatments through out the experimental period. Broilers fed with control ration (T1) and a combination of 0.5 per cent GP and 1 per cent NSC (T6) recorded significantly ($P \leq 0.05$) higher body weight from first week to sixth week of age. Whereas, significantly ($P \leq 0.05$) lower body weight was recorded in group fed with combination of 1 per cent GP and 2 per cent NSC

(T7). However, T7 was statistically similar to group fed with 2 per cent NSC (T5) except at second week. The result of fourth week body weight indicates that at high level inclusion of NSC (2 per cent) and GP (1 per cent) there was significant ($P \leq 0.05$) reduction in body weight when compared to control and T6. Contrary to this finding, Konjufca *et al.* (1997) and Sarica *et al.* (2005) reported that garlic supplementation did not cause any effect on body weight in broilers. Significant reduction in body weight of broiler chicken by feeding neem cake was reported by Lather *et al.* (2002), Virmani *et al.* (2005) and Uko and Kamalu (2006). The decreased body weight of birds fed with 1 and 2 per cent NSC may be due to anti feedant activity of triterpenoids present in the neem seed cake (Lather *et al.*, 2002). Toxic effects of neem seed cake at 2.5 per cent level was reported by Biswas *et al.* (2002).

At sixth week of age also the same trend in body weight as in fourth week was noticed. The broilers fed with control ration (T1) and group fed with combination of 0.5 per cent GP and 1 per cent NSC (T6) recorded significantly ($P \leq 0.05$) higher body weight than other treatments. Based on the results of the present study it can be concluded that inclusion of GP or NSC individually did not cause any positive effect on body weight but a combination of GP and NSC at lower level significantly ($P \leq 0.05$) improved body weight. However, literature regarding the combination of GP and NSC effect in chicken or any other species is scanty. Based on the present study a combination of 0.5 per cent GP and 1 per cent NSC can be included in the broiler ration without deleterious effect as far as body weight is concerned.

5.3 BODY WEIGHT GAIN

The data on mean body weight gain of broilers for different treatments recorded at weekly interval are presented in Table 7. Statistical analysis of the data revealed significant ($P \leq 0.05$) difference between treatments except during third and

fifth week of age. Broilers fed with control ration (T1) recorded significantly ($P \leq 0.05$) higher body weight gain during first, second, fourth and sixth week of age. During fourth week of age T6 recorded statistically similar body weight gain to that of control group. Treatment group fed with 1 per cent GP and 2 per cent NSC (T7) recorded significantly ($P \leq 0.05$) lower body weight gain during fourth week of age but it was statistically similar to T2, T3, T4 and T5. During sixth week of age significantly ($P \leq 0.05$) lower weight gain was recorded in T3, T4, T5, T6 and T7. The mean cumulative body weight gain recorded up to sixth week of age was significantly ($P \leq 0.05$) lower in T2, T3, T4, T5, T6 and T7. This agrees with the findings of Sharma *et al.* (2004). They reported that the supplementation of NSC in broiler ration resulted in significant reduction in weight gain. Contrary to the present findings, Gowda *et al.* (1998) reported that the incorporation of neem kernel meal did not affect body weight gain. Horton *et al.* (1991) reported that supplementation of dried garlic in broiler chicken did not influence body weight gain. But in the present study, supplementation of GP or NSC as such or their combinations decreased body weight gain of broilers at sixth week of age.

The overall body weight gain recorded during first to sixth week of age revealed increased body weight gain during fourth, fifth and sixth week of age which follows normal trend in body weight gain of broiler chicken.

5.4 FEED INTAKE

Data on mean weekly feed intake (g) of broilers and cumulative feed intake up to fourth week and sixth week of age for different dietary treatments is presented in Table 8. Statistical analysis of data revealed that feed intake at fourth week of age was not affected by either garlic powder or neem seed cake supplementation. But at sixth week of age even though broilers fed with control diet (T1) recorded significantly ($P \leq 0.05$) higher feed consumption, it was statistically comparable to T2, T3, T4 and T6. The results of the present study indicate that garlic

supplementation and supplementation of neem seed cake at 1 per cent level did not affect feed consumption. Horton *et al.* (1991) reported that feeding dried garlic in broiler ration did not improve feed intake. Sarica *et al.* (2005) also reported that one per cent garlic supplementation did not reveal significant difference in feed intake. Girish Kumar (1997) also reported that one per cent garlic supplementation did not have significant difference in feed intake in quails during fourth week of age, while at fifth and sixth week of age feed intake was found to be improved.

During the sixth week of age groups fed with 2 per cent NSC (T5) alone or in combination with 1 per cent GP (T7) recorded lower feed consumption indicating NSC at 2 per cent level reduce feed consumption of broilers. Gowda *et al.* (1998) reported significant reduction in feed intake in White Leghorn layers when neem kernel meal was included in the ration. Uko and Kamalu (2006) also reported decreased feed intake in cockerel chicks when neem seed kernel was included in the ration. The lower feed consumption at higher level of inclusion of neem seed cake may be due to presence of triterpenoids, an antinutritional factor in neem seed or low palatability of NSC.

