EFFECT OF SODIUM SULPHATE SUPPLEMENTATION IN BROILER DIET

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"EFFECT OF SODIUM SULPHATE SUPPLEMENTATION IN BROILER DIET"** is a bonafide record of research work done by me during the course of research and that this 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.

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CERTIFICATE

Certified that this thesis entitled " **EFFECT OF SODIUM SULPHATE SUPPLEMENTATION IN BROILER DIET** " is a record of research work done independently by **Shri. Anil, B .,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to him.

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INTRODUCTION

INTRODUCTION

The potential of poultry production is widely recognized in several countries, and its contribution is becoming increasingly significant globally. All efforts are being taken to overcome malnutrition and poverty in developing countries through innovative projects under poultry sector. A decline in per capita availability of pulses could pose serious health problems if the human diet is not supplemented with protein from other sources. Eggs and poultry meat play significant role in human nutrition because of their excellent amino acid profile and adequate quantity of vitamins and minerals.

In India during the last two decades the poultry industry was one of the fastest growing segment under the agricultural sector with an annual growth rate of 10 and 20 per cent for egg and broiler production respectively. Broiler industry recorded an explosive growth from four million in 1971 to 275 million in 1994 and was projected to be 400 million in 1996 (Anon,1994). Despite the impressive achievements of broiler industry in India, a wide gap exists between the current availability and the minimum requirement of poultry meat in the country. In India, the per capita availability of poultry meat is only 566 g in 1994 (Anon, 1994). The National Institute of Nutrition recommended per capita consumption of 10.8 Kg meat per annum ie. 30 g meat / day/ person. To meet fifty percentage of this target by poultry meat, the broiler output has to be increased ten times from the present level of production.

Taking into consideration of meat from all sources, the present annual per capita availability of meat accounts to a margin of 1.5 kg in India. With the limited scope for increasing meat from other sources, poultry meat offers vast scope for filling the gap. In Kerala the broiler production is estimated to be nine million, with a per capita consumption of 1.5 kg poultry meat which is higher than the national average.

The requirement of poultry feed in India was estimated to be 10 million tonnes as against the present production of seven million tonnes (Nandakumar, 1994). Major problem faced by the poultry industry at present is the high cost and non-availability of feed ingredients in Kerala. Feed cost accounts for 60 to 70 per cent of the total cost of production. Competition between human and livestock population for the existing animal and plant resources has been of great concern to the poultry nutritionists. Efforts are on to look forward for alternate feed resources and to evaluate them for their inclusion in the livestock and poultry rations.

In poultry feed formulation, ingredients are compared according to their amino acid profile. Fish occupies an important position among the protein sources because of its high lysine and methionine content. Out of the total crude protein requirement in poultry feeds, 10 per cent is met through fish alone. Among the 12 leading fish producing countries in the world, India produce about 3,172 million tonnes annually (Rajammal *et al.* 1993). In developing countries about 60 per cent of the population derives more than 40 per cent of the total animal protein from fish alone. Fish is also a major source of poly unsaturated fatty acids especially omega- 3 fatty acids, which help in lowering of blood cholesterol and relieves inflammatory condition such as arthritis and aid in brain development. In addition, fish is a rich source of vitamins and minerals (Reddy, 1996) and hence used as an important item for human food.

Because of the regular use of fish in human diet, good quality fish is not available for poultry feeding. Further the cost of fish and fish meal is fluctuating and quality of fish available is often inconsistent. Presently poultry nutritionists are computing rations using vegetable protein sources, sparing the valuable fish protein for human diet. In such cases the requirement of sulphur containing amino acids in poultry rations are met either by supplementation of synthetic methionine or inorganic sulphate in vegetable protein diet.

The sparing action of sulphate for methionine and cysteine was reported by many scientists. Studies also have indicated that sulphate is beneficial in sparing sulphur containing amino acids that are catabolised during aflatoxicosis (Leeson and Summers, 1991). Vidhyadharan (1998) reported that methionine or sodium sulphate can be effectively utilized in formulation of all vegetable protein diet devoid of fish for layers.

The present study was planned to find out the feasibility of supplementation of sodium sulphate (anhydrous) in broiler rations devoid of unsalted dried fish.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Meteorological profile of Mannuthy

Data pertaining to the meteorological profile of Mannuthy (latitude 10°32″; N. Longitude 76°16′ E; Altitude 22.25m above MSL) for five years were summarised by Somanathan (1980). He reported the highest mean maximum temperature of 32.35°C during May and lowest during July (28.15°C). The lowest mean minimum temperature recorded was 23.28°C during July and highest mean minimum temperature as 25.27°C during May. The daily average per cent relative humidity varied between 75.68 during May and 86.52 during July. Climatograph of this locality fell within the hot and humid climate.

Geo (1992) reported mean maximum temperature of 33.96°C during May-June and 28.11°C during July-August. The mean minimum temperatures were 26.92°C and 23.74°C respectively during the above periods. The per cent relative humidity was 79.96 and 89.71 in the forenoon and 58.04 and 78.89 in the afternoon for the above periods respectively.

Impact of meteorological parameters on the performance of broilers

Reece and Lott (1983) found that growth rate of commercial broilers decreased as environmental temperature increased. The growth rate at 26.7°C was six per cent lesser at 35 days and 10 per cent lesser at 55 days of age than at 15.6°C. At 49 days of age, the birds grown at 15.6°C required 16 per cent more feed than at 26.7°C.

Al-Fataftah (1987) studied the effect of high temperature on broiler performance in Jordan. He reported that exposure of broilers at high temperature exceeding 29.0°C significantly decreased feed intake, feed efficiency and body weight gain.

Osmon *et al.* (1989) conducted two experiments to study the effect of environmental temperature on growth and carcass quality of broilers. They found that higher temperatures from 30 to 32°C reduced body weight gain and feed efficiency.

Body weight

Gordon (1955) reported that the addition of sodium sulphate or sulphur to the ration of chicken did not improve growth rate, but when the sulphate of the mineral mixture was replaced by the chlorides or oxides, the addition of sodium sulphate improved growth rate and feed efficiency.

Gordon and Sizer (1955) reported the effect of inorganic sulphate in poultry nutrition for the first time. A basal diet deficient in cystine (0.08 per cent cystine, 0.51 per cent methionine) and sulphate free was fed to growing chicks. An addition of 0.50 per cent sodium sulphate resulted in 31.4 per cent growth response over the basal diet (371.5 g gain vs 488.1g) at the end of the fifth week. The addition of 0.22 per cent methionine gave a 39.1 per cent growth response over the basal diet (371.5 vs 617.0g). The authors summarised that the chicken can satisfy part of its total sulphur requirement with inorganic sulphate.

Machlin (1955) reported that female chicks fed a supplement of 0.5 per cent sodium sulphate gave growth response of 4.5 to 5 per cent over those fed on basal diet. The growth response obtained by the feeding of sulphate is due to a physiological requirement for sulphate as such. This requirement can be satisfied either by the addition of sulphate to the diet or presumably from the sulphate furnished by the oxidation of the sulphur containing amino acids.

Machlin and Pearson (1956) evaluated the effect of sulphate supplementation on a cysteine deficient sulphate free purified diet on chicks (0.06 per cent cysteine, 0.54 per cent methionine). The average of nine experiments showed 22 per cent growth response over the basal diet due to 0.50 per cent sodium sulphate supplementation.

Almquist (1964) published the results of his experiments using a sulphate free purified diet with measured levels of methionine supplementation and a level of 0.50 per cent sodium sulphate addition. The higher the level of methionine supplementation (0.30, 0.50 and 0.70 per cent) the greater the growth response, but for each level of methionine, the addition of 0.50 per cent sodium sulphate gave a growth response.

Ross and Harms (1970) studied the response of broiler chicks to inorganic sulphur in a high energy corn- soybean basal diet. The diet was formulated to be deficient in methionine (0.40 per cent methionine, 0.39 per cent cysteine) and low in added sulphate. The greatest response was obtained from 0.10 per cent sodium sulphate supplementation for all levels of methionine addition. However only 5.2 per cent growth response over the basal diet was obtained.

Hinton and Harms (1972) investigated the effect of sodium sulphate supplementation in corn-soybean basal diet. Their findings revealed that the supplementation with 0.2 per cent sodium sulphate resulted in a 14.5 per cent growth response over the unsupplemented basal diet.

The effect of sodium sulphate and methionine on weight gain and feed efficiency of chicks fed purified diets based on glucose and isolated soy protein was studied by Ross *et al.* (1972). Broiler chicks showed consistent increase in weight gain when the methionine deficient diet low in sulphate was supplemented with 0.08 to 0.32 per cent sulphate in the presence of methionine. The greatest response was obtained at 0.08

per cent sodium sulphate when either 0.08 or 0.16 per cent methionine was present in the diet.

Sloan and Harms (1972) observed a significant increase (6.5 per cent) in body weight of three-week-old poults with the addition of 0.25 per cent sodium sulphate to a practical type 26 per cent protein diet without added methionine.

Sasse and Baker (1974) studied the effect of feeding purified crystalline amino acid diet devoid of inorganic sulphate and deficient in cysteine (0.30 per cent methionine and 0.10 per cent cysteine). They found that a 40 per cent increase in weight gain from 0.50 per cent potassium sulphate supplementation. When the diet was adequate in sulphur containing amino acids (0.30 per cent methionine, 0.30 per cent cysteine) or methionine deficient (0.10 per cent methionine and 0.30 per cent cysteine) or equally deficient in both methionine and cysteine (0.22 per cent each) a response to potassium sulphate did not occur.

Soares *et al.* (1974) conducted experiments to test the use of sulphate under practical conditions and to find the optimal levels of sulphate supplementation to the growing chicks. Five levels of sodium sulphate and three levels of methionine were used in a corn- soybean meal diet of broiler chicks. The addition of 0.16 per cent sodium sulphate was most effective in stimulating growth in chicks for all levels of methionine supplementation. A maximum growth response of 8.6 per cent was obtained over the unsupplemented basal diet. When 1.8 and 0.36 per cent potassium sulphate were added with and without methionine, only 3.8 per cent maximum growth response was obtained.

Van Weerden *et al.* (1976) conducted an experiment to study the relation between methionine and inorganic sulphate in broiler rations. Addition of 0.1 percent sodium sulphate to the basal and methionine supplemented diets resulted in an overall increase in weight gain at five weeks of age.

The interrelationship between inorganic sulphate and sulphur amino acids in broiler diets was evaluated by Bornstein and Plavnik (1977). They found that addition of 0.06 per cent sodium sulphate to the basal diet supplemented with 0.08 per cent methionine resulted in a five per cent increase in growth rate. Further studies using the soybean meal-milo diet revealed an age effect on the growth response from sulphate supplementation. Growth rate as great as 10 per cent was obtained as the diet was supplemented with sulphate up to five weeks of age. A combination of 0.1 per cent methionine and 0.12 per cent sulphate supplementation to basal diet was used in these experiments.

Plavnik and Bornstein (1978) using practical broiler finisher diets conducted three trials to detect the extent of replacement of methionine by sodium sulphate in terms of growth rate and feed conversion. They found that sodium sulphate can replace 20 to 50 per cent of synthetic methionine.

Pesti *et al.* (1979) conducted experiments to determine the effect of corn-soybean meal white grease diets with sulphur amino acids and methyl group donors for starting broiler chicks. They found that supplementing diet with 0.23 per cent DL-methionine significantly improved 3 week-gain and feed per gain over that obtained with the basal diet.

Blackman and Waldroup (1980) reported that sodium sulphate supplementation in diets of young broiler chicks significantly improved body weight.

Scott *et al* (1982) reported that when chicks received diets containing adequate amounts of methionine and suboptimal levels of cystine, growth rate was improved by addition of sodium or potassium sulphate in the diet. Apparently sulphate spares cysteine for synthesis of taurine or sulphated mucopolysaccharides.

Miles *et al.* (1983) reported that the basal diet supplemented with potassium sulphate and choline or methionine in broilers gave a greater growth than that with only one supplement. A consistent sulphate response occurred when the diet contained choline but not methionine. The results indicated that sulphate must be present for choline to spare a maximum amount of methionine. However supplementation of the basal diet with inorganic sulphate alone resulted in a significant growth depression at two weeks of age and a numerical depression at three weeks of age.

Potter and Shelton (1984) conducted experiments to evaluate the effect of supplementation of methionine, cysteine and sodium sulphate in young turkey diets. A total of 1296 poults divided into 144 groups to determine the effect of adding 0.10 per cent DL-methionine, 0.10 per cent L-cysteine, 0.05 per cent sodium sulphate. The two and four week body weights were increased by 3.2 and 2.1 per cent respectively by supplementation of sodium sulphate (0.05 per cent).

Hikami *et al.* (1985) reported the effect of dietary sodium sulphate on growth and chemical components of serum in chicks. No significant difference in body weight occurred between chicks fed on diets supplemented with 0.44 per cent methionine and with 0.22 per cent methionine + 0.22 per cent sodium sulphate. Body weight of chicks fed with 0.44 per cent sodium sulphate alone were about 60 per cent of body weight of chicks given diets supplemented with the methionine. Addition of higher levels of (0.88 per cent) sodium sulphate did not improve body weight gain.

Hikami *et al.* (1988) fed chickens with commercial diets having three different levels of sulphur amino acids with or without sodium sulphate at 0.8 per cent level. The results showed that supplementary inorganic sulphate decreased gain in body weight with diets high in sulphur amino acids but increased it with those low in sulphur amino acids.

Jensen *et al.* (1989) studied the sulphur amino acid requirement of broiler chickens from three to six weeks of age and found that methionine supplementation in broiler diet from three to six weeks of age significantly improved body weight gain.

Reddy and Eswaraiah (1991) reared broilers with five different diets, two reference diets viz., groundnut meal + fish meal and soybean meal + fish meal and three test diets viz., Groundnut meal alone, soy bean meal alone and sesame meal + soy bean meal in equal proportions duly supplemented with lysine and methionine. They found that weight gains on diets having soybean meal alone were appreciably better than those on other diets. Feed efficiency on diets containing vegetable protein sources only was better than those containing fish meal.

Sadagopan *et al.* (1993) reported that broilers can be raised satisfactorily on vegetable protein diets duly supplemented with limiting amino acids (lysine and methionine) to meet the requirements.

Sharma *et al.* (1994) reported that sodium sulphate at 0.3 per cent level included in rations devoid of fishmeal covered up the deficiency of methionine and improved the performance of egg type pullets.

Yadav *et al.* (1994) in their study on the effect of supplementation of sodium sulphate on the performance of egg type chicks revealed that sodium sulphate at 0.3 per cent level in a ration devoid of fish meal gave body weight gains comparable to fish meal included diets without sodium sulphate.

Bharadwaj *et al.* (1999) conducted studies to find out the possibility of replacing fish meal with soybean meal and supplemented with sodium sulphate (0.1 per cent), choline (0.05 per cent) and cow dung (5 per cent) in the diets of growing pullets of 12 weeks of age and found that body weight gain obtained from fishmeal free treatments were statistically similar to the control diet. They concluded that supplementation of sodium sulphate alone or along with choline or cow dung in all vegetable protein diets was beneficial in promoting growth in growing pullets.

Raju *et al.* (1999) studied the performance of broilers on diets with animal protein or vegetable protein alone. They found that diets containing fish meal or soybean meal alone as protein source had similar effect on the performance of broilers implying that soybean meal adequately balanced for methionine and lysine can replace fish meal in broiler diets.

Feed intake

Damron and Harms (1973) after carrying out experiments using six dietary treatments found that feed intake was significantly influenced by amino acid levels but not by sodium sulphate supplementation. The five dietary treatments consisted of sulphur amino acid levels of 0.355, 0.412, 0.470, 0.528 and 0.592 per cent respectively and sixth treatment had 0.10 per cent sodium sulphate with 0.47 per cent sulphur amino acids. The daily feed intake of birds receiving 0.355 per cent sulphur containing amino acids was lower than the other treatment groups. Diets containing 0.47 per cent sulphur amino acid with and without sodium sulphate had the highest consumption, while diets with 0.528 and 0.592 per cent of sulphur amino acids had the lowest intake in comparison with the remaining diets. None of these values showed statistically significant difference.

