REQUIREMENTS OF PROTEIN AND ENERGY FOR BROILERS DURING SUMMER SEASON

By

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DECLARATION

I hereby declare that this thesis entitled **REQUIREMENTS OF PROTEIN AND ENERGY FOR BROILERS DURING SUMMER SEASON** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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Introduction

INTRODUCTION

Poultry farming has emerged as an important agribusiness by itself for operation in commercial scale and, as a means of generating self employment. Eventhough during the earlier part of its growth, the progress was essentially in the layer sector, recently broiler chicken production has shown a faster rate of growth than layers throughout our country. The broiler production which was only four million in 1971, rose to 168 million in 1988 and is expected to reach a level of 1200 million by the turn of this century (Chatterjee and Acharya, 1990). This phenomenal growth in broiler chicken production is because of its low cost, better quality of meat with low fat content and superior protein.

According to a study made in 15 states of India in 1983 by the United States Agency for International Development (USAID), over 60-70 per cent of the population consume less than the minimum requirement of protein and calories. In India the per-capita availability of poultry meat in 1987 was 309 g, whereas it was 15.6 kg in developed countries and the world average is 5.9 kg (Anon., 1990). The National Institute of Nutrition recommends per-capita consumption of 10.8 kg of meat per annum. To meet a conservative consumption of two broilers a month by only 20 per cent of the population in the next five years, annual production should reach 450 million broilers in 1994-'95 (Anon., 1990). Kerala occupies only thirteenth place in the broiler map of India, with a broiler population of 1.5 million which accounted only for two per cent production in 1985.

Biologists have long recognized that the climatic environment has a profound effect on growth, reproduction and other functions of both plants and animals. It is widely accepted that the average performance of livestock of tropical areas remains much lower than those of temperate zones (Mc Dowell, 1972). The region of tropical climate has been designated as the area lying between tropic of Cancer and tropic of Capricorn. India, located in the northern hemisphere extends between latitude 8°4' and 37°6' north and longitude 68°7' and 97°25' east. The climate in this region is described as tropical monsoon type (Anon., 1975).

The seasons in India have been classified (ICAR, 1977) into winter (October to February), summer (March to June) and rainy (July to September). In South India no distinct winter season prevails and there are two wet periods and a distinct dry season (Nair, 1973). Somanathan (1980) classified the climate at Mannuthy (latitude 10°32"N, longitude 76°16"E and altitude 22.25 M above MSL) as cold and wet (June to August), warm and wet (May and September to November), warm and dry (December and January) and hot and dry (February to April). At Mannuthy, the highest temperature of 35.99°C was recorded during March and lowest temperature of 20.76°C during January with a mean maximum temperature of 31.67°C and mean minimum temperature of 23.56°C. The relative humidity varies from 58.51 per cent during February to 84.60 per cent in September with a mean value of 73.99 per cent (Xavier, 1981). The prevailing ambient temperature and humidity in this region therefore impose stress on animals and birds.

Broiler farmers of Kerala predominantly belong to the smaller and marginal category. Therefore, any reduction in efficiency of feed utilisation will adversely affect their margin of profit and may even result in throwing them out of their business.

Many attempts have been made to overcome the growth depression associated with heat stress and several possible nutritional solutions have been recommended with inconsistent results. Most attempts dealing with these problems have centered around the merits of feeding diets with low heat increment or increased amino acid concentration.

In view of the inconsistent results reported in the literature and the importance of research of this nature especially under Kerala situation, the study was planned to assess the requirements of protein and energy for broilers during the summer season in the hot and humid climatic environment of Kerala.

Review of Literature

REVIEW OF LITERATURE

Dietary Protein and Energy Requirement for Broilers

The faster growth of broilers is the result of accelerated rate of protein synthesis in the body. This depends on feed intake and composition of feed. Environmental temperature is an important factor deciding feed intake. Various studies conducted over the past two decades revealed that growth rate and body weight gain could be improved if diets were formulated to contain higher levels of nutrients especially protein and energy.

The following is an attempt to review the researches conducted both in India and abroad. The requirements of protein and energy for broilers as reported by various authors are presented in Table 1 and 2.

Hill and Dansky (1950) reported no improvement in growth of cross bred chicks upto seven weeks of age by increasing the protein level above 20 per cent in a diet of relatively high productive energy content.

Hill and Dansky (1954) studied the energy requirement of chicken and found that maximum growth rate measured by body weight and shank length was obtained with a ration containing 623 calories of productive energy per pound.

They also reported that the quantity of feed consumed was determined primarily by the energy level of the ration and not by the protein level.

Sunde (1956) studied the influence of two levels of protein, viz., 20 and 28 per cent with energy levels of 655, 730, 771, 806, 845 and 932 productive calories per pound and reported that a high protein low energy diet caused a reduction in the growth rate and a reduced efficiency of feed utilization. He further observed that raising the energy level by the addition of fat increased the weight of the chicks and also improved the feed utilization.

Donaldson et al. (1956) reported that productive energy level of the ration was found to influence the protein level required in the ration. They also reported that a highly significant positive correlation existed between the calorie-protein ratio of the diet and fat content of the carcass.

Spring and Wilkinson (1957) found that at two weeks of age the diet had no effect on weight gain. But at eight weeks of age increasing dietary energy caused increased weight gain. They also reported that increasing dietary protein from 22 to 28 per cent had no effect on weight gain.

Essary <u>et al</u>. (1964) studied the influence of feeding two levels of protein and energy in broiler ration upto 12 weeks and found that birds fed with 22 per cent protein upto six weeks and 18 per cent protein upto 12 weeks showed better performance with regard to live weight, feed conversion and dressing percentage.

Essary <u>et al</u>. (1965) studied the influence of different levels of fat and protein in broiler diets by feeding 15 different rations containing C:P ratio ranging from 35.7 to 50.1. They found that different levels of protein and fat significantly influenced live weight.

Payne and Lewis (1966) reported that either increasing the supply of protein or energy yielding nutrients in the starter diets improved the overall growth performance.

Wells (1968) opined that dietary energy governed the food intake of chicks. Growth rate of chicks upto seven weeks of age fed the highest energy diet (1477 Kcal/lb) was significantly better than those fed the low (1278 Kcal/lb) and medium energy (1354 Kcal/lb) diet. He also noticed that total feed consumption values showed a tendency to decrease as metabolizable energy levels increased. Highly significant differences in feed conversion were noticed among three groups.

Kelly and Potter (1971) fed broilers of 0-4 weeks of age with a diet containing 27 per cent protein and 22 per cent protein from 6-8 weeks of age and observed that they were 11.7 per cent heavier and had 9 per cent better feed efficiency than those fed a diet containing 22 per cent protein.

Rao *et al*. (1973) studied the optimum protein and energy requirement of different broiler breeds. They found that different protein levels significantly influenced the body weights at eight weeks of age. An increase in protein level from 18 to 26 per cent during the starter phase resulted in corresponding increase in body weights. Body weight of 26 per cent protein fed group was more than that of 22 per cent group. Group fed with 18 per cent protein was significantly lower in body weight in all breeds. The feed efficiency of 26 per cent protein level group was superior than 18 and 22 per cent level groups.

Bartov *et al*.(1974) reported that rearing broilers on diets containing protein levels slightly above or below the accepted optimum did not affect growth rate.

Waldroup *et al*. (1976) reported that nutrient density significantly influenced body weight gains in broilers. They noticed that increase in nutrient density reduced the total amount of feed consumed ie. increasing energy levels from 2970 to 3740 Kcal ME/kg resulted in 3.8 per cent reduction in total feed intake. Feed:gain ratio was improved in response to increased nutrient density.

Fuller (1976) reported that reducing protein level by one per cent per week from 24 per cent in the first week to 17 per cent in the eighth week and increasing energy levels from 3070 to 3330 Kcal ME/kg did not affect the performance of broilers.

Knestrick and Yacowitz (1976) found that one per cent additional protein added to a control ration containing 24, 22.8 and 20.8 per cent protein in starter, finisher and withdrawal diets significantly improved feed conversion without affecting body weights at a temperature range of 24 and 32.5°C. They recommended an energy level of 1475-1525 Kcal/lb. Addition of 25 calories/lb did not significantly improve conversion.

Protein requirement of pure bred broilers was reported by Gowda *et al*. (1976), by feeding four levels of protein viz., 15, 18, 21 and 24 per cent in an isocaloric diet (3000 Kcal ME/kg) upto 6 weeks. They found that with the increase in protein levels from 15 to 24 per cent, a significant increase in weight gain and feed efficiency was observed. The protein requirement for optimum growth and feed efficiency as reported by them was around 24 per cent for White Plymouth Rock, White Cornish and New Hampshire.

Scott et al. (1976) reported that protein requirements of broiler chicken depends on energy content of the diet. As the energy content of the ration increased, protein requirement increased in both starter and finisher rations.

Saxena and Singh (1976) raised broilers in three planes of nutrition ie. 20, 22 and 26 per cent protein in the pre-starter (0-3 weeks) phase and found that high plane of nutrition in the pre-starter phase did not result in any specific advantage and reasoned that chicken were capable of compensating for the low plane diets by an increase in their feed consumption.

Studies were conducted to determine the levels of dietary protein needed for optimum body weights and feed efficiency in three pure bred broiler chicks from day old to eight weeks of age (Johri, 1977). A protein level of

22 per cent for New Hampshire and White Cornish and 26 per cent for White Plymouth Rock satisfied the requirement for growth and feed utilisation. He found that feed efficiency of purebred broiler chicks increased as dietary protein levels increased.

Bureau of Indian Standards (ISI, 1977) has recommended 22 per cent crude protein with 2900 Kcal ME/kg for starter period and 19 per cent crude protein with 3000 Kcal ME/kg for finisher period in broiler rations.

Broilers fed starter diet containing 3080 Kcal ME/kg with 24 per cent protein and finisher diet containing 3135 Kcal ME/kg with 22 per cent protein had significantly lesser body weights and feed conversion efficiency than did broilers fed starter diets containing 3160 Kcal ME/kg with 24.8 per cent protein, 3300 Kcal ME/kg with 25.6 per cent protein and 3410 Kcal ME/kg with 26.4 per cent protein followed by finisher diet containing 3245 Kcal ME/kg with 22.8 per cent protein, 3355 Kcal ME/kg with 23.6 per cent protein and 3465 Kcal ME/kg with 24.4 per cent protein (Cherry et al., 1978).

Moran Jr. (1978) fed commercial sexed broilers with a ration containing 24 per cent crude protein with 3100 Kcal

ME/kg for 0-2 weeks and then for males upto five weeks on ration containing 24, 22 and 20 per cent crude protein with 3100 Kcal ME/kg. Females were fed with ration containing 24, 20 and 16 per cent protein with same energy levels upto five weeks. Then males were fed with finisher ration upto seven weeks containing 20 per cent protein with 3200 Kcal ME/kg and females with 16 per cent protein with 3200 Kcal ME/kg upto eight weeks. Results of the study showed that body weight gain and feed efficiency were reduced in low protein diets (20 per cent). There was no significant difference in body weight gain between 24 and 22 per cent protein groups. Feed conversion was poor in 22 per cent protein fed groups than 24 per cent protein fed groups.

Brown and McCartney (1979) reported that commercial broilers fed with iso-caloric ration (3400 Kcal ME/kg) containing 23 per cent protein recorded best growth than that of 27 and 31 per cent protein ration from 2 to 8 weeks of age. A definite decrease in body weight resulted from decreasing the calorie-protein ratio.

Hebert et al. (1979) reported that feeding high energy diet (3300 Kcal ME/kg), resulted in higher body weights, lowered feed consumption, higher abdominal fat and lower yield compared to birds fed the low energy diet (3080 Kcal ME/kg) each with 20 per cent protein.

The effect of different protein and energy levels on the performance of broiler chicken in the tropics was studied by Olomu and Offiong (1980). They recommended a protein level of 23 per cent and an energy level of 2800 to 3000 Kcal ME/kg for starting broiler chicks and a level of 20 per cent protein with an energy level of 3000 Kcal/Kg for finishing broiler chicks raised in Nigeria. They arrived at the optimum time of change from starter to finisher ration as at 5 or 6 weeks of age.

The effect of increasing dietary protein levels in broiler finisher feeds on growth and energy utilisation was studied by Musharaf and Latshaw (1981) by feeding diet containing 18, 20, 22 and 24 per cent protein. They found that males fed with 18 per cent protein weighed less, whereas females fed with 18 and 20 per cent protein weighed more than those fed 22 and 24 per cent protein. The feed/gain ratio was slightly higher for both males and females fed 18 per cent protein diet than higher protein levels.

Coon et al. (1981) reported the effect of feeding two levels of protein and energy in the starter and finisher diets in broilers. They fed a low energy diet containing 3135 Kcal ME/kg with 23 per cent protein and a high energy diet containing 3410 Kcal ME/kg with 25 per cent protein from 0-28 days and finisher diets containing 3190 Kcal ME/kg with 18.9 per cent protein and 3465 Kcal ME/kg with 20.5 per cent protein from 28 to 56 days of age. They found that feed conversion of broilers fed high energy starter and finisher diet was significantly superior when compared to diets with lesser energy. Weight gain upto 28 days of age was not affected by energy level. They also noted that males fed low energy starter and finisher diets gained more weight ($P < 0.05$) during the 28 to 56 day period than males in high energy diets.

Ren-Yu-Tzeng and Becker (1981) reported that male broilers reached the peak live weight gain (64.4 g/day) at 44 days of age, then the weight gain decreased to 46.8 g/day at 69 days and approached zero as the chicken grew older.

The effect of varying levels of dietary protein (20, 24, 28 and 32 per cent) and energy (3000, 3200 and 3400 Kcal ME/kg) on performance and body composition of male broilers to 49 days of age was studied by Jackson *et al*. (1982). They found that increasing dietary protein and energy levels produced heavier broilers with improved feed efficiency. But increases in dietary energy depressed body weight on low protein ration, while the converse was found to be with the elevation of dietary energy on high protein rations.

Bhargava (1982) conducted seven experiments to study the influence of energy and protein on the performance of female broilers and found significant depression in the performance of broiler chicks fed diet containing 18.7, 19.7 and 20.7 per cent protein with 2960 or 2880 and 3040 or 2960 Kcal ME/kg in starter phase (0-4 weeks). There was no deleterious effect on performance and carcass grade of chicks fed grower-finisher diets containing either 17.8, 16.9 or 16.0 per cent protein. The lowest level of energy ie. 2960 Kcal ME/kg resulted in poor performance both in starter and finisher stage. He also reported that diets containing either 18.6 or 17.8 per cent protein and two levels of energy, 3120 or 3040 Kcal ME/kg within each protein level had no influence on performance and carcass grade of birds.

Brown and McCartney (1982) studied the effect of dietary energy-protein and feeding time on broiler performance from 2-8 weeks of age. They found that birds fed with 3400 Kcal ME/kg diet were the heaviest. Energy level of 3700 Kcal ME/kg was found to be in excess and 3100 Kcal ME/kg was found to be deficient, each resulting in decreased body weight at 8 weeks of age. They also reported that dietary energy had a significant effect on total feed intake, whereas there was no significant effect of protein in the total amount of feed intake. Higher energy provided better feed conversion, which was not affected by feeding time, while increase in dietary protein along with changes in feeding time significantly affected feed conversion.

The effect of dietary protein level on the performance of four to eight week old broilers was reported by Trinadade et al. (1982 a). They found that with an isocaloric diet (3000 Kcal ME/kg) birds fed with 20 per cent protein performed better than 16 or 18 per cent protein fed group.

Trinadade et al. (1982 b) fed broilers with diet containing 23, 20 and 18 per cent protein with 3000 or 3200 Kcal ME/kg and found that weight gain and feed efficiency were greatest in birds fed with 3200 Kcal ME/kg than 3000 Kcal ME/kg fed group.

Trindade et al. (1983) fed Hubbard broiler chicken with a diet containing 24 per cent protein upto two weeks, 22 or 18 per cent from two to five weeks and 20, 18 or 16 per cent from five to seven weeks with an energy level of 2900, 2900 and 3000 Kcal ME/kg in three phases. They found that body weight gain was greater in groups fed higher protein at grower stages. During finisher period, gain and feed conversion were not affected by dietary protein.

Salmon et al. (1983) reported that weight gain upto four weeks improved (P <0.01) as the starting protein level was increased, but subsequent gain was not affected by the starter diet. They also reported that there was no significant effect on feed efficiency from 0-8 weeks. Weight gain from four to eight weeks were not significantly affected by finisher protein levels, but feed efficiency improved with increase in protein levels.

Leclercq (1983) studied the influence of dietary protein content on the performance of lean or fat lines from three to eight weeks of age. He found that lower protein content depressed growth of lean chicken, but had no adverse effect on fat chicken. In both lines increasing dietary protein decreased food:gain ratio.

Pesti (1983) reported that birds fed 18 per cent protein diet weighed significantly less than birds fed 22 and 26 per cent protein diets. He also found that feed intake was similar for all the treatment groups. Feed conversion was indirectly proportional to protein content ie. high protein diet had low feed conversion.

To study the response of male broiler chickens to diets with various protein and energy content, two growth trials using 2400 male broilers were conducted with five levels of dietary protein (17.5, 18.6, 19.8, 20.9 and 22.0 per cent) and five levels of metabolizable energy (12.13, 12.68, 13.18, 13.73 and 14.23 MJ/kg) by Pesti and Fletcher (1983). They found that body weight increased with increasing dietary protein and metabolizable energy content. Feed consumption and feed utilisation were dependent on dietary protein and energy content.

National Research Council (NRC, 1984) has recommended 23 per cent protein from 0-3 weeks, 20 per cent protein from 3-6 weeks and 18 per cent protein from 6-8 weeks for broilers with a uniform energy level of 3200 Kcal ME/kg diet.

Pesti and Fletcher (1984) reported that increasing dietary protein from 175 to 220 g/kg from 21 to 42 days in male broilers increased body weight from 986 to 1090 g. Gain:Feed ratio increased with increasing protein content, while body weight gain and abdominal fat were not affected.

Dietary energy levels of 3100 to 3200 Kcal ME/kg of diet irrespective of feed form resulted in no difference in mean body weight and feed consumption in broilers upto 28 days of age (McNaugton and Reece, 1984a).

Significant correlations were found in growing broiler chicken between the independent variables of metabolizable energy, protein and added fat contents by Pesti and Smith (1984). Significant linear and quadratic effects were found in metabolizable energy and protein content on body weight gain, feed utilization ratio and food, energy and protein intake.

Tion et al. (1984) from their feeding experiments in broilers, concluded that energy and protein variation of the diets did not significantly influence weight gain, feed intake or feed conversion efficiency. The dietary treatments assigned were 25 per cent protein with 3140 Kcal ME/kg, 22 per cent protein with 3360 Kcal ME/kg and 22 per cent protein with 3140 Kcal ME/kg.

Jones and Wiseman (1985) fed three isonitrogenous starter (230 g/kg) and three finisher diets (200 g/kg) with metabolizable energy content of 10.78, 12.78 and 14.78 MJ/kg to 1512 male and female broilers. Results of their study showed that broilers fed on the low energy starter diet were significantly lighter and their carcass contained less abdominal fat. They also noticed that the energy content of the finisher diet had no significant effect on body weight.

Chaudhary *et al*. (1985) found that there was compensatory growth in female chicken given 18 per ent protein in the starter diet than those given 13 per cent protein when compared with 23 per cent protein fed group in the starter. Finisher diet contained 20 per cent protein in all the three groups.

Diambra and McCartney (1985) found that body weight gain was directly proportional to dietary protein levels in broilers. Four finisher diets containing 9, 12, 15 and 18 per cent protein and of isocaloric values (3250 Kcal/kg) were fed to broilers from 42 to 49 days of age. They also found that there was no significant difference in finisher feed conversion and total feed conversion between 15 and 18 per cent protein and 12 and 15 per cent protein.

Maximum body weight gain and feed conversion efficiency were seen in birds fed diet containing 22, 23 and 24 per cent protein in starter and 20, 21 and 22 per cent protein in finisher diet than birds fed with 21 per cent protein in the starter and 19 per cent in the finisher ration. The energy content of the ration was 2900 and 3000 Kcal ME/kg in the starter and finisher respectively (Mukhtar *et al*., 1985).

Yaghi and Daghur (1985) conducted experiments in broilers to determine the possibility of reducing NRC (1977) recommended protein and found that if NRC recommended levels of methionine and lysine were met, the protein levels of starter, grower and finisher ration can be reduced to 20-17-15 per cent without any significant reduction in body weight gain, feed consumption or feed efficiency.

Indian Council of Agricultural Research (ICAR, 1985) recommended the requirements of crude protein and metabolizable energy for broiler starter ration as 24 per cent and 2900 Kcal ME/kg and for broiler finisher ration as 19 per cent and 2900 Kcal ME/kg.