Contrary to the present findings, Elangovan *et al.* (1996) reported that inclusion of neem seed kernel meal in layer mash did not affect feed consumption. Nagalakshmi *et al.* (1998) also reported non significant effect in feed consumption when broiler chicken fed with 2.0 per cent alkali treated and 2.5 per cent urea treated neem cake.

Cumulative feed intake from zero to four weeks of age showed significant ($P \leq 0.05$) difference between treatments. Broilers fed with 2 per cent NSC recorded significantly ($P \leq 0.05$) lower feed consumption of 1479 g but it was statistically comparable to T4 and T7. Results of the present study revealed that inclusion of neem seed cake in broiler ration reduces feed consumption up to four weeks of age. This agrees with the findings of Sharma *et al.* (2004) and Uko and Kamalu (2006). Non significant difference in feed consumption due to inclusion of garlic powder

was reported by Horton *et al.* (1991) and Sarica *et al.* (2005). Non significant difference in feed consumption due to inclusion of NSC was reported by Elangovan *et al.* (1996) and Nagalakshmi *et al.* (1998). However literatures regarding the study on the combination of GP and NSC are scanty.

Data on cumulative feed consumption from zero to six weeks of age did not reveal any significant ($P \leq 0.05$) differences between treatments. But numerically lower feed consumption was recorded in T5 and T7 where neem seed cake was included at 2 per cent level. Lower feed consumption of NSC included group may be due to low palatability of NSC.

5.5 FEED EFFICIENCY

Feed efficiency calculated weekly wise and cumulative feed efficiency at fourth and sixth week of age (Table 9) revealed significant ($P \leq 0.05$) differences among treatments during first and second week only. Non significant difference in feed efficiency was recorded during third, fourth, fifth and sixth week of age. However, cumulative feed efficiency recorded at fourth and sixth week of age revealed significant ($P \leq 0.05$) differences between treatments. Significantly ($P \leq 0.05$) better cumulative feed efficiency up to four weeks of age was recorded in treatments T1, T2, T3, T4, T5 and T6. Broilers fed with a combination of 1 per cent GP and 2 per cent NSC (T7) recorded lower feed efficiency but statistically comparable to T3. The lower feed efficiency recorded in T7 up to four weeks of age may be due to significantly ($P \leq 0.05$) lower body weight and feed consumption recorded for this treatment group. Horton *et al.*, 1991; Konjufca *et al.*, 1997 and Sarica *et al.*, 2005 reported non-significant difference in feed efficiency by garlic supplementation. In contrast to the present findings, Gaikwad (2005) reported lowest feed efficiency at 0.5 per cent GP supplementation and highest at 1.5 per cent supplementation in broiler chicken at the end of five weeks of age. The findings of the present study revealed that supplementation of GP at 0.5 and 1 per

cent level in the diet of broiler chicken did not improve the feed efficiency indicating that the supplementation of garlic in the broiler diet did not affect the digestion and absorption of nutrients.

Cumulative feed efficiency recorded up to six weeks of age also revealed significant ($P \leq 0.05$) differences between treatments. Broilers fed with control diet (T1) recorded significantly ($P \leq 0.05$) better feed efficiency and it was statistically comparable to T2, T3, T4, T5 and T6. Group fed with a combination of 1 per cent GP and 2 per cent NSC (T7) recorded lower feed efficiency but was comparable to T2, T3, T4, T5 and T6. This finding agrees with the findings of Reddy *et al.* (1988) and Virmani *et al.* (2005). Lower feed efficiency of T7 may be due to significantly ($P \leq 0.05$) lower body weight and feed consumption recorded in this group throughout the experimental period. On the contrary, improvement in feed efficiency due to inclusion of NSC was reported by Nemade and Kukde (1993) and Uko and Kamalu (2006).

5.6 PROCESSING YIELDS AND LOSSES

The data on processing yields and losses recorded at the end of six weeks of age are presented in Table 10. The statistical analysis of data revealed that per cent dressed yield, eviscerated yield, ready-to-cook yield, blood loss, feather loss and total loss were not influenced by dietary treatments. But per cent giblet yield was affected by dietary supplementation of GP and NSC. The birds supplemented with 0.5 per cent GP and 1 per cent NSC (T6) had low per cent giblet yield. The per cent giblet yield recorded with this treatment was significantly ($P \leq 0.05$) lower, but comparable to T2. Gaikwad (2005) reported that different levels of garlic supplementation in broiler chicken had significant effect on liver weight percentage while gizzard and heart weight were statistically non significant. Since, the other garlic levels had no significant effect on giblet weight, no definite conclusion can

be drawn for the lower giblet weight observed with 0.5 per cent GP and 1 per cent NSC.