Potter and Shelton (1984) reported that the addition of 0.50 per cent sodium sulphate to the diet did not affect feed consumption at seven and eight weeks of age in turkey poults. Added sulphate increased feed consumption by 2.9 per cent at two weeks of age and increased feed consumption by 2.3 per cent during the fourth week.

Miles *et al.* (1986) reported that supplementation of choline alone or in combination with inorganic sulphate significantly increased feed consumption. However, inorganic sulphate alone resulted in only numerical increase in feed consumption with an average of 94 g/ bird/ day on a ration based on corn-soybean meal, in layers.

Bharadwaj *et al.* (1999) studied the effect of supplementation of sodium sulphate, choline and cow dung in a grower ration where fish meal was replaced completely by soybean meal and mustard cake. They reported that feed intake was statistically similar in all treatment groups, but apparently seven per cent less feed was consumed by birds kept on vegetable protein diet supplemented with sulphate alone or with choline in comparison to control diet containing fish meal.

Feed efficiency

Gorden and Sizer (1955) reported the effect of sodium sulphate supplementation in broiler ration. They found that the supplementation of sodium sulphate improved the feed efficiency and growth rate.

The response of broiler chicks to inorganic sulphur in a high energy corn- soybean basal diet was studied by Ross and Harms (1970). The diet was formulated to be deficient in methionine (0.40 per cent methionine, 0.39 per cent cysteine) and low in added sulphate. The greatest response was obtained from 0.10 per cent sodium sulphate supplementation for all levels of methionine addition. However only 5.2 per cent growth response over the basal diet was obtained.

Hinton and Harms (1972) studied the effect of supplementation of sodium sulphate on body weight and feed efficiency in broiler chicks. He found that 0.2 per cent sodium sulphate significantly improved feed conversion efficiency.

The effect of sodium sulphate and methionine supplementation on weight gain and feed efficiency in broiler chicks fed a purified diet based on glucose and isolated soy protein was studied by Ross *et al.* (1972). Broiler chicks showed consistent increase in weight gain and feed efficiency when the methionine deficient diet low in sulphates was supplemented with 0.08 to 0.32 per cent sulphate, in the presence of methionine.

Van Weerden *et al.* (1976) conducted experiments to study the relation between methionine and inorganic sulphate in broiler rations. Synthetic methionine was added to the basal ration so that it contained 0.78, 0.82, 0.92 and 1.02 per cent methionine respectively.

The addition of methionine to the basal ration produced significant improvement in feed conversion efficiency. Addition of 0.10 per cent sodium sulphate to the basal and methionine supplemented diets resulted in reduction in feed conversion efficiency.

Bornstein and Plavnik (1977) utilized a diet based on soybean and milo devoid of supplemental sulphate and low in sulphur amino acids to evaluate the interrelationship between inorganic sulphate and sulphur amino acids in broiler chicks and found that feed efficiency in chicks improved from 1.72 to 1.68 by the addition of sodium sulphate.

Kadirvel and Kothandaraman (1978) in their experiment with White Leghorn pullets of 22 weeks to 42 weeks of age, reported feed efficiency of 1.57, 1.65, 1.55 and 1.64 respectively for four dietary treatments viz. control diet, control diet with 0.2 per cent methionine, control diet with 0.25 per cent sodium sulphate, and both. These values were not statistically different.

Plavnik and Bornstein (1978) using practical broiler finisher diets conducted three trials in terms of growth rate and feed conversion and found that sodium sulphate can replace 20 to 50 per cent of synthetic methionine.

Blackman and Waldroup (1980) reported that sodium sulphate supplementation can significantly improve feed efficiency of young broiler chicks.

Potter and Shelton (1984) reported that the feed efficiency of turkey poults supplemented with 0.50 per cent sodium sulphate did not show significant difference at seven and eight weeks of age. At two weeks of age the added sulphate increased feed efficiency by 1.8 per cent.

Hikami *et al.* (1988) formulated three diets with three levels of sulphur amino acids (0.78, 0.67 and 0.51 per cent) and the diets were fed to the chicks with or without the addition of 0.8 per cent sodium sulphate and found that feed efficiency was not affected either with the addition of sodium sulphate or with the levels of sulphur amino acids.

Jensen *et al.* (1989) reported that methionine supplementation in broiler diet at 0.71 per cent level from three to six weeks of age significantly improved feed efficiency in male broilers.

Harms *et al.* (1990) conducted an experiment in commercial laying hens of 24 weeks of age to study the response of adding choline and sulphate in a corn-soybean meal diet containing different levels of supplemental DL-methionine. They found that addition of sulphate improved feed efficiency when added to the basal diet alone, but not when added to a diet containing supplemental methionine and choline. Significant improvement in feed efficiency was obtained at a level of 0.033 per cent methionine. No response was obtained when sulphate was added to diet containing 0.033 and 0.067 per cent methionine.

Reddy and Eswaraiah (1991) studied the performance of broilers on vegetable sources of protein. One hundred and five commercial day-old broiler chicks were randomly divided into five equal groups. Two reference diets and three test diets were fed to these groups. Feed efficiency on diets containing vegetable protein sources was better than those containing fishmeal.

Sadagopan *et al.* (1993) reported that feed conversion efficiency was not significantly affected by feeding vegetable protein diet when compared to control diet containing fish meal.

Inclusion of sodium sulphate at 0.2 , 0.3 and 0.4 percent level in all vegetable protein diet did not significantly affect feed efficiency of White Leghorn layers (Vidhyadharan, 1998).

Kharbal *et al.* (1999) studied the performance of broiler chicks on diets with or without fishmeal. They conducted trials in four groups of broilers fed with control diet (T1) and test diets replacing fish meal with soybean meal at 50 per cent (T2) and 100 per cent (T3) level. They found that feed conversion efficiency of group T2 (2.20) was significantly better than T1 (2.36) and T3 (2.58).

Processing yields and losses

Skinner *et al.* (1991) reported that dietary amino acid levels had little effect on dressing percentage and abdominal fat of female broilers of 42 to 49 days of age.

Rejikumar (1991) reported, ready-to-cook yield of 72.76 per cent, total loss of 27.24 per cent, blood loss of 3.42 per cent and feather loss of 3.06 per cent for broilers reared up to eight weeks of age.

Jyoti and Baghel (1998) conducted experiments to study the effect of feeding fishmeal and soybean meal on carcass traits of broilers using twelve diets containing different levels (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5 and 6.0 per cent) of fish meal protein (FMP) along with soybean meal. Studies showed that dressed weight of broilers were maximum in groups fed one per cent fish meal diet. While, eviscerated weights and carcass yields were maximum in groups fed five per cent fishmeal protein diet. The visceral losses were maximum in groups allotted 1.5 per cent FMP diet. It was observed that five per cent FMP along with soybean meal is the best for efficient carcass yields.

Raju *et al.* (1999) reported that ready to cook yield and giblet weights were not influenced by the lysine and methionine supplementation.

Sini (1999) reported blood loss of 3.56 per cent, feather loss of 4.13 per cent, total loss of 24.17 per cent and the ready-to-cook yield of 75.72 per cent in broilers.

Haematology

Sturkie (1976) reported that the normal haemoglobin content of chicken blood is 9.7 g/dl and the total protein content is 3.6 per cent at 42 days of age.

Singh *et al.* (1992) in their study to evaluate the changes in haematological and biochemical parameters in broiler chicks fed aflatoxin B_1, reported that haemoglobin and total serum protein values in control group fed normal basal ration were 11.62 g / dl and 3.27 per cent respectively.

Moudgal *et al.* (1996) conducted studies on physio-biochemical parameters in broilers during the month of June and found that the haemoglobin content of blood is 6.34 g/ dl.

Bounous and Stedman (2000) reported the normal haemoglobin content of chicken blood as 7 to 13 g/dl.

Livability

Sodium sulphate or methionine supplementation in all vegetable protein diet did not significantly affect livability of White Leghorn layers (Vidhyadharan, 1998).

Bharadwaj *et al.* (1999) reported that addition of choline, sodium sulphate and cow dung to a ration devoid of fish meal did not affect livability in growing pullets.

Economics

Jyoti and Baghel (1996) reported that along with soybean meal as vegetable protein supplement, fish meal containing about 39 per cent protein when used at a level of 5.1 per cent gave more profit over feed cost as well as net profit.

Vidhyadharan, (1998) studied cost benefit analysis in layers fed with vegetable protein diet supplemented with methionine and sodium sulphate. Results revealed that cost of egg production in the group fed with control ration was lower compared with methionine or sodium sulphate supplemented ration.

Kharbal *et al.* (1999) fed a standard control diet prepared by replacing fish meal with soybean meal at 50 and 100 per cent levels in broilers. The results indicated significantly better cost-return ratios for treatments in which 50 per cent of fish meal was replaced by soybean meal.

MATERIALS AND METHODS

MATERIALS AND METHODS

An experiment was carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to evaluate the effect of supplementation of sodium sulphate in broiler diets devoid of animal protein sources. The study was carried out during the period from May to June 2000.

Two hundred and ten, day-old, straight-run commercial broiler chicks (Cobb) were used for the study. The chicks were wing banded, vaccinated against Ranikhet disease and weighed individually. They were allotted randomly to five treatment groups with three replicates of fourteen birds each as detailed below.

Treat-ment group	Number of replica tions	Type of ration	Level of added methionine (g/ 100 kg diet)	Level of added sodium sulphate (g/ 100 kg diet)
T1	3	Control diet containing unsalted dried fish	0	0
T2	3	All vegetable protein diet	300	0
T3	3	All vegetable protein diet	0	200
T4	3	All vegetable protein diet	0	300
T5	3	All vegetable protein diet	0	400

The mean body weight of chicks within each treatment or replicate was kept uniform at the commencement of the experiment.

The experimental house was cleaned and disinfected before housing the chicks. Litter materials were spread to a thickness of six centimeters in each pen. Floor space of 925 sq. cm. for each chick was allotted. The chicks were brooded for a period of four weeks. Thereafter light was provided to enhance feed intake during night hours. Chicks were protected against Ranikhet disease and infectious bursal disease. The chicks were reared under standard managemental conditions up to eight weeks of age.

Chicks were provided with broiler starter ration till the end of six weeks of age and broiler finisher ration till the end of the experiment. The rations were formulated as per BIS (1992) specifications of nutrients for broiler chicken. The ingredient composition of experimental diets is presented in Tables 1 and 2. The proximate analysis of the ration was carried out according to the procedure described by AOAC (1990). The chemical components of diets are presented in Table 3.

The production performance of the birds was recorded for a period of eight weeks. The following parameters were recorded during the experimental period.

1. Meteorological parameters

Temperature and humidity inside the experimental house were recorded daily to assess the influence of the microenvironment on the body weight and feed efficiency. The dry bulb and wet bulb thermometer readings were taken at 8am and 2pm daily. The maximum and minimum temperatures were recorded on all days.

2. Body weight

The body weight of individual birds was recorded at fortnightly intervals from day-old to study the pattern of body weight gain on different feeding regimes.

3. Feed intake

The feed given to each replicate and the balance feed on the last day of each fortnight was recorded. From this data the average feed intake per bird per day in each fortnight was calculated for each treatment group.

4. Feed efficiency

Feed efficiency was calculated at fortnightly intervals in each treatment group from the amount of feed consumed per kilogram of body weight gain.

5. Processing yields and losses

At the end of the eighth week, two birds from each replicate were taken at random and were subjected to studies on processing yields and losses. The birds were fasted overnight. The jugular vein was severed and the birds were allowed to bleed for two minutes.

The birds were weighed before and after bleeding to find out the weight of blood. Thereafter they were scalded and defeathered by using mechanical feather pluckers. The pinfeathers were removed using pinning knife. Singeing was done using blowlamp to remove hair like structures. The birds were weighed again to find out the weight of feathers. Head and legs were removed and evisceration was done. The gizzard was sliced and the inner lining and the contents inside were removed. The eviscerated weight and the weight of giblets were recorded and ready-to-cook weight was calculated by adding eviscerated weight and weight of giblets.

6. Haematological parameters

Blood was collected from the birds, which were used for processing studies. Whole blood was collected with anticoagulant for haemoglobin estimation by cyanmethmoglobin method (Benjamin, 1979). Serum was separated from collected sample of blood without adding anticoagulant for estimation of total serum proteins. Serum protein is estimated using the kit supplied by M/S E, Merck (India) Limited, Worli, Mumbai 400018.

7. Livability

The mortality of birds in the different treatment groups was recorded during the experimental period and the livability was worked out.

8. Economics

Costs for rearing broilers in each treatment were calculated based on body weight attained and recurring expenses until sixth and eighth week of age.

9. Statistical analysis

The data collected on various parameters were statistically analysed as per the method of Snedecor and Cochran (1985).

Table 1. Per cent ingredient composition of experimental diets (starter)

Ingredients	Control diet	Experimental diets			
	T1	T2	T3	T4	T5
Maize	44	44	44	44	44
Groundnut cake	17	17	17	17	17
Soybean meal	15	20	20	20	20
Gingelly oil cake	5	5	5	5	5
Unsalted dried fish	7	0	0	0	0
Rice polish	10	12	12	12	12
Salt	0.25	0.25	0.25	0.25	0.25
Mineral mixture[1]	1.75	1.75	1.75	1.75	1.75
Total	100	100	100	100	100
Added per 100 kg feed					
Vitamin mixture[2] (g)	10	10	10	10	10
Lysine hydrochloride (g)	50	100	100	100	100
Choline chloride (g)	50	50	50	50	50
Coccidiostat[3] (g)	25	25	25	25	25
DL - Methionine[4] (g)	0	300	0	0	0
Sodium sulphate[5] (g)	0	0	200	300	400

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 composition (Indomix)
   Each gram contains Vitamin A 82500 IU, Vitamin B2 50 mg, Vitamin D3 12000 IU and Vitamin K - 10 mg.
3. Coccidiostat composition
   Each gram contains Maduramycin ammonium - 20 mg.
4. DL- Methionine (Rhone - poulenc): 99 per cent.
5. Sodium sulphate (anhydrous): M/s Nice Chemicals (AR).

Table 2. Percentage ingredient composition of experimental diets (Finisher)

Ingredients	Control diet	Treatment diets			
	T1	T2	T3	T4	T5
Maize	53	53	53	53	53
Groundnut cake	12	14	14	14	14
Soybean meal	10	15	15	15	15
Gingelly oil cake	5	5	5	5	5
Unsalted dried fish	6	0	0	0	0
Rice polish	12	11	11	11	11
Salt	0.25	0.25	0.25	0.25	0.25
Mineral mixture[1]	1.75	1.75	1.75	1.75	1.75
Total	100	100	100	100	100
Added per 100 kg feed					
Vitamin mixture[2] (g)	10	10	10	10	10
Lysine hydrochloride (g)	50	100	100	100	100
Choline chloride (g)	30	30	30	30	30
DL - Methionine[3] (g)	0	300	0	0	0
Coccidiostat[4] (g)	25	25	25	25	25
Sodium sulphate[5] (g)	0	0	200	300	400

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 composition (Indomix)
   Each gram contains Vitamin A 82500 IU, Vitamin B2 50 mg, Vitamin D3 12000 IU and Vitamin K - 10 mg.