Rosebrough and Steele (1985) observed that level of protein in the diet influenced the level of feed intake. Broiler chicks were fed with diet containing 23 per cent protein for one week, then they were allocated to diets containing 18, 23 or 30 per cent protein for 21 days with same energy level. Chicks were also fed on 18, 23 or 30 per cent protein on a three day rotation. They reported that feed intakes were equal for the 18, 23 and rotational dietary protein groups and lower for 30 per cent *ad lib.* group.

Requirements of protein and energy for broilers were studied under the maritime monsoon type of climate in Madras by Babu et al. (1986) by employing three levels of protein ie. 20, 22 and 24 per cent and three levels of energy ie. 2600, 2800 and 3000 Kcal ME/kg in starter diet (0-5 weeks) in a 3 x 3 factorial design. In finisher diet (6-8 weeks) the effect of reducing protein level by 2 per cent was tried. Body weight and feed efficiency of broilers fed with 22 per cent and 24 per cent protein diets were significantly higher than 20 per cent group upto 5 weeks of age. High energy (3000 Kcal/kg) low protein (20 per cent) diet reduced the growth of broilers from 0-5 weeks of age. Reduction of protein level by two per cent in finisher diet did not adversely affect the body weight. They also reported that feed consumption decreased with increased energy in diets at all protein levels.

Lilburn et al. (1986) reported that the level of energy in the starter diet had a greater influence on final body weight than level of protein, but it affected feed conversion ratio. Birds fed with 2992 Kcal ME/kg had low feed conversion (2.092), whereas birds fed on 3090 Kcal ME/kg had higher feed conversion (1.985).

Maurus *et al.* (1987) reported that with increased protein and energy level body weight of finisher broilers (6-8 weeks of age) increased.

Omer and Musharaf (1987) compared the NRC recommendation for broiler diets with low protein diet (18.8 and 17.9 per cent) and high protein diet (24 and 23 per cent) in the starter and finisher periods in tropics and found that body weight at eight weeks was low for high protein diet than NRC and low protein diet. No difference in performance was reported with NRC diets and low protein diets.

Effect of diets with different protein and metabolizable energy and optimum market age on the broilers was reported by Nakamura *et al.* (1988). They fed grower-finisher diets containing energy levels of 2900, 3100 and 3300 Kcal ME/kg and protein levels of 16, 19 and 22 per cent in each of five seasons of the year. They found that when protein level was high, gain of body weight and feed efficiency progressed, but ratio of abdominal fat dropped gradually. When metabolizable energy level was high, gain of body weight, feed efficiency and profit progressed gradually.

Baghel and Pradhan (1988 a) studied the effect of energy and protein levels on body weight gain, feed efficiency and retention of limiting amino acids in broilers and found that diet containing 25, 24 and 21 per cent protein in starting, growing and finishing phases of growth respectively was responsible for significantly higher weight gain and feed efficiency. They recommended single energy levels of 2800 Kcal ME/kg throughout the starter, grower and finisher period.

Ekermans et al. (1988) reported that in broilers the rate of gain and efficiency of feed utilization in terms of g feed/g gain were better on the higher energy level and the response was linear. They also reported that feed intake in terms of g feed, was linearly but negatively associated with energy level, but constant in terms of KJ of ME intake.

Okorie et al. (1988) conducted two experiments to determine the crude protein and metabolizable energy requirements of starting and finishing broiler chicks in the humid tropics. Results of their study showed that, dietary crude protein levels of 24.5 to 26 per cent in combination with ME levels of 11.7 to 12.6 MJ/kg gave faster growth rates and best feed conversion ratios during the starting phase. During finisher period, diets containing

13.4 MJ ME/kg with 20 to 22 per cent crude protein gave the fastest growth rates and best feed conversion ratio. In both the experiments there were significant protein x energy interaction for feed intake and growth rate, but not for feed conversion ratio. They concluded that starting broiler chicks required more crude protein and less metabolizable energy in their diets in the humid tropics than similar genotype in temperate climate. The crude protein and metabolizable energy requirements of the finishing broiler chicks in the humid tropics, however did not seem to differ significantly from those of similar birds in temperate environment.

For optimum performance a dietary protein of 22 per cent with 2900 Kcal ME/kg during starter phase (0-5 weeks) and during finisher phase a protein level of 17 per cent with 2700 Kcal ME/kg was found sufficient for broilers (Sudhakar *et al.*, 1988).

Effects of dietary energy levels and sex on broiler performance and carcass traits were reported by Mendes and Cury (1988) by feeding diets with 2800, 2950 and 3100 Kcal ME/kg in the starter and 2900, 3050 and 3200 Kcal ME/kg in the finisher period. They found that weight gain increased ($P < 0.01$) with increase of dietary energy and chicken given the high energy diet had the best feed conversion.

In a factorial design of 4 x 3 the influence of four dietary protein levels (23, 21, 19 or 17 per cent) in combination with three energy levels (3200, 3000 and 2800 Kcal ME/kg) were studied in purebred White Plymouth Rock chicks by Shyam Sunder et al. (1988). They found that higher protein levels ie. 23 or 21 per cent produced significantly better growth compared to 19 or 17 per cent protein upto five weeks of age. At eighth week, birds fed 19 per cent protein had similar effect as that of higher levels. Reduced feed intake and better feed conversion efficiency were noticed in groups fed 23 per cent protein. Protein x energy interaction effects were better reflected with 23 per cent protein and 3000 Kcal ME/kg.

Broilers fed with diet containing 20 per cent crude protein and 2700 Kcal ME/kg upto three or four weeks and 22 per cent crude protein with 2900 Kcal ME/kg upto eight weeks recorded highest body weight gain and best feed efficiency and was comparable to those fed with 22 per cent crude protein and 2900 Kcal ME/kg throughout (Reddy, 1989).

Skinner et al.(1990) fed broilers with diets formulated to contain 3205 to 3520 Kcal ME/kg in increments of 55 Kcal ME/kg from 42 to 49 days of age and found that dietary metabolizable energy had no significant effect on body weight gain.

Effect of Temperature and Humidity on Performance of Broilers

The interaction between performance, environmental temperature and feed intake is of utmost importance in the formulation of poultry diets for different seasons and geographical location.

According to Hammond (1950) season of the year influenced the economic factors involved in broiler production.

Adams *et al*. (1962 a) reported that high environmental temperature (29°C) reduced growth rate and feed consumption than those reared at low temperature (21°C). The protein requirement for maximal growth did not appear to be influenced by ambient temperature and a level of 17 per cent protein was adequate in both the environment. They also observed that poor growth obtained in the 29°C environment was not due to reduction in protein intake per day since the protein intake with the higher protein levels in the 29°C environment was greater than that of the lower protein levels in the 21°C environment.

Fisher et al. (1962) stated that the subcutaneous fat from hens maintained at 0°C was more unsaturated than fat from hens maintained at 21°C or 32°C, but that there was no difference in the degree of saturation between hens maintained at 21°C or 32°C. The change noted at 0°C was accounted for primarily by an increase in dienoic acid.

Adams et al. (1962 b) reported that higher environmental temperature reduced growth and voluntary intake of feed. Increasing the energy level of the ration improved growth rate and efficiency of feed utilisation in 70°F and 90°F. Relatively high temperature especially during the last few weeks of brooding period could interfere with optimal growth of broilers.

Milligan and Winn (1964) studied the effects of temperatures of 46, 53, 60, 70, 80, 95 and 100°F and relative humidities ranging from 30 to 90 per cent on broiler performance. They concluded that 60-80°F as optimum constant temperature for such criteria as body weight gain, feed conversion, pigmentation and feathering. They observed that chicken were extremely sensitive to constant high relative humidity at constant temperature of 95-100°F. Gain, feed conversion, feathering and pigmentation were adversely affected. Constant intermediate temperatures of

60, 70 or 80°F, constant high or low humidities did not affect chick performance.

Godfrey and Winn (1966) had pointed out that abrupt increase in temperature combined with low (40 per cent) or high (80 per cent) relative humidity caused a marked reduction of growth and feed efficiency, the hot and wet conditions having greater depressing effect.

Parkhurst (1967) stated that temperature from 85 to 95°F did not markedly affect growth and feed efficiency in broilers upto six weeks of age, at six weeks and beyond, broilers started to show temperature effect at 85°F and above.

Deaton et al. (1968) reported that in broilers reared upto 5 weeks at temperature above 26.7°C, body weight gain was significantly reduced as compared to temperature regimes below 26.7°C. Feed efficiency was better at higher temperatures, but mortality was not affected.

Adams and Rogler (1968) comparing constant temperature of 29°C with varying relative humidity (R.H) of 40 and 80 per cent found that growth rate was superior in 40 per cent R.H. as compared with 80 per cent R.H. Feed conversion was superior for males at 40 per cent R.H. as compared to 80 per cent R.H. but not in the case of females.

Depression of secondary immunity by high environmental temperature has been reported by Thaxton and Siegel (1970). They noted that young chickens heated at temperatures of 41.7-43.3°C for 30 minute periods produced only lowered circulating agglutinins following secondary challenge with sheep red blood cells.

Rao (1971) observed that weight at hatching was highest among chicks hatched in spring followed by winter, monsoon and summer. They also noticed a sudden drop in chick size on the onset of summer which gradually improved and reached to maximum size in spring.

Reece and Deaton (1971) reported that temperature should be near 21°C and relative humidity 60 per cent to optimise feed utilisation and body weight gain, for the growing period of broiler chicken on litter.

Panda and Mitra (1971) reported that growth performance of December hatched broiler chicks was good although it was slightly lower than January hatched chicks. Next in order were November and February hatched chicks, which were almost comparable. The October, March and April hatched chicks were placed in the order of decreasing performance.

Deaton *et al*. (1973 a) reared broilers from 4 to 8 weeks of age in constant temperature of 10° and 21.1°C and found no difference in body weight gain at 6 and 8 weeks of age. When a comparison was made with cyclic temperatures, the birds that were cycled in the moderate and low temperature range had more average body weight gain. The amount of feed required to produce a unit of body weight was higher for the birds reared in lower temperature.

Growth and feed utilization were equal for broilers reared from four weeks at a 24 hour cyclic temperature of 24° to 35° to 24°C as compared to broilers reared at a constant temperature of 29.4°C (Deaton *et al*., 1973 b).

As the rearing temperature increased, the percentage of abdominal fat increased (Kubena *et al*., 1974). They also reported that there was no significant difference in the quantity of abdominal fat at seven, eight or nine weeks of age.

Effect of different temperature regimes on body composition and carry over effects on energy metabolism of growing chickens was reported by Swain and Farrell (1975). Food consumption and growth rate declined with increased temperature and there was a significant increase in fat and decrease in water content of the carcass. Metabolizable energy concentration and nitrogen retention increased, heat increment decreased as a result of prior exposure of the birds to increasing temperture.

Reid et al. (1976) opined that decrease in intake of feed and consequent reduction in anticoccidial intake could be the cause of coccidiosis outbreaks in warm seasons.

Influence of climatic condition on protein and energy requirements of poultry was noted by Virk et al. (1976) in winter and summer. Broiler birds were fed with an isocaloric ration (3000 Kcal/kg) having 18.2, 20.1, 22.5, 24.3 and 26.6 per cent protein. Results showed that the protein requirement of broiler starter for optimum growth was adequately met by about 24 per cent dietary protein in winter as well as in summer. On the other hand, dietary protein requirement of broiler finisher was about 20 and 22.5 per cent in winter and summer respectively. They also stated that growth rate was higher in winter than in summer even when fed with 26.6 per cent protein. This they attributed to higher thyroxine secretion in winter than in summer.

Sykes (1977) reported that exposure of birds to high temperature (35°C) resulted in reduction in metabolizable energy intake, but ambient temperature did not increase or decrease the requirement of protein. Feed intake of ad lib. fed birds fell by about 1.5 per cent per degree celcius temperature rise, but not linearly.

Siegel (1977) reported that short periods of temperature outside the range of acclimatization produced physiological stress in birds. Under these conditions endocrino-logical responses mediated by pituitary and adrenal glands resulted in increased carbohydrate and lipid deposition and decreased muscle protein, consequent growth suppression.

Harris et al. (1977) studied the influence of the nutritional variables of dietary energy (2970, 3190 and 3410 Kcal ME/kg) and amino acids and their interaction with relative humidity (30, 50 and 80 per cent) at high temperature (29.4°C). They found that as the per cent relative humidity increased, the gain in body weight and feed consumption were decreased. Increasing the dietary energy levels resulted in increased weight gains, reduction in feed intake and improved efficiency of feed utilisation.

Nesheim <u>et al</u>. (1979) reported that symptoms of heat stress started at 26.6°C leading to reduced production performance. AT 28.4 to 37.8°C there was reduction in feed intake and subsequent increase in water intake leading to damp litter and subsequent higher humidity in the house, enhancing the adverse effects of higher temperature.

Cowan and Michie (1978) fed five diets containing different amounts of protein (178, 210, 243, 275 and 308 g/kg) to broilers reared at 16, 21, 26 and 31°C from 27, 21, 11 and 1 days of age. They found that feeding diets with increased amount of protein did not reduce the growth rate depression of the broilers reared at 26 or 31°C. The birds kept on the 21°C temperature regime grew at a significantly faster rate than those kept under the 26°C regime, which in turn grew significantly faster than those on the 31°C temperature regime. Feed intake was down with each increase in rearing temperature.

Deaton <u>et al</u>. (1978) reared broilers in five environmental controlled chambers both constant and cyclic and found that normal body weight gain and feed conversion were attained for broilers reared in the lower temperature regime (10°C) when compared to broilers reared in 21.1°C. Growth rate was lower for broilers reared at a simulated summer temperature (23.9 to 35 to 23.9°C) than for those reared at 21.1°C.

A study was undertaken by Dale and Fuller (1978) to determine the performance of broiler chicks under conditions of high environmental temperature. Chicks were maintained in a comfortable environment (20.5°C) as well as in heat stress (32.5°C), considered typical of the tropics. They found that at high temperature chicks prefered a high fat diet and significantly higher body weight was observed in birds receiving high fat diet.

Dale and Fuller (1979 a) conducted a study to determine the extent to which heat stress might be alleviated by reducing the heat increment of the diet and how much of the benefit of high fat levels might be attributable to the increased density of the diet. Results showed that metabolizable energy intake was increased when fat calories replaced carbohydrate calories. In the high fat treatment, chicks gained significantly more body weight than did the high carbohydrate content groups at both temperatures (31.1$\pm$2°C and 20.0$\pm$2°C) indicating that the beneficial effect of dietary fat was independent of temperature.

Dale and Fuller (1979 b) reported that environmental temperature had significant influence on body weight. Broiler chicks in the cool 13.9±1°C chamber gained significantly more body weight than those in the hot (31.1±1°C) chamber. Chicks fed high fat and high fat - high density diets gained more weight than low fat controls at both the temperatures with no diet x temperature interaction. When temperature was cycled as would occur under natural condition the growth depression due to heat stress was less in chicks fed the high fat diets.

Increasing nutrient concentration increased growth rate, decreased food intake and improved conversion efficiency in both winter and summer (Yule *et al.*, 1979).

The effect of ambient temperature on nutrient utilisation of broiler chicks was studied by El Husseiny (1979). He reared broilers at a temperature of 22°C to 32°C for 21 days. He found that feed consumption was greater for birds brooded in the cooler environment. Feed efficiency was better at warm temperature. No significant difference was noticed between treatment groups for gain in body weight.

Hurwitz *et al*. (1980) studied the energy requirements for growth and maintenance in male and female broiler chicks and turkeys, in environmental chambers for four to five weeks (12, 19, 28 and 34°C) following the brooding period. In both the species and sexes the maintenance requirement decreased with a constant temperature from 12-24°C reaching a low between 24 and 28°C followed by an increase as the temperature was raised further. Weight gain decreased between 19 and 34°C in broiler chicks. Feeding of high protein diets tended to reduce but did not overcome the growth depression by temperature. Feed intake decreased over the entire range of temperature tested. Feed efficiency increased with temperature to reach a maximum at 27°C and then decreased between 27 and 34°C especially in females.

Dale and Fuller (1980) noted the effect of diet composition on feed intake and growth of chicks under constant versus cyclic temperature and found that in both the environments chicks fed high fat-high density diets gained more weight than those fed low fat-low density diets. Chicks gained significantly ($P < 0.01$) more body weight in the cool than in the hot environment. When temperature was cycled as in natural condition, the growth depression due to heat stress was less in chicks fed the diets high in fat.

Under constant temperature conditions, chicks in the cool environment pair fed with those in the hot environment gained significantly ($P < 0.05$) more weight than the latter. This indicated that factors other than reduced feed intake contributed to the growth depression associated with high temperature. In hot chamber in addition to reduced feed consumption panting and wing lifting to dissipate heat were frequently observed. This necessitated expenditure of energy resulting in higher feed conversion ratio in heat stressed chicks. They also noted that thyroid size was significantly ($P < 0.05$) reduced in chicks subjected to heat stress. This reduced thyroid size was a reflection of thyroid activity and this in turn might have affected protein synthesis and subsequent depression of body weight gain.

Kezhavarz and Fuller (1980) found no diet x temperature interaction in Cobb broilers of four weeks of age subjected to cyclic cold (1.7 to 12.8°C) to cyclic hot (23.7 to 35°C) temperature and cyclic normal temperature. The birds were fed with a control ration (3200:20), low protein diet (3200:17) and low energy diet (2800:20). Body weight gain and feed conversion were significantly decreased by the changing temperature programme. Abdominal fat and carcass fat were lower for birds in the changing temperature regimes within each dietary treatment. Energetic efficiency was greater for birds housed at normal temperature than in the changing temperature.

As dietary animal fat increased, the amount of abdominal fat increased in broilers under both moderate (21°C) and high temperature (29°C) rearing regimes (Deaton et al., 1981).

Charles et al. (1981) observed no interaction between temperature and dietary nutrient concentration in a feeding regime having four temperature ranges from 15 to 27°C and four nutrient concentrations ie. 13.3, 12.9, 12.4 and 11.7 MJ/ kg at 199, 197, 195 and 188 g protein/kg respectively.

Effect of early heat stress on growth and feed conversion of day old broiler chicks was studied by Ernest et al. (1982) and found that body weight of heat stressed groups was significantly lower than non stressed control group.

Birds subjected to high temperature stress showed a significant reduction in live weight, carcass weight, shank length, keel length and ulna length at four weeks of age (Vo, 1982). Both high (41°C) and low (15°C) temperature stress significantly increased mortality during the stress period and also during the post stress period. A suppression of humoral immunity in temperature stressed birds was also evidenced by a reduction in primary and secondary H.I. titres.

The effect of dietary fat and ambient temperature on broiler performance was reported by Weaver Jr. et al. (1982). They found that birds fed with high fat diet, had better feed efficiency, but body weight was similar to those fed a diet containing a lower level of added fat. Birds under the three lower ambient temperatures (21°, 16°, 13°C) had higher and similar body weights when compared to broilers on the highest temperature regime (29°C). Feed efficiency was the best under the higher temperature regime (29°C) and lowest under the two low temperature regimes (16 and 13°C).

Kazuaki Takahashi et al. (1982) reported that environmental temperature, dietary composition, oestrogen and their interaction influenced hepatic lipid deposition and also suggested that high temperature augmented liver responses to oestrogen. The increases in liver lipid was significantly greater at 23-35°C than at 15-23°C.

Body weight and feed utilization increased when broilers were exposed to 15.6°C and fed with 3375 Kcal ME/kg than feeding 3250 Kcal ME/kg in the same environment (Mc Naughton and Reece, 1982). They also reported that when broilers were reared at 10°C maximum body weight was not obtained by increasing the energy from 3250 to 3500 Kcal/kg. Feed utilization was the same when broilers were reared in a 15.6°C environment and fed 3375 Kcal ME/kg as compared to 21.1°C with 3250 Kcal ME/kg.

Processing yields as affected by dietary energy level in summer and winter was reported by Janky and Harms (1982). They found that dietary energy did not affect ready-to-cook yield in summer, whereas during winter increasing the dietary energy level significantly increased per cent yield, but had no effect on shrink or water uptake. Fat and moisture of the carcass were affected by dietary energy level in the summer.

The effect of summer season and cold season on the production parameters of pure bred broiler chicken was carried out under maritime monsoon climate of Madras (Nair, 1983). Results of his study showed that high temperature of tropics decreased growth rate and increased feed conversion. Fat deposition was more in summer. Haemoglobin showed tendency towards haemodilution in summer reared birds. Ready-to-cook yield indicated no significant difference between seasons. Carcass composition such as protein and fat did not show any significant difference between seasons. In summer maximum temperature reported during the experimental period was 37.15°C and the minimum 29.21°C and average relative humidity 62.66 per cent.

Cerniglia et al. (1983) conducted 2 trials using Cobb broilers to determine the effect of constant ambient temperature on growth and feed consumption of broilers offered diets varying in energy and protein levels. Constant ambient temperature of 18 and 29°C in trial I and 24 and 35°C in trial 2 were allotted. The results of the study showed that the eighth week body weights were significantly greater ($P < 0.05$) for those birds at 18°C than 29°C in trial I and for those birds reared at 24° than at 35°C in trial 2. The birds reared at 18 and 24°C consumed significantly ($P < 0.01$) more feed, energy and protein than those birds reared at 29 and 35°C. Birds reared at 29°C were significantly more efficient in their utilisation of feed consumed than those at 18°C.