In the present study, per cent ready-to-cook yield, blood loss and total loss in control birds are well within the normal range as reported by Rejikumar and Narayanankutty (1992). In contrast to the findings of this study, Gaikwad (2005) reported that edible carcass yield percentage was higher in broiler chickens received 1 per cent GP followed by 2.0, 3.0, 2.5, 0.5 and 1.5 per cent of GP received groups at the end of fifth week of age. In case of neem supplementation the reports of earlier workers are not in conformity with present findings. Nemade and Kukde (1993) reported that administration of 0.25 per cent neem leaf extract in broiler chicken from second to sixth week of age significantly increased dressed weight and edible meat weight while giblet weight was non-significant. Uko and Kamalu (2006) reported decreased eviscerated carcass weight and increased carcass yield in cockerel chicks fed with 75, 150 and 225 g of unextracted neem seed kernel per kg diet for a period of 35 days from day old age, which might be due to higher inclusion level of neem seed kernel in the diet as compared to present study. However, the literature citation about the effect of combination of GP and NSC on processing yields and losses are scanty.

5.7 WEIGHT OF BURSA OF FABRICIOUS AND SPLEEN

The average weight of bursa of fabricious and spleen of birds at six weeks of age as influenced by different levels of GP and NSC and their combinations are presented in Table 11. The birds supplemented with combination of 0.5 per cent GP and 1 per cent NSC (T6) and 1per cent GP and 2 per cent NSC (T7) had significantly ($P \leq 0.05$) higher bursa of fabricious weight than that of control birds. Eventhough, weight of bursa of fabricious of T2, T3, T4 and T5 were statistically similar to that of control birds (T1), it was numerically higher. The weight of spleen of birds supplemented with different levels of GP and NSC individually and

their combinations was significantly ($P \leq 0.05$) more than the control birds. However, the literature citation regarding the influence of GP and NSC and their combinations on bursa of fabricious and spleen weight are scanty. The present study indicated that supplementation of GP and NSC and their combinations might increased the immunity in birds and thereby health status of birds.

5.8 SERUM TOTAL CHOLESTEROL

The mean values for serum cholesterol as influenced by the dietary supplementation of GP and NSC and their combination are presented in Table 12. The supplementation of GP and NSC significantly ($P \leq 0.05$) reduced serum total cholesterol both at fourth and sixth week of age. Eventhough, serum cholesterol (mg per dl) of birds fed 0.5 per cent GP (T2) did not reveal significant difference with control birds (T1) it was numerically lower by 2.75 and 3.68 per cent during fourth and sixth week of age respectively. Supplementation of garlic at 1 per cent level (T3) significantly ($P \leq 0.05$) reduced serum cholesterol by 5.85 and 10.93 per cent respectively at fourth and sixth week of age. This finding is in agreement with results of Premkumar *et al.* (2002) who reported that the supplementation of 0.5 per cent GP did not reduce serum cholesterol, but supplementation of 1 per cent level significantly decreased the same by 12.8 and 15.3 per cent at fifth and sixth week of age respectively in broiler chicken. Horton *et al.* (1991) reported that the feeding of dried garlic powder at 10 g per kg feed for a period of 35 days to male broiler chickens resulted in a significant reduction in serum cholesterol. Asaf *et al.* (1983) opined that different concentrations of polar fractions of garlic added to corn-soybean based diet of 12 weeks old layer for 24 days significantly decreased the serum total cholesterol by 20 to 25 per cent. A similar trend of reduction in serum cholesterol by supplementation of garlic was observed in rats (Lata *et al.*, 1991; Merat *et al.*, 1996; Ahmed and Sharma, 1997; Yeh and Liu, 1998; Effraim *et al.*, 2000 and Matsuura, 2001). The principle behind the pharmacological action of

garlic is that the sulphur containing compounds can remove thiol group and also oxidize NADPH, which is necessary for cholesterol synthesis. The active ingredients of garlic bring about oxidation of NADPH, then inhibit the cholesterol synthesis (Augusti, 1990). The water-soluble organosulphur compounds present in garlic especially S- allylcysteine, S- ethylcysteine and S- propylcysteine are potent inhibitors of cholesterol synthesis, which was confirmed by Yeh and Liu (1998).