3. DL- Methionine (Rhone - poulenc): 99 per cent

4 Coccidiostat composition
   Each gram contains Maduramycin ammonium - 20 mg.

5. Sodium sulphate (anhydrous): M/s Nice Chemicals (AR)

Table 3. Percentage composition of nutrients in broiler rations (on dry matter basis)

Sl. No.	Nutrients	T1	T2, T3, T4 & T5	T1	T2, T3, T4 & T5
		STARTER		**FINISHER**	
1	Moisture	9.82	10.15	9.61	9.68
2	Crude protein	23.35	23.42	20.27	20.38
3	Ether extract	5.53	4.45	4.95	4.79
4	Crude fibre	4.68	4.98	5.5	5.66
5	Nitrogen free extract	54.67	55.56	59.22	58.55
6	Total ash	11.58	11.21	10.24	10.15
7	Acid insoluble ash	2.61	2.75	3.02	2.98
8	Calcium	1.35	1.47	1.28	1.25
9	Phosphorus	0.61	0.73	0.62	0.68
Calculated values					
10	ME (kcal / kg)	2808	2812	2910	2915

RESULTS

RESULTS

The results of the experiment conducted to study the effect of supplementation of sodium sulphate in broiler diets devoid of animal protein sources are presented in this chapter.

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 period from May to June 2000 are presented in Table 4 and the meteorological profile is graphically represented in Fig. 1 and 2. During the experimental period, the mean maximum temperature ranged from 29.57 to 34.57°C while the mean minimum temperature from 22.14 to 25.41°C. The per cent relative humidity varied from 74.10 to 80.70 at 8 a m and 50.43 to 55.29 per cent at 2 p m.

Body weight

The data on body weight at fortnightly intervals as influenced by dietary supplementation of sodium

Table 4. Mean weekly meteorological parameters recorded in the experimental house during the period from May to June 2000.

Period (Weeks)	Temperature (°C)		Relative humidity (%)	
	Maximum	Minimum	8 a.m.	2 p.m.
1	33.00	25.00	78.20	53.71
2	32.10	25.41	74.10	50.43
3	34.57	24.70	76.29	52.43
4	31.28	22.14	80.50	53.42
5	29.57	22.85	80.70	55.29
6	32.85	24.20	76.00	52.43
7	32.10	24.10	75.00	50.71
8	32.42	24.28	74.40	50.43
Overall mean	32.23	24.08	76.89	52.35

Fig. 1. Mean Maximum and minimum temperature (°C) in the experimental house

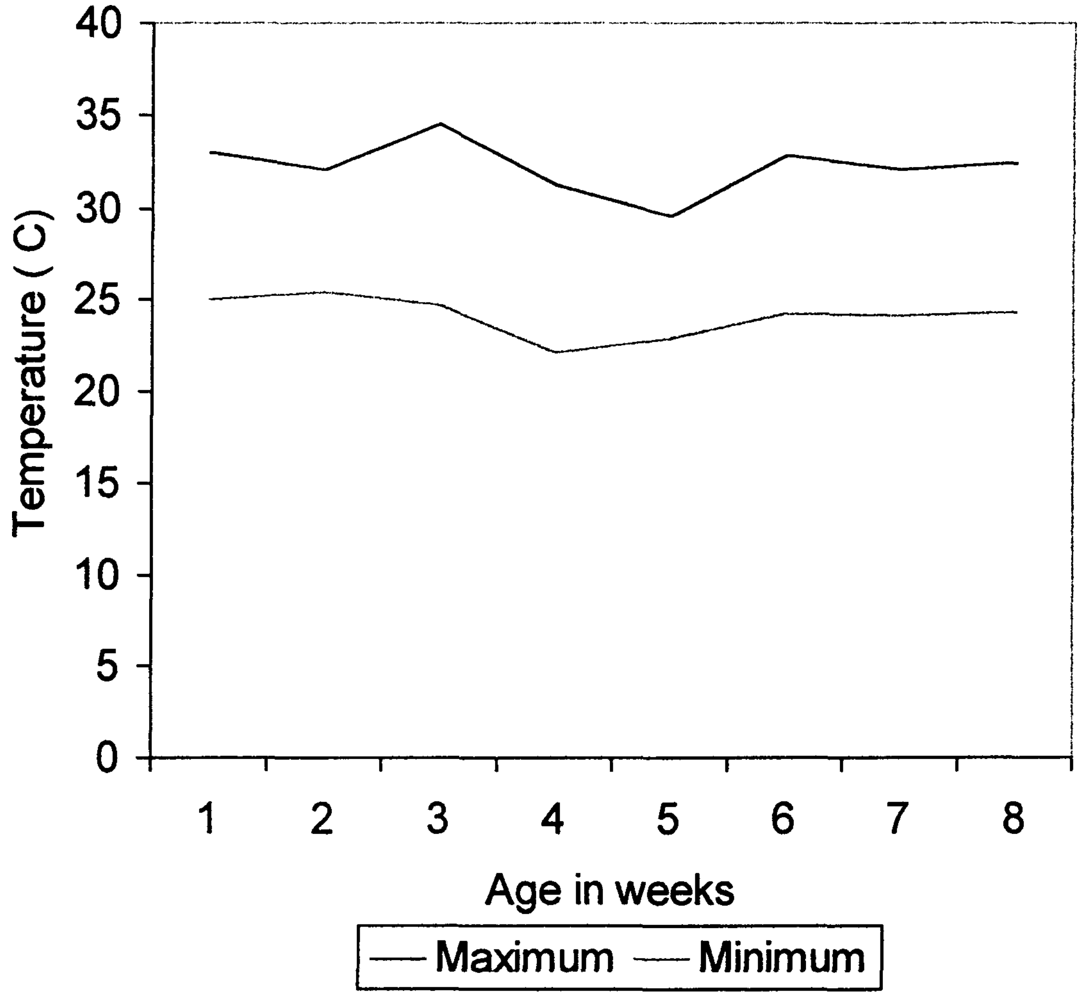
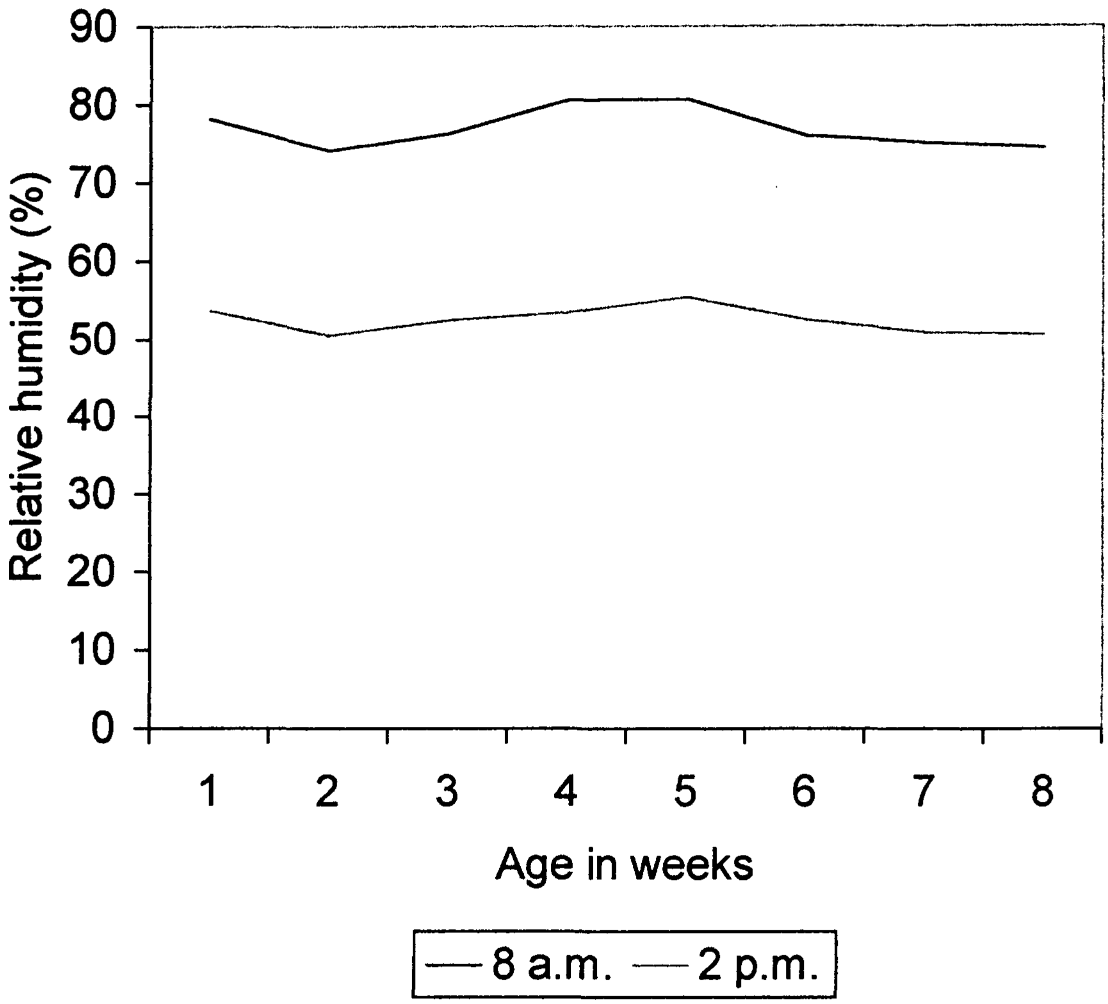


Fig. 2. Mean relative humidity (%) in the experimental house



sulphate is given in Table 5 and graphically represented in Fig. 3. The day-old body weight of chicks among different treatment groups ranged from 43.31 to 45.14 g with a difference of 1.83 g between the lowest and highest values. Statistical analysis of the data on day-old body weight of chicks did not reveal any significant difference between treatment groups.

At second week of age, the mean body weight recorded for treatments T1, T2, T3, T4 and T5 were 308.43, 293.14, 294.52, 295.71 and 305.21 g with an overall mean of 299.40 g and statistical analysis of the data did not reveal any significant difference among treatments.

At fourth week of age, the mean body weights recorded for treatments T1, T2, T3, T4 and T5 were 1011.91, 981.91, 988.10, 1000.48 and 1018.00 g respectively with an overall mean of 1000.08 g. Statistical analysis of the data on body weight at fourth week of age did not reveal any significant difference. The highest body weight of 1018.00g was recorded in birds fed diet containing 0.4 per cent sodium sulphate (T5) and the lowest in group fed diet with 0.3 per cent added methionine (981.91g).

The mean body weight recorded at sixth week of age for treatments T1, T2, T3, T4 and T5 were 1839.52, 1778.81, 1781.19, 1808.10 and 1794.05 g respectively with an overall mean of 1800.33 g. The highest body weight (1839.52 g) was recorded in the group fed with standard broiler ration (T1) while lowest in the group fed with vegetable protein ration supplemented with 0.3 per cent methionine (T2). Statistical analysis of the data did not reveal any significant difference between treatments.

At eighth week of age, the mean body weights recorded for treatments T1, T2, T3, T4 and T5 were 2527.14, 2435.48, 2443.60, 2490.00 and 2422.38g respectively with an overall mean of 2463.72 g. Statistical analysis of the eighth week body weight data presented in Table 5 revealed that it was significantly ($P<0.05$) influenced by various dietary regimes employed. Broilers fed with control ration (T1) recorded significantly ($P<0.05$) higher body weight of 2527.14 g but was statistically similar to group fed with diet supplemented with 0.3 per cent sodium

Table 5. Mean fortnightly body weight (g) in broilers as influenced by different dietary treatments

Treatment groups	Age in weeks				
	0 NS	2 NS	4 NS	6 NS	8*
T1	43.79	308.43	1011.91	1839.52	2527.14^{a}
T2	44.88	293.14	981.91	1778.81	2435.48^{b}
T3	45.14	294.52	988.10	1781.19	2443.60^{b}
T4	43.86	295.71	1000.48	1808.10	2490.00^{ab}
T5	43.31	305.21	1018.00	1794.05	2422.38^{b}
Overall mean ± SE	44.20 ± 2.30	299.40 ± 2.74	1000.08 ± 6.78	1800.33 ± 10.22	2463.72 ± 11.93

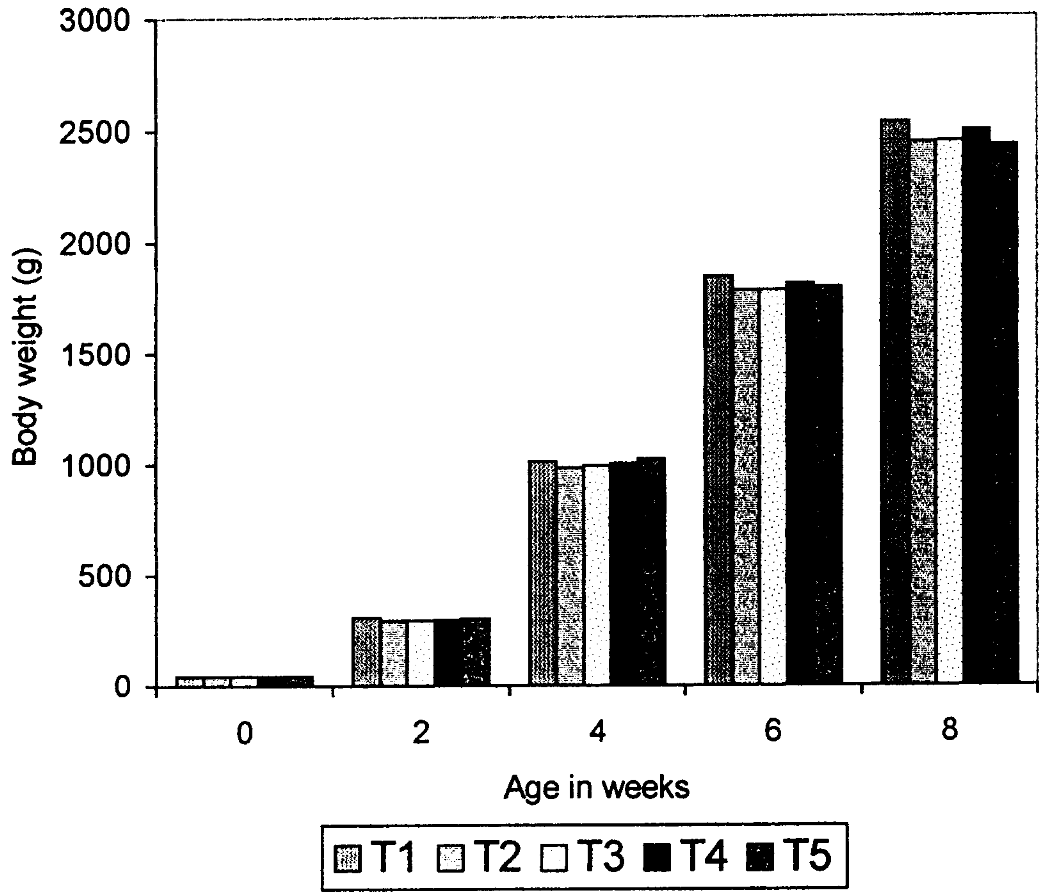
* Means bearing the different superscript within the same column differ significantly (P<0.05)

NS- Non-significant

Table 6. Analysis of variance for fortnightly body weight(g) in broilers as influenced by different dietary treatments.

Period/ Age in weeks	Source	D.f	SS	MSS	F
0	Treatment	4	102.257	25.56	2.362
	Error	205	2218.738	10.82	
2	Treatment	4	8057.04	2014.26	1.287
	Error	205	320797.54	1564.86	
4	Treatment	4	39273.44	9818.36	1.019
	Error	205	1975991.33	9638.98	
6	Treatment	4	103545.71	25886.43	1.183
	Error	205	4483930.95	21872.83	
8	Treatment	4	320238.78	80059.69	2.768*
	Error	205	5929957.64	28926.63	

Fig. 3. Mean fortnightly body weight (g) of broilers as influenced by different dietary treatments



sulphate (T4), which recorded mean body weight of 2490 g . It was also revealed that broilers fed with all vegetable ration supplemented with 0.3 per cent sodium sulphate (T4) was statistically similar to T2, T3 and T5.

Body weight gain

The mean fortnightly body weight gain of broilers fed different experimental rations from 0 to 8 weeks of age is presented in Table 7 and graphically represented in Fig. 4 and 5. The analysis of variance data on body weight gain at fortnightly intervals is presented in Table 8.