Energy and protein requirements of broiler chicks in the humid tropics were studied by Onwudike (1983). Broiler chicken were given diets containing protein levels of 20, 22, 24 and 26 per cent with energy levels of 2800, 3000 or 3200 Kcal ME/kg. He found that daily feed intake dropped significantly as dietary energy increased beyond 2800 Kcal/kg. Feed efficiency significantly increased as dietary protein increased from 20 to 22 and 24 per cent, while an increase to 26 per cent caused a drop in feed efficiency. Increasing dietary energy beyond 2800 Kcal ME/kg significantly increased feed efficiency. He found that a ration containing 22 per cent protein and 3000 Kcal ME/kg was adequate for broilers in the tropics.

Weaver Jr. et al. (1983) found that body weight was significantly lower and feed efficiency was similar for broilers under high ambient temperature (32°C) when compared to birds reared at 29°C for the first week and reduced 2.8°C each week until room temperature reached 21, 18 and 13°C. Broilers fed diets with the higher level of added fat had lower feed to gain ratios and similar body weights when compared to birds fed diets containing low levels of fat.

The effects of temperature and age on body weight and feed efficiency of broiler chicken was reported by Reece and Lott (1983). They found that growth rate of commercial broilers decreased as environmental temperature increased. The growth rate at 26.7°C was 6 per cent less at 35 days and 10 per cent less at 55 days of age than at 15.6°C. There was no difference in feed conversion between broilers grown at 21.1 and 26.7°C. Feed consumption per unit of weight was more at lower temperature than at 21.1 or 26.7°C. At 49 days of age the birds grown at 15.6°C required 16 per cent more feed than at 26.7°C.

Four levels of protein ie. 17, 18, 19 and 20 per cent with two dietary metabolizable energy levels ie. 3032 and 3109 Kcal/kg were used by Reece et al. (1984) to formulate eight grower-finisher diets to study the effect of feed form, protein profile, energy levels and gender in broiler performance in a warm (26.7°C) environment. They found that best feed conversion was with high protein (20 per cent) diet given as crumbles than low protein diet in mash form. At 20 per cent protein level, feed conversion increased by two per cent by increasing the metabolizable energy levels from 3032 to 3109 Kcal/kg.

Lowering the temperature from 26.7 to 21.1°C during the cool portion of the 24 hour period in summer significantly increased body weight at 48 days of age in broilers (Deaton et al., 1984).

Response of broiler chicken to dietary energy and lysine level in a warm environment (26.7°C) was studied by McNaughton and Reece (1984 b). They fed broilers with diets containing 3100, 3175, 3250 and 3325 Kcal ME/kg with either 0.308 or 0.322 per cent lysine per M cal/kg with a constant dietary protein level (18.7 per cent). Results of their study suggested that the body weight response to dietary energy level occured only when broilers were reared in a warm environment with adequate amino acids. They recommended dietary energy requirement as 3250 Kcal ME/kg of feed when 23 to 47 day old broilers were fed 0.322 per cent lysine per Mcal/kg and reared in hot environment.

Body weight gain and feed efficiency at high temperature can be improved by increasing the energy content of diet, at the same time inducing a slight dietary amino acid deficiency (Sinurat and Balnave, 1984). They found that, this stimulated food intake and thereby increased body weight gain, but was associated with an increased body fat content.

North (1984) reported that when the atmospheric temperature increased to 37.8°C, feed intake decreased from 100 g/bird/day to 48 g/bird/day.

Sinurat and Balnave (1985) reported that increasing the dietary metabolizable energy at particular amino acid; metabolizable energy ratios, significantly improved growth and food utilization of broilers kept at moderate (18 to 26°C) and high (25 to 35°C) ambient temperatures from 22 days of age. Whereas increasing the dietary protein at particular metabolizable energy concentration had little or no effect on food intake and growth rate of broilers kept at high temperature. They also found that supplementation with dietary fat had no beneficial effect on performance at high temperature.

Lower body weight and higher feed consumption were recorded in October hatched chicks than September hatched broiler chicks (Joshi and Kumar, 1986). In September ambient temperature ranged from 22 to 32°C during day and from 7° to 10.5°C at night and corresponding figures in October were 14.0 and 23°C and -2° to -7°C.

Bartov (1987) reported that weight gain and feed intake were not affected by dietary fat sources in broiler chicks reared in summer and winter.

The deleterious effect of high temperature on broiler performance was studied by Al-Fataftah (1987) in Jordan. He reported that exposure of broilers to high temperature (exceeding 29°C) significantly decreased feed intake, feed efficiency and body weight gain.

Smith and Teeter (1987) reported the influence of feed intake and ambient temperature stress with relative yield of broiler parts. They found that free feed intake increased by 25 per cent and decreased by 10 per cent as the ambient temperature was reduced to 7.2°C or increased to 35°C respectively. Growth rate and feed efficiency, dressing percentage and yield of edible parts were optimum at 23.9°C.

Effect of interaction between various protein and metabolizable energy concentration under high ambient temperature on the growth performance of broiler chicken was investigated by Husseini et al. (1987). They found that broilers performed best when given 20 per cent dietary protein with metabolizable energy of 14.24 MJ/kg.

Abasiekong (1987) reported the effect of environmental temperature on broiler meat production. He found that feed intake of broilers was significantly depressed at 35°C than 23°C. Feed intake was 69.6±0.11 g at 23°C and 56.6±0.02 g at 35°C. Feed conversion efficiency was significantly

(P<0.05) better (2.30±0.006) under high ambient temperature (35°C) than at 23°C(2.5±0.001).

Exposing broiler chicks to mild heat stress (35 to 37.8°C) for 24 days at 5 days of age significantly reduced mortality from high environmental temperature later in life (Arjona et al., 1988). They also noted that feed efficiency was improved significantly in early heat stressed birds, whereas body weight gain was not affected.

Baghel and Pradhan (1989 a) reported that average liver weight was maximum in cold season (December 21 to February 15) followed by hot humid (July 10 to September 4) and hot season (May 10 to July 5).

Effect of protein level and stocking density on broiler performance in different seasons was reported by Al-Ribdawi and Singh (1989). Three factorial experiments were designed using three stocking rates (10, 15 and 20 birds/sq.m.), three levels of protein (26, 24 and 20 per cent) and three seasons (hot-humid, hot-dry and cold). Results of their study showed that body weight gain was maximum in cold season (1158.6 g) followed by hot-humid (836.1 g) and hot-dry season (734.8g). Daily feed intake was affected by stocking rate, protein level as well as season. Daily feed intake of 104.7 g in cold, 77.9 g in hot humid and 64.9 g in hot dry season was reported by them. Feed conversion were 2.96, 2.95 and 3.10 for the three seasons.

Thiagarajan (1989) reported a maximum temperature of 29.36°C to 37.79°C and a minimum temperature of 22.33 to 25.93°C from April to July in 1988 and relative humidity of 55 to 87 per cent at Mannuthy.

Effect of environmental temperature on protein and energy requirements of broilers reared in Taiwan was studied by Koh *et al*. (1989) using a factorial design with metabolizable energy levels of 3200, 3040, 2880 Kcal/kg and 2 levels of proteins in cool and hot seasons from 0 to 8 weeks old. Average temperature was 16° and 18.6°C for cool seasons and 30° and 30.6°C for hot season. Feed intake and weight gain in hot season were 15-20 per cent lower than in the cool season. Weight gain of broilers fed on a high energy diet was significantly higher than of those fed on a low energy diet. There was no difference between cool and hot seasons in feed efficiency and energy and protein requirements per unit weight gain.

Osman *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 (30-32°C) reduced the body weight gain and feed efficiency.

Influence of dietary energy and protein levels on the utilisation of metabolizable energy in broilers during the hot-humid season was reported by Baghel and Pradhan (1991). Results of their study showed that the metabolizable energy required for maintenance was significantly low, while for growth it was significantly high in birds receiving higher levels of protein. Conversely the metabolizable energy required for growth and maintenance per kilogram weight gain increased in broilers receiving higher levels of energy in their diet.

Multani *et al*. (1991) reported the effect of three dietary protein levels (20, 22 and 24 per cent) and three energy levels (2500, 2700 and 2900 Kcal ME/kg) in broilers in autumn (November-December), winter (January-March), summer (May-June) and rainy season (July-September). Results of their study showed that birds fed with 24 per cent protein had significantly better body weight gain in summer and rainy seasons. In birds fed with 2900 Kcal

ME/kg, the performance in terms of body weight gain and feed conversion efficiency was significantly better in all seasons. Protein and energy interaction was better reflected with 20, 22 or 24 per cent protein with 2900 Kcal ME/kg in autumn and winter, 24 per cent protein with 2700 Kcal ME/kg in summer and 24 per cent protein with 2900 Kcal ME/kg in rainy season.

Abdominal Fat and Carcass Composition

Growth rate, feed consumption, body composition and feathering of broiler chickens have been shown to be influenced by the ratio of energy to protein content of ration.

Fraps (1943) reported that quantity of fat stored in growing chicken can be regulated to a certain extent by adjusting the composition of ration fed. The substitution of cotton seed oil for corn meal in the ration had a marked effect upon the fat content. Addition of 10, 20 and 30 per cent cotton seed oil in the ration increased the fat content from 5.4 per cent to 11.2 per cent and the protein decreased slightly from 20.9 to 18.6 per cent.

Spring and Wilkinson (1957) studied the influence of dietary protein and energy level on body composition of broilers. The results showed that at two weeks of age increasing dietary protein from 22 to 28 per cent increased body protein (18.3 to 18.5 per cent) and water (71.5 to 73.6 per cent) and decreased body fat (6.7 to 5.0 per cent). Increasing dietary energy from 1200 to 1500 cal/lb decreased body protein and increased body fat (4.4 to 7.8 per cent). At 8 weeks of age increasing dietary energy caused increased weight gain and body fat (6.0 to 9.1 per cent) but decreased body protein (22.1 to 21.2 per cent) and water (69.6 to 67.8 per cent). Increasing dietary protein level had no effect on gain but decreased body fat (8.6 to 5.9 per cent) and increased body protein (21.3 to 21.8) at 8 weeks of age.

Adams et al. (1962 a) studied the effect of environmental temperature on the protein requirement of male broilers between 4 and 8 weeks of age. Results of their study showed that increasing temperature had little effect, if any, upon carcass composition. Increasing the protein level of the diet decreased the carcass fat ($P < 0.05$).

The influence of dietary fat and environmental temperature upon chick growth and carcass composition was reported by Mickelberry et al. (1966). They found that elevated temperature markedly retarded growth and feed consumption but had no influence upon either the moisture, fat, Iodine Value, total cholestrol content or the fatty acid composition. An overall trend of the carcass fat to be similar to the derived dietary fat was observed in both Iodine Value and fatty acid composition.

Wolford (1971) evaluated the effect of diet and temperature on the accumulation of liver lipid. He found that housing the birds in cool environment (17°C) for 28 days significantly reduced the liver lipid level (9.0 g Vs 24.3 g/100 wet liver weight) in comparison to those birds housed in a warm environment (26.7°C).

Body composition of chicks as influenced by environmental temperature and selected dietary factors was reported by Kubena et al. (1972). They found that there was a significant decrease in carcass ether extract with a concomitant increase in moisture content with decreasing temperature. Carcass from birds reared at 18.3°C and 29.4°C receiving a diet containing lower energy (2877 Kcal ME/kg) contained significantly less ether extract than carcasses of birds receiving the higher energy diets. At 18.3°C birds receiving low protein diet contained significantly more ether extract than carcasses of birds receiving the high protein diets. Protein level did not significantly affect carcass composition at 29.4°C.

Bartov et al. (1974) reported that fat content of liver and thigh muscle was not affected by different calorie-protein ratios.

Poultry meat contained a higher proportion of unsaturated fatty acids than fats from red meat. Low Iodine Value indicated saturated fats and high ones unsaturated (Mountney, 1976). He reported 28-30 per cent of saturated fatty acids in chicken fat and an Iodine Value of 63-80. Scott et al. (1976) reported Iodine Value of 80 in chicken fat. Waldroup et al. (1976) reported that broilers fed with higher energy diets had greater abdominal fat.

Increasing the energy : protein ratio caused increased fat deposition with increase in the proportion of palmatic and oleic acid and a decrease in linoleic acid (Bartov and Bornstein, 1976). They also reported highly significant negative correlation between the degree of fatness and on unsaturation of abdominal fat (expressed as Iodine Value) among individual broilers fed on the diet of lowest E:P ratio. When the E:P ratio was 0.536 the Iodine Value of abdominal fat was 70.7 and that of thigh muscle fat was

82.5. Iodine Value varied with the energy content and type of fat.

Farr *et al*. (1977) reported that energy content of the ration significantly affected live weight, dry carcass weight and abdominal fat weight.

Influence of energy system and levels of various fat sources on the performance and carcass composition of broilers were reported by Griffiths *et al*. (1977). They found that dietary fat levels of 0, 3, 6 and 9 per cent had no significant effect ($P < 0.05$) on carcass composition or abdominal fat pad size. At zero per cent added fat they found abdominal fat of 0.596 g per 100 g body weight and 28.4 per cent fat and 57.0 per cent carcass protein, whereas at six per cent added fat, 0.683 g abdominal fat per 100 g body weight, 31.4 per cent carcass fat and 55.5 per cent carcass protein.

Four commercial strain crosses were used to study strain differences in abdominal fat deposition by Griffiths *et al*. (1978). The birds were fed with commercial ration containing 24 per cent crude protein and 2970 Kcal ME/kg upto four weeks and finisher ration containing 18 per cent crude protein and 3080 Kcal ME/kg upto 8 weeks. Strain differences were noted in abdominal fat deposition. At eighth week abdominal fat (as per cent body weight) was 2.44, 2.35, 2.76 and 2.66 for all the four strains. Carcass fat (as per cent dry matter) was 47.4, 44.9, 46.5 and 47.9 respectively for four strains.

Birds receiving low protein diet had less carcass protein and moisture and more carcass fat than the birds receiving the high protein diets (Twining *et al.*, 1978). They also reported that there was strain x sex effect in carcass fat deposition. Cobb x Cobb broiler had greater carcass protein (19.65 per cent) and less fat (15.19 per cent) than the Hubbard x Hubbard crosses.

The ratio of protein to fat in the carcass of chicken broilers was influenced by such diverse factors as diet composition, environmental temperature, type of housing, age and sex (Summers and Leeson, 1979). They found that energy intake was the main factor influencing abdominal fat deposition. The abdominal fat content varied from 1.60 to 2.90 per cent of body weight.

Keshavarz and Fuller (1980) found that the abdominal fat and carcass fat as per cent body weight, were lowered in the hot and cold temperatures than in normal temperature.

They reported abdominal fat per cent of 1.01 and 0.89 in the hot (23.9-35°C) and cold temperature (1.7-12.8°C) respectively than in normal (12.8-23.9°C) temperature (2.03 per cent). Carcass fat per cent was 10.05 for hot temperature and 11.41 per cent for normal temperature.

Hargis and Creger (1980) reported that deletion of added fat from the diet during the first seven days decreased the per cent abdominal fat by 0.57 per cent and 0.85 per cent. As the metabolizable energy level increased from 2550 to 2750 Kcal/kg the per cent of abdominal fat increased from 0.97 per cent to 1.82 per cent of the total body weight. In the finisher diet when the protein level increased from 27 per cent to 30 per cent, the abdominal fat decreased from 1.53 per cent to 0.85 per cent of the total body weight.

Leeson and Summers (1980) reported abdominal fat per cent of 2.0±0.3 and 4.1±0.8 for male and female broilers respectively and percentage body fat of male broilers at 56 days of age as 21.1±2.7 and for females 23.3±2.9.

Broadbent _et al_. (1981) reported the chemical composition of broiler chicken at 56 days of age. Meat of male broilers contained fat 57.8, protein 211.2, ash 10.9

and moisture 719.2 g/kg and that of females contained fat 56.5, protein 211.0 and ash 10.9 g/kg. Liver of male broilers contained 125.9 g fat, 174.1 g protein and 11.3 g ash/kg and in case of females 230.3 g fat, 154.3 g protein and 10.2 g ash per kilogram.

Mabray and Waldroup (1981) found that through dietary manipulations carcass of widely varying abdominal fat pad size could be produced. They fed diets containing 2970, 3190 and 3410 Kcal of ME/kg for 57 days. They also reported that the degree of fatness could be significantly reduced by increasing the dietary amino acid levels within a given energy level.

Touchburn et al. (1981) reported that increasing the ratio of energy protein increased fat deposition.

Trinadade et al. (1982 a) fed diets containng 16, 18, 20 per cent protein with 3000 Kcal ME/kg, to Hubbard broilers from 4 to 8 weeks of age and found that abdominal fat inversely related to dietary protein level and ranged from 1.9 to 3.30 per cent of body weight in male and from 2.70 to 3.70 per cent in female chicken.

Trinadade et al. (1982 b) fed 18, 20 or 23 per cent crude protein with 3000 or 3200 Kcal ME/kg to Hubbard broilers and reported that abdominal fat deposition was not affected by feeding different protein or energy, but amount of protein and fat in leg muscle and abdominal fat deposition were affected by dietary energy:protein ratio.

The effect of alteration in nutrient density in carcass composition and efficiency of nutrient utilisation was reported by Jackson et al. (1982). They fed day-old broilers with diets varying in protein (16, 20, 24, 28, 32, 36 per cent) and energy (2600, 3000, 3200, 3400, 3600 Kcal ME/kg) to 49 days of age. They found that abdominal and total carcass fat contents responded similarly to alteration in dietary energy and protein. Birds fed with 20 per cent dietary protein had 46.2 per cent carcass fat and 44.9 per cent carcass protein on dry matter basis. The abdominal fat was 2.55 per cent of live weight. Whereas group fed with 24 per cent dietary protein had 42.4 per cent carcass fat and 47.7 per cent carcass protein on dry matter basis and 1.92 per cent abdominal fat on per cent live weight. Maximum protein deposition occurred with the 20 per cent crude protein diet. Increasing dietary protein produced carcass that were lower in fat and higher in protein. Increase in carcass fat and decrease in carcass moisture and protein contents occurred with increase in energy intake. Abdominal fat pad weight was significantly ($P < 0.01$) increased as dietary energy increased.

Highly significant ($P < 0.01$) correlation was reported between live weight and abdominal fat weight, live weight and per cent abdominal fat and fat weight and fat thickness by Sonaiya and Benyi (1983). They also reported that correlation between age and per cent abdominal fat was significant ($P < 0.05$).

Leclercq (1983) found that increasing dietary protein increased abdominal fat deposition.

Pesti (1983) reported that abdominal fat pad weights were indirectly proportional to dietary protein content. The fat pad weights were 10.2, 9.0 and 8.0 g for the 18 per cent, 22 per cent and 26 per cent protein diets respectively.

Onwudike (1983) reported that amount of carcass fat decreased as dietary protein increased and increased as dietary energy increased.

Abdominal fat percentage of the eviscerated carcass was positively correlated with abdominal fat weight (0.98) and carcass fat weight percentage (Chambers and Fortin, 1984). They fed broilers with starter ration containing 23.5 per cent crude protein and 3155 Kcal ME/kg and finisher ration containing 20.8 per cent crude protein and 3210 Kcal ME/kg and birds were slaughtered at 47 days and 61 days in experiments 1 and 2 respectively. The abdominal fat weights recorded were 34.0 ± 2.6 g and 38.7 ± 3.3 g for the two groups. Chemical composition of body showed fat percentage of 14.5 ± 0.3 in experiment 1 and 14.8 ± 0.5 in experiment 2.

Reduction of abdominal fat by dietary energy and protein manipulation was reported as minimal by Lawin et al. (1984) from a study to find the effect of dietary energy and protein on growth and abdominal fat at seven weeks of age. They found that feeding low energy diets (2700 to 2800 Kcal ME/kg) versus high energy diets (3200 to 3300 Kcal ME/kg) significantly ($P < 0.05$) reduced abdominal fat from 3.38 to 2.77 per cent of live weight. They also reported that a high protein feeding programme (25, 23 and 21 per cent for starter, grower and finisher diets) versus a low protein feeding programme (23, 21 and 19 per cent) reduced abdominal fat from 3.3 to 3.0 per cent of live weight, but this reduction was not significant.

Broiler chicks fed with two dietary regimes (27.7 per cent protein and 2800 Kcal ME/kg and 24.4 per cent protein and 3000 Kcal ME/kg) did not showed significant difference for per cent moisture, protein, ether extract and ash content of meat. The means of per cent moisture, protein, ether extract and ash content varied from 73.27 to 75.08, 19.05 to 19.72, 2.99 to 4.88 and 0.94 to 1.21 respectively (Mahapatra et al., 1984).