Eventhough, there was numerical reduction in serum cholesterol level at fourth and sixth week of age by the supplementation of 1 per cent NSC as compared to control birds, it was non significant. The birds fed with 2 per cent NSC had significantly ($P \leq 0.05$) lower cholesterol level at fourth and sixth week of age when compared to birds fed with control diet. Supplementation of 1 per cent NSC non-significantly reduced the serum cholesterol by 1.58 and 2.31 per cent, respectively whereas, supplementation at 2 per cent level significantly ($P \leq 0.05$) reduced the same by 5.84 and 6.16 per cent at fourth and sixth week of age respectively. Reduction of cholesterol by feeding higher level of neem kernel powder was reported by Bopanna *et al.* (1997) and Uko and Kamalu (2006). The present finding is in conformity with that of their findings. Non significant decline in serum cholesterol by neem seed cake supplementation was reported by Virmani *et al.* (2005). The hypocholesterolemic effect of neem observed in this study might be due to down regulation of NADPH which act as cofactor in cholesterol metabolism. Another possible mechanism of action is that neem might have decreased synthesis or increased excretion of cholesterol through intestinal tract (Sathyan, 2004).

Supplementation of combination of 0.5 per cent GP and 1 per cent NSC in broiler diet significantly ($P \leq 0.05$) reduced the serum cholesterol by 8.78 and 10.87 per cent respectively, whereas the supplementation of 1 per cent GP and 2 per cent NSC combination significantly ($P \leq 0.05$) reduced the same by 12.09 and 17.09 per cent at fourth and sixth week of age respectively. However no literature evidences

are available regarding the supplementation of GP and NSC combination. In the present study, it was found that as level of GP and NSC combination increased, the serum cholesterol level decreased. This might be due to the synergistic effect of garlic and neem in broiler diet, which resulted in reduction of serum cholesterol.

5.9 SERUM TOTAL PROTEIN

The mean serum total protein estimated at the end of fourth and sixth week of age is presented in Table 12. Statistical analysis of the data on serum protein revealed that supplementation of GP and NSC and their combinations did not differ significantly. The mean serum protein values recorded in the control birds were 4.37 and 5.20 g per dl at the end of fourth and sixth week of age respectively which are well within the normal range as reported by Sturkey (1976). The literature citation about the influence of GP and NSC and their combinations on serum protein in avian species are scanty. However, Annongu *et al.* (2003) reported that inclusion of 20 and 30 per cent raw neem seed kernel meal in the diet of swine significantly lowered the serum total protein, which might be due to high level inclusion of neem seed kernel meal. The present study indicated that supplementation of GP and NSC and their combinations in broiler chicken did not influence serum total protein.

5.10 BREAST MEAT TOTAL CHOLESTEROL

The mean breast meat total cholesterol in broilers maintained on different dietary treatments is presented in Table 13. The supplementation of 0.5 per cent GP significantly ($P \leq 0.05$) reduced the breast meat cholesterol by 4.24 and 5.94 per cent respectively, while the supplementation of GP at 1 per cent level reduced the total cholesterol by 11.29 and 15.99 per cent at fourth and sixth week of age respectively. This is in agreement with the findings of Premkumar *et al.* (2002) who reported that supplementation of 0.5 per cent GP in broiler diet decreased the

breast meat cholesterol by 4.9, 8.8 and 3.3 per cent while 1 per cent GP supplementation reduced the same by 11.9, 15.1 and 11.0 per cent at fifth, sixth and seventh week of age respectively. Similarly, Konjufca *et al.* (1997) found that supplementation of garlic at 1.5, 3.0 or 4.5 per cent to male broiler chicken for a period of 21 days resulted in reduction in breast meat cholesterol by about 15 per cent. Whereas, Girish Kumar (1997) reported non significant decrease in muscle cholesterol in Japanese Quails. In the present study, reduction of cholesterol in breast meat was higher during sixth week of age in 0.5 per cent as well as 1 per cent GP supplementation in broiler diet. The reduction in breast meat cholesterol might be attributed to the reduced cholesterol biosynthesis mediated through the changes in the enzyme (HMG-CoA reductase) responsible for regulating cholesterol metabolism (Konjufca *et al.*, 1997).

The supplementation of 1 per cent NSC in broiler diet significantly ($P \leq 0.05$) reduced the breast meat cholesterol level by 5.44 and 12.69 per cent respectively, whereas the supplementation at 2 per cent NSC reduced the cholesterol level by 6.89 and 13.13 at fourth and sixth week of age respectively. However, the literature citation regarding the influence of NSC on breast meat cholesterol is scanty. Biswas *et al.* (2002) reported that neem contains organosulphur compounds. Reduction in cholesterol level observed in this trial might be due to the presence of organosulphur compounds, which inhibits the endogenous synthesis of cholesterol by decreasing the activity of cholesterol regulating (HMG-CoA reductase) enzyme or might be due to the down regulation of NADPH which is acting as a cofactor for the cholesterol metabolism (Sathyan, 2004).

The supplementation of combination of 0.5 per cent GP and 1 per cent NSC in broiler diet significantly ($P \leq 0.05$) reduced the breast meat cholesterol by 11.86 and 18.25 per cent, while the supplementation of 1 per cent GP and 2 per cent NSC combination caused the greater response and reduced the cholesterol level by 18.23 and 18.55 per cent at fourth and sixth week of age respectively. However, the

literature citation about the combination of GP and NSC is scanty. The present study indicated that the supplementation of higher level combination of GP and NSC reduced the breast meat cholesterol more significantly ($P \leq 0.05$) than the lower level combination of the same. Reduction in cholesterol level might be due to synergistic effect of GP and NSC.