At second week of age, the mean fortnightly weight gain among the different treatment groups viz., T1, T2, T3, T4 and T5 were 264.64, 248.26, 249.38, 251.86 and 261.91g respectively with an overall mean of 255.21g. Statistical analysis of the data did not reveal any significant difference between treatment groups.

At fourth week of age, the mean fortnightly body weight gain recorded for the five treatment groups viz., T1, T2, T3, T4 and T5 were 703.48, 688.76,

Table 7. Mean fortnightly body weight gain (g) of broilers as influenced by different dietary treatments.

Treatment groups	Age in weeks				Cumulative weight gain	
	0-2 NS	3-4 NS	5-6 NS	7-8 NS	0-6 weeks NS	0-8 weeks *
T1	264.64	703.48	827.62	687.62	1795.74	2483.36[a]
T2	248.26	688.76	796.91	656.67	1733.93	2390.60[b]
T3	249.38	693.57	793.09	662.41	1736.05	2398.45[b]
T4	251.86	704.76	807.62	681.91	1764.24	2446.14[ab]
T5	261.91	712.79	776.05	628.33	1750.74	2379.67[b]
Overall mean ± SE	255.21 ± 2.70	700.67 ± 5.54	800.26 ± 7.89	663.39 ± 7.82	1756.14 ± 10.20	2419.64 ± 11.91

* Means bearing the different superscript within the same column differ significantly (P<0.01)

N.S- Non-significant

Table 8. Analysis of variance for fortnightly body weight gain of experimental birds as influenced by different dietary treatments.

Period (Age in weeks)	Source	D.f	SS	MSS	F
0-2	Treatment	4	9546.35	2386.59	1.581
	Error	205	309444.43	1509.49	
3-4	Treatment	4	15271.26	3817.81	0.588
	Error	205	1331669.07	6495.95	
5-6	Treatment	4	60963.16	15240.79	1.171
	Error	205	2668408.95	13016.63	
7-8	Treatment	4	92609.45	23152.36	1.831
	Error	205	2592204.31	12644.89	
Cumulative 0-6 weeks	Treatment	4	107512.45	26878.11	1.235
	Error	205	4460992.55	26878	
0-8 weeks	Treatment	4	323422.29	80855.57	2.808*
	Error	205	5902536.09	28792.86	

693.57, 704.76 and 712.79g respectively with an overall mean of 700.67g. Statistical analysis of the data did not reveal any significant difference between treatment groups.

At sixth week of age, eventhough the weight gain of birds fed standard broiler ration (T1) was higher than that of other treatment groups (827.62 g), it was not significantly different from T2, T3, T4 and T5. Weight gain of birds in T2, T3, T4 and T5 were 796.91, 793.09, 807.62 and 776.05g respectively.

The body weight gain recorded at eight weeks of age for treatments T1, T2, T3, T4 and T5 were 687.62, 656.67, 662.41, 681.91 and 628.33g respectively with an overall mean of 663.39g. Statistical analysis of the data did not reveal any significant difference between treatment groups.

The cumulative weight gain recorded up to six weeks of age for treatment groups T1, T2, T3, T4 and T5 were 1795.74, 1733.93, 1736.05, 1764.24 and 1750.74g respectively with an overall mean of 1756.14g. Statistical analysis of the data did not reveal any significant difference between treatment groups.

Fig. 4. Mean fortnightly body weight gain (g) of broilers as influenced by different dietary treatments

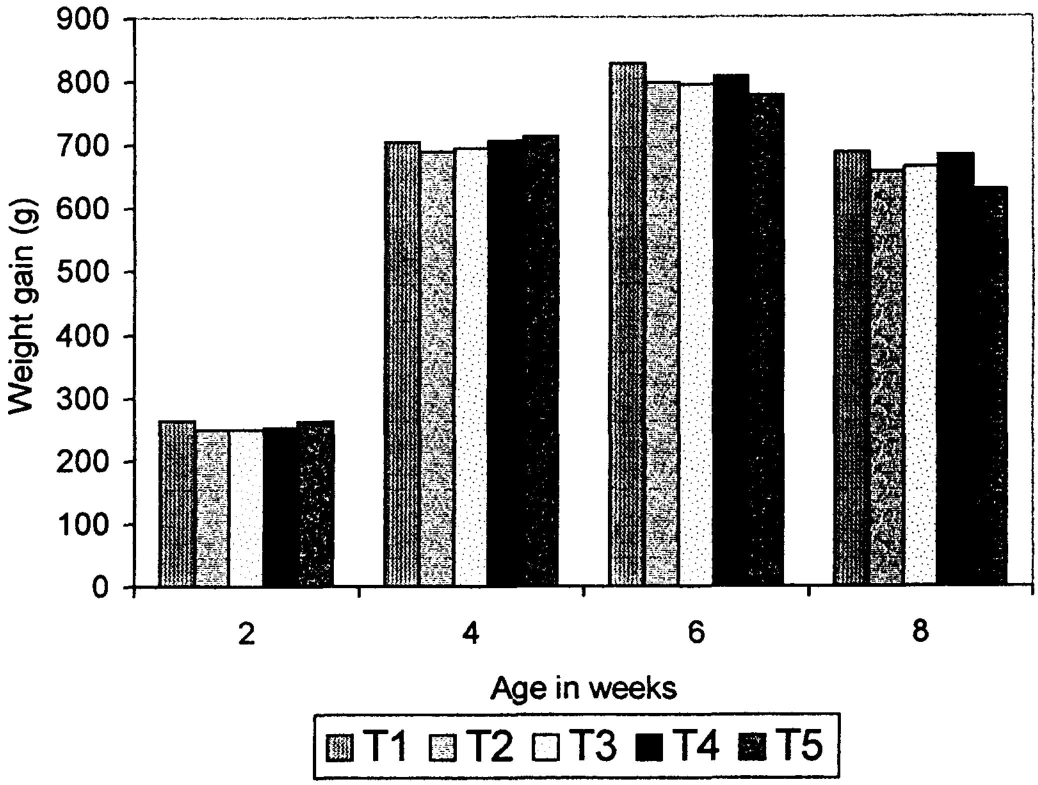
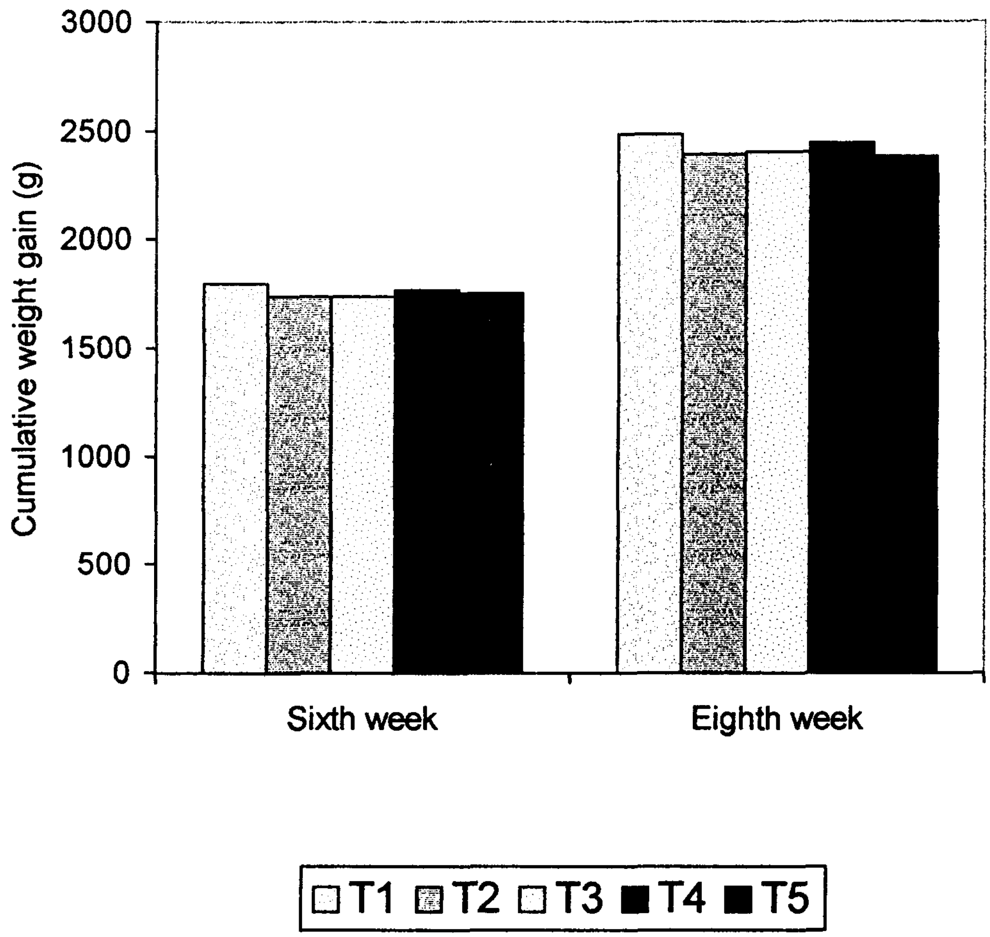


Fig. 5. Sixth and eighth week cumulative mean body weight gain of broilers as influenced by different dietary treatments



The cumulative weight gain from zero to eight weeks of age recorded for T1, T2, T3, T4 and T5 were 2483.36, 2390.60, 2398.45, 2446.14 and 2379.67 g respectively with an overall mean of 2419.64 g. Statistical analysis of the data revealed significant difference ($P<0.01$) between treatments. The weight gain recorded for birds fed with standard broiler ration (T1) was statistically higher ($P<0.01$) than those of T2, T3 and T5, but was statistically similar to group fed with ration supplemented with 0.3 per cent sodium sulphate (T4). Statistical analysis of the data also showed that cumulative weight gain from zero to eight weeks of age was comparable among treatments T2, T3, T4 and T5.

Feed intake

The mean daily feed consumption (g/ bird) during the fortnightly periods among different treatment groups are given in Table 9 and graphically represented in Fig. 6 and 7. Statistical analysis of the data is presented in Table 10.

The mean daily feed intake during the first two weeks showed significant difference among different

Table 9. Mean daily feed consumption (g/bird) in broilers at fortnightly intervals as influenced by different dietary treatments.

Treatment groups	Age in weeks				Cumulative feed consumption	
	0-2 *	3-4 NS	5-6 *	7-8 NS	0-6 weeks*	0-8 weeks NS
T1	24.97[a]	75.98	131.66[bc]	178.12	3257.03[bc]	5688.07
T2	23.03[b]	79.01	145.26[a]	174.90	3463.41[a]	5911.81
T3	24.73[a]	77.30	125.79[c]	173.06	3189.95[c]	5641.79
T4	23.63[b]	80.19	133.50[bc]	172.53	3324.16[b]	5739.79
T5	22.47[b]	79.83	134.28[b]	163.99	3312.54[b]	5608.16
Overall mean ± SE	23.77 ± 0.31	78.46 ± 0.69	134.10 ± 1.97	172.52 ± 3.18	3309.42 ± 26.36	5717.92 ± 55.44

* Means bearing the different super script within the same column differ significantly (P<0.01).

NS. Non-significant

Table 10. Analysis of variance for fortnightly feed consumption as influenced by different dietary treatments.

Period	Source	D.f	SS	MSS	F
0-2	Treatment	4	13.85	3.464	5.16*
	Error	10	6.714	0.671	
3-4	Treatment	4	37.98	9.49	1.57
	Error	10	60.68	6.7	
5-6	Treatment	4	599.88	149.87	6.93*
	Error	10	216.52	21.65	
7-8	Treatment	4	330.34	82.58	0.462
	Error	10	1787.95	178.80	
Cumulative 0-6 weeks	Treatment	4	122869.08	30717.27	13.32**
	Error	10	23065.01	2306.50	
0-8 weeks	Treatment	4	170490.62	42622.66	0.897
	Error	10	475042.60	47504.26	

Fig. 6.Mean Daily feed consumption of broilers at fortnightly intervals as influenced by different dietary treatments

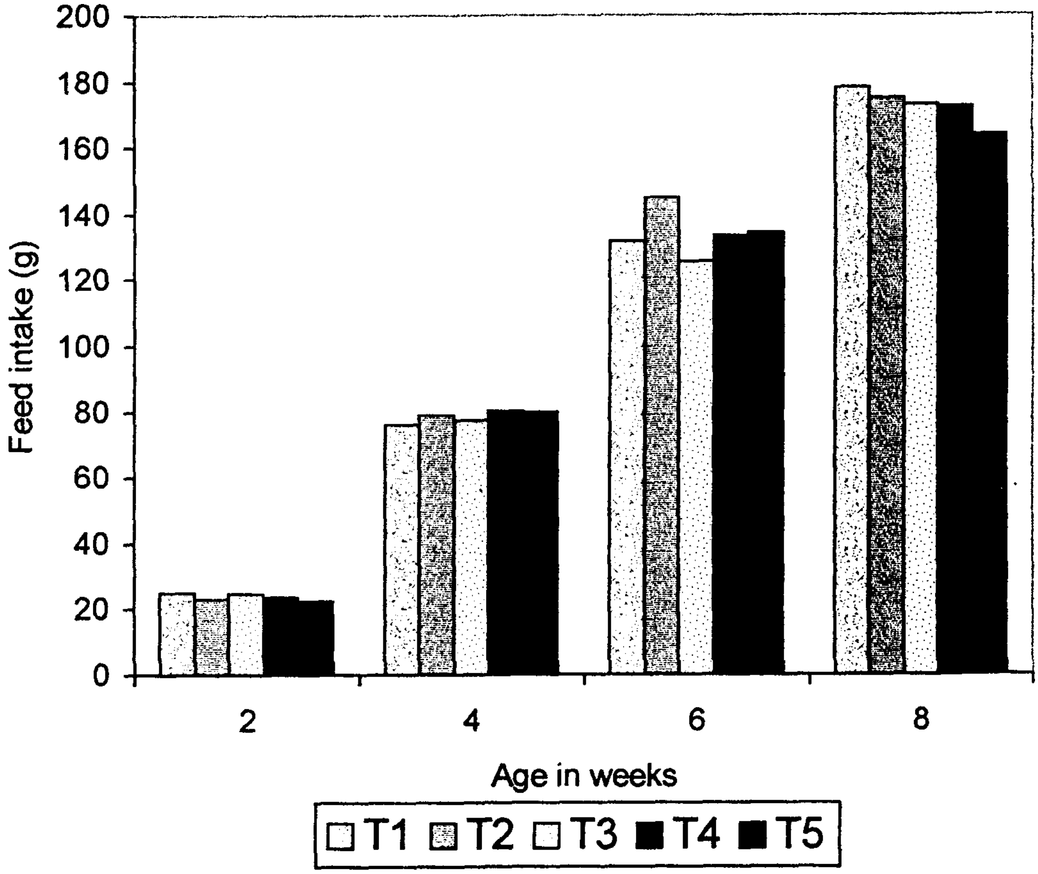
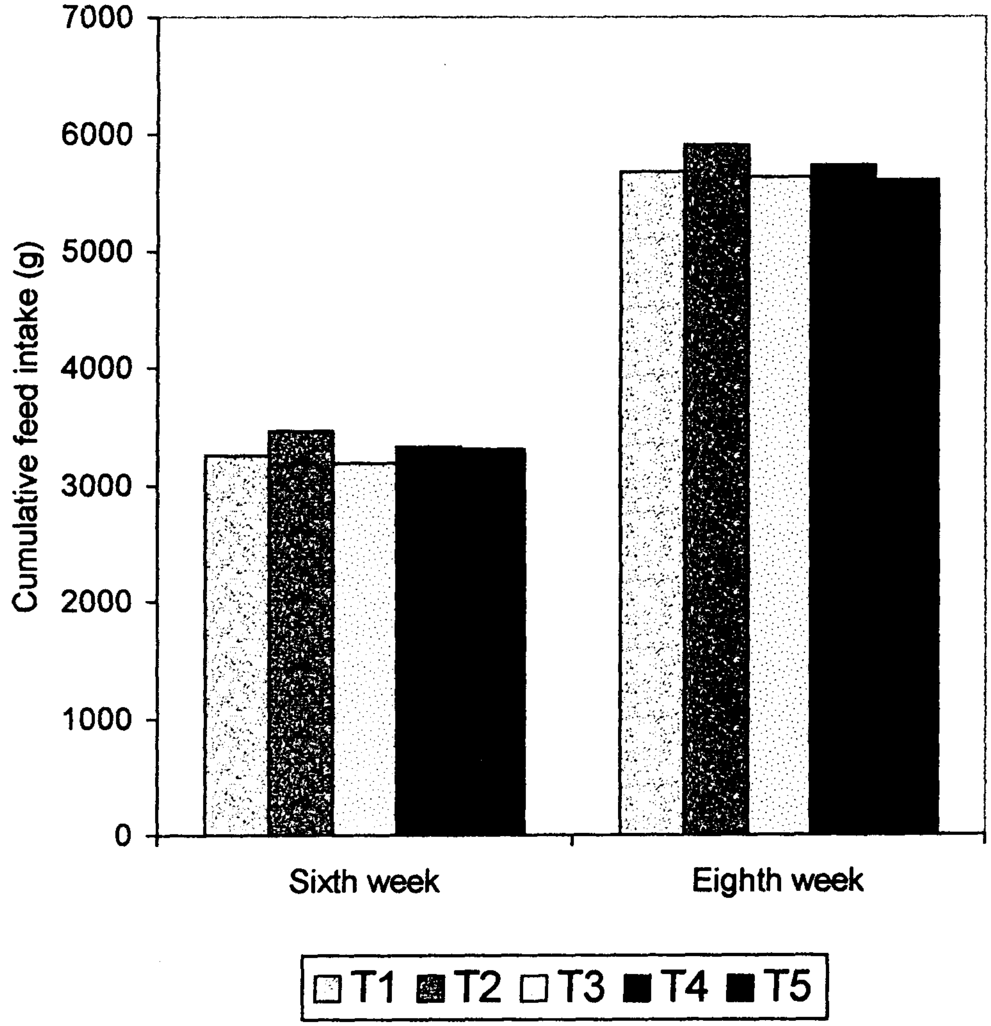