The role of protein level and form of diet on abdominal fat pad deposition of broilers were studied by Marks and Pesti (1984). They found that chicks fed with higher protein diet had less abdominal fat than those fed lower protein diets. Birds fed 26, 22 and 17 per cent protein had abdominal fat pad weight of 7.95, 8.97 and 10.18 g and 1.42, 1.62 and 2.08 per cent fat respectively.

March et al. (1984) reported that mean weights of abdominal fat pads were inversely related to dietary concentration of protein between 20 and 35 per cent.

Lipid characteristics of broiler carcass fat as influenced by strain, diet and age was reported by Reddy and Varadarajulu (1984). Commercial broiler strains were fed three levels of dietary energy with C:P ratio of 168.1, 151.7 and 141.5:1 from 35-days of age until slaughter at 56 or 73 days. They found that fatty acid composition of abdominal fat samples was not significantly affected by strain or diet. Fat from younger bird had significantly lower Iodine Value (67.022) than fat from older birds (71.470). Fat from birds fed low energy diet had significantly higher Iodine Value (72.230) than fat from birds fed standard energy and high energy diets (68.230).

The proportion of abdominal fat and total carcass fat deposited were lower for birds fed on the low energy finisher was reported by Jones and Wiseman, 1985 from a feeding experiment in broilers with iso-nitrogenous starter and finisher diet with metabolizable energy content of 10.78, 12.78 and 14.78 MJ/kg.

Rosebrough and Steele (1985 b) reported that total body fat was lowest in broilers fed with 30 per cent protein diet than those with 18 or 23 per cent protein. Total body protein deposition was greater in birds fed the diet containing 23 per cent protein than the birds fed the diet containing 30 per cent protein.

Carcass composition of broilers fed three levels of protein (20, 18 and 13 per cent) followed by 20 per cent finisher protein was reported by Chaudhary and Aggarwal (1986). Results showed that per cent protein content of meat increased with increase in age, however, with a decrease in protein in feed, the percentage protein of meat decreased. An increase in per cent of ether extract content of meat was noted in birds fed low protein diets. The percentage ether extract reported was 16.00, 19.15 and 20.33 at 8 weeks of age for group fed 20, 18 and 13 per cent respectively.

Smith and Teeter (1987) reported that abdominal fat increased with increasing feed intake at all temperatures.

Wurzner et al. (1987) reported fat content of 27 and 36 g for male and female broilers and crude protein content of 18.6 and 17.5 per cent. They also reported body fat content of 17 and 20 per cent for males and females.

Jenson et al. (1987) reported that abdominal fat content in market broilers was influnced by the composition of diet fed during the first week of life.

Effect of varying protein and supplementary fat levels on abdominal fat deposition in broiler chicken was reported by Kanat (1987). He stated that abdominal fat pad weight decreased significantly as dietary protein increased. Addition of fat in the diet caused significant increase in abdominal fat pad weight.

Al-Fataftah (1987) reported that exposure of broilers to temperature exceeding 29°C decreased the carcass weight and edible yield and increased the abdominal fat content.

Effect of different protein and energy levels on the broiler performance was reported by Nakamura _et al_. (1988). They found that ratio of abdominal fat dropped when level of protein in the diet was high.

Babu _et al_. (1987) fed diets with three protein (20, 22 and 24 per cent) and three energy (2600, 2800 or 3000 K cal ME/kg) levels upto five weeks in broilers and from 6 to 8 weeks 20 birds at random in each treatment were continued with the same diet and the other 20 birds with two per cent less protein diets. They found that increasing the energy content at a particular protein level showed a slight increase in fat in the carcass. They also reported that ether extractives of carcass ranged from 30.22 to 46.76 per cent.

Increased deposition of abdominal fat due to increased levels of energy in the diet was reported by Baghel and Pradhan (1988 a).

Effect of different protein and energy levels on the broiler performance was reported by Nakamura et al. (1988). They found that ratio of abdominal fat dropped when level of protein in the diet was high.

Mendes et al. (1989) reported that abdominal fat increased as the energy level of the diet increased ($P<0.01$) and the females presented higher ($P < 0.01$) abdominal fat.

Akiba et al. (1989) reported that hepatic lipid accumulation can be reduced by either protein or fat content in diets, while it was increased with an increase in carbohydrate content.

Abdominal fat content was positively correlated with dietary energy and was higher in broilers reared in the cool season (Koh et al., 1989). They also reported that broilers fed on high protein diet had decreased abdominal fat.

Carcass Yield

Jull (1951) reported the eviscerated yield of broilers as 66 to 76 per cent and loss due to blood as 3.5 to 4.5 and feather loss as 4.5 to 7.5 per cent.

The effect of diet and sex of broilers on meat yield was investigated by Kondra *et al*. (1962) who observed that edible meat as per cent of eviscerated weight was not influenced by the level of energy or protein in the diet.

Essary *et al*. (1965) reported that different level of added protein and fat fed to broilers from one day to 10 weeks of age did not appreciably influence dressing percentage.

Mathur and Ahmed (1968) reported total yield of 71.08 per cent in male broilers and 71.13 per cent in female broilers at 10 weeks of age. Total blood loss was 4.44 per cent for males and 4.23 per cent for females. Total feather loss was 4.33 per cent for males and 5.86 per cent for female broilers.

Hayse and Marion (1973) observed that broiler males and females had 72.04 and 70.08 per cent eviscerated yield;

73.48 and 75.23 per cent edible yield respectively at eight weeks of age.

Diets containing of 3005 and 3304 Kcal ME/kg produced eviscerated and ready-to-cook yield significantly higher than those obtained with level of 2614 Kcal ME/kg (Janky *et al*., 1976).

Mellor and Fowler (1977) observed that birds grown on the low energy diet (3110 Kcal ME/kg) had significantly more shrink and significantly less carcass yield, than birds on either the medium (3270 Kcal ME/kg) or high energy (3470 Kcal ME/kg) diets. There was no statistically significant difference between medium and high energy diets on either shrink or yield.

Percentage carcass yield was not affected by protein levels of 24, 22 or 20 per cent with 3100 Kcal ME/kg in males and 24, 20 or 16 per cent protein with same energy in females (Moran Jr., 1979).

Nesheim *et al*. (1979) reported that the dressed weight of broilers ranged from 83.2 to 87.8 and eviscerated weight with giblets from 65.6 to 71.7 per cent.

The effect of controlled temperature (4.4, 12.7, 23.9 and 32.2°C) on the percentage edible yield of broiler and laying stock reared from four to nine weeks of age was determined by Huggins and Lewis (1980). They found that higher temperature (23.9 and 32.2°C) caused a reduction in edible yield of broiler stock.

Differences due to strain, sex and dietary energy on broiler processing parameters were reported by Satterlee *et al*.(1980). They found that feeding high energy diet significantly elevated body weight, carcass weight, carcass yield, abdominal fat and percentage of dressed carcass weight.

Broadbent *et al*. (1981) observed that eviscerated carcass with giblets as 702±3.6 g and 690 ±4.7 g/kg for male and female broilers respectively. The loss of approximately 300 g/kg of the live weight in preparing carcass was accounted as follows: blood 34±1.5 and 35±3.5 g/kg, feathers 60±3.0 and 69±3.5, head 29.9±0.7 and 28.4±0.6, feet and shanks 43.3±0.7 and 34.5±0.4, wing tips 24.9±1.5 and 29.7±1.2; abdominal fat 27.1±0.9 and 28.1±0.9; viscera and fat contents 72.1±1.5 and 73.7±2.9 g/kg for males and females respectively.

Moran Jr. (1980) from his studies reported that apparent carcass yield, grades for conformation, fleshing and finish were not influenced by marginal dietary protein changes during the starting period.

Carcass, organ and by-product weights as related to live weights of male and female broilers were reported by Benoff (1981). The per cent dressed carcass yield were 66.6 and 66.7 for the male and female respectively. The percentage of feathers, blood, head, feet, viscera, oil gland and crop were 5.4, 3.9, 3.0, 4.6, 5.8, 0.15 and 0.68 per cent respectively. Neck, gizzard, liver and heart percentages for the sexes combined were 4.5, 1.6, 1.7 and 0.45 respectively.

Trinadade <u>et al</u>. (1982 b) observed that carcass yield was 1.8 per cent less with broilers fed 3200 Kcal/kg than birds fed with 3000 Kcal/kg.

Pesti and Fletcher (1983) fed broilers with five levels of dietary protein (17.5, 18.6, 19.8, 20.9 and 22.0 per cent) and five levels of metabolizable energy (12.13, 12.68, 13.18, 13.73 and 14.23 MJ/kg) and reported that carcass fat increased with increasing dietary energy and decreased with increasing dietary protein. Dressed weight and mortality was not affected by dietary protein or energy levels.

Orr and Hunt (1984) reported the carcass yield of eight commercial strains and found that carcass weight expressed as percentage of live weight ranged from 69.9 to 71.5 per cent (based on water chilled carcass weight).

Effect of diet, strain and sex on the carcass yield and meat quality of broilers was reported by Mahapatra et al. (1984). They fed ration containing 27.7 per cent protein and 2800 Kcal ME/kg and 24.4 per cent protein and 3000 Kcal ME/kg to broilers and the carcass characteristics and meat quality were studied. They reported that diet had no significant effect on live weight at slaughter, eviscerated carcass weight, giblet weight and total yield. However the per cent shrinkage in live weight was significantly higher in birds reared in low protein and energy diet. The means of per cent moisture, protein, ether extract and ash content varied from 73.27 to 75.08, 19.05 to 19.72, 2.99 to 4.88 and 0.94 to 1.21 respectively. Differences among treatments were statistically non-significant for the above chemical composition.

Rosebrough and Steele (1985 b) observed that broilers fed with diet containing 23 per cent protein had significantly smaller liver size than those fed 18 or 30 per cent protein diet.

Wurzner et al. (1987) reported dressing percentage of 77.2 and 78.2 in male and female broilers respectively.

Mǎrus et al. (1987) reported that percentage carcass yield was not affected by different energy and protein levels during six to eight weeks of age in broilers.

Effect of dietary protein and energy on broiler carcass characteristics were reported by Babu et al. (1987). The results showed that New York dressed weights between different treatments were highly significant ($P < 0.01$). R-to-C weight of broilers fed different dietary treatments ranged from 74 to 79.35 per cent and were not significantly different in different treatments. Giblet weight of broilers ranged from 5.62 to 6.90 per cent of R-to-C weight. The chemical composition exhibited significant difference. Fat as ether extract of carcass ranged from 30.22 to 46.76 per cent. Increasing the energy content of the ration showed a slight increase in fat in the carcass. Reducing the protein level by 2 per cent in finisher diets tended to increase the ether extract of carcass significantly ($P < 0.05$).

From a study on the influence of feed intake and ambient temperature, Smith and Teeter (1987) reported that dressing percentage and yield of edible parts were optimum at 23.9°C. They also reported that at higher temperature there was decrease in ready-to-cook weight.

Abasiekong (1987) reported the effect of environmental temperature on broiler carcass composition. He reported that dressing percentage improved significantly under 25°C (82 per cent) then at 23°C (78.2 per cent). While the proportion of inedible parts was higher ($P < 0.01$) for birds under 23°C.

Baghel and Pradhan (1988 b) reported influence of dietary energy, protein and limiting amino acid levels on live weight and dressing yield in broilers. In each phase three levels of energy 2800, 3000 and 3200 Kcal of ME/kg, each with four levels of protein ie. starter 20, 22, 23 and 25 per cent, grower 18, 20, 22 and 24 per cent and finisher 16, 18, 19 and 21 per cent were tested. Results showed that total processing losses as well as meat yields were not influenced by the energy-or protein levels. Total meat yield of 69.6 per cent was obtained from their study.

The influence of four protein levels ie. 17, 19, 21 and 23 per cent in combination with three energy levels 3200, 3000 and 2800 Kcal ME/kg diet on the live and meat characteristics of eight week old broilers were studied by Shyam Sunder et al. (1988). They reported that live weight, breast angle and shank length were significantly influenced by the level of dietary protein but not energy. Increase or decrease in protein and energy levels on diets had no effect on per cent evisceration weight, total meat yield and cut up parts except that the low energy diets produced heavier legs than others. Giblet weight was inversely related to dietary density. They reported shrinkage, eviscerated yield, total yield, blood, feather, offal and total loss in per cent live weight of broilers as 3.61 to 6.99, 65.74 to 67.94, 70.80 to 73.64, 3.94 to 4.88, 6.82 to 8.58, 13.51 to 16.78 and 16.80 to 29.20 respectively.

Baghel and Pradhan (1989 a) studied the seasonal effect on carcass traits, organ weights and processing losses in broilers. They found that dressed weight and eviscerated weight was maximum in cold season, followed by hot humid and hot season. Abdominal fat loss was 1.99 per cent in hot, 1.35 per cent in hot-humid and 1.79 per cent in cold seasons. Blood loss was 3.82 per cent in hot, 4.40 per cent in hot-humid and 3.58 per cent in cold season. Feather loss was 7.06 per cent in hot, 6.82 per cent in hot-humid and 6.77 per cent in cold season.

Akiba et al. (1989) reported that liver weight had a trend towards increase with an increase of protein content rather than that of fat or carbohydrate content.

Baghel and Pradhan (1989 b) reported that carcass traits, organ weights and bone:meat ratios were significantly ($P < 0.05$) influenced by energy levels. Dressed weight of the broilers getting 3000 Kcal ME/kg diet was significantly higher than those getting 2800 or 3200 Kcal ME/kg; but the advantage effect of better dressing percentage was nullified due to higher visceral losses in this group. They also reported that higher levels of protein improved the eviscerated weights significantly ($P<0.05$). The organ weights were significantly influenced by the energy and protein levels of the diet. The lower level of protein (20-18-16) was responsible for higher organ weights. The giblet weights were highest in broilers fed with 3000 Kcal ME/kg diet followed by those fed with 2800 Kcal ME/kg.

Skinner *et al*. (1990) pointed out that abdominal fat decreased as metabolizable energy increased. 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, feather loss of 3.06 per cent in broilers at eight weeks of age.

Jacob (1991) from his studies in broilers reported blood loss of 3.2 per cent, total loss of 26.64 per cent, ready-to-cook yield of 73.31 per cent and eviscerated yield of 68.03 per cent.

Livability

Salmon *et al*. (1983) found that increasing starter protein significantly increased total mortality. But mortality decreased linearly with increase in finisher protein.

Pesti and Fletcher (1983) reported the response of male broiler chicken to diets with various protein and energy contents. They found that mortality was not affected by dietary treatments.

Babu *et al*. (1986) reported that under maritime monsoon climate of Madras, livability was not influenced by feeding three levels of protein (20, 22 and 24 per cent) with three levels of energy (2600, 2800 and 3000 Kcal ME/kg) in starter diets and three levels of protein (18, 20 and 22 per cent) with same energy levels in the finisher diet.

Al-Fataftah (1987) reported that exposure of broilers to high temperature (exceeding 29°C) significantly increased mortality upto 55 per cent.

Reddy (1989) generalised the view that mortality percentage was not influenced by different energy - protein dietary regimes.

Al-Ribdawi and Singh (1989) reported the influence of protein levels on broiler performance in different seasons. They reported 4.2, 5.9 and 6.8 per cent mortality for cold, hot-humid and hot-dry seasons.

Osman *et al*. (1989) studied the effect of environmental temperature on broiler performance. They reported increased mortality rate at higher temperatures (30-32°C).

Biochemical Parameters

Influence of dietary protein level on serum protein and cholesterol level in the growing chick was reported by Leveille and Sauberlich (1961). Results of their study showed that serum protein was related to dietary protein at all four levels of protein fed (10, 15, 20 and 25 per cent). Total serum protein increased from 2.33 per 100 ml at the 10 per cent dietary protein level to 3.06 g per 100 ml at the 25 per cent level.

Thomas and Combs (1967) conducted studies to determine the effect of varying protein and energy levels on body composition and serum protein levels. Results of their study showed that, when the dietary protein level was reduced without changing the energy level, both total serum protein and albumen levels were reduced.

Deaton _et_ _al_. (1969) reported that birds reared at higher temperature (32.2°C or 23.9°C) had signifiantly lower haemoglobin than birds reared at 7.2°C. Male birds reared at 7.2°C recorded 10.97 g/100 ml whereas birds at 32.2°C recorded 9.24 g/100 ml. Plasma protein level was significantly higher (3.93 g/100 ml) at lower temperature (7.2°C) than at higher temperature of 32.2°C (3.18g/100 ml).

Morgan Jr. and Glick (1972) reported that total serum protein in chicken increased from 2.68 g per 100 ml at one week of age to 4.63 g per 100 ml at 12 weeks of age.

Bartov *et al.* (1974) reported that plasma triglycerrides and protein levels were not affected by different calorie-protein ratio of the diet. They reported plasma protein level of 3.54±0.24 g/100 ml in male and 3.73±0.36 g/100 ml in female broilers.

Sturkie (1976) reported haemoglobin value of 9.8 g/100 ml at 46 days of age and a total protein of 4 g/100 ml for males and 5.24 g/100 ml for females.

Vo *et al.* (1977) observed significant difference in blood parameters due to temperature. Red blood cell, haematocrit, haemoglobin and plasma protein values decreased as ambient temperature increased.

Nair (1983) found that in summer reared broiler birds there was a tendency for haemodilution and birds exhibited lower haemoglobin value (9.62 g/100 ml) , haematocrit values and faster ESR values.

Studies on the biochemical parameters of the blood of adult broiler parents (Darshan et al., 1987) showed that total protein content was 3.76 ± 0.11 g/100 ml in males and 4.50 ± 0.09 g/100 ml in females.

Table 1. Requirements of dietary protein (%) for broilers as reported by various authors.

References	Broiler strain/ breed	Age in weeks I	II	III	IV	V	VI	VII	VIII
Essary *et al.* (1964)	--				22			18	
Kelly and Potter (1971)	--			27				22	
Knestrick and Yacowitz (1976)	--				24			22.8	
Virk *et al.* (1976)	--				24			22.5	
Gowda *et al.* (1976)	WPR, NH, WC				24				
Johri (1977)	WPR					26			
ISI (1977)	--				22				19
Moran Jr.(1978)	WC & NH						22		
	Hubbard	24			22			20	
Brown and McCartney(1979)	Commercial broilers					23			
Olomu and Offiong (1980)	--				23			20	

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(Table 1 Contd.....)

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<tr><th rowspan="2">References</th><th rowspan="2">Broiler strain/ breed</th><th colspan="8">Age in weeks</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th><th>V</th><th>VI</th><th>VII</th><th>VIII</th></tr>
<tr><td>Musharaf and Latshaw (1981)</td><td>Commercial broilers</td><td></td><td></td><td></td><td></td><td></td><td colspan="3">18</td></tr>
<tr><td>Trinadade <u>et al</u>. (1983)</td><td>Hubbard</td><td colspan="2">24</td><td colspan="3">22</td><td colspan="2">20</td><td></td></tr>
<tr><td>Onwudike (1983)</td><td>–</td><td colspan="8">22</td></tr>
<tr><td>NRC (1984)</td><td>–</td><td colspan="3">23</td><td colspan="3">20</td><td colspan="2">18</td></tr>
<tr><td>Mukhtar <u>et al</u>. (1985)</td><td></td><td colspan="6">22</td><td colspan="2">20</td></tr>
<tr><td>Yaghi and Daghur (1985)</td><td></td><td colspan="3">20</td><td colspan="3">17</td><td colspan="2">15</td></tr>
<tr><td>Babu <u>et al</u>. (1986)</td><td></td><td colspan="6">22</td><td colspan="2">20</td></tr>
<tr><td>Husseini <u>et al</u>. (1987)</td><td></td><td colspan="8">20</td></tr>
<tr><td>Baghel and Pradhan(1988a)</td><td>Commercial broilers</td><td colspan="3">25</td><td colspan="3">24</td><td colspan="2">21</td></tr>
<tr><td>Shyam Sunder <u>et al</u>.(1988)</td><td>White Plymouth Rock</td><td colspan="5">23</td><td colspan="3">19</td></tr>
<tr><td>Sudhakar <u>et al</u>. (1988)</td><td>Commercial broilers</td><td colspan="5">22</td><td colspan="3">17</td></tr>
</table>

Table 2. Requirements of dietary energy (Kcal ME/kg) for broilers as reported by various authors.

References	Broiler strain/ breed	Age of broilers in weeks							
		I	II	III	IV	V	VI	VII	VIII
1. Gowda *et al*. (1976)					3000				
2. Knestrick and Yacowitz (1976)	Hubbard				1475-1575 Kcal/lb				
3. ISI (1977)				2900				3000	
4. Hebert *et al*. (1979)	Hubbard				3300				
5. Olomu and Offiong (1980)				2800-3000				3000	
6. Coon *et al*. (1981)	Hubbard		3410					3465	
7. Brown and McCartny (1982)	Commerical broilers						3400		
8. Trinadade *et al*. (1983)			2900					3000	

(Contd....)

(Table 2 Contd....)