5.11 THIGH MEAT TOTAL CHOLESTEROL

The mean values for thigh meat cholesterol level in birds maintained on different dietary treatments are presented in Table 13. Supplementation of 0.5 per cent GP reduced the thigh meat cholesterol by 4.96 and 6.77 per cent during fourth and sixth week of age respectively. The supplementation of 1 per cent GP reduced the thigh meat cholesterol by 11.01 and 10.91 per cent during fourth and sixth week of age respectively. This is in agreement with the reports of Premkumar *et al.* (2002) who found that 0.5 per cent GP supplementation reduced the thigh meat cholesterol by 4.6, 4.8 and 2.3 per cent in broilers at fifth, sixth and seventh week of age respectively, whereas the supplementation of 1 per cent GP reduced the same by 9.3, 7.9 and 9.4 per cent in broilers at fifth, sixth and seventh week of age respectively. Konjufca *et al.* (1997) observed that supplementation of garlic powder to male broilers significantly reduced the thigh muscle cholesterol by 23.0 per cent. The level of reduction in this study was higher than present result, which may be due to higher level inclusion of the garlic powder (1.5 per cent). In the present study the more pronounced reduction in thigh meat cholesterol was observed at 1 per cent garlic powder than that of 0.5 per cent supplementation.

The supplementation of NSC at 1 per cent level in broiler diet reduced the thigh meat cholesterol by 3.37 and 3.96 per cent respectively, while at 2 per cent level of inclusion the reduction was by 5.76 and 4.81 per cent at fourth and sixth week of age respectively. However, the literature citation regarding the effect of neem on thigh meat cholesterol is scanty.

Dietary supplementation of combination of 0.5 per cent GP and 1 per cent NSC significantly ($P \leq 0.05$) reduced the thigh meat cholesterol by 10.43 and 11.55 per cent at the end of fourth and sixth week of age respectively, while the greatest reduction was occurred by supplementation of combination of 1 per cent GP and 2 per cent NSC. Supplementation of combination of 1 per cent GP and 2 per cent NSC reduced the thigh meat cholesterol by 11.84 and 12.11 per cent at the end of fourth and sixth week of age respectively.

Generally, the cholesterol concentration is much higher in the thigh meat than that of breast meat. A possible explanation is that cholesterol is usually associated with adipose tissue, which is more abundant in thigh than in breast muscle. Also, thigh muscles have a much greater content of slow-twitch fibers than the breast muscles. Slow-twitch fibers have more mitochondria, their mitochondria are bigger and the metabolic rate much faster in comparison to fast-twitch fibers. Slow-twitch sarcoplasmic reticulums are found to contain two to three times as much cholesterol as fast-twitch sarcoplasmic reticulums (Bloch, 1991).

5.12 BREAST AND THIGH MEAT CRUDE PROTEIN

The mean per cent breast and thigh meat protein on fresh basis estimated at fourth and sixth week of age in birds maintained on different dietary treatments are presented in Table 14. Statistical analysis of the data on mean per cent breast and thigh meat crude protein did not reveal any significant difference between treatments. The per cent breast meat protein values in birds fed with control diet are well within the normal range as reported by Simeonovova, 1999 and Suchy *et al.* (2002). The literature citation regarding the effect of GP and NSC and their combination on breast meat protein is scanty. In the present study it was found that per cent breast meat protein vary with age which is in agreement with that of Suchy *et al.* (2002).

The per cent thigh meat protein recorded in birds fed with control diet was well within the normal range as reported by Keshri *et al.* (1989). In the present study it was found that thigh meat protein varied with age, which is in agreement with the findings of Suchy *et al.* (2002). However the literature citation about the effect of garlic and neem on thigh meat protein is not available.

The protein percentage in breast muscle was higher than the thigh muscle, which might be due to the higher moisture content in breast muscle as compared to thigh muscle, which is in agreement with the findings of Keshri *et al.* (1989); Simeonovova (1999) and Suchy *et al.* (2002). The results of the study indicated that supplementation of GP and NSC alone or their combinations did not alter the protein content in breast and thigh meat.

5.13 LIVABILITY

There was no mortality recorded during the entire experimental period. The overall livability in GP and NSC supplemented treatments and their combinations was 100 per cent. These results are in agreement with Shi *et al.* (1999), Soliman *et al.* (1999) and Gaikwad (2005) who have reported that supplementation of GP in broiler diet did not cause deleterious effect on livability. Chakravarthy and Prasad (1991) and Sridhar *et al.* (2003) reported that administration of neem leaf extract and neem cake extract to broiler chicken did not cause deleterious effect on livability. Similarly, Uko and Kamalu (2006) reported no deleteterious effect on livability by supplementation of unextracted neem seed kernel and raw neem seed kernel in male chicks. Inclusion levels of GP and NSC alone or their combinations in the present study were well tolerated by birds.