Fig. 7. Sixth and eighth week cumulative mean feed consumption of broilers as influenced by different dietary treatments



treatment groups (P<0.01). Among the five different dietary treatments, the group fed with 0.4 per cent sodium sulphate (T5) recorded the lowest mean daily feed intake (22.47g), and it was statistically comparable to treatments T2 and T4. Feed intake of birds fed with 0.2 per cent sodium sulphate (T3) was statistically similar to the control group. The mean daily feed intake for T1, T2, T3, T4 and T5 were 24.97, 23.03, 24.73, 23.63 and 22.47g respectively indicating that there was significant reduction in feed intake in groups T2, T4 and T5 in comparison with groups T1 and T3.

Mean daily feed intake of birds during second fortnight for treatments T1, T2, T3, T4 and T5 were 75.98, 79.01, 77.30, 80.19 and 79.83g respectively with an overall mean of 78.46g. Statistical analysis of the data revealed no significant difference between treatment groups.

At third fortnight, ie. from fifth to sixth week of age, the mean daily feed consumption revealed significant difference between treatments (P<0.01). The feed intake was lowest for the group fed diet containing 0.2 per cent sodium sulphate (T3), and it was statistically similar to T1 and T4. Significantly higher mean daily feed intake was recorded in birds fed diets with 0.3 per cent methionine (T2) in comparison with all other groups. The feed intake per bird per day for treatments T1, T2, T3, T4 and T5 were 131.66, 145.26, 125.79, 133.50 and 134.28 g respectively with an overall mean of 134.10 g.

During the fourth fortnight, the group fed diets with 0.4 per cent sodium sulphate (T5) recorded lowest mean daily feed intake (163.99 g) and the birds fed with standard broiler ration (T1) recorded the highest mean daily feed intake per bird (178.12 g). The feed intake for treatment groups T2, T3 and T4 were 174.90, 173.06 and 172.53 g respectively. The overall mean daily feed intake during the last fortnight was 172.52g. Statistical analysis of the data did not reveal any significant difference between treatments (Table10).

Cumulative feed intake at six weeks of age for treatments T1, T2, T3, T4 and T5 were 3257.03, 3463.41, 3189.95, 3324.16 and 3312.54 g respectively with an overall mean of 3309.42 g. Statistical analysis of the data revealed that feed intake of birds in the group fed vegetable protein diet supplemented with methionine (T2) was significantly higher (P<0.05) compared to all other treatment groups. Feed intake in broilers in treatments T1, T4 and T5 were statistically comparable to each other, while the feed intake in the group fed diet with 0.2 per cent sodium sulphate (T3) was the lowest (3189.95 g), and was statistically comparable with the control group (3257.03 g).

Cumulative feed intake at eight weeks of age were 5688.07, 5911.81, 5641.79, 5739.79 and 5608.16g respectively with an overall mean of 5717.92 g. Statistical analysis of the data did not reveal any significant difference between treatment groups.

Feed efficiency

The mean feed efficiency recorded at fortnightly intervals in the five treatment groups are presented in Table 11 and its statistical analysis in Table 12. The graphical representation of the mean feed efficiency are shown in Fig. 8 and 9.

Analysis of data on feed efficiency during first fortnight revealed significant difference (P<0.05)

Table 11. Fortnightly feed efficiency (kg feed / kg body weight) as influenced by different dietary treatments

Treat-ment groups	Age in weeks				Cumulative feed efficiency	
	0-2 *	3-4 NS	5-6 *	7-8 NS	0-6 weeks *	0-8 weeks NS
T1	1.32[a]	1.51	2.23[c]	3.62	1.81[a]	2.29
T2	1.30[a]	1.61	2.55[a]	3.73	1.99[b]	2.47
T3	1.39[a]	1.56	2.22[c]	3.66	1.88[a]	2.34
T4	1.31[a]	1.59	2.31[bc]	3.54	1.88[a]	2.35
T5	1.19[b]	1.57	2.42[ab]	3.65	1.89[a]	2.36
Overall mean ± SE	1.30 ± 0.02	1.57 ± 0.01	2.35 ± 0.04	3.64 ± 0.06	1.89 ± 0.02	2.36 ± 0.03

* Means bearing the different super script within the same column differ significantly ($P<0.05$)

NS. Non-significant

Table 12. Analysis of variance for fortnightly feed efficiency as influenced by different dietary treatments.

Period	Source	D.f	SS	MSS	F
0-2	Treatment	4	0.058	0.015	4.337*
	Error	10	0.034	0.003	
3-4	Treatment	4	0.016	0.004	1.729
	Error	10	0.023	0.002	
5-6	Treatment	4	0.236	0.059	8.663*
	Error	10	0.068	0.007	
7-8	Treatment	4	0.053	0.013	0.204
	Error	10	0.647	0.065	
Cumulative 0-6 weeks	Treatment	4	0.050	0.013	7.079*
	Error	10	0.018	0.002	
0-8 weeks	Treatment	4	0.056	0.014	1.802
	Error	10	0.078	0.008	

Fig. 8. Fortnightly feed efficiency of broilers as influenced by different dietary treatments

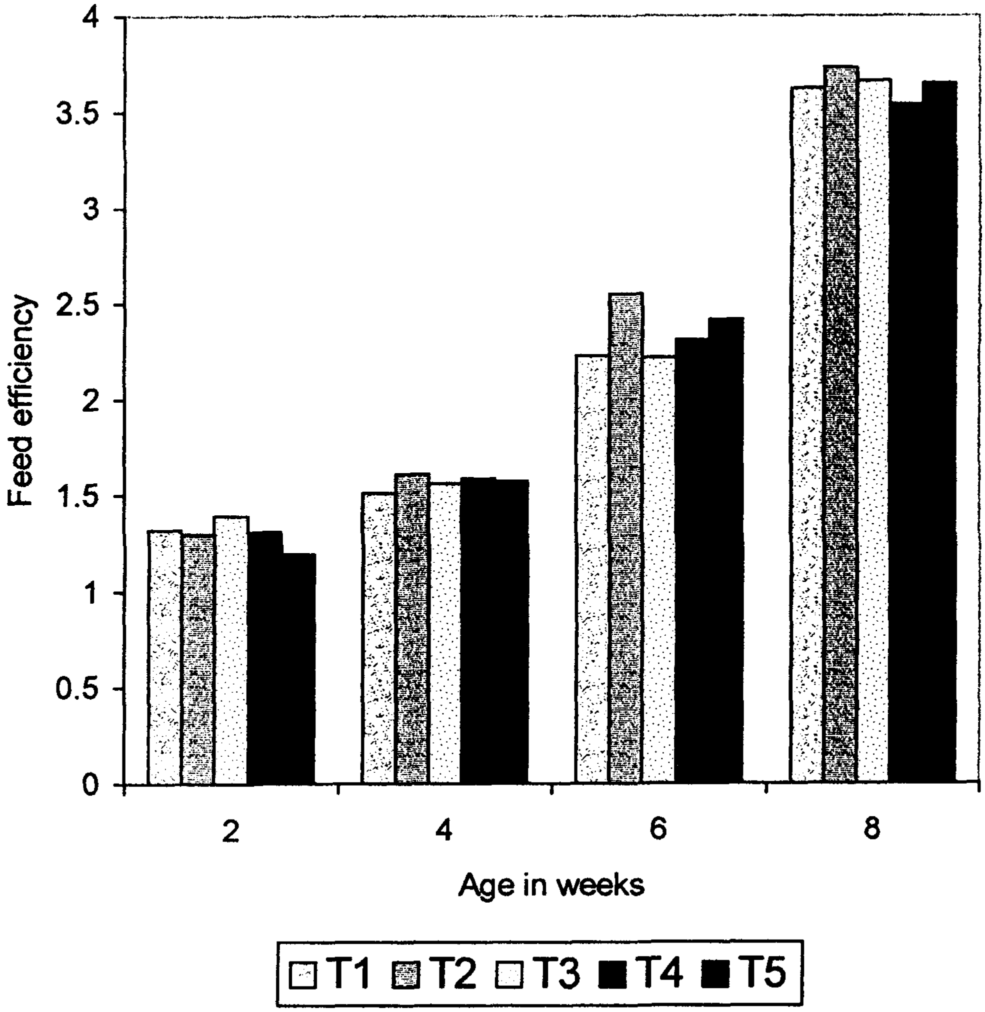
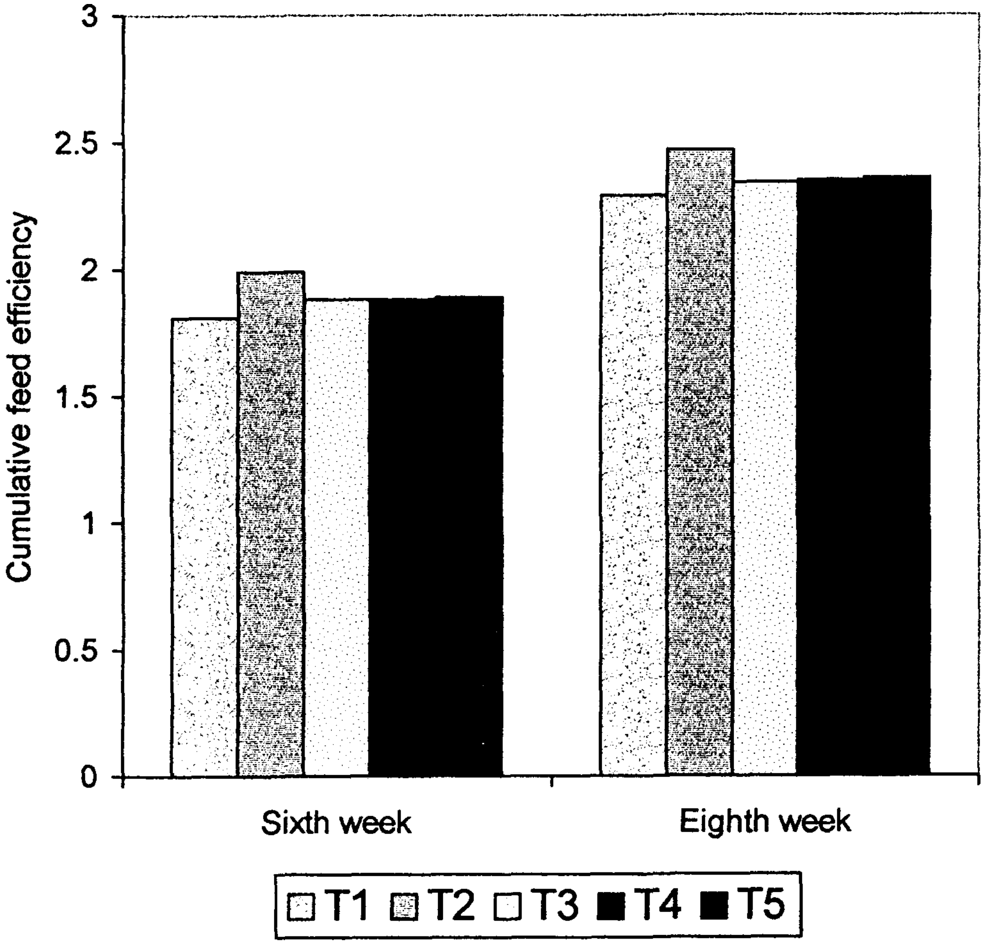


Fig. 9. Sixth and eighth week cumulative feed efficiency as influenced by different dietary treatments



between treatments. During the first fortnight period covering first and second weeks of age, feed efficiency (1.19) was significantly better for treatment group fed diet with 0.4 per cent sodium sulphate (T5), when compared to all other treatment groups. For treatments T1, T2, T3 and T4, feed efficiency recorded were 1.32, 1.30, 1.39 and 1.31 respectively.

During the second fortnight (3 to 4 weeks of age) of the experiment, the feed efficiency recorded for T1, T2, T3, T4 and T5 were 1.51, 1.61, 1.56, 1.59 and 1.57 respectively with an overall mean of 1.57. Statistical analysis of data did not reveal any significant difference between treatment groups.

During the third fortnight (5 to 6 weeks of age), the group fed with 0.2 per cent sodium sulphate (T3) recorded the best feed efficiency of 2.22 and was statistically comparable with the feed efficiency in the control group T1 (2.23) and group T4 (2.31) fed with 0.3 per cent sodium sulphate. The feed efficiency recorded in groups T2 (2.55) and T5 (2.42) were lower and were statistically comparable each other.

The feed efficiency during seven to eight weeks of age, for treatments T1, T2, T3, T4 and T5 were 3.62, 3.73, 3.66, 3.54 and 3.65 respectively with an overall mean of 3.64. Statistical analysis of the data did not reveal any significant difference between treatment groups.

Cumulative feed efficiency from zero to six weeks of age for T1, T2, T3, T4 and T5 were 1.81, 1.99, 1.88, 1.88 and 1.89 respectively with an overall mean of 1.89. Statistical analysis of the data revealed that feed efficiency of birds fed with vegetable protein diet supplemented with methionine (T2) was significantly lower (1.99) compared to all other treatment groups.

Cumulative feed efficiency from zero to eight weeks of age for T1, T2, T3, T4 and T5 were 2.29, 2.47, 2.34, 2.35 and 2.36 with an overall mean of 2.36. Statistical analysis of the data did not reveal any significant difference between treatment groups.

Processing yields and losses

The mean per cent dressed yield, ready-to-cook yield, giblet yield, feather loss and blood loss recorded in broilers slaughtered at eight weeks of age as influenced by different dietary treatments are presented in Table 13 and graphically represented in Fig. 10. The statistical analysis of the data on processing yields and losses did not reveal significant difference between dietary treatments (Table 14).