References	Broiler strain/ breed	Age in weeks I	II	III	IV	V	VI	VII	VIII
9. Onwudike(1983)							3000		
10.NRC (1984)							3200		
11.Mahapatra *et al.* (1984)	Cornish						2800		
12.Babu *et al.* (1986)							2800		
13.Mukhtar *et al.* (1985)				2900				3000	
14.Husseini *et al.* (1987)					14.24 MJ/kg				
15.Sudhakar *et al.* (1988)				2900				2700	
16.Baghel and Pradhan(1988a)	Commercial broilers						2800		
17.Shyam Sunder *et al.* (1988)	WPR						3000		

Materials and Methods

MATERIALS AND METHODS

An experiment was designed and carried out at the Centre for Advanced Studies in Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to assess the requirements of protein and energy for broiler chicks during the summer season. In Kerala the day time temperature starts increasing from the month of February. Since broilers are marketed around eight weeks of age, in order to make the two phases of growth of broilers namely, starter and finisher phases coincide during the peak summer, four trials were planned in a span of two years (one trial started from February and the other from April in 1989 and 1990).

In each trial the following energy-protein combinations at starter and subsequent finisher diets were tested in a completely randomised design.

Treatments	Starter	Finisher
Diet 1	22 per cent crude protein with 2900 Kcal ME/kg	19 per cent crude protein with 3000 Kcal ME/kg
Diet 2	24 per cent crude protein with 2900 Kcal ME/kg	19 per cent crude protein with 2900 Kcal ME/kg
Diet 3	26 per cent crude protein with 2900 Kcal ME/kg	19 per cent crude protein with 3000 Kcal ME/kg
Diet 4	26 per cent crude protein with 2900 Kcal ME/kg	19 per cent crude protein with 2900 Kcal ME/kg

Two hundred and forty commercial one-day old broiler chicks (Cobb) were procured for each trial of this experiment. The chicks were wing banded, weighed individually and allotted randomly to the dietary treatment groups and replicates in such a way that the weight of chicks, within a group as well as between groups are reasonably similar. Each replicate had 20 chicks. The chicks were brooded upto three weeks of age. From fourth week onwards lights were provided at the roof level at night. They were housed in deep litter pens providing one sq.foot (900 sq.cm) per bird. The chicks were fed with respective energy-protein combination of starter diet till the end of sixth week and respective finisher diet thereafter till the end of eighth week. Feed and water were provided ad lib. The routine managemental practices were followed throughout the experimental period.

The composition of the different treatment diets are given in Table 3. The ingredients used for formulation of the diet were analysed for proximate composition and screened for aflatoxin before each mixing. Of the feed ingredients, the level of fish meal, being the animal protein source, was kept constant in all the diets. Depending on the analysed composition of feed ingredients,

Table 3. Percentage composition of broiler starter and finisher rations.

Ingredients	D1 Starter 22:2900	D1 Finisher 19:3000	D2 Starter 24:2900	D2 Finisher 19:2900	D3 Starter 26:2900	D3 Finisher 19:3000	D4 Starter 26:2900	D4 Finisher 19:2900
Yellow Maize	48.00	60.00	45.00	50.00	36.00	60.00	36.00	50.00
Groundnut cake	24.00	18.00	25.00	16.00	30.00	18.00	30.00	16.00
Gingelly oil cake	7.00	5.00	10.00	5.00	10.00	5.00	10.00	5.00
Rice Polish	7.00	3.00	6.00	15.00	10.00	3.00	10.00	15.00
Fish meal	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Mineral Mixture	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vegetable oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Total	100.00	100.00	100.00	100.00	100.0	100.00	100.00	100.00

(Contd.....)

(Table 3 Contd.....)

Added per 100kg of diet								
Merivite AB_2D_3K(g)[2]	10	10	10	10	10	10	10	10
Amprosol (g)[3]	50	50	50	50	50	50	50	50
Liv.52(g)	100	100	100	100	100	100	100	100

1. Poultrymin (Aries Agro-Vet Industries Private Ltd.), the mineral mixture contained Calcium (Min)-32.00%, Phosphorus (Min)-6.00%, Copper (Min)-100ppm, Cobalt (Min)-60ppm, Manganese (Min)-2700ppm, Iodine-100ppm, Zinc-2600ppm, Iron-0.1% and Magnesium-1000ppm

2. Merivite A B_2 D_3 K (Merind Ltd.) contained Vitamin A, B_2, D_3 and K at levels of 82,500 I.U., 52mg, 12,000 I.U., and 10mg per g. respectively.

3. Amprol plus (Merck Sharp & Dohme of India Ltd.) contained Amprolium hydrochloride B Vet C 25g, Ethopabate-8g per 500g

4. Liv 52 powder (The Himalaya Drug Co.)

marginal adjustments were made in the other ingredients to obtain the required protein and energy level of the diets. The proximate analysis of feed ingredients as well as finished feed was carried out using the method outlined in AOAC (1980). The analysed values of protein and metabolizable energy and the calculated values of lysine and methionine of experimental diets are presented in Table 4. Starch and Sugar in the feed ingredient were estimated using the modified method of Clegg (1956) and metabolizable energy was arrived at using the prediction equation suggested by Carpenter and Clegg (1956).

The meteorological variables such as maximum and minimum temperatures and relative humidity inside the house were recorded daily and weekly average was calculated.

Individual body weight at day old and at the end of each week was recorded to study the pattern of body weight gain under the different feeding regimes. Weekly feed efficiency was calculated based on the ratio of feed consumption to body weight.

Mortality during the experimental period was recorded for assessing the livability groupwise.

Table 4. Per cent proximate composition of experimental diets on dry-matter basis.

Ingredients	D1		D2		D3		D4	
	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher
A. Analysed values								
Dry matter	92.81	90.29	92.91	90.84	92.97	90.29	92.97	90.84
Crude protein	22.04	19.25	24.21	19.04	26.04	19.25	26.04	19.04
Ether extract	6.80	5.97	5.77	5.73	5.44	5.97	5.44	5.73
Crude fibre	5.50	4.47	5.54	5.56	6.43	4.47	6.43	5.56
Total ash	11.18	9.95	11.41	11.25	11.98	9.95	11.98	11.25
Nitrogen free extract	54.48	60.36	53.07	58.42	50.11	60.36	50.11	58.42
Acid insoluble Ash	4.65	4.03	4.67	4.59	4.85	4.03	4.85	4.57
Metabolizable Energy (Kcal/kg)	2944	3042	2940	2919	2922	3042	2922	2919
B. Calculated values								
Lysine	0.92	0.82	0.95	0.84	1.00	0.82	1.00	0.84
Methionine	0.46	0.39	0.48	0.41	0.50	0.39	0.50	0.41

At the end of eighth week three birds from each replicate were sacrificed at random to assess processing yields and losses. The birds were fasted for 12 hours and killed by modified Kosher's method. The jugular vein was severed just below the ear and bled for one-two minutes. Blood samples were collected for estimation of haemoglobin and plasma protein. Ethylene diamine tetra acetate (EDTA) was used as the anticoagulant. Plasma protein was estimated by the Biuret Method (Gornall et al., 1949) and Haemoglobin was estimated by Cyanmethmoglobin Method (Benjamin, 1979).

The birds were weighed after bleeding to find out the weight of blood. After this they were scalded and then defeathered. A mechanical poultry feather picker was used for defeathering and the pin feathers were removed using a pinning knife. Singeing was done to remove hair like feathers. The carcass was weighed again to find out the weight of feathers. Head and shank were removed and weighed. Then the evisceration was done. The gizzard was sliced and the innerlining and contents were removed. Gall bladder was removed carefully from the liver. Giblet ie. liver, heart and gizzard were weighed. The eviscerated weight was recorded. A piece of thigh including skin and bone and one piece of liver from each bird was saved, marked and sealed in polyethelene bags and were stored in deep freezer for estimation of fats. The samples were thawed, dried and finely ground before analysis. Fat was estimated as ether extract as per AOAC (1980).

The abdominal fat as leaf fat was found using the method suggested by Sadjadi and Becker (1980). Abdominal leaf fat consisted of fat within the abdominal cavity including that attached to the viscera and giblet that can be dissected from the carcass. The fat was weighed, marked and sealed in polyethylene bags and was stored in deep freezer for estimation of Iodine Value (Hanus method) and Saponification Value as outlined in Woodman (1941).

The data collected were subjected to statistical analysis (Snedecor and Cochran, 1967).

Results

RESULTS

An experiment with four different energy-protein combinations of starter and subsequent finisher diets as outlined in the materials and methods was conducted and tested in a completely randomized design. The experiment was conducted in four trials - one ended in peak summer and another started in peak summer, during 1989 (Trial I and Trial II) and 1990 (Trial III and Trial IV). In trials III and IV, the birds registered low body weight consequent to an inapparent non specific infection and hence the data were discarded. The experiment was repeated in February and April, 1991 (Trial III and Trial IV). The trials corresponding to the same period for 1989 and 1991 were pooled and the results presented in this chapter as Period A (started in early summer and ended in peak summer) and Period B (started in peak summer and ended in late summer).

The mean temperature and relative humidity recorded during the experimental period in the experimental shed is presented in Table 5. It could be seen from the table, that during trials I and trial III (Period A) the maximum temperature ranged from 32.29 to 38.33°C and from 32.67 to 37.71°C respectively. Likewise, the minimum temperature ranged from 23.57 to 27.60°C and from 22.14 to 27.86°C for trials I and III respectively. The relative humidity ranged

Table 5. Mean weekly temperature (°C) and relative humidity (RH) recorded inside the experimental shed.

Age in weeks	First trial: Temperature Maximum	First trial: Temperature Minimum	First trial: R.H. (%)	Second trial: Temperature Maximum	Second trial: Temperature Minimum	Second trial: R.H. (%)	Third trial: Temperature Maximum	Third trial: Temperature Minimum	Third trial: R.H. (%)	Fourth trial: Temperature Maximum	Fourth trial: Temperature Minimum	Fourth trial: R.H. (%)
1	32.29	23.57	46	32.00	25.75	66	32.67	23.11	53	35.00	26.71	77
2	35.83	26.17	57	32.86	28.57	59	35.29	22.14	49	35.00	28.42	76
3	37.17	25.67	42	35.29	29.86	62	36.29	23.14	61	35.29	28.43	66
4	36.60	27.60	48	33.43	26.29	71	36.57	26.57	54	36.29	27.57	75
5	37.33	25.67	55	32.86	27.00	67	35.86	27.00	77	34.00	27.57	79
6	38.22	25.67	66	31.33	25.33	72	35.43	26.57	80	31.43	26.29	89
7	38.33	26.00	68	30.57	24.57	81	36.43	23.14	65	29.86	25.57	92
8	38.29	25.86	58	28.00	24.50	85	37.71	27.86	64	30.00	25.57	89
Overall mean±SE	36.76± 0.71	25.78± 0.39	55.00± 3.28	32.04± 0.77	25.98± 0.47	70.38± 3.16	35.78± 0.52	24.94± 0.80	62.88± 3.94	33.36± 0.90	27.02± 0.41	80.38± 3.14

from 42 to 68 and 49 to 80 per cent for trials I and III respectively.

The maximum temperature during trials II and IV (Period B) ranged from 28.0 to 35.29°C and from 29.86 to 36.29°C respectively. The range of minimum temperature was 24.50 to 28.57°C and from 25.53 to 28.42°C during trials II and IV respectively. The relative humidity during trials II and IV ranged from 59 to 85 per cent and from 66 to 92 per cent respectively.

Period-wise mean weekly temperature and relative humidity are presented in Table 6 and graphically represented in Figures 1 and 2. It could be seen from the table that mean maximum temperature for Period A ranged from 32.48 to 38.00°C and mean minimum temperature ranged from 23.34 to 27.09°C. During Period B the mean maximum temperature ranged from 29.00 to 35.29°C and mean minimum temperature ranged from 25.04 to 28.50°C. The relative humidity ranged from 49.50 to 73.00 per cent with an overall mean of 58.94 per cent for Period A. During Period B the relative humidity ranged from 64.00 to 87.00 per cent with an overall mean of 75.38 per cent.

Table 6. Period-wise mean weekly temperature and relative humidity in the experimental shed.

Experi-mental Period	Parameters	AGE IN WEEKS 1	2	3	4	5	6	7	8	Overall mean ± SE
PERIOD A	Max.Temp(°C)	32.48	35.56	36.73	36.59	36.60	36.83	37.38	38.00	36.27±0.60
	Min.Temp(°C)	23.34	24.16	24.41	27.09	26.34	26.12	24.57	26.86	25.36±0.50
	Relative humidity(%)	49.50	53.00	51.50	51.00	66.00	73.00	66.50	61.00	58.94±3.14
PERIOD B	Max.Temp(°C)	33.50	33.93	35.29	34.86	33.43	31.38	30.22	29.00	32.70±0.80
	Min.Temp(°C)	26.23	28.50	27.15	26.93	27.29	25.81	25.07	25.04	26.50±0.39
	Relative humidity(%)	71.50	67.50	64.00	73.00	73.00	80.50	86.50	87.00	75.38±3.00

FIG.1. PERIOD-WISE MEAN WEEKLY TEMPERATURE (°C)

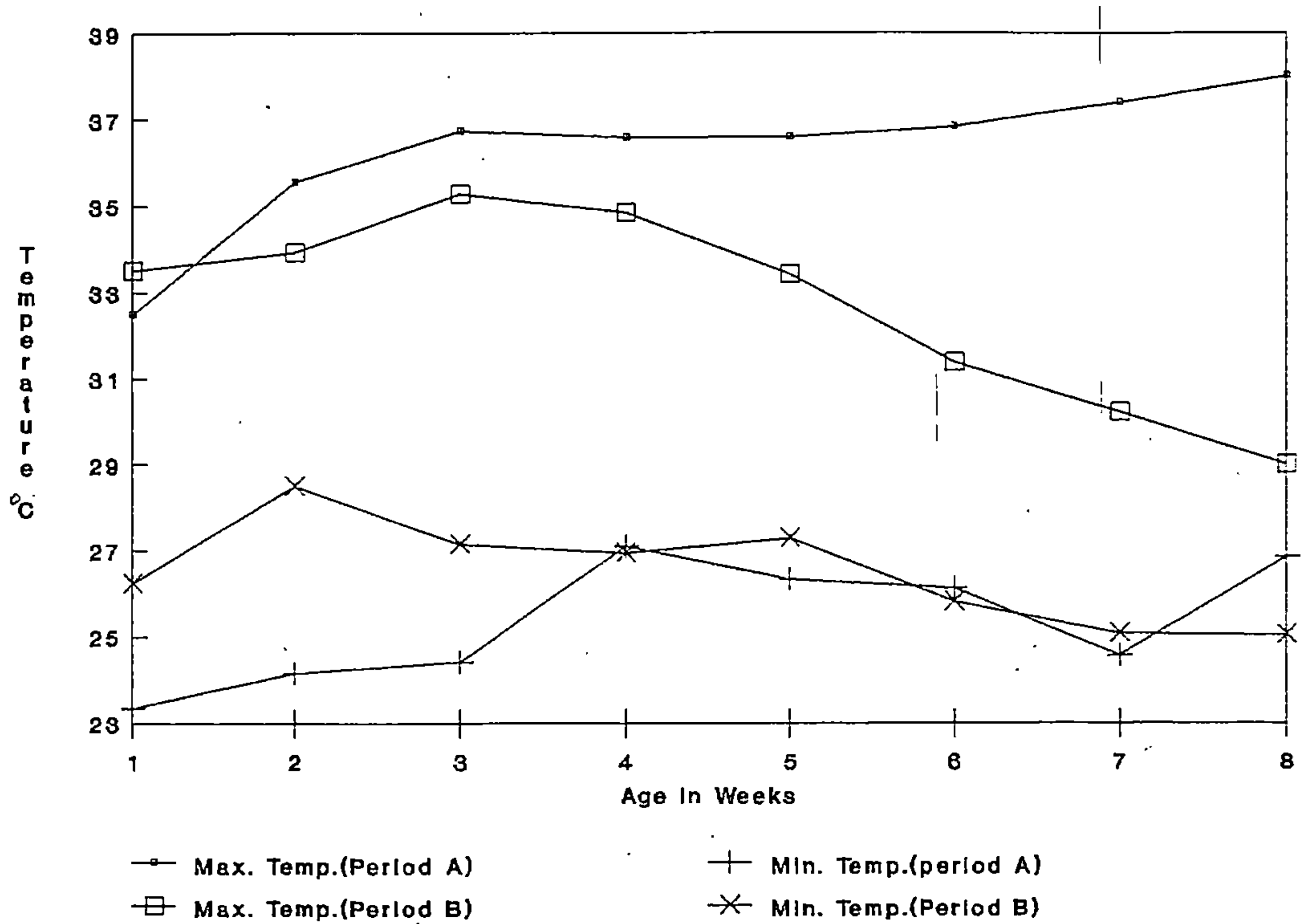
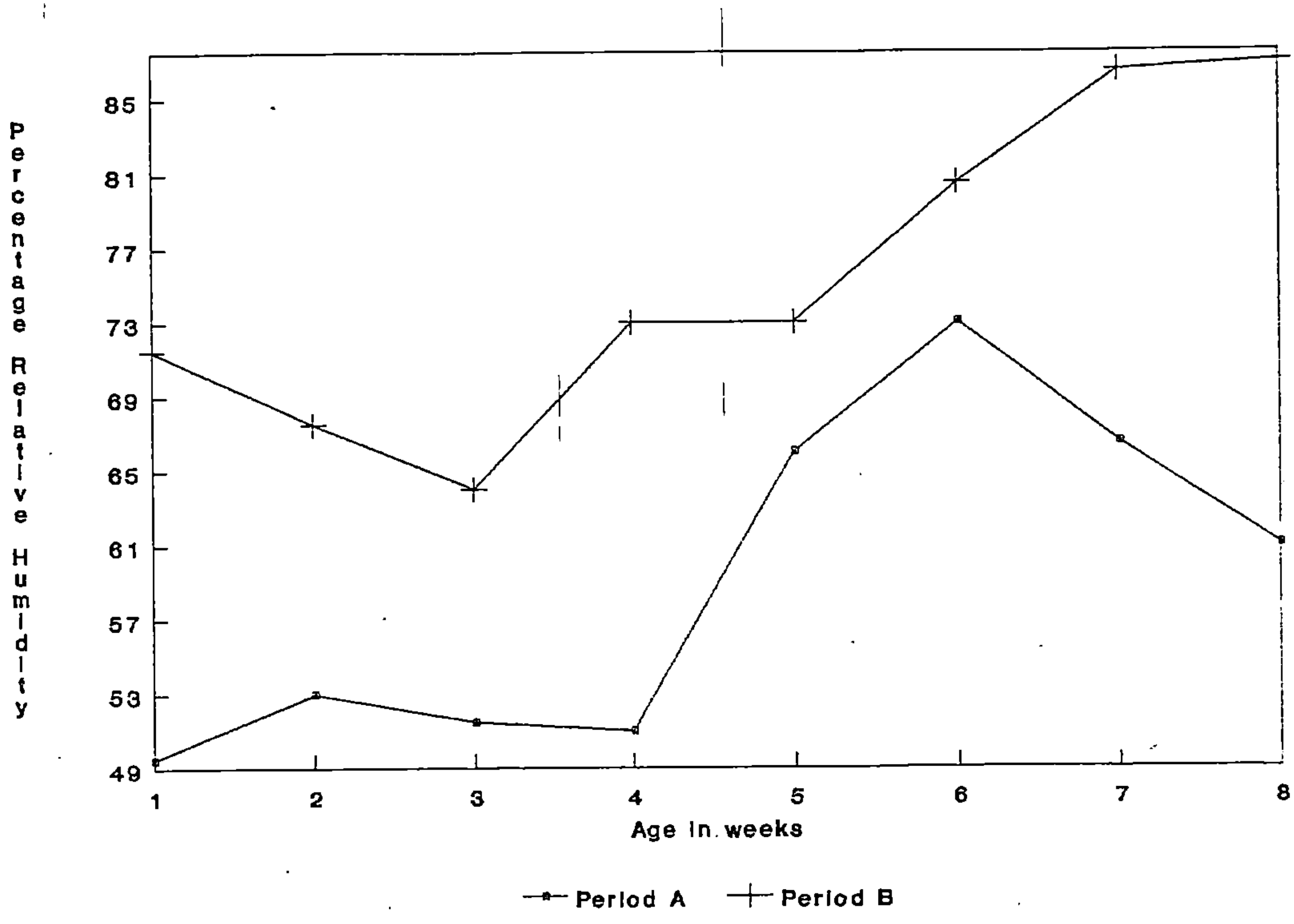


FIG.2. PERIOD-WISE MEAN WEEKLY RELATIVE HUMIDITY %



Production Parameters

Body weight

The mean weekly body weights of broilers fed four different diets in all the four trials are presented in appendices i, ii, iii and iv. The mean initial body weight of trial I was 43.43g, trial II was 38.61 g, trial III was 43.20 g and trial IV was 38.17 g.

The mean weekly body weights of broilers fed different diets pooled according to Periods are presented in Table 7 and graphically represented in Figure 3. The analysis of pooled data revealed that the difference between Period was statistically significant (P < 0.01) while the differences among dietary treatments or interactions between diet x period were not significant. The initial body weight of broiler chicks in Period A was 43.32 g and in Period B 38.39 g. The differences showed statistical significance (P < 0.01) between the two periods.