5.14 ECONOMICS

The economics of rearing broiler chickens by supplementation of different levels GP and NSC and their combinations are worked out and given in Table 15.

The net profit per kg body weight at the end of six weeks of age was Rs. 5.72, 3.48, 2.85, 4.08, 3.88, 4.15 and 0.85 for the treatments T1, T2, T3, T4, T5, T6 and T7 respectively. The net profit per kg body weight was more with the control group. Low cost of starter and finisher rations and significantly ($P \leq 0.05$) higher body weight at the end of six weeks of age for this group have contributed for this. Less net profit per kg body weight calculated for the treatments T2 (0.5 per cent GP) and T3 (1 per cent GP) could be due to high cost of the garlic powder (Rs. 48 per kg), which increased the cost of starter and finisher rations. The net profit per kg body weight for the birds supplemented with NSC was more as compared to birds supplemented with GP which could be due to low cost of neem seed cake (Rs. 10 per kg).

In comparison with the higher level combination of GP and NSC net profit per kg live weight was more (Rs. 4.15) for the lower level combination of GP and NSC. This could be attributed to higher body weight of birds supplemented with lower level combination, i.e. 0.5 per cent GP and 1 per cent NSC which gives more return over per bird.

In terms of the cost benefit analysis the birds supplemented with a combination of 0.5 per cent GP and 1 per cent NSC was more economical than the birds fed with 0.5 and 1 per cent levels of GP, 1 and 2 per cent levels of NSC and a combination of 1 per cent GP and 2 per cent NSC. But when compared to control birds, the groups supplemented with different levels of GP and NSC and their combinations, the economic benefit was low. Gaikwad (2005) reported that birds supplemented with 1 per cent GP gained higher profit per kg live weight and GP beyond 1.5 per cent had no additional benefit in terms of profit realized. However, the merit of low cholesterol meat by feeding garlic powder and neem seed cake is much worthy when compared to its low profit margin from that of control birds. Further, the low cholesterol meat will fetch higher price if it is marketed as a branded item.

Summary

6. SUMMARY

An experiment was conducted at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to study the effect of dietary supplementation of garlic (*Allium sativum*) powder and neem (*Azadirachta indica*) seed cake on the performance and cholesterol content of meat and serum in broiler chicken. The study was conducted for a period of six weeks with two hundred and ten day-old straight run commercial broiler chicks. The chicks were wing banded, weighed individually and randomly divided into seven dietary treatment groups viz., T1, T2, T3, T4, T5, T6 and T7 with three replicates of ten chicks each. The T1 was control and the ration for which was formulated as per the BIS specifications (1992). The garlic powder and neem seed cake were supplemented in the basal diet to form T2 to T7. The experiment was carried out with two levels of GP supplementation, 0.5 per cent (T2) and 1.0 per cent (T3), two levels of NSC supplementation, 1.0 per cent (T4) and 2.0 per cent (T5) and two levels of GP and NSC combination, 0.5 per cent GP and 1.0 per cent NSC (T6) and 1.0 per cent GP and 2.0 per cent NSC (T7). The rations were made isocaloric and isonitrogenous. Standard managemental practices were followed throughout the experimental period. Feed and water were provided *ad libitum*. The birds were provided with broiler starter ration from zero to four weeks and broiler finisher ration from five to six weeks of age.

Performance parameters such as body weight, weight gain, feed intake and feed efficiency were evaluated. The processing yields and losses were studied at the end of sixth week of age. The weight of bursa of fabricious and spleen was recorded at the end of sixth week of age. The serum total cholesterol, serum total protein, breast and thigh meat total cholesterol and breast and thigh meat crude protein were determined at the end of fourth and sixth week of age. Livability and cost benefit analysis were also ascertained.

Based on the results obtained during the course of the study, the following conclusions were made.

1) The final body weight of broilers was significantly ($P \leq 0.05$) more with control birds (T1) as well as the group supplemented with a combination of 0.5 per cent GP and 1 per cent NSC (T6). Dietary supplementation of GP at 0.5 and 1.0 per cent, NSC at 1.0 and 2.0 per cent and a combination of 1.0 per cent GP and 2 .0 per cent NSC significantly ($P \leq 0.05$) depressed the final body weight of broilers.

2) The cumulative body weight gain of broilers up to sixth week of age was 2069.19, 1939.39, 1937.85, 1904.83, 1813.19, 2007.57, 1776.68 g for treatments T1, T2, T3, T4, T5, T6 and T7, respectively. The cumulative body weight gain for the control birds (T1) was significantly ($P \leq 0.05$) more. Dietary supplementation of GP or NSC alone or their combination significantly ($P \leq 0.05$) decreased the weight gain in broilers.