The percentage of eviscerated yield recorded for treatments T1 to T5 were 64.99, 62.86, 62.90, 63.76 and 64.06 respectively with an overall mean of 63.71. Statistical analysis of the data did not reveal any significant difference between treatments.

The highest dressing percentage of 86.72 was recorded in the group fed with 0.3 per cent sodium sulphate (T4) and the lowest (85.41 per cent) in birds fed with 0.3 per cent methionine (T2). The dressing percentage recorded for treatments T1, T3 and T5 were 86.12, 85.90 and 86.07 respectively. Statistical analysis of the data did not reveal any significant difference among treatment groups.

Table 13. The mean per cent processing yields and losses of broilers at eight weeks of age as influenced by different dietary treatments.

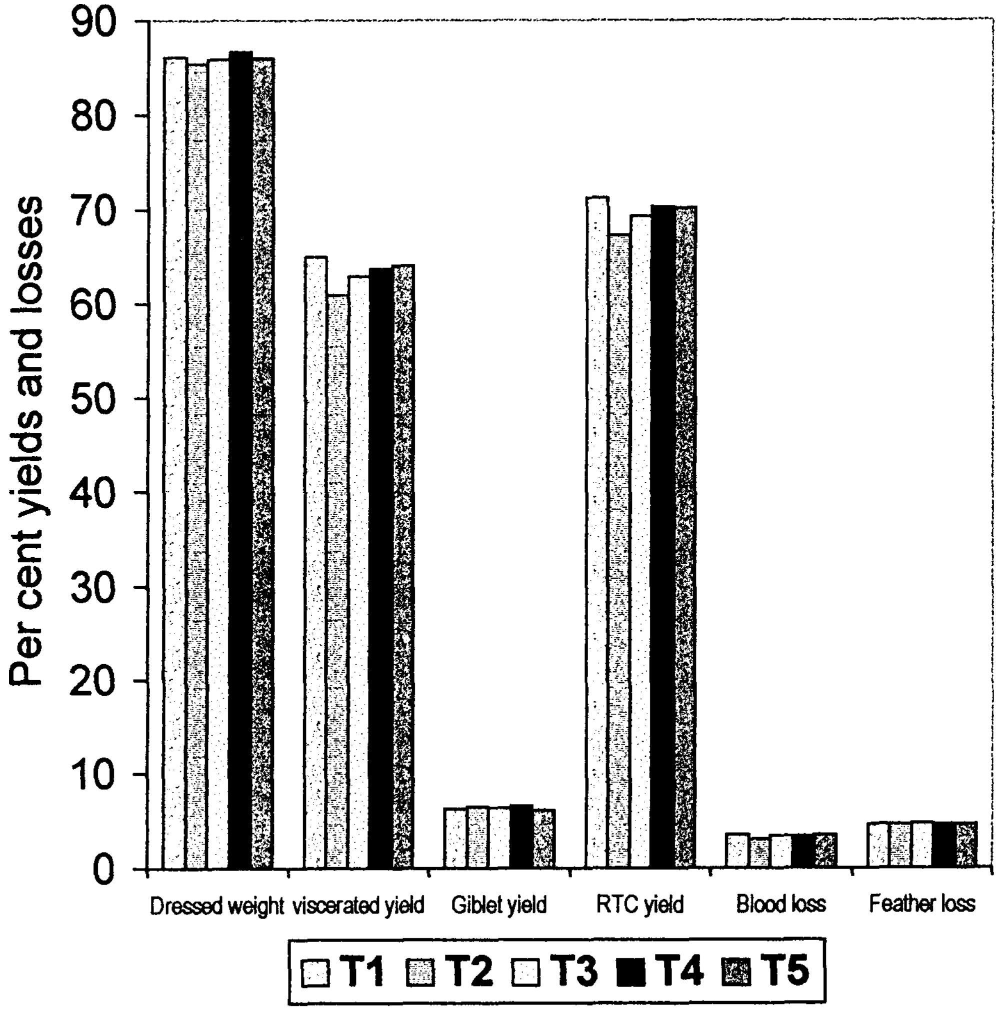
Treat-ment group	Dressed yield NS (%)	Eviscer ated yield NS (%)	Giblet yield NS (%)	Ready-to-cook yield NS (%)	Blood loss NS (%)	Feather loss NS (%)
T1	86.12	64.99	6.28	71.27	3.57	4.62
T2	85.41	62.86	6.45	69.31	3.12	4.68
T3	85.90	62.90	6.39	69.29	3.43	4.74
T4	86.72	63.76	6.59	70.35	3.43	4.70
T5	86.07	64.06	6.12	70.18	3.49	4.67
Overall mean ± SE	86.04 ± 0.31	63.71 ± 0.48	6.37 ± 0.07	70.08 ± 0.28	3.41 ± 0.04	4.68 ± 0.02

N S. Non-significant

Table 14. Analysis of variance for mean processing yield and losses at eight weeks of age

Yields and losses	Source	D.f	SS	MSS	F
Dressed yield	Treatment	4	5.36	1.34	0.434
	Error	25	77.25	3.09	
Eviscerated yield	Treatment	4	38.96	9.74	2.005
	Error	25	121.52	4.86	
Goblet yield	Treatment	4	0.76	0.19	1.365
	Error	25	3.48	0.14	
Ready-to-cook yield	Treatment	4	15.60	3.90	2.234
	Error	25	43.76	1.75	
Blood loss	Treatment	4	0.107	0.027	0.868
	Error	25	0.308	0.031	
Feather loss	Treatment	4	0.021	0.005	1.000
	Error	25	1.175	0.005	

Fig. 10 Mean percent processing yields and losses of broilers at eight weeks of age as influenced by different dietary treatments



The mean per cent giblet yields were 6.28, 6.45, 6.39, 6.59 and 6.12 for T1 to T5 respectively with an overall mean of 6.37 per cent. Statistical analysis of the data on giblet yield revealed no significant difference between treatment groups.

The mean per cent ready to cook yield for the treatments T1, T2, T3, T4 and T5 were 71.27, 69.31, 69.29, 70.35 and 70.18 respectively with an overall mean of 70.08. Statistical analysis of the data revealed no significant difference between treatment groups.

The blood loss for T1, T2, T3, T4 and T5 were 3.57, 3.12, 3.43, 3.43 and 3.49 respectively with an overall mean of 3.41. Statistical analysis of data did not reveal any significant difference between treatment groups.

The per cent feather loss for T1, T2, T3, T4 and T5 were 4.62, 4.68, 4.74, 4.70 and 4.67 respectively with an overall mean of 4.68. Statistical analysis of the data did not reveal any significant difference between treatment groups.

Serum protein

The per cent serum protein estimated at eight weeks of age is presented in Table 15. The total serum protein recorded for treatments T1, T2, T3, T4 and T5 were 4.97, 4.63, 4.63, 4.40 and 4.53 g per cent respectively with an overall mean of 4.63 g per cent. Statistical analysis of the data did not reveal any significant difference among different dietary treatments (Table 16).

Haemoglobin

The mean haemoglobin content (g per cent) of blood estimated at eight weeks of age were 10.60, 10.58, 11.60, 11.22 and 10.62 for T1, T2, T3, T4 and T5 respectively with an overall mean of 10.92 g per cent (Table 15). Statistical analysis of the data did not reveal any significant difference between treatment groups (Table 16).

Livability

The weekly mortality of birds and the overall livability per cent under different dietary treatments are given in Table 17.

Table 15. Haemoglobin (g %) and serum protein (g %) in broilers as influenced by different dietary treatments.

Treatment	Haemoglobin (g %) NS	Total serum protein (g %) NS
T1	10.60	4.97
T2	10.58	4.63
T3	11.60	4.63
T4	11.22	4.40
T5	10.62	4.53
Overall mean ± SE	10.92	4.63

NS- Non significant

Table 16. Analysis of variance for per cent haemoglobin and serum protein in broilers as influenced by different dietary treatments.

Source	Haemoglobin				Serum protein			
	D.f	S.S	M.S.S	F	D.f	SS	M.S.S	F
Treatment	4	5.15	1.287	0.71	4	1.053	0.263	0.936
Error	25	45.36	1.815		25	7.033	0.281	
Total	29	50.51			29	8.081		

Fig. 11. Total serum protein (g %) of broilers as influenced by different dietary treatments

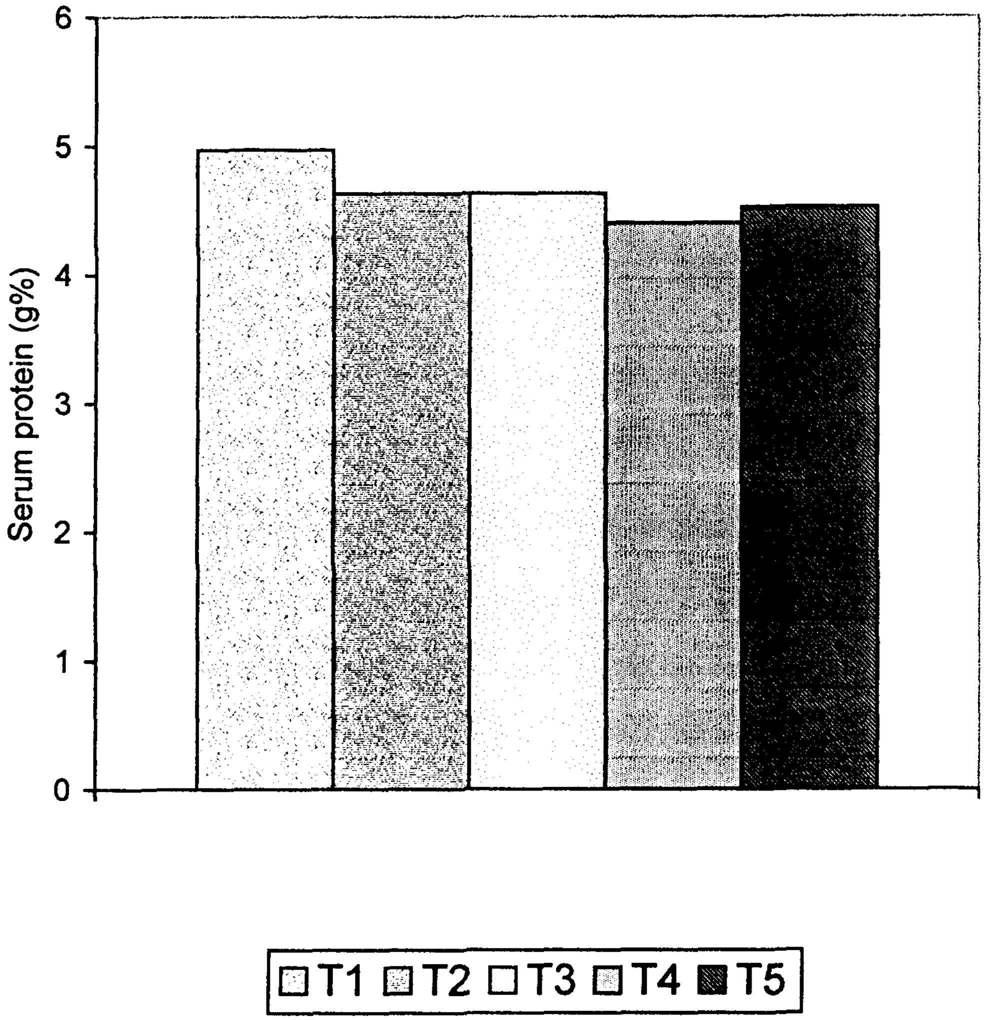


Fig. 12. Haemoglobin (g %) content of broilers as influenced by different dietary treatments

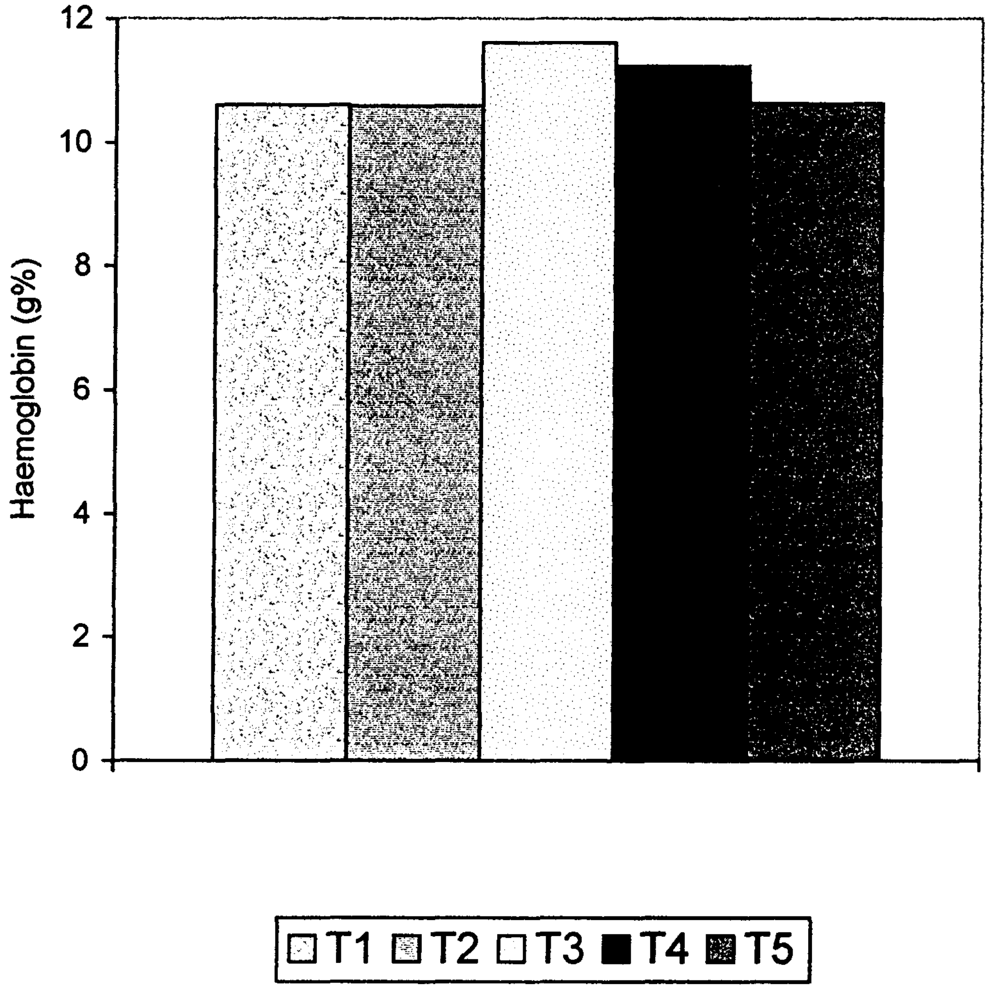


Table 17. Mortality number and overall livability per cent in different dietary treatment groups

Treatment	Age in weeks								Total	Overall livability per cent
	1	2	3	4	5	6	7	8		
T1	1	1	0	0	0	1	0	0	2	95.24
T2	0	0	0	1	0	0	1	0	2	95.24
T3	0	1	0	0	0	0	0	0	1	97.62
T4	0	0	0	0	1	0	0	0	1	97.62
T5	0	0	0	1	0	0	0	0	1	97.62
Total	1	2	0	2	1	1	1	0	7	96.67

There was no mortality during the first, third and eighth weeks of the experiment. During the second week, one bird died in the group fed with standard broiler ration (T1) and one bird from the group supplemented with 0.2% sodium sulphate (T3).

During fourth week, there was one mortality each in groups T2 and T5. One bird each died during fifth, sixth and seventh week of experiment from groups T1, T2 and T4 respectively. Thus the overall livability in treatment groups T1 to T5 were 95.24, 95.24, 97.62, 97.62 and 97.62 per cent respectively with an overall mean value of 96.67 per cent.