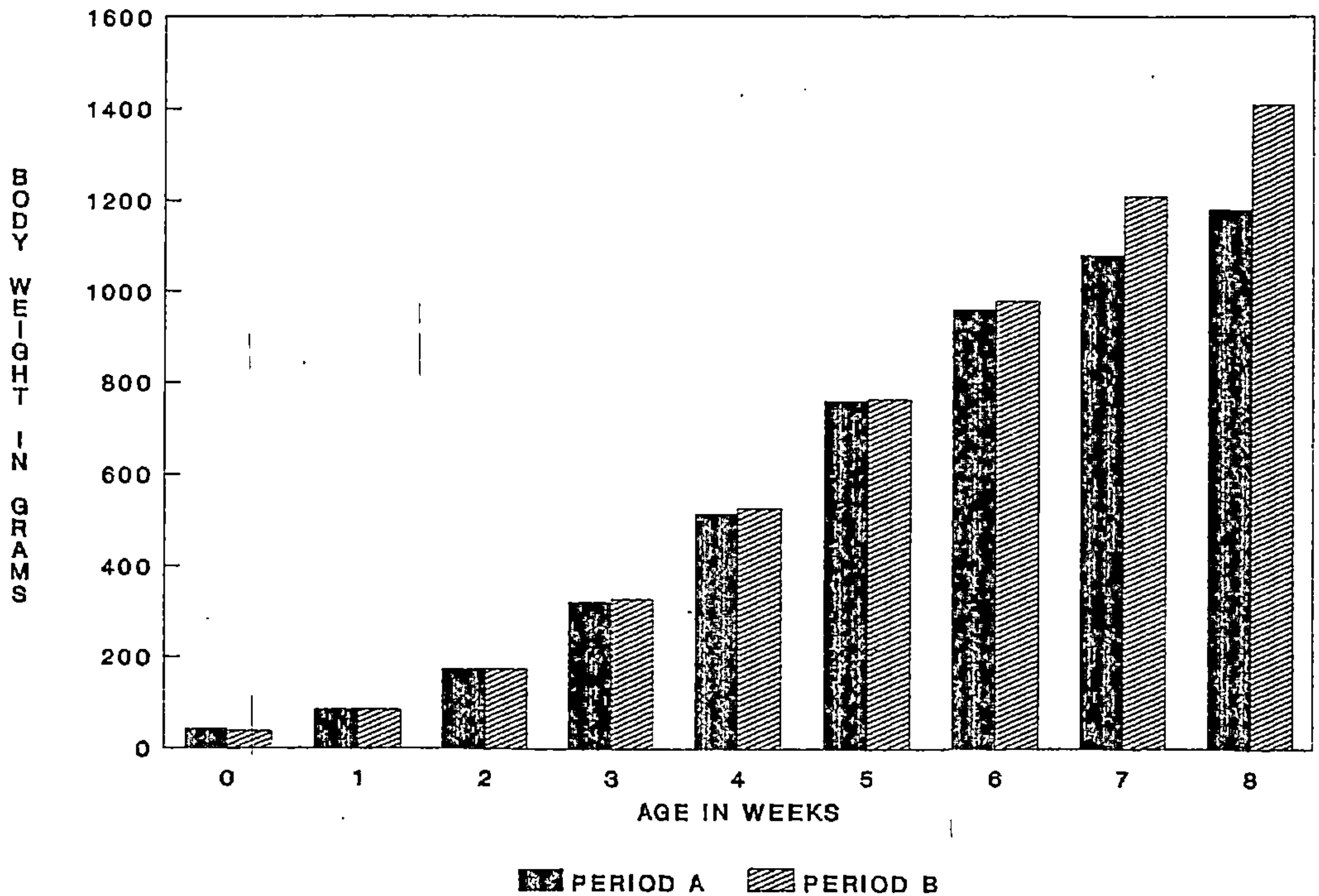
At first week the average body weights for broilers fed diets 1, 2, 3 and 4 in Period A were 86.78, 87.34, 87.80 and 87.32g respectively. There was statistically no difference among dietary treatments. In Period B low body weight of

Table 7. Mean weekly body weight (g) of broilers fed experimental diets from 0-8 weeks(Pooled data).

Treatments	AGE IN WEEKS 0	1	2	3	4	5	6	7	8
					PERIOD - A				
D1	43.24±0.35	86.78±1.30	176.15±3.30	310.53±6.30	487.63± 9.99	725.71±13.22	919.71±17.64	1046.57±22.74	1167.03±25.75
D2	43.30±0.39	87.34±1.20	172.30±3.05	314.38±6.19	504.89±10.13	759.88±13.68	971.72±20.08	1112.56±22.28	1208.88±26.94
D3	43.62±0.43	87.80±1.38	181.43±3.09	332.23±6.81	530.56±10.03	779.10±12.72	975.54±18.07	1091.37±23.25	1184.57±27.31
D4	43.12±0.34	87.32±1.20	174.62±3.06	325.06±6.34	524.13± 9.15	769.21±12.80	966.66±18.30	1069.41±22.25	1168.52±24.94
Mean for diets	43.32^{a}±0.11	87.31±0.21^{a}	176.13±2.25^{a}	320.55±4.96^{a}	511.80± 9.73^{a}	758.48±11.61^{a}	958.41±13.03^{a}	1079.98±14.20^{a}	1182.25±9.72^{a}
					PERIOD - B				
D1	38.27±0.34	84.40±1.23	164.88±3.35	302.51±6.35	474.13±10.09	700.38±14.82	923.04±17.93	1170.30±22.91	1397.22±29.82
D2	38.55±0.36	86.46±1.27	174.75±3.11	331.17±6.59	537.00± 9.47	795.34±12.05	1022.92±17.77	1234.98±24.23	1423.56±30.42
D3	38.53±0.35	86.99±1.34	181.92±3.68	339.80±7.54	547.78±11.78	790.90±16.03	1012.69±22.03	1274.67±28.95	1472.21±34.51
D4	38.20±0.35	87.10±1.25	178.03±3.62	331.84±7.71	539.38±10.57	764.01±14.91	958.54±22.29	1152.67±32.27	1340.56±42.37
Mean for diets.	38.39±0.09^{b}	86.24±0.63^{a}	174.90±0.65^{a}	326.33±8.18^{a}	524.57±16.97^{a}	762.66±21.88^{a}	979.30±23.48^{a}	1208.16±28.37^{b}	1408.39±27.43^{b}

Means bearing the same superscript within the same column do not differ significantly (P<0.01).

FIG. 3. MEAN WEEKLY BODYWEIGHT OF BROILERS FED EXPERIMENTAL DIETS



84.40 g was recorded for diet 1 and numerically high body weight of 86.46, 86.99 and 87.10 g with diet 2, 3 and 4 respectively during first week, but the differences were not statistically significant. Comparison of data between periods for first week body weight revealed that the mean weekly body weight of birds fed different energy-protein combinations were statistically homogenous.

The body weight of broilers at second week of age showed lowest body weight (172.30 g) in birds fed diet 2 (24:2900 in starter and 19:2900 in finisher) than diet 1, 3 and 4 which recorded body weights of 176.15, 181.43 and 174.62 g respectively in Period A and in Period B, the lowest body weight (164.88 g) was in group fed diet containing 22:2900 in starter and 19:3000 in finisher (Diet 1) than the other treatment groups. Eventhough highest body weight of 181.92 g was recorded in group fed with diet 3 (26:2900 in starter and 19:2900 in finisher) the difference neither among dietary treatments nor between periods for body weight at second week was significant.

At third week the average body weight in Period A was 320.55 g and in Period B it was 326.33 g. There was no statistical difference between periods. In both the periods lower body weight was recorded with dietary treatment containing protein and energy levels of 22:2900 in starter and 19:3000 in finisher (Diet 1). Higher body weight (332.23 g in Period A and 339.80 g in Period B) was recorded for diet 3 in both the periods. However, the difference among dietary treatments in both the periods was statistically similar.

The mean weekly body weight of broilers fed different treatment diets at fourth week of age showed that the highest body weight of 530.56 g in Period A for diet 3 and in Period B maximum body weight of 547.78 g was recorded for diet containing protein-energy combination of 26:2900 in starter and 19:2900 in finisher (Diet 3). The lowest body weight of 487.63 g in Period A and 474.13 g in Period B was recorded in group fed with diet 1. The average body weight at fourth week for all the diets for Period A was 511.80 g and in Period B 524.57 g revealing no statistical difference between periods.

At fifth week of age, highest body weight of 779.10g was recorded in Period A in birds fed with protein and energy level of 26:2900 in the starter and 19:3000 in the finisher diet (Diet 3). In Period B the highest body weight of 795.34 g was recorded in birds receiving protein-energy levels of 24:2900 in the starter and 19:2900 in the finisher

(Diet 2). However, the statistical analysis of the data revealed that neither protein - energy nor season (Periods) influenced body weight at this age.

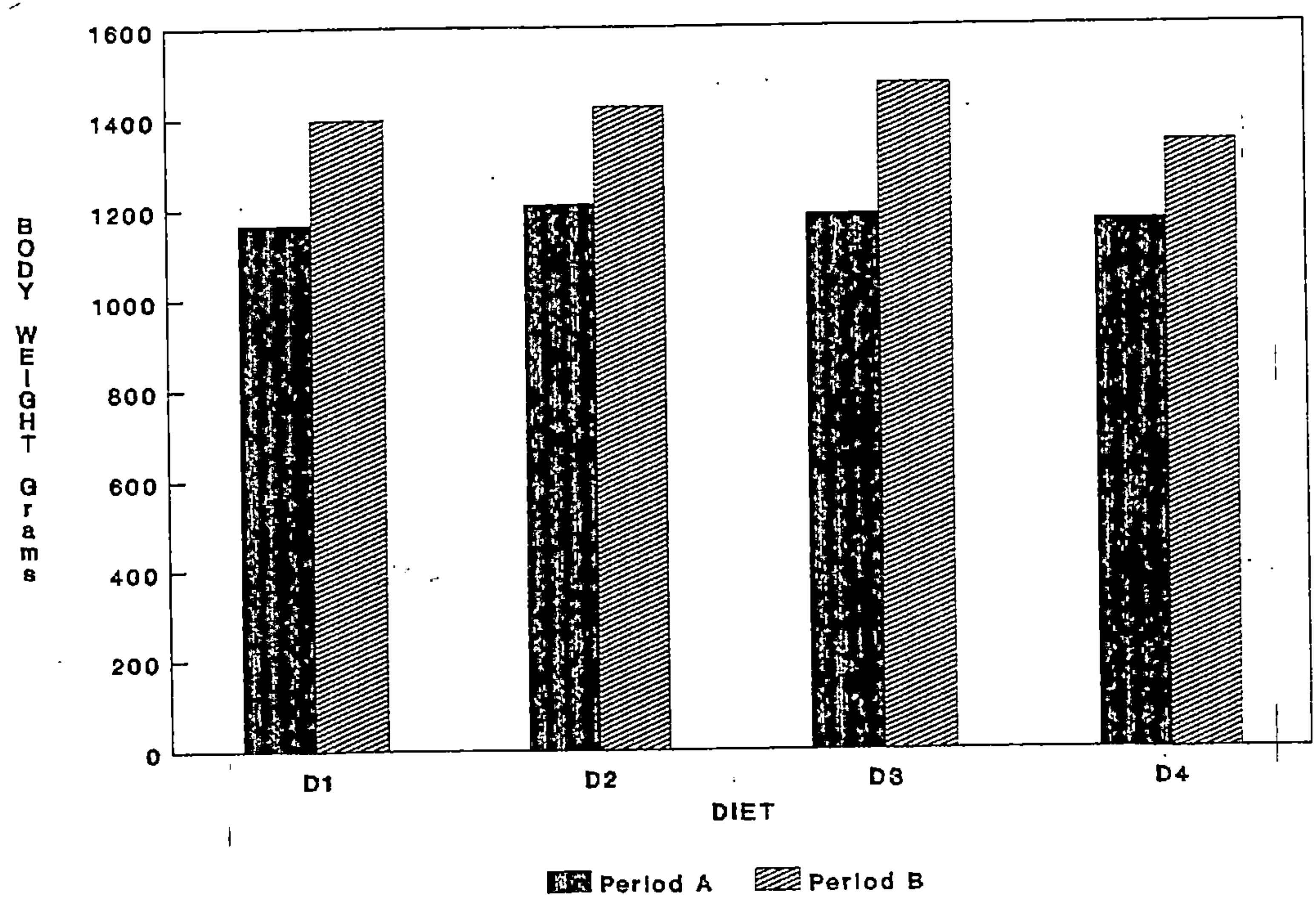
At sixth week of age the highest mean body weight of 975.54 g was recorded in broilers fed with diet containing protein and energy level of 26:2900 in the starter and 19:3000 in the finisher (Diet 3) in the trial ended in peak summer (Period A). In the trial ended in the late summer (Period B), the highest body weight of 1022.92 g was recorded in birds fed with protein and energy level of 24:2900 in the starter and 19:2900 in the finisher (Diet 2). However, the statistical analysis of the data did not show any significant influence due to either dietary treatment or periods.

The body weight of broilers fed different protein energy combinations showed highest weight of 1112.56 g in groups fed with diet 2 (24:2900 in the starter and 19:2900 in the finisher) at seventh week of age in the trials ended in peak summer (Period A). During Period B, the highest body weight of 1274.67 g was recorded in the birds fed protein-energy levels of 26:2900 in the starter and 19:3000 in the finisher stage (Diet 3). However statistical analysis of the data did not show any significant influence due to different dietary treaments. But the trials ended in the peak summer (Period A) showed significantly ($P < 0.01$) lower overall mean body weight (1079.98 g) than the trials that ended in late summer (1208.16 g).

At eighth week of age the highest body weight of 1472.21 g was recorded in the group fed with protein and energy levels of 26:2900 in the starter and 19:3000 in the finisher (Diet 3) in the trials ended in the late summer (Period B). In the Period A the highest body weight of 1208.88 g was recorded in the group fed with protein-energy levels of 24:2900 in the starter and 19:2900 in the finisher (Diet 2). The lowest body weight (1167.03 g) was recorded in broilers fed with diet containing protein and energy level of 22:2900 in the starter and 19:3000 in the finisher (Diet 1) in Period A.

There was significant difference between periods ($P < 0.01$) in the final body weight at eighth week (Fig. 4). The trials that ended in peak summer (Period A) showed significantly lower mean body weight at eighth week (1182.25 g) than the trials ended in late summer (Period B), which had a final body weight of 1408.39 g.

FIG. 4. MEAN BODY WEIGHT OF BROILERS FED EXPTL. DIETS AT EIGHT WEEKS OF AGE



Body weight gain

Mean weekly body weight gain of broilers fed different dietary treatments from 0-8 weeks of age for the trials pooled according to Period A and Period B is presented in Table 8 and graphically represented in Figure 5. The data of individual trials are presented in the Appendices v, vi, vii, viii. Statistical analysis of the pooled data revealed that the body weight gain was not influenced by the dietary treatments and the periods upto sixth week of age. Thereafter body weight gain was in favour of Period B.

Maximum body weight gain was recorded at fifth week of age in both Period A and Period B. In Period A body weight gain at fifth week of age was 246.19 g and in Period B it was 238.13 g. Among the different dietary treatments maximum body weight gain, even though statistically not significant, was recorded in groups fed with protein and energy levels of 24:2900 in the starter and 19:2900 in the finisher (Diet 2) in both the periods.

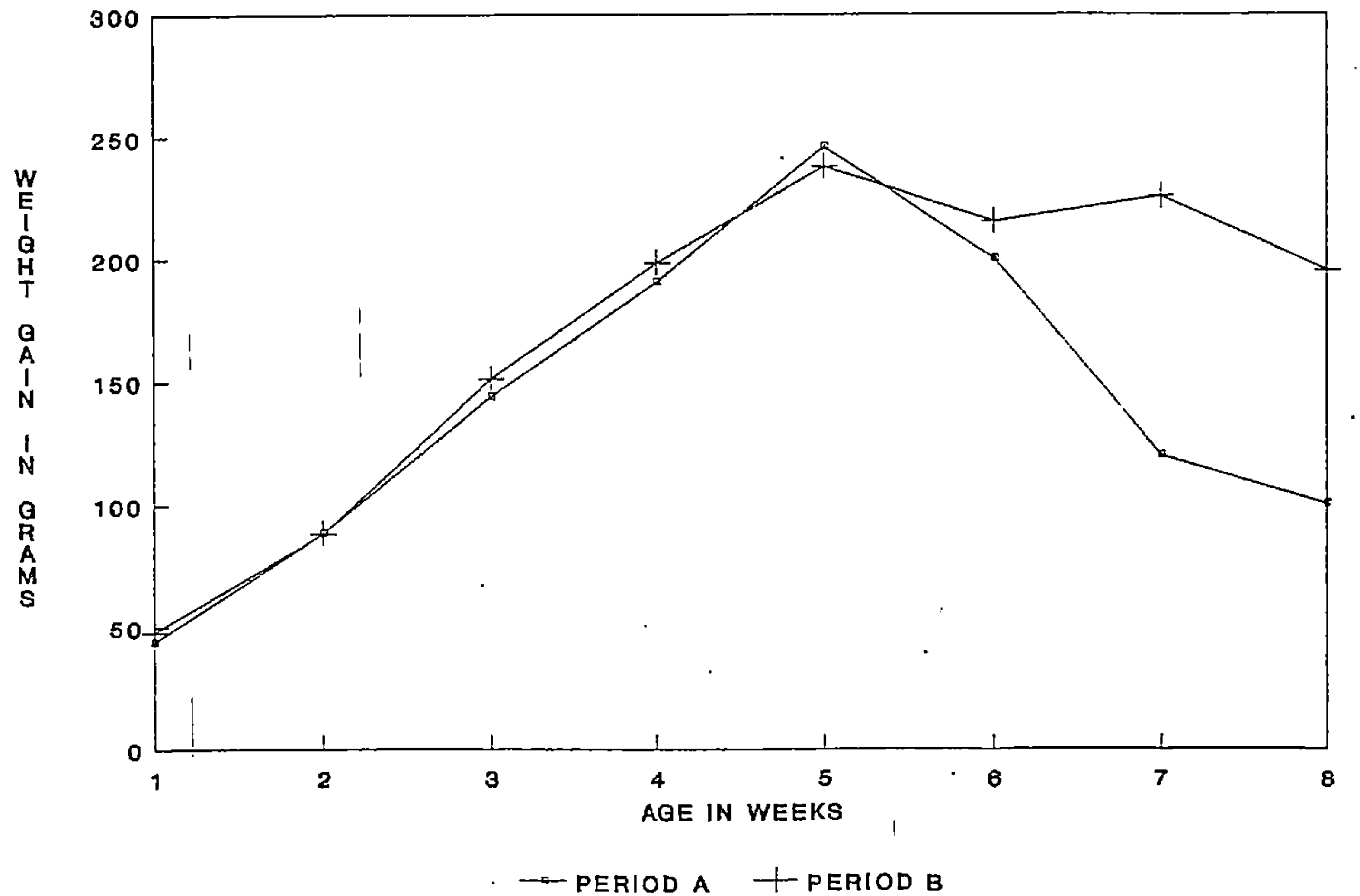
At seventh week of age, the trial that ended in extreme summer (Period A) showed significantly lower body weight gain (120.12 g) than that ended in late summer in period B (226.09 g).

Table 8. Mean weekly body weight gain(g) of broilers fed experimental diets from 0-8 weeks (Pooled data).

Treat-ments	AGE IN WEEKS							
	1	2	3	4	5	6	7	8
				PERIOD - A				
D1	43.58	89.13	134.89	175.77	235.67	195.06	130.02	114.81
D2	44.04	84.82	141.52	190.93	255.00	209.86	138.06	104.10
D3	44.19	93.35	151.02	197.04	249.79	195.41	110.33	89.06
D4	44.19	88.16	149.66	199.07	244.30	200.30	102.30	92.20
Mean for diets	44.00^{a} ± 0.14	88.87^{a} ± 1.76	144.27^{a} ± 3.77	190.71^{a} ± 5.27	246.19^{a} ± 4.13	200.18^{a} ± 3.44	120.12^{a} ± 8.37	100.22^{a} ± 5.82
				PERIOD - B				
D1	46.14	80.45	137.89	171.62	226.25	218.38	242.71	224.30
D2	47.91	88.31	156.25	205.83	258.17	227.25	207.03	182.89
D3	48.39	94.93	157.96	208.21	243.47	223.20	262.65	197.69
D4	48.82	90.96	153.81	209.02	224.63	193.43	191.98	176.73
Mean for diets	47.82^{a} ± 0.59	88.66^{a} ± 3.06	151.48^{a} ± 4.61	198.67^{a} ± 9.04	238.13^{a} ± 7.92	215.57^{a} ± 7.60	226.09^{b} ± 16.18	195.40^{b} ± 10.59

Means bearing the same superscript within the same column do not differ significantly ($P<0.01$) .