3) The mean cumulative feed intake of birds up to sixth week of age was 3295.08, 3229.18, 3301.66, 3208.32, 3015.41, 3371.57 and 3057.74 g for treatments T1, T2, T3, T4, T5, T6 and T7 respectively. The cumulative feed intake from zero to six weeks of age did not reveal any significant difference between treatments. But numerically lower feed consumption was recorded in T5 and T7 where neem seed cake was included at 2 per cent level.

4) The mean cumulative feed efficiency of birds up to six weeks of age recorded for the treatments T1, T2, T3, T4, T5, T6 and T7 were 1.58, 1.61, 1.67, 1.65, 1.64, 1.64 and 1.71 respectively. Birds fed with the control diet (T1) had statistically superior feed efficiency and was comparable with T2, T3, T4, T5

and T6, while the group fed with a combination of 1.0 per cent GP and 2.0 per cent NSC (T7) recorded significantly ($P \leq 0.05$) inferior feed efficiency.

5) Dietary supplementation of garlic powder, neem seed cake and their combination did not influence the per cent dressed yield, eviscerated yield, ready-to-cook yield, blood loss, feather loss and total loss. On the other hand, supplementation of combination of 0.5 per cent GP and 1.0 per cent NSC (T6) caused a significant ($P \leq 0.05$) reduction in per cent giblet yield.

6) Dietary supplementation of GP, NSC and their combination increased the weight of bursa of fabricious and spleen.

7) The supplementation of GP at 1.0 per cent (T3), NSC at 2.0 per cent (T5) and a combination of 0.5 per cent GP and 1.0 per cent NSC (T6) and 1.0 per cent GP and 2.0 per cent NSC (T7) resulted in a significant ($P \leq 0.05$) reduction in serum cholesterol level. The extent of reduction was 10.87 and 17.09 per cent for the treatments T6 and T7, respectively.

8) The supplementation of GP and NSC alone and their combination significantly ($P \leq 0.05$) reduced the breast meat total cholesterol in broilers. A combination of 1.0 per cent GP and 2.0 per cent NSC reduced the breast meat cholesterol by 18.55 per cent.

9) The supplementation of GP and NSC alone and their combination significantly ($P \leq 0.05$) reduced the thigh meat total cholesterol in broilers.

10) Supplementation of GP, NSC and their combination did not influence the serum total protein and breast and thigh meat crude protein content.

11) The dietary supplementation of GP, NSC and their combination at the levels employed in this study had no deleterious effect on livability.

12) The profit margin was less by supplementation of GP, NSC and their combination in broiler diet.

The summary of results obtained in this study are presented in Table 16.

It could be concluded that the inclusion of garlic powder and neem seed cake in broiler feed was acceptable in reducing the meat cholesterol. The merit of low cholesterol meat by feeding garlic powder and neem seed cake is worthy eventhough margin of profit is low in these groups. Moreover, the low cholesterol meat will fetch higher price if marketed as branded item.

Table 16. Summary of results of the study to assess the influence of garlic powder and neem seed cake on the performance and cholesterol content of meat and serum of broiler chicken

Parameter	Period in weeks	T1 GP= 0.0% NSC= 0.0%	T2 GP= 0.5% NSC= 0.0%	T3 GP=1.0% NSC= 0.0%	T4 GP= 0.0% NSC= 1.0%	T5 GP= 0.0% NSC= 2.0%	T6 GP= 0.5% NSC=1.0%	T7 GP=1.0% NSC= 2.0%
Body weight (g)	4	1202.00^{d}	1109.00^{bc}	1148.33^{c}	1113.40^{bc}	1066.00^{ab}	1202.00^{d}	1030.83^{a}
	6	2113.33^{d}	1951.67^{c}	1742.00^{a}	1938.58^{c}	1857.08^{bc}	2052.29^{d}	1806.67^{ab}
Cumulative body weight gain (g)	0-4	1157.86^{a}	1065.06^{c}	1100.81^{b}	1069.26^{c}	1025.23^{d}	1157.24^{a}	986.35^{e}
	0-6	2069.19^{a}	1939.39^{b}	1937.85^{b}	1904.83^{c}	1813.19^{d}	2007.57^{b}	1776.68^{d}
Cumulative feed intake (g)	0-4	1691.50^{a}	1621.83^{a}	1696.00^{a}	1592.17^{ab}	1479.00^{b}	1722.83^{a}	1579.17^{ab}
	0-6	3295.08	3229.18	3301.66	3208.32	3015.41	3371.57	3057.74
Cumulative feed efficiency (kg feed/kg wt gain)	0-4	1.48^{a}	1.50^{a}	1.55^{ab}	1.50^{a}	1.48^{a}	1.49^{a}	1.62^{b}
	0-6	1.58^{a}	1.61^{ab}	1.67^{ab}	1.65^{ab}	1.64^{ab}	1.64^{ab}	1.71^{b}
Serum total cholesterol (mg/dl)	4	160.59^{a}	156.18^{a}	151.19^{c}	158.06^{a}	151.21^{c}	146.49^{b}	141.18^{d}
	6	181.73^{a}	175.04^{a}	164.86^{b}	177.54^{a}	170.53^{b}	161.98^{b}	150.67^{c}
Breast meat total cholesterol (mg/dl)	4	49.09^{a}	47.01^{b}	43.55^{c}	46.42^{b}	45.71^{b}	43.27^{c}	40.14^{d}
	6	54.07^{a}	50.36^{b}	45.42^{cd}	47.21^{c}	46.97^{c}	44.20^{de}	42.04^{e}
Thigh meat total cholesterol (mg/dl)	4	109.09^{a}	103.68^{bc}	97.08^{d}	105.41^{b}	102.81^{b}	97.71^{d}	96.17^{d}
	6	111.09^{a}	103.57^{b}	98.97^{d}	106.69^{c}	105.74^{bc}	98.26^{d}	97.64^{d}