Economics

The cost of different rations used in the study was calculated based on the actual price of feed ingredients at the time of the experiment and are presented in Table 18. The average cost of production and the total return from a bird at sixth week and eighth week was calculated to assess the cost-benefit analysis. The cost of production includes the cost for chicks, feed, methionine, sodium sulphate and other miscellaneous costs pertaining to vaccination and medication. Cost of rations computed for different treatments viz., T1, T2, T3, T4 and T5 were Rs. 8.52, 9.31, 9.14, 9.55 and 9.98 per kilogram for starter ration and Rs. 8.06, 8.93, 8.75, 9.16 and 9.58 per kilogram for finisher feed respectively (Table 18).

At six weeks of age total feed cost (Rs. 49.03) was highest in the treatment group T5 with sodium sulphate supplementation at 0.4 per cent level and the lowest (Rs. 43.77) with control diet (T1). Sale price of broilers at that time was thirty five rupees per kilogram live body weight. The return from sale of birds for T1, T2, T3, T4 and T5 were Rs. 64.36, 62.23, 62.30, 63.28 and 62.65 respectively. Net profit per bird (Rs. 20.59) was the highest with control diet (T1) and the lowest (Rs. 13.62) in the treatment group fed with 0.4 per cent sodium sulphate (T5). The net profit per kg body weight for T1, T2, T3, T4 and T5 were Rs. 11.25, 7.92, 9.63, 8.61 and 7.60 respectively.

At eight weeks of age, the cost benefit analysis (Table 19) revealed that the feeding cost per bird (Rs.71.00) was the highest in the group T5 and the lowest (Rs. 61.67) with the control group. The receipts by sale of birds were Rs. 88.55, 85.05, 85.51, 87.15

and 84.70 in groups T1 to T5 respectively. The net profit per bird (Rs. 26.88) was highest in the control group and the lowest (Rs. 13.70) in the group T5. The net profit per kg body weight was Rs. 10.66, 6.13, 7.86, 6.94 and 5.60 in groups T1 to T5 respectively.

The present study revealed that the margin of profit over feed cost was lower at eight weeks of age in all treatment groups in comparison with the corresponding values recorded at sixth week of age. Moreover it was observed that the control diet is superior over other diets with respect to net profit per bird. Among the treatment groups, the diet supplemented with 0.2 per cent sodium sulphate (T3) recorded better net profit per bird.

Table 18. Cost of experimental rations.

Ingredients	Cost/ kg (Rs.)	Broiler starter ration					Broiler finisher ration				
		T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Yellow maize	6.27	275.88	275.88	275.88	275.88	275.88	332.31	323.31	323.31	323.31	323.31
Rice polish	4.59	45.90	55.08	55.08	55.08	55.08	55.08	55.08	50.49	50.49	50.49
Groundnut cake (exp.)	10.33	175.60	175.60	175.60	175.60	175.60	123.96	144.62	144.62	144.62	144.62
Soy bean meal	8.87	133.05	177.40	177.40	177.40	177.40	88.70	133.05	133.05	133.05	133.05
Unsalted dried fish	12.60	88.20	-	-	-	-	75.60	0	0	0	0
Gingelly oil cake	12.14	60.70	60.70	60.70	60.70	60.70	60.70	60.70	60.70	60.70	60.70
Common salt	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Mineral mixture	25.15	44.01	44.01	44.01	44.01	44.01	44.01	44.01	44.01	44.01	44.01
Vitamin mixture	600.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Lysine hydrochloride	185.00	9.20	18.40	18.40	18.40	18.40	9.20	18.40	18.40	18.40	18.40
D.L. methionine	340.00	-	102.00	0	0	0	0	102.00	0	0	0
Choline chloride	70.00	3.50	3.50	3.50	3.50	3.5	2.10	2.10	2.10	2.10	2.10
Coccidiostat	350.00	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
Sodium sulphate	417.00	-	-	83.4	125	166.80	0	0	83.40	125.00	166.80
Total cost / 100 kg		852.60	931.20	914.20	955.20	998.20	806.90	893.93	875.33	916.20	958.2
Cost / kg feed		8.52	9.31	9.14	9.55	9.98	8.06	8.93	8.75	9.16	9.58

Table 19. Cost benefit analysis per bird for the different treatment groups at the end of sixth and eighth week of the experiment

Particulars	0 - 6 weeks					0 - 8 weeks				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Body weight (g)	1839.52	1778.81	1781.19	1808.10	1794.05	2527.14	2435.48	2443.59	2490.00	2422.38
Feed consumption/ bird (g)	3256.60	3463.90	3190.00	3324.00	3312.38	5688.07	5911.81	5641.79	5739.79	5608.16
Feed cost/ bird	27.70	32.20	29.15	31.70	33.03	45.67	54.07	50.32	53.86	55.00
Cost (Rs/ bird)	43.77	48.20	45.15	47.70	49.03	61.67	70.07	66.32	69.86	71.00
Return from sale of birds (Rs)	64.36	62.23	62.30	63.28	62.65	88.55	85.05	85.51	87.15	84.70
Net profit/ bird (Rs)	20.59	14.10	17.15	15.58	13.62	26.88	14.98	19.19	17.29	13.70
Net profit/ kg body weight (Rs)	11.25	7.92	9.63	8.61	7.60	10.66	6.13	7.86	6.94	5.60

DISCUSSION

DISCUSSION

The results obtained in the study to evaluate the effect of supplementation of sodium sulphate in the diets devoid of animal protein sources on the production performance of broilers are discussed in this chapter.

Meteorological parameters

The data pertaining to microclimate inside the experimental house are presented in Table 4. During the course of the experiment from May to June 2000, the mean maximum temperature recorded ranged from 29.57 to 34.57°C with an average of 32.23°C. The mean minimum temperature ranged from 22.14 to 25.41°C with an average of 24.08°C. The mean relative humidity ranged from 74.40 to 80.70 per cent in the morning and 50.43 to 55.29 per cent in the evening during the experimental period. The mean maximum and minimum temperature as well as the mean relative humidity in the morning and evening during the course of the experiment are similar in trend to that reported by Geo (1992). The data obtained in this study therefore indicated that maximum temperature were within the stress level as reported by Reece and Lott (1983). The addition of sodium sulphate or methionine to all vegetable diet did not have any additional stress effect as evidenced by performance of broilers.

Body weight

The data on mean body weight recorded at fortnightly intervals for the five different dietary treatments is presented in Table 5. Statistical analysis of the fortnightly data on body weight revealed significant difference only in the fourth fortnight. The apparent increase in body weight from first fortnight to fourth fortnight in sodium sulphate supplemented group compared to methionine supplemented group indicate that broilers use sodium sulphate effectively for body weight gain. Inclusion of sodium sulphate did not affect the body weights upto six weeks of age in the present study. Significant improvement in body weight upto five weeks of age with sodium sulphate supplementation in broilers was reported by Bornstein and Plavnik (1977).

At eighth week of age birds fed control diet (T1) recorded significantly ($P<0.05$) higher body weight (2527.14 g) than T2, T3 and T5 but it was statistically similar to T4. Group containing 0.3 per cent sodium sulphate (T4) was statistically similar to T2, T3 and T5 indicating that 0.3 per cent methionine supplementation or 0.2 and 0.4 per cent sodium sulphate in vegetable protein diet has no deleterious effects on the body weight as the broilers performed equally well in all treatment groups. Results of the study revealed that broilers can meet part of its sulphur requirement from inorganic sulphate. This finding is in agreement with the observations of Gordon and Sizer (1955), who reported addition of 0.5 per cent sodium sulphate resulted in increased weight gain in chicks at five weeks of age. Bharadwaj *et al.* (1999) reported that supplementation of sodium sulphate in all vegetable protein diet was beneficial in promoting growth of pullets. Positive growth response in chicks were reported when sodium sulphate was added in ration by Ross and Harms (1972), Soares *et al* (1974), Bornstein and Plavnik (1977), Plavnik and Bornstein (1978), Scott *et al.* (1982), and Yadav *et al.* (1990). Miles *et al.* (1983) reported that supplementation of the basal diet with inorganic sulphate alone resulted in a significant growth depression at two weeks of age and a numerical depression at three weeks of age.

Body weight gain

The data on mean body weight gain in broilers fed with five different dietary treatments, recorded at fortnightly intervals is presented in Table 7. Statistical analysis of the data did not reveal any significant difference between treatments. Results of the study revealed that methionine or inorganic sodium sulphate can replace unsalted dried fish in all vegetable broiler ration.

Analysis of data on cumulative body weight gain at six weeks of age did not reveal any significant difference between treatments, even though the group fed with control diet (T1) recorded numerically higher value. This finding corroborates with the findings of Yadav *et al.* (1994) who reported comparable body weight gains in 0.3 per cent sodium sulphate supplemented and fish meal included diets in egg type chicks. Non-significant effect on weight gain till five weeks of age, in broilers was reported by Van Weerden *et al.* (1976) when 0.1 per cent sodium sulphate was added to the basal diet.

It could be seen from the results that the cumulative body weight gain differed significantly at eight weeks of age and followed the same trend as body weight at this age. The group fed with control diet (T1) and diet with 0.3 per cent sodium sulphate (T4) recorded significantly ($P<0.05$) higher body weight gain than the rest of the groups. But the group T4 was statistically comparable to T2, T3 and T5 indicating that addition of methionine or sodium sulphate to all vegetable protein ration does not have any detrimental effect with regard to this parameter. This finding is in agreement with the findings of Bharadwaj *et al.* (1999), who supplemented 0.1 per cent sodium sulphate in diets of pullets of 12 weeks of age and found that body weight gain was similar to that fed with control diet.

Ross *et al.* (1972) reported consistent increase in weight gain in broiler chicks when the methionine deficient diet low in sulphate was supplemented with 0.08 to 0.32 per cent sulphate in the presence of methionine. Likewise, Van Weerden *et al.* (1976) reported that the addition of 0.1 per cent sodium sulphate to the basal diet and methionine supplemented diet resulted in an increase in weight gain in broilers. Scott *et al.* (1982) also reported that addition of inorganic sodium or potassium sulphate in practical diets have small positive influence on weight gain in chicks. Contrary to the present findings, Hikami *et al.* (1988) reported decrease in body weight gain in a ration high in sulphur amino acids supplemented with inorganic sulphate.

The trend in body weight gain in general was of normal pattern and was similar to that reported by AmrithaViswanath (1992) and Sini (1999). Highest body weight gain was recorded during 5-6 weeks of age and there after decrease in body weight gain during 7-8 weeks of age. Based on the results obtained in the present study it can be concluded that inorganic sodium sulphate or methionine can replace fish meal in the broiler rations.

Feed intake

Data on mean daily feed consumption (g/bird/day) of broilers in different dietary treatment groups (Table 9) revealed that there is significant difference in feed consumption during first and third fortnight period. Mean daily feed consumption did not differ significantly during second and fourth fortnight period. During the first fortnight, broilers fed with control ration (T1) and that fed with all vegetable protein diet with 0.2 per cent sodium sulphate (T3) showed significantly ($P<0.05$) higher feed consumption than T2, T4 and T5. The mean daily feed intake of broilers fed with vegetable protein diet containing 0.4 per cent sodium sulphate (T5) was significantly lower during this period, but was statistically similar to T2 and T4.

Analysis of data on mean daily feed consumption of broilers fed different diets during second fortnight did not reveal significant difference between treatments. This is in agreement with the findings of Bharadwaj *et al.* (1999). They reported non-significant difference in feed consumption when fish meal was completely replaced by all vegetable protein diet supplemented with 0.1 per cent sodium sulphate alone or with choline or cow dung in the diet of growing pullets.

During the third fortnight mean daily feed consumption of broilers fed vegetable protein diet containing 0.3 per cent methionine (T2) was significantly ($P<0.05$) higher than other treatment groups. This finding is in contrary to the findings of Waldroup *et al.* (1976) who reported non-significant difference in feed consumption in relation to the amino acid status of the diet of broilers. The higher feed consumption obtained in broilers fed all vegetable protein diet supplemented with 0.3 per cent methionine (T2) is difficult to explain and need further investigation. Broilers fed with all vegetable protein diet supplemented with 0.2 per cent sodium sulphate (T3) recorded significantly lower feed consumption and is statistically comparable to control group (T1) and T4. Group fed all vegetable diet with 0.3 per cent sodium sulphate (T4) did not differ significantly from T5 and T1 indicating that inorganic sulphate included in the ration did not have any deleterious effect on feed consumption. Thus the present study revealed that feed intake in control group was comparable with all other groups except methionine supplemented group. Statistical analysis of the data on feed consumption during fourth fortnight did not reveal any significant difference between treatments. This findings agreed with the findings of Damron and Harms (1973) and Bharadwaj *et al.* (1999). Contrary to the present findings Miles *et al.* (1986) reported numerical increase in feed consumption when inorganic sulphate was supplemented with corn-soybean meal in layers.

Cumulative feed consumption up to six weeks of age revealed significant difference between treatments. Broilers fed with 0.2 per cent sodium sulphate in all vegetable protein ration (T3) revealed significantly ($P<0.05$) lower feed consumption, but it was statistically similar to control (T1) diet. Groups fed with control ration (T1) was statistically similar to T4 and T5. Broilers fed with all vegetable ration with 0.3 per cent methionine (T2) recorded significantly higher feed consumption. Contrary to the present findings Plavnik and Bornstein (1978) reported decreased feed consumption in broilers by the addition of synthetic methionine or sodium sulphate in broiler finisher diets.

The cumulative feed consumption up to eight weeks of age did not reveal any significant difference between treatment groups. Similar findings were reported by Damron and Harms (1973) and Bharadwaj *et al.* (1999). Potter and Shelton (1984) also reported non-significant difference in feed consumption when 0.5 per cent sodium sulphate was added to the diets of turkey poults of seven to eight weeks of age. Contrary to the present findings Miles *et al.* (1986) could notice numerical increase in feed consumption in broilers when inorganic sulphate was supplemented with diet.

Feed consumption data revealed that feed intake of broilers reared in all vegetable protein diet with methionine or sodium sulphate did not affect feed intake. This is due to the fact that feed consumption in broilers is related to the energy level of the ration and the dietary treatments used in this study were isocaloric and isonitrogenous.

Feed efficiency

Feed efficiency calculated based on kilograms of feed consumed per kilogram body weight at fortnightly intervals for five treatment groups are presented in Table 11. During the first fortnight period, significantly better feed efficiency (1.19) was noticed in broilers fed with 0.4 per cent sodium sulphate (T5). The reason for this might be due to the significantly lower daily feed consumption for this group recorded during the first fortnight period. Ross *et al.* (1972) and Potter and Shelton (1984) reported that addition of sodium sulphate improved feed efficiency. Sadagopan *et al.* (1993) reported non-significant difference in feed efficiency when vegetable protein diet was supplemented with lysine and methionine compared to fish meal ration.

During third and fourth week period, statistical analysis of the data on feed efficiency revealed non significant difference between treatment groups. During five to six weeks of age feed efficiency were 2.23, 2.55, 2.22, 2.31 and 2.42 for T1, T2, T3, T4 and T5 respectively. Significantly inferior feed efficiency recorded in T2 might be due to the higher mean daily feed consumption recorded in this group during the period. Birds fed with 0.2 per cent sodium sulphate (T3) and 0.3 per cent sodium sulphate (T4) were statistically comparable with birds fed with control ration (T1). Significant improvement in feed efficiency in broiler chicks fed with 0.2 per cent sodium sulphate was also recorded by Hinton and Harms (1972). Blackman and Waldroup (1980) also reported significant improvement in feed efficiency in broilers supplemented with sodium sulphate. Even though the feed efficiency recorded for the group fed with all vegetable protein ration supplemented with 0.4 per cent sodium sulphate (T5) was statistically comparable to T2, it was not significantly different from T4 (birds fed with 0.3 per cent sodium sulphate).