FIG. 5. MEAN WEEKLY BODY WEIGHT GAIN (g) OF BROILERS FED EXPERIMENTAL DIETS



At eighth week of age body weight gain showed a decreasing trend. The trial that ended in March (Period A) had significantly ($P < 0.01$) lower body weight gain (100.22g) than the period B which had a body weight gain of 195.40 g. Overall body weight gain for the pooled trials for Period A was 1138.93 g and for Period B was 1370.00 g upto eighth week of age.

Daily feed consumption

Week-wise, mean daily feed consumption of broilers fed different energy-protein combinations upto eighth week of age for four trials were presented in Appendices ix, x, xi, xii and pooled data are presented in Table 9. The graphical representation of pooled data is presented in Figure 6. The statistical analysis of the data indicated that the dietary treatments did not influence feed consumption upto eighth week of age in both Period A and Period B. However, the magnitude of difference in daily feed consumption at seventh and eighth week of age between Period A and Period B was statistically significant ($P < 0.05$).

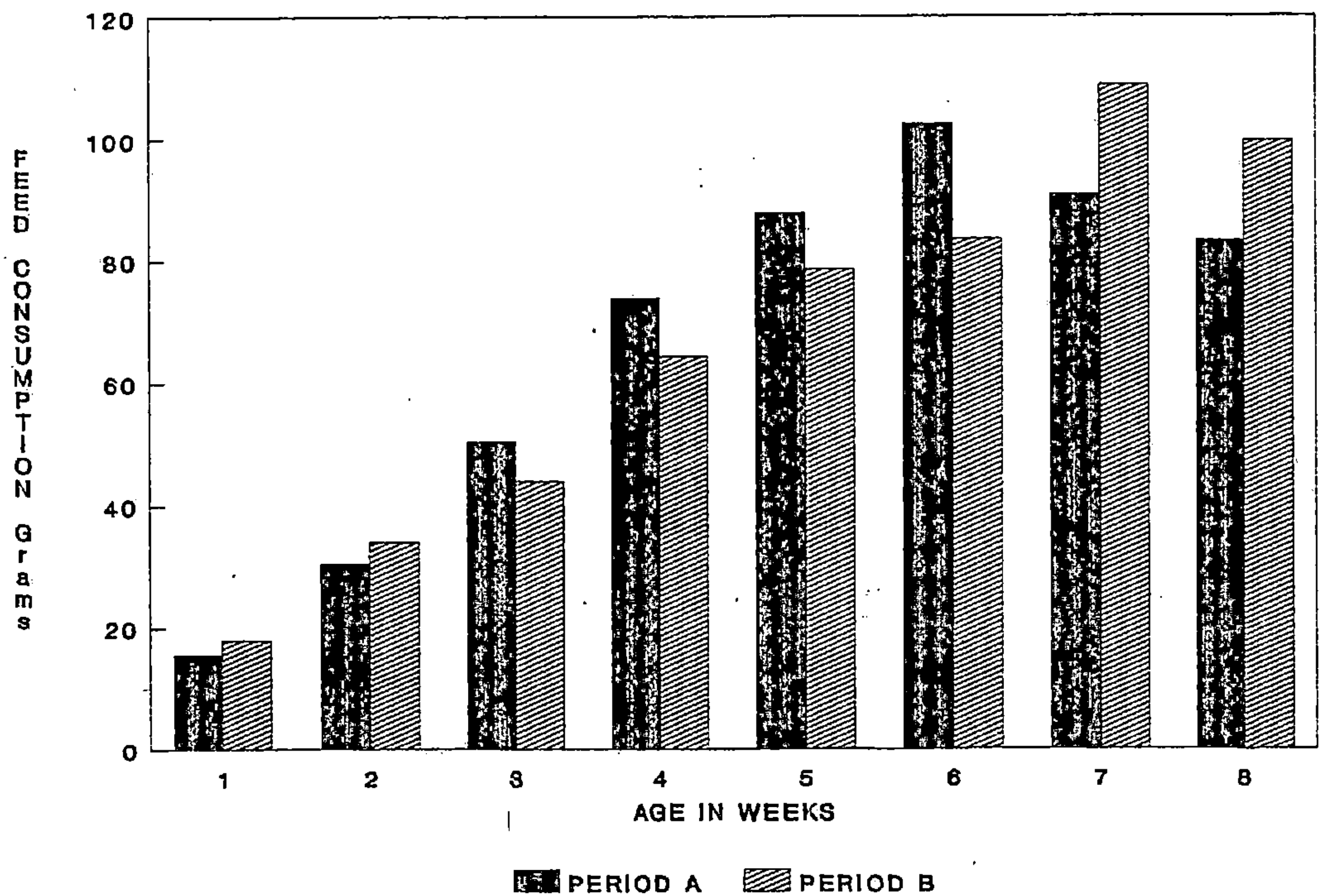
Mean daily feed consumption at first week of age was 15.62 g for Period A and 17.92 g for Period B. For second week of age it was 30.50 g for Period A and 34.05 g for the

Table 9. Mean feed consumption (g)/bird/day of broilers fed experimental diets from 0 to 8 week of age (Pooled data).

Treatments	AGE IN WEEKS							
	1	2	3	4	5	6	7	8
PERIOD - A								
D1	15.38	29.42	50.60	73.10	88.84	99.39	95.31	81.49
D2	16.01	30.69	52.21	75.89	88.60	103.63	88.62	83.87
D3	15.54	31.14	50.36	70.68	87.78	101.92	86.95	84.82
D4	15.54	30.75	48.33	75.36	86.91	104.75	93.23	83.12
Mean for diets	15.62 $\pm$0.14[a]	30.50 $\pm$0.37[a]	50.38 $\pm$0.80[a]	73.76 $\pm$1.19[a]	88.03 $\pm$0.44[a]	102.42 $\pm$1.17[a]	91.03 $\pm$1.95[a]	83.33 $\pm$0.70[a]
PERIOD - B								
D1	18.25	35.00	44.65	58.21	80.95	83.80	109.64	101.88
D2	18.12	35.84	42.27	68.93	81.80	81.25	110.34	97.11
D3	17.19	32.50	44.29	66.76	76.93	85.39	112.40	104.20
D4	18.11	32.86	44.64	63.20	74.78	83.94	102.89	95.64
Mean for diets	17.92 $\pm$0.24[a]	34.05 $\pm$0.81[a]	43.96 $\pm$0.57[a]	64.28 $\pm$2.34[a]	78.62 $\pm$1.66[a]	83.60 $\pm$0.86[a]	108.82 $\pm$2.06[b]	99.71 $\pm$2.00[b]

Means bearing the same superscript within the same column do not differ significantly ($P<0.01$).

FIG. 6. MEAN WEEKLY FEED CONSUMPTION(G/BIRD/DAY) OF BROILERS FED EXPERIMENTAL DIETS



trial that ended at late summer (Period B). At third week of age trials that ended in peak summer (Period A) recorded mean daily feed consumption of 50.38 g and for Period B, 43.96 g. At fourth week of age mean daily feed consumption of Period A was 73.76 g and for Period B it was 64.28 g.

At fifth week of age, trials that ended in peak summer (Period A) had mean daily feed consumption of 88.03 g and for Period B average daily consumption was 78.62 g. At sixth week of age eventhough there was no statistical difference between periods there was numerical difference. During Period A feed consumption was 102.42 g and during Period B it was 83.60 g per day.

At seventh week of age trials that ended in peak summer (Period A) showed significantly ($P < 0.05$) lower feed consumption (91.03 g) than during Period B where the average daily feed consumption was 108.82 g. Likewise, at eighth week of age Period A showed significantly ($P < 0.05$) lower feed consumption (83.33 g) than period B where mean daily feed consumption was 99.91 g.

<u>Feed Efficiency</u>

The mean cumulative feed efficiency of broilers fed different diets, recorded weekly for the four trials are presented in Appendices xiii, xiv, xv, xvi and pooled data pertaining to Period A and Period B are presented in Table 10 and graphically represented in Figures 7 and 8. Analysis of pooled data revealed that there was no significant difference between periods in feed efficiency upto fifth week of age barring second week and from sixth week onwards Period B showed significantly ($P < 0.01$) better feed efficiency than Period A. The overall mean feed efficiency for the first week in Period A was 1.15 and in Period B it was 1.37.

At second week of age, Period A showed significantly ($P < 0.05$) better feed efficiency of 1.76 than Period B, in which feed efficiency was 2.04. At third week of age pooled data did not reveal any statistically significant difference between periods. During Period A feed efficiency was 2.07 and during Period B it was 2.09. At fourth week of age the feed efficiency during Period A and B were 2.30 and 2.21 respectively. At fifth week of age, feed efficiency in Period A was 2.37 and in Period B was 2.22.

At sixth week, trials that ended at peak summer (Period A) showed significantly ($P < 0.01$) poorer feed efficiency of 2.67 than Period B in which the feed efficiency was 2.33. At seventh week of age the same trend

FIG. 7. MEAN WEEKLY FEED EFFICIENCY OF BROILERS FED EXPERIMENTAL DIETS

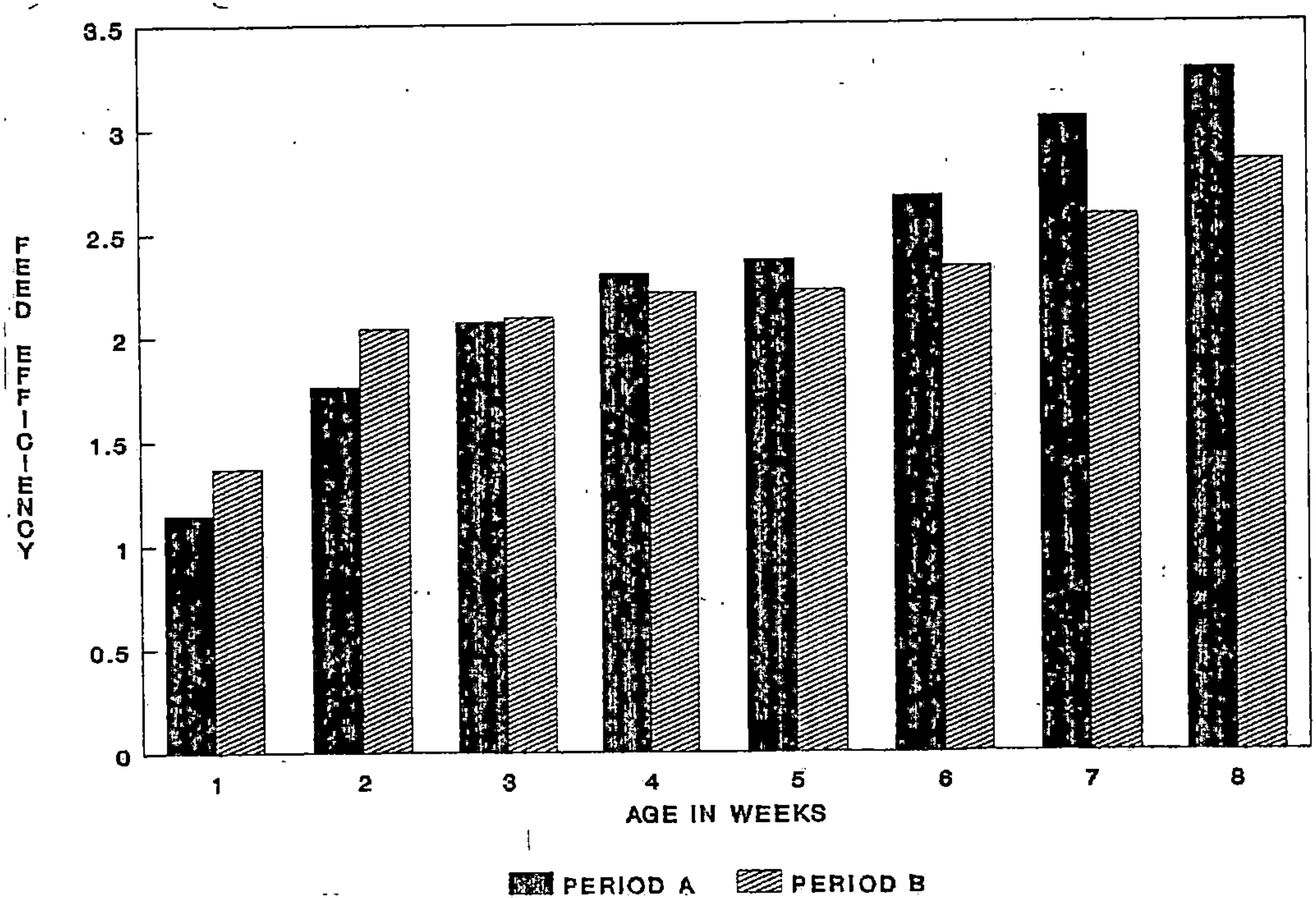
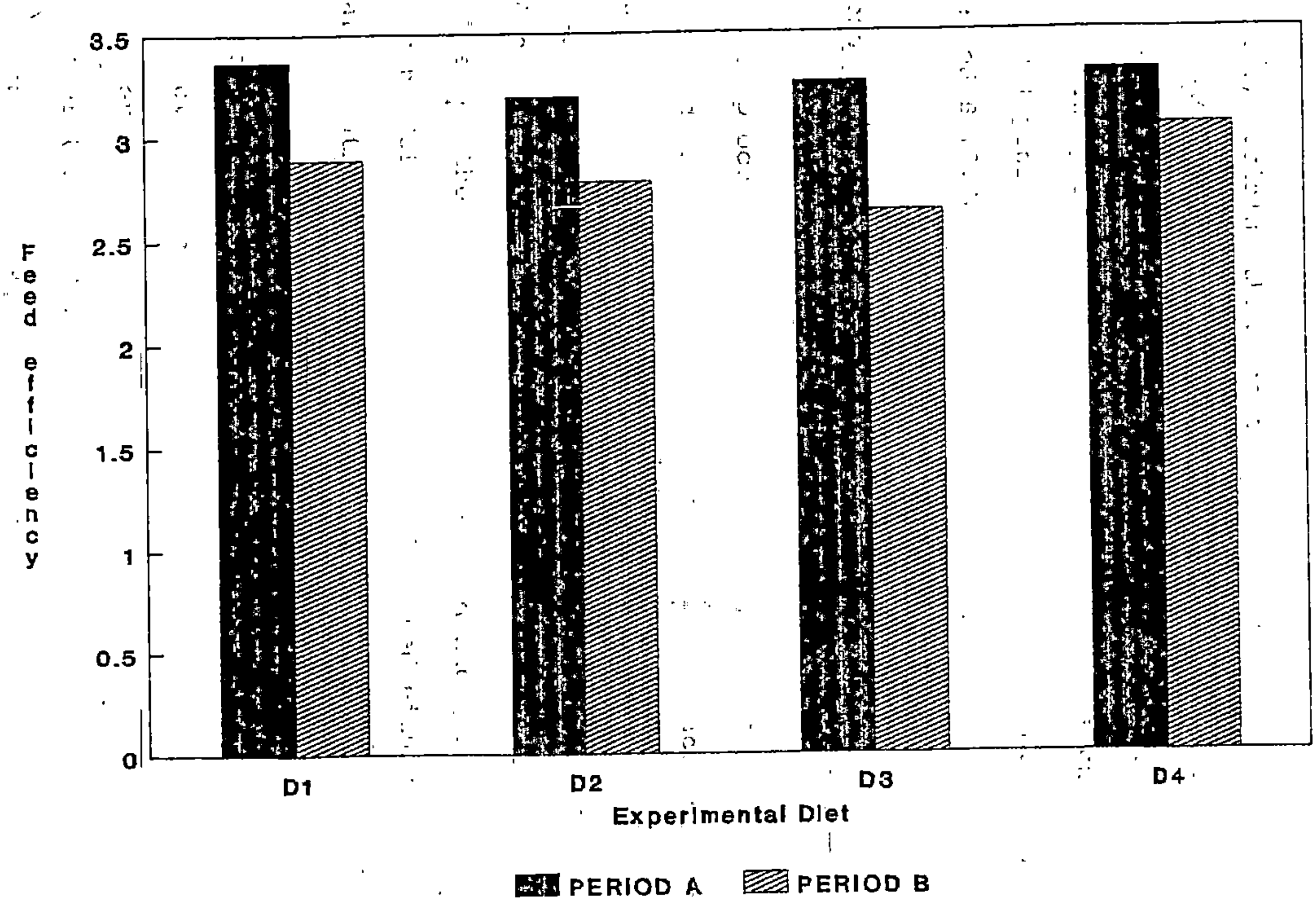


Table 10. Mean weekly cumulative feed efficiency of broilers fed experimental diets from 0-8 weeks (Pooled data).

Treat-ments	AGE IN WEEKS							
	1	2	3	4	5	6	7	8
PERIOD - A								
D1	1.15±0.08	1.72±0.08	2.11±0.08	2.39±0.09	2.45±0.09	2.70±0.11	3.16±0.13	3.37±0.12
D2	1.13±0.11	1.79±0.14	2.17±0.10	2.41±0.09	2.43±0.08	2.66±0.07	2.96±0.05	3.19±0.06
D3	1.15±0.09	1.73±0.10	1.99±0.06	2.18±0.08	2.29±0.05	2.58±0.07	3.02±0.11	3.26±0.09
D4	1.18±0.05	1.78±0.08	2.02±0.05	2.22±0.06	2.31±0.02	2.74±0.12	3.05±0.09	3.31±0.09
Mean for diets	1.15[a]±0.01	1.76[a]±0.02	2.07[a]±0.04	2.30[a]±0.06	2.37[a]±0.04	2.67[a]±0.03	3.05[a]±0.04	3.28[a]±0.04
PERIOD - B								
D1	1.43±0.12	2.21±0.08	2.56±0.04	2.50±0.18	2.39±0.11	2.45±0.05	2.69±0.06	2.89±0.10
D2	1.37±0.10	2.12±0.05	2.01±0.05	2.14±0.09	2.16±0.06	2.24±0.03	2.51±0.07	2.78±0.13
D2	1.30±0.12	1.88±0.08	1.79±0.13	2.06±0.06	2.13±0.07	2.26±0.04	2.42±0.04	2.63±0.07
D4	1.36±0.09	1.96±0.07	2.00±0.05	2.13±0.08	2.19±0.06	2.38±0.08	2.70±0.13	3.04±0.44
Mean for diets	1.37[a]±0.03	2.04[b]±0.07	2.09[a]±0.16	2.21[a]±0.10	2.22[a]±0.06	2.33[b]±0.05	2.58[b]±0.07	2.84[b]±0.09

Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

FIG. 8. MEAN CUMULATIVE FEED EFFICIENCY OF BROILERS AT 8 WEEKS OF AGE



continued, trials that ended at peak summer (Period A) had significantly ($P < 0.01$) poorer feed efficiency (3.05) than Period B (2.58). At eighth week of age trials that ended at peak summer (Period A) had significantly ($P < 0.01$) poorer feed efficiency (3.28) than that recorded in Period B (2.84).

Processing Yield and losses

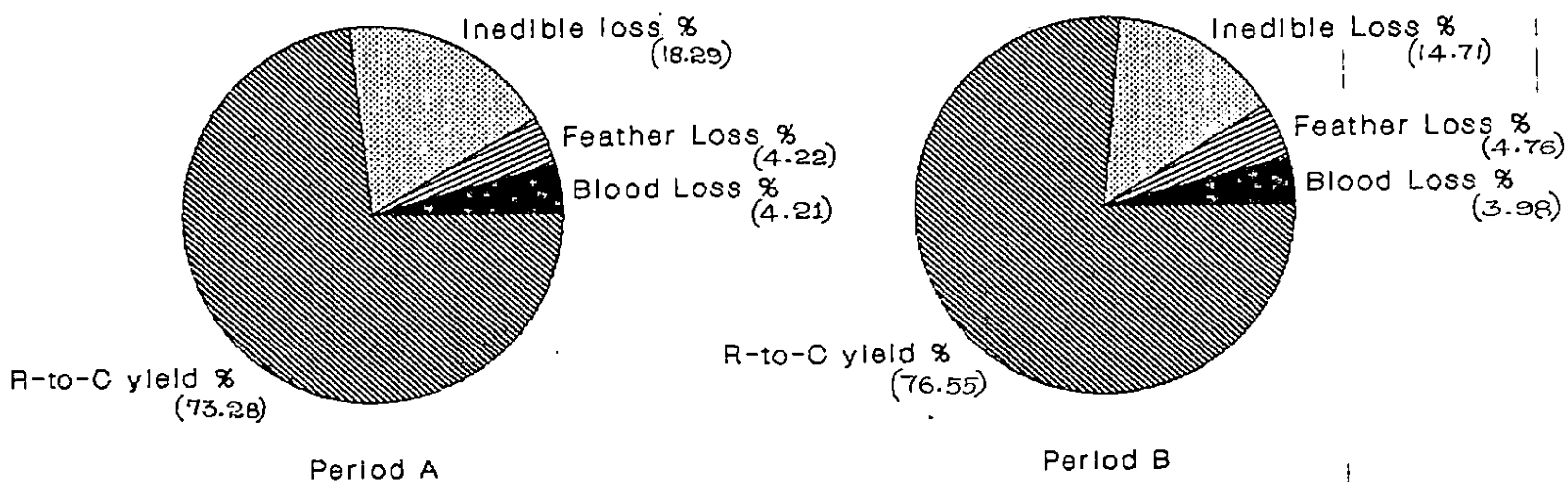
The processing yield and losses recorded in birds slaughtered at eighth week of age pooled according to periods is presented in Table 11 and graphically represented in Figure 9. The data for individual trials are presented in Appendices xvii, xviii, xix and xx. The statistical analysis of the data revealed that yield and losses due to processing of broilers were not influenced either by the dietary treatments or by the periods.