Means bearing the different superscript within the same row differ significantly ($P \leq 0.05$)

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EFFECT OF GARLIC (*Allium sativum*) POWDER AND NEEM (*Azadirachta indica*) SEED CAKE ON CHOLESTEROL CONTENT IN BROILER CHICKEN

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ABSTRACT

An experiment was conducted at the Department of Poultry Science to investigate the effect of dietary supplementation of garlic (*Allium sativum*) powder and neem (*Azadirachta indica*) seed cake and their combination on the performance and cholesterol content of meat and serum in broiler chicken.

Two hundred and ten day-old straight run commercial broiler chicks were reared under seven different treatments with three replicates of ten chicks each. The T1 was control with standard broiler ration and garlic powder (GP) and neem seed cake (NSC) were supplemented in the basal diet to form diets T2 to T7. The experiment was carried out with two levels of GP supplementation, 0.5 per cent (T2) and 1.0 per cent (T3), two levels of NSC supplementation, 1.0 per cent (T4) and 2.0 per cent (T5) and two levels of GP and NSC combination, 0.5 per cent GP and 1.0 per cent NSC (T6) and 1.0 per cent GP and 2.0 per cent NSC (T7). The rations were made isocaloric and isonitrogenous. Chicks were reared under standard managemental conditions up to six weeks of age. The broiler starter ration was fed from zero to four weeks and finisher ration from five to six weeks of age.

Results of the study revealed that, supplementation of GP at 0.5 or 1.0 per cent and NSC at 1.0 or 2.0 per cent levels and a combination of 1.0 per cent GP and 2.0 per cent NSC significantly ($P \leq 0.05$) depressed the final body weight, while a combination of 0.5 per cent GP and 1.0 per cent NSC did not influence final body weight of broilers. The cumulative body weight gain up to sixth week of age was significantly ($P \leq 0.05$) lower by supplementation of GP or NSC alone or their combination in broiler diet. The cumulative feed intake up to sixth week of age did not reveal any significant difference between treatments. But numerically lower feed consumption was recorded in T5 and T7 where NSC was included at 2.0 per cent level. Cumulative feed efficiency up to six weeks of age was significantly ($P \leq 0.05$) inferior in T7 and was superior with control group (T1) and groups T1 to

T6 was in a homogenous comparable group. The per cent dressed yield, eviscerated yield, ready-to-cook yield, blood loss, feather loss and total loss in broilers were not influenced by dietary supplementation of GP and NSC alone or in combination. The per cent giblet yield of birds supplemented with 0.5 per cent GP and 1.0 per cent NSC (T6) was significantly ($P \leq 0.05$) lower, while other levels of GP and NSC and their combination did not influence the same. The weight of bursa of fabricious and spleen at sixth week of age was increased by supplementation of GP and NSC and their combination in broiler diet. The dietary supplementation of GP at 0.5 per cent and NSC at 1.0 per cent level numerically reduced the serum total cholesterol level, while in T3, T5, T6 and T7 there was significant ($P \leq 0.05$) reduction in serum total cholesterol.

The supplementation of GP and NSC alone and in combination significantly ($P \leq 0.05$) reduced the breast and thigh meat total cholesterol in broilers. Supplementation of GP and NSC alone and in combination in broiler diet did not influence the serum total protein and breast and thigh meat crude protein. Livability of all treatment groups was 100 per cent. It shows that dietary supplementation of GP, NSC and their combination at the levels employed in this study had no deleterious effect in broilers. Net profit per kg body weight was reduced as a result of inclusion of GP and NSC alone and their combination in broiler diet. The results of the present study suggest that supplementation of garlic powder and neem seed cake in broiler rations is beneficial for substantial reduction in the cholesterol content of poultry meat.