During the fourth fortnight period mean feed efficiency recorded did not reveal significant difference between treatment groups. This agreed with the findings of Hikami *et al.* (1988), who reported that feed efficiency was not affected either with the addition of 0.8 per cent sodium sulphate or with the addition of sulphur amino acids. Contrary to the present findings Jensen *et al.* (1989) and Harms *et al.*

(1990) reported significant improvement in feed efficiency in birds fed with 0.71 per cent methionine. The lower feed efficiency recorded during fourth fortnight may be due to lower body weight gain recorded during the period.

Cumulative feed efficiency recorded at the end of six weeks showed significant difference between treatment groups. Group fed with 0.3 per cent methionine (T2) recorded significantly lower feed efficiency when compared to T1, T3, T4 and T5. The lower feed efficiency recorded for the group fed with all vegetable diet with methionine (T2) is due to its significantly ($P<0.05$) higher feed consumption recorded for this group. Improvement in feed efficiency when diet supplemented with sodium sulphate was reported by Gordon and Sizer (1955), Ross and Harms (1970), Ross *et al.* (1972), Hinton and Harms (1972) and Van Weerden *et al.* (1976). Contrary to this finding Hikami *et al.* (1988) reported that addition of sodium sulphate in the diet of chicks did not affect feed efficiency. Harms *et al.* (1990) reported significant improvement in feed efficiency by the addition of sodium sulphate to the basal diet.

Cumulative feed efficiency at the end of eight weeks were 2.29, 2.47, 2.34, 2.35 and 2.36 for treatments T1 to T5 respectively. Statistical analysis of the data did not reveal any significant difference between treatments indicating that sodium sulphate or methionine can replace unsalted dried fish in broiler diets without affecting feed efficiency.

Sadagopan *et al.* (1993) reported non-significant difference in feed efficiency in methionine supplemented all vegetable protein ration compared to control ration with fish meal in broilers. Damron and Harms (1973) and Kadirvel and Kothandaraman (1978) also reported that supplementation of sodium sulphate in layers did not influence feed efficiency.

Contrary to the present findings Van Weerden *et al.* (1976) reported reduction in feed conversion efficiency when 0.1 per cent sodium sulphate was added to the basal and methionine supplemented diets in broilers.

Processing yields and losses

The processing yields and losses recorded at the end of eight weeks of age are given in the Table 13. The blood loss ranged from 3.12 to 3.57 per cent and feather loss from 4.62 to 4.74 per cent. The mean dressed weight, the eviscerated yield, giblet yield and ready-to-cook yield were 86.04, 63.31, 6.37 and 70.08 respectively. Statistical analysis of the data did not reveal any significant difference between treatment groups. Skinner *et al* (1991) reported that dietary amino acid levels had little effect on dressing percentage and abdominal fat of female broilers. Rejikumar (1991), reported per cent ready-to-cook yield of 72.76 with mean blood loss of 3.42 per cent and feather loss of 3.06 per cent in broilers at eight weeks of age. Sini (1999) reported, blood loss of 3.56, feather loss of 4.13, and ready-to-cook yield of 75.72 per cent. The present findings corroborates with that of the above studies. The present study also revealed that the supplementation of sodium sulphate did not influence processing yields and losses in broilers.

Serum protein

Haematological studies conducted at the end of eight weeks showed that the serum protein levels ranged from 4.40 to 4.97 gram per cent. Statistical analysis of the data did not reveal any significant difference between treatment groups. Sturkie (1976) and Singh *et al.* (1992) reported that the normal serum protein value in chicken blood was 3.6 and 3.27 gram per cent respectively. Darshan *et al.* (1987) reported plasma protein value of 3.76 g /100 ml in male and 4.50 g/100 ml in female broiler parents. The present findings are in close agreement with that of above values. The present study revealed that supplementation of sodium sulphate has no significant effect on the serum protein content of blood.

Haemoglobin

The haemoglobin content of blood estimated at the end of eight weeks period ranged from 10.58 to 11.62 g/dl. Different dietary treatments have statistically comparable haemoglobin levels. Sturkie (1976), Singh *et al.* (1992) and Bounous and Stedman. (2000) reported the haemoglobin content of chicken blood as 9.7, 11.62

and 7 to 13 mg/dl respectively. The haemoglobin content of blood estimated in this study were within the normal range and did not differ significantly between treatment groups. This indicated that the supplementation of sodium sulphate did not influence the haemoglobin content in blood.

Livability

The percentage livability for different treatment groups at the end of the experimental period are given in Table 17. The per cent livability for T1, T2, T3, T4 and T5 were 95.24, 95.24, 97.62, 97.62 and 97.62 respectively with a mean value of 96.67. Necropsy findings revealed that birds died due to Airsacculitis (3 numbers), Hepatosis (1 number), pericarditis (1 number) and pulmonary congestion (1 number). The lesion did not show any signs attributable to treatment effect. Thus it is evident that sodium sulphate did not have any detrimental effect on the physiological well being of broilers. The results of the experiment agreed with that of Bharadwaj *et al.* (1999). They reported that addition of sodium sulphate did not affect livability of growing pullets. Results of the present study revealed that supplementation of methionine or sodium sulphate in the diet of broilers did not have any deleterious effect on the livability. The per cent livability recorded in the present study is within the normal range for broilers.

Economics

The cost of different rations used in the study was calculated to assess the cost benefit particulars of sodium sulphate supplementation (Table 18). Cost of rations computed for different treatments viz., T1, T2, T3, T4 and T5 were Rs. 8.52, 9.31, 9.14, 9.55 and 9.98 per kilogram for starter ration and Rs. 8.06, 8.93, 8.75, 9.16 and 9.58 per kilogram for finisher rations respectively. The higher cost of the feed for T4 and T5 was due to the high cost of sodium sulphate. Net profit per kilogram body weight for T1, T2, T3, T4 and T5 were Rs. 11.25, 7.92, 9.63, 8.61 and 7.60 respectively at sixth week and Rs. 10.66, 6.13, 7.86, 6.94 and 5.60 at eighth week of age.

Among the treatment groups, control diet (T1) was the cheapest with Rs. 8.52 / kg starter and Rs. 8.06 /kg finisher, followed by diet supplemented with 0.2 per cent sodium sulphate (T3). Higher levels of inclusion of sodium sulphate increased the cost of ration due to the higher rate of sodium sulphate prevalent in the market at the time of study. The diet supplemented with 0.3 per cent methionine recorded higher cost compared to control diet and diet supplemented with 0.2 per cent sodium sulphate. But compared to methionine supplemented diet, 0.3 and 0.4 per cent sodium sulphate supplemented diets were costlier.

Based on the above findings, it can be concluded that supplementation of sodium sulphate at 0.2, 0.3 and 0.4 per cent levels in all vegetable protein diet replacing fish meal has no deleterious effect in the performance of broilers. On the economic consideration about which a farmer is more concerned with, sodium sulphate can be included in the broiler starter and finisher ration at 0.2 per cent level replacing unsalted dried fish.

SUMMARY

SUMMARY

An investigation was carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to evaluate the effect of supplementation of sodium sulphate in broiler diets devoid of animal protein sources.

Two hundred and ten, one-day old straight-run commercial broiler chicks (Cobb) were used for the study. These chicks were wing banded, weighed individually and allotted randomly to five different treatment groups. Each treatment group consisted of three replicates of fourteen birds each. Standard routine managemental practices were followed throughout the experimental period. Feed and water were provided *ad libitum*. The dietary treatments consisted of a standard broiler ration prepared using unsalted dried fish as animal protein source and is used as control diet (T1). All vegetable protein diet (T2) was prepared using soybean meal, ground nut cake and gingelly oil cake as protein sources with the addition of 300 g DL-methionine in every 100 kg diet. Other experimental diets were prepared using same

vegetable protein sources mentioned above with the addition of anhydrous sodium sulphate at the levels of 200 g (T3), 300 g (T4) and 400 g (T5) in every 100 kg diet. All the rations were formulated as per BIS (1992) specifications of nutrients for broiler chicken. The chicks were provided with broiler starter ration up to six weeks of age and thereafter broiler finisher ration up to eight weeks of age.

The production performance of the birds were recorded for a period of eight weeks. The following observations were recorded during the experimental period and the effect of supplementation of sodium sulphate was evaluated.

The body weight, body weight gain, feed intake and feed efficiency were recorded at fortnightly intervals and processing yields and losses, total serum protein and haemoglobin content of blood at the end of eight weeks of age were also recorded. Livability and cost-benefit analysis due to supplementation of sodium sulphate were also ascertained.

The results obtained during the course of the study are summarized in Table 20. Based on the results of this study following conclusions were made.

1. The mean fortnightly body weight of broilers recorded at sixth week of age did not reveal any significant difference between dietary treatments, while that recorded at eighth week of age revealed significant ($P<0.05$) difference between dietary treatments. Broilers fed control diet (T1) recorded significantly ($P<0.05$) higher body weight than T2, T3 and T5, but it was statistically similar to T4. Group fed with all vegetable protein diet with 0.3 per cent sodium sulphate (T4) and was statistically comparable to T2, T3 and T5 indicating that body weights were not affected by either sodium sulphate or methionine supplementation in all vegetable protein diet.

2. The fortnightly body weight gain were not influenced by the dietary treatments at sixth and eighth weeks of age. But cumulative body weight gain at eighth week of age showed significant difference ($P<0.01$)

between treatments as in the case of mean body weight recorded at eight weeks of age.

3. Analysis of data on cumulative feed consumption (g / bird / day) at sixth week of age indicated significant differences ($P<0.05$) between dietary treatments. Broilers fed with vegetable protein diet supplemented with methionine (T2) consumed significantly more feed compared to all other treatment groups. Feed intake of T1, T4 and T5 were statistically comparable. Feed intake of birds in the group fed diet with 0.2 per cent sodium sulphate (T3) was the lowest and was statistically comparable with control group (T1). Cumulative feed consumption up to eight weeks of age was not affected by either sodium sulphate or methionine supplementation.

4. The data on mean cumulative feed efficiency of broilers at sixth week of age showed significant ($P<0.05$) difference between treatments. The group fed with control diet (T1) and groups fed all vegetable protein diet with 0.2 per cent (T3), 0.3 per cent (T4) and 0.4 per cent (T5) sodium sulphate registered significantly better feed efficiency when compared to all vegetable protein diet supplemented

with methionine (T2). Statistical analysis of the data on cumulative feed efficiency up to eight weeks of age did not reveal any significant difference between dietary treatments indicating that feed efficiency was not affected by supplementation of methionine or sodium sulphate.

5. Data on processing yields and losses viz. blood loss, feather loss, eviscerated yield, giblet yield and ready-to-cook yield were not significantly affected by different dietary treatments.

6. Analysis of the data on total serum protein and haemoglobin content revealed that these parameters were not influenced by dietary treatments.

7. Weekly per cent mortality was not influenced by different dietary treatments. The livability was within the normal range for broilers.

8. Cost-benefit analysis revealed that net profit per bird was highest in group fed standard broiler ration (T1) and least in group supplemented with 0.4 per cent sodium sulphate (T5). Among the sodium sulphate supplemented groups T3 was more economical

than T4 ant T5 both during sixth and eighth weeks of age.

9. The mean maximum temperature during the experimental period inside the experimental house ranged from 29.57 to 34.57°C and the mean minimum temperature ranged from 22.14 to 25.41°C. The relative humidity ranged from 74.48 to 80.70 at 8 a.m. and 50.43 to 55.29 per cent at 2 p.m.

Based on the above findings it can be inferred that supplementation of sodium sulphate at the levels of 0.2, 0.3 and 0.4 per cent have no deleterious effect in all vegetable broiler ration. Incorporation of sodium sulphate in all vegetable protein ration appears to provide sulphur for the synthesis of sulphur containing amino acids, which other wise would have bean provided by fish. Thus it can be concluded that sodium sulphate or methionine can be supplemented effectively in vegetable protein diets replacing fish or fish meal.

Table 20. Effect of supplementation of sodium sulphate on the performance of broilers

No	Particulars		T1	T2	T3	T4	T5
1	Body weight	6^{th} week	1839.52	1778.81	1781.19	1808.10	1794.05
		8^{th} week*	2527.14^{a}	2435.48^{b}	2443.60^{b}	2490.00^{ab}	2422.38^{b}
2	Feed efficiency	6^{th} week*	1.81^{a}	1.99^{b}	1.88^{a}	1.88^{a}	1.89^{a}
		8^{th} week	2.29	2.47	2.34	2.35	2.36
3	Ready-to-cook yield (%)		71.27	69.31	69.29	70.35	70.18
4	Total serum protein (g%)		4.97	4.63	4.63	4.40	4.53
5	Haemoglobin (g%)		10.60	10.58	11.60	11.22	10.62
6	Livability (%)		95.24	95.24	97.62	97.62	97.62
7	Cost benefit analysis	a) Cost of feeding (Rs/kg)	8.06	8.93	8.75	9.16	9.58
		b) Net profit per kg body weight at 6^{th} week (Rs.)	11.25	7.92	9.63	8.61	7.60
		c) Net profit per kg body weight at 8^{th} week (Rs.)	10.66	6.13	7.86	6.94	5.60

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EFFECT OF SODIUM SULPHATE SUPPLEMENTATION IN BROILER DIET

By

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ABSTRACT OF A THESIS

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ABSTRACT

An investigation was carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to evaluate the effect of supplementation of sodium sulphate in broiler diets devoid of animal protein sources. Two hundred and ten, one-day old straight-run commercial broiler chicks were reared for a period of eight weeks under five different dietary treatments. The dietary treatments consisted of control ration (T1) prepared using unsalted dried fish as animal protein source, all vegetable protein diets with the addition of 300 g DL- methionine (T2), anhydrous sodium sulphate at the levels of 200 g (T3), 300 g (T4) and 400 g (T5) in every 100 kg diet. All the rations were formulated as per BIS (1992) specification of nutrients for broiler chicken. Soybean meal, ground nut cake and gingelly oil cake were used as protein sources in all vegetable protein diet. The chicks were fed with starter diets upto six weeks of age and there after finisher diet up to eight weeks of age. Except for the difference in feed, all the management practices followed were uniform for the different treatment groups. Body weight, body weight gain, feed

intake and feed efficiency were recorded at fortnightly intervals. At the end of eighth week processing yields and losses, total serum protein and haemoglobin content of blood were recorded. Cost benefit analysis were ascertained for different dietary treatment groups at sixth and eighth weeks of age.

Results of the study revealed that the mean cumulative body weight of broiler recorded at sixth week of age did not reveal any significant difference between dietary treatments. But body weight recorded at eighth week of age revealed significant difference ($P<0.05$) between dietary treatments. Broilers fed with control diet (T1) recorded the highest ($P<0.05$) body weight but is statistically comparable to group fed with 0.3 per cent sodium sulphate (T4). Broilers fed all vegetable protein diet with 0.4 per cent sodium sulphate (T4) is statistically comparable to T2, T3 and T5. Similar trend was followed in body weight gain also. Feed intake of broilers in the group fed with 0.2 per cent sodium sulphate (T3) was the lowest and was statistically comparable to control group (T1). Broilers fed with all vegetable protein diet supplemented with methionine (T2) recorded significantly higher feed consumption. The cumulative feed consumption upto eight weeks of age was not affected by either sodium sulphate or methionine supplementation. Mean cumulative feed efficiency at sixth week of age recorded significant ($P<0.05$) difference between treatments. Broilers fed control diet and sodium sulphate supplemented diet recorded better feed efficiency when compared to all vegetable protein diet supplemented with methionine (T2). At eighth week of age cumulative feed efficiency was not affected by supplementation of either sodium sulphate or methionine. Processing yields or losses were not affected by different dietary treatments. Haemoglobin and serum protein were not influenced by dietary treatments. Mortality pattern showed no difference among the five dietary treatment groups. All vegetable protein rations prepared with the addition of either methionine or sodium sulphate had higher price when compared to control ration. Based on this study it was summarized that supplementation of methionine or sodium sulphate in all vegetable protein diet has no deleterious effects on the performance of broilers. Moreover it was revealed that sodium sulphate can be added at 0.2 per cent level in the broiler starter and finisher vegetable protein ration when good quality fish is not available.