The per cent of blood loss varied from 3.94 to 4.63 with an overall mean of 4.21 for the trials that ended in peak summer (Period A) and 3.98 for the trials that ended in late summer (Period B). The per cent blood loss in Period B ranged from 3.79 to 4.14.

Table 11. Mean processing yield and losses at eighth week of broilers fed experimental diets (Pooled data).

Observations	PERIOD - A					PERIOD - B				
	D1	D2	D3	D4	Overall mean for diets	D1	D2	D3	D4	Overall mean for diets
Starved body weight(g)	1191.11 ±48.12	1310.00 ±47.69	1250.00 ±46.17	1252.23 ±48.46	1250.84 ±24.27	1471.67 ±35.64	1429.72 ±65.62	1614.17 ±48.66	1431.95 ±50.42	1486.88 ±43.26
Blood loss(%)	4.63 ±0.29	4.25 ±0.20	4.00 ±0.27	3.94 ±0.20	4.21 ±0.15	4.05 ±0.15	3.97 ±0.20	3.79 ±0.20	4.14 ±0.13	3.98 ±0.07
Feather loss(%)	4.31 ±0.22	4.25 ±0.23	4.04 ±0.26	4.27 ±0.24	4.22 ±0.06	4.86 ±0.25	4.72 ±0.33	4.60 ±0.33	4.84 ±0.31	4.76 ±0.05
Total loss(%)	27.57 ±1.06	26.25 ±0.65	25.31 ±0.57	27.76 ±0.88	26.72 ±0.58	23.51 ±0.83	23.92 ±0.75	22.46 ±0.84	23.90 ±0.55	23.45 ±0.34
Eviscerated yield(%)	66.69 ±1.15	68.52 ±0.77	69.37 ±0.77	66.76 ±0.82	67.84 ±0.73	71.94 ±0.84	71.09 ±0.84	72.74 ±0.92	70.88 ±0.53	71.66 ±0.43
Giblet yield(%)	5.74 ±0.23	5.23 ±0.23	5.32 ±0.22	5.48 ±0.26	5.44 ±0.11	4.55 ±0.14	4.99 ±0.17	4.80 ±0.14	5.22 ±0.15	4.89 ±0.10
R-to-C Yield(%)	72.43 ±1.05	73.75 ±0.65	74.69 ±0.71	72.24 ±0.82	73.28 ±0.65	76.49 ±0.83	76.08 ±0.75	77.54 ±0.90	76.10 ±0.55	76.55 ±0.34
Abdominal fat (%)	1.65 ±0.17	1.48 ±0.17	1.40 ±0.14	1.23 ±0.12	1.44 ±0.09	1.59 ±0.13	1.17 ±0.11	1.21 ±0.15	0.85 ±0.12	1.21 ±0.15

FIG.9. PERCENT MEAN PROCESSING YIELD AND LOSSES OF BROILERS FED DIFF. DIETS AT 8 WEEKS



The per cent feather loss ranged from 4.04 to 4.31 with an overall mean of 4.22 for Period A. During Period B the per cent feather loss ranged from 4.60 to 4.86 with an overall mean of 4.76.

The total offal in processing ranged from 22.46 to 27.78 per cent and the mean value was 26.72 per cent for trials that ended in extreme summer (Period A) and 23.45 for Period B.

The percentage eviscerated yield obtained was 67.84 in Period A and 71.66 during Period B and the values ranged from 66.69 to 69.37 per cent in Period A and 70.88 to 72.74 in Period B.

The giblet yield ranged from 5.23 to 5.74 per cent with an overall mean of 5.44 per cent in Period A. The range was 4.55 to 5.22 per cent for Period B with an overall mean of 4.89 per cent.

The mean per cent ready-to-cook yield was 73.28 during Period A and ranged from 72.24 to 74.69. In Period B the mean yield was 76.55 per cent and ranged from 76.08 to 77.54 per cent.

The abdominal fat per cent ranged from 1.23 to 1.65 with a mean value of 1.44 in Period A and during Period B it ranged from 0.85 to 1.59 per cent with an overall mean of 1.21 per cent.

Plasma Protein

The mean plasma protein values of broilers fed different levels of protein and energy trial-wise and data pooled according to periods is presented in Table 12. Statistical analysis of the data did not reveal any significant difference among different diets or periods. The mean plasma protein (g per cent) during Period A ranged from 3.28 to 3.44 with a mean value of 3.36 g per cent and in Period B the values ranged from 3.20 to 3.41 with a mean value of 3.27 g per cent.

Haemoglobin

The mean haemoglobin values for broilers fed different diets trial-wise and data pooled according to periods is presented in Table 13. Statistical analysis of the data did not reveal significant difference between periods. Mean haemoglobin value for Period A was 9.68 g per cent and for Period B the value was 9.53 g per cent.

Table 12. Mean plasma protein (g%) values of broilers fed experimental diets at 8 weeks of age.

Trial No.	D1	D2	D3	D4	Overall Mean
	Treatments				
I	3.38±0.24	3.39±0.18	3.47±0.23	3.30±0.20	3.39±0.03
II	3.34±0.20	3.42±0.20	3.25±0.11	3.38±0.17	3.35±0.04
III	3.19±0.15	3.40±0.18	3.41±0.17	3.29±0.16	3.32±0.05
IV	3.17±0.05	3.41±0.05	3.18±0.18	3.14±0.17	3.23±0.06
Mean for diets	3.27±0.05	3.41±0.05	3.33±0.07	3.28±0.05	3.32±0.03
			POOLED DATA		
Period A	3.28±0.03	3.40±0.03	3.44±0.03	3.30±0.03	3.36±0.04
Period B	3.25±0.03	3.41±0.03	3.22±0.02	3.20±0.03	3.27±0.05

Means bearing the same superscript within the same column do not differ significantly (P<0.01).

Table 13. Mean haemoglobin (g%) values of broilers fed experimental diets at 8 weeks of age.

Trial No.	Treatments D1	D2	D3	D4	Overall mean
I	9.76 ± 0.06^{ab}	9.48 ± 0.07^{ab}	9.62 ± 0.09^{a}	10.18 ± 0.10^{b}	9.76 ± 0.15
II	9.27 ± 0.03^{a}	9.41 ± 0.04^{a}	9.27 ± 0.03^{a}	9.34 ± 0.12^{a}	9.32 ± 0.03
III	9.92 ± 0.23^{abc}	10.25 ± 0.38^{a}	9.20 ± 0.16^{bc}	9.01 ± 0.27^{c}	9.52 ± 0.27
IV	9.68 ± 0.28^{a}	9.80 ± 0.14^{a}	10.01 ± 0.20^{a}	9.55 ± 0.32^{a}	9.76 ± 0.10
Mean for diets	9.66 ± 0.11	9.74 ± 0.19	9.53 ± 0.19	9.52 ± 0.25	9.59 ± 0.11

Means bearing the same superscript within the same row do not differ significantly (P<0.01).

POOLED DATA

	D1	D2	D3	D4	Overall mean
Period A	9.84 ± 0.08	9.87 ± 0.39	9.41 ± 0.21	9.60 ± 0.59	9.68 ± 0.11
Period B	9.43 ± 0.16	9.61 ± 0.20	9.64 ± 0.37	9.45 ± 0.11	9.53 ± 0.05

Body fat

Body fat estimated as ether extract is presented in Table 14. Statistical analysis of the data did not reveal any significant difference in body fat among dietary treatments or periods. The per cent body fat in Period A was 35.90 and in Period B it was 35.89. Mean data for treatments were 37.64, 35.25, 35.91 and 34.75 per cent respectively for diet 1, 2, 3 and 4.

Liver fat

Liver fat estimated as ether extract of broilers fed different diets, trial-wise and period-wise are presented in Table 15. Statistical analysis of the data did not reveal any significant difference among dietary treatments, but difference due to periods was significant. Mean per cent liver fat of broilers in Period A was 23.38 and in Period B it was 21.59. In Period B per cent liver fat was significantly ($P < 0.01$) lower than in Period A. The mean per cent liver fat in broilers fed different diets were 22.06, 22.41, 22.63 and 23.33 respectively for diets 1, 2, 3 and 4.

Table 14. Mean per cent body fat (Ether extract) of broilers fed experimental diets on dry matter basis at 8 weeks of age.

Trial No.	Treatments D1	D2	D3	D4	Overall mean
I	35.90±3.05	36.31±1.23	34.97±2.94	34.83±1.45	35.50±0.36
II	34.30±1.76	34.22±2.59	36.90±1.36	34.22±2.22	34.91±0.66
III	36.93±1.54	36.82±2.30	35.50±2.70	35.87±1.89	36.28±0.35
IV	43.41±2.15	33.67±3.19	36.27±3.56	34.07±3.06	36.85±2.26
Mean for diets	37.64±2.00	35.25±0.77	35.91±0.43	34.75±0.41	35.89±0.43
POOLED DATA					
Period A	36.43±1.66	36.57±1.27	35.24±1.94	35.35±1.17	35.90±0.35
Period B	38.86±1.75	33.95±1.95	36.59±1.57	34.15±1.92	35.89±1.16

Table 15. Mean per cent liver fat (Ether extract) of broilers fed experimental diets on dry matter basis at 8 weeks of age.

Trial No.	Treatments D1	D2	D3	D4	Overall mean
I	22.44±0.91	23.84±1.34	23.90±1.53	24.10±2.59	23.57±0.38
II	22.96±1.04	24.96±1.05	24.07±2.94	23.42±0.56	23.71±0.39
III	23.80±1.30	21.31±0.65	23.51±1.06	24.12±1.10	23.18±0.64
IV	19.03±1.06	19.55±1.11	19.06±1.73	21.66±1.88	19.82±0.62
Mean of diets	22.06±1.05	22.41±1.22	22.63±1.20	23.33±0.58	22.58±0.92
POOLED DATA					
Period A	23.12±0.83[a]	22.58±0.79[a]	23.71±0.79[a]	24.11±1.30[a]	23.38±0.34[a]
Period B	21.00±0.86[b]	21.26±1.06[b]	21.57±1.95[b]	22.54±3.23[b]	21.59±0.34[b]

Means bearing the same superscript within the same column do not differ significantly (P<0.01).

Fat constants

The Iodine Value and Saponification Value of abdominal fat of broilers fed different diets are presented in Table 16. Mean Iodine Values obtained were 70.64, 73.47, 73.87 and 76.99 for diets 1, 2, 3 and 4 respectively. The overall mean Iodine Value for different treatments was 73.74. Statistical analysis of the data did not reveal any significant difference between treatments.

The Saponification Value of abdominal fat obtained were 165.83, 169.49, 147.66 and 147.96 for diets 1, 2, 3 and 4 respectively. Overall mean Saponification Value for different dietary treatments was 157.74. Statistical analysis of the data did not reveal any significant difference between treatments.

Mortality

The mortality among the experimental birds upto 8 weeks of age in each trial and treatment is presented in Table 17. Per cent mortality for trials I, II, III and IV were 10.83, 10.42, 3.75 and 3.33 respectively. Pooled data revealed mortality percentage of 7.29 for period A and 6.88 for Period B. The overall mean mortality among broilers was 7.08 per cent.

Table 16. Mean Iodine Value and Saponification Value of abdominal fat at 8 weeks of age of broilers fed different diets.

Treatments	Iodine Value	Saponification Value
D1	70.64 ± 2.67	165.83 ± 8.27
D2	73.47 ± 4.29	169.49 ±20.37
D3	73.87 ± 1.93	147.66 ± 7.26
D4	76.99 ± 6.90	147.96 ± 8.23
Mean of diets	73.74 ± 1.30	157.74 ± 5.78

Table 17. Mortality (number) in broilers fed experimental diets from 0-8 weeks of age.

Trial No.	D1	D2	D3	D4	Total	Mean percentage mortality
I	7 (60)	6 (60)	7 (60)	6 (60)	26 (240)	10.83
II	9 (60)	6 (60)	2 (60)	8 (60)	25 (240)	10.42
III	2 (60)	4 (60)	2 (60)	1 (60)	9 (240)	3.75
IV	0 (60)	0 (60)	3 (60)	5 (60)	8 (240)	3.33
Mean for diets	18 (240)	16 (240)	14 (240)	20 (240)	68 (960)	7.08
POOLED DATA						
Period A	9 (120)	10 (120)	9 (120)	7 (120)	35 (480)	7.29
Period B	9 (120)	6 (120)	5 (120)	13 (120)	33 (480)	6.88

(Figures in parenthesis indicate number of birds)

Discussion

DISCUSSION

The results obtained in an experiment to examine whether the nutrient requirement specifically the dietary content of protein and energy are influenced by the summer in Kerala, are discussed in this chapter.

The mean maximum temperature recorded inside the experimental shed during the experimental period of two years was 38.33°C and the mean minimum temperature was 22.14°C. The highest relative humidity was 92 per cent and the lowest was 42 per cent (Table 5). Thus, the microclimatic situation in the shed can be classified as hot-humid. Thiagarajan (1989) reported a maximum temperature of 29.36°C to 37.94°C and a minimum of 22.33 to 25.93°C from April to July and a relative humidity of 73.57 to 91.57 per cent in the morning and 55 to 87 per cent in the evening at Mannuthy. The maximum temperature is well above the stress level and the minimum temperature is also much above the recommended optimum range of 15-20°C after four weeks of age (Reece and Deaton, 1971a and Deaton <u>et al</u>., 1978). The relative humidity is on the higher side which coupled with the higher temperature prevailing made the period extremely stressful. The summer in 1989 and 1991 during which the study was carried out was therefore highly stressful for birds.

Production Parameters

Growth

The initial body weight of chicks that were reared during Period A was 43.32g, which was significantly ($P<0.01$) higher than those reared during Period B (38.39 g) (Table 7). It is to be noted that the chicks for experiment in Period B was obtained during peak summer, therefore it is logical that they have lower body weight. Rao (1971) observed that weight at hatching was lowest among chicks hatched in summer. Panda and Mitra (1971) also reported that the performance of the October, March and April hatched chicks were comparatively poorer and were in decreasing order. The present findings corroborate the findings of earlier workers that the February hatched chicks are higher in body weight than April hatched chicks.

It could also be seen from Table 7 that the mean weekly body weight of chicks recorded from first week of age to sixth week of age did not show any statistically significant difference between those reared during Period A and Period B. Parkhurst (1967) stated that temperature from 85 to 95°F did not markedly affect growth and feed efficiency in broilers upto six weeks of age, at six weeks and beyond broilers started to show temperature effect. The present findings are in agreement with the above report in literature.

The body weight at seventh week of age was 1208.16 g for birds reared during Period B and 1079.98 g for those reared during Period A, the difference being statistically significant ($P < 0.01$). At both the stages of growth (seventh and eighth weeks) the birds reared in Period A were during the peak summer, whereas, those reared in Period B were during late summer. The poorer body weight for those birds reared in Period A can be explained in terms of higher thermal stress that the birds have been subjected to during the finisher phase. Godfrey and Winn (1966) reported that with higher temperature and relatively higher humidity the magnitude of stress will be more.

Adams et al. (1962 b), Mickelberry et al. (1966), Cowan and Michie (1978), Smith and Teeter (1987) and Cerniglia et al. (1983) reported detrimental effect of high environmental temperature on the performance of broilers during the finishing period mainly through reducing feed intake and growth rate. But Kubena et al. (1972), Cowan and Michie (1978), Charles et al. (1981), Mahapatra et al. (1984) and Sinurat and Balnave (1985) showed no evidence of a direct relationship for broiler performance between environmental temperature and dietary nutrient concentration. Dale and Fuller (1980) reported a decrease in growth rate at high environmental temperature accompanied with a reduction in thyroid size. Reduced thyroid size, they opined, is a reflection of thyroid activity which affect protein synthesis and consequent depression in body weight gain. Adams and Rogler (1968) reported influence of relative humidity on growth rate. They found that growth rate was superior in 40 per cent relative humidity as compared with 80 per cent relative humidity at 29°C.

Hurwitz et al. (1980) reported that feeding of high protein diet tended to reduce, but did not overcome the growth depression of higher temperature. Contrary to their findings Payne and Lewis (1966), Pesti and Fletcher (1983), Salmon et al. (1983) and Maurus et al. (1987) reported that body weight gain can be improved with increase of protein and energy level. But McNaughton and Reece (1984 a) reported no difference in body weight when fed dietary energy levels of 3100 to 3200 Kcal ME/kg.

In the present study all the four combinations of diet tested both during Period A and Period B did not reveal any statistically significant difference during any phase of growth, thereby indicating that the growth depression could not be compensated by manipulating dietary protein and/or energy level. It also pointed out that the requirement per se of protein and energy are not altered due to summer stress.

Body weight gain

The data on body weight gain that are presented in Table 8 revealed that the gain in body weight was statistically similar for the groups reared during Period A as well as in Period B upto six weeks of age. But thereafter the gain in weight differed. At seventh week of age, the gain recorded was 226.09 g for the birds in Period B and 120.12 g for those in Period A. The difference being statistically significant. Likewise, at eight week of age, the body weight gain was significantly poor for those birds in Period A. The trend of results is similar to the body-weight data, in that the gain was poorer in those birds which are experiencing thermal stress (Period A). Dale and Fuller (1980), Keshavarz and Fuller (1980) and Cowan and Michie (1978) reported that body weight gain was significantly lower in hot environment. Ren-Yu-Tzeng and Becker (1981) reported peak body weight gain (64.4g/day) at 44 days of age, then the weight gain decreased to 46.7g/day at 65 days of age. In the present study maximum body weight gain was recorded during fifth week of age for both Period A and Period B. Reece and Deaton (1971 a) reported that temperature should be near 21°C and relative humidity 60 per cent to optimise body weight gain and feed utilization for the growing period of broiler chicken on litter. The lower gain in the present study may be due to higher temperature and humidity.

The dietary treatments employed did not influence the gain in body weight of birds reared either during Period A or Period B. Salmon <u>et al</u>. (1983) reported that weight gain from four to eight weeks of age were not significantly affected by protein levels. Skinner <u>et al</u>. (1990) reported that dietary energy had no significant effect on body weight gain. Contrary to the present findings Waldroup <u>et al</u>. (1976), Gowda <u>et al</u>. (1976 b), Diambra and McCartney (1985) and Baghel and Pradhan (1988 a) reported that nutrient density influenced body weight gain. They reasoned that the high energy, high protein diets contained higher proportions of all the nutrients and probably supplied adequate amounts of nutrients, despite lower feed intakes, leading to higher weight gain and improved efficiency of food utilization.

Feed consumption

The feed consumption of the birds (g/bird/day) under experimentation presented in Table 9 revealed that the intake was statistically similar upto sixth week of age. During seventh and eighth week of age, the birds reared in Period A consumed significantly lesser feed per day (91.03 and 83.33 g respectively) than those reared during Period B. Here again, the birds in Period A were attaining the seventh and eighth week of age during peak summer and consequently ate less. The present finding is in agreement with the findings of Cowan and Michie (1978). They reported a decreased feed intake of 72.9 to 77.4 g/bird/day from 22 to 57 days of age in broilers reared at a temperature regime of 31°C and fed with 178 to 308 g protein/kg of diet. Al-Ribdawi and Singh (1989) also reported influence of season on feed intake. They reported a daily feed intake of 104.7 g in cold, 77.9 g in hot-humid and 64.9 g in hot-dry season. Dale and Fuller (1980), Charles *et al.* (1981), Al-Fataftah (1987) and Abasiekong (1987) reported decreased feed consumption with increase in temperature. Koh *et al.* (1989) reported that feed intake and weight gain in the hot season were 15-20 per cent lower than in the cool season.

In the present study in both Period A and Period B the dietary combinations tested did not significantly influence feed intake. Similarly Cerniglia *et al*. (1983) showed no indications of selective consumption of any of the energy-protein ratios at any temperature and difference in feed consumption was entirely due to tempereature effect. Brown and McCartney (1982) also reported no significant effect of protein on the total amount of feed intake. McNaughton and Reece (1984a) reported no difference in feed consumption when fed dietary energy levels of 3100 to 3200 Kcal ME/kg.

Feed efficiency

The mean cumulative feed efficiency data (Table 10) did not reveal any statistically significant difference due to protein-energy levels in the diet either during Period A or Period B. The present finding is in agreement with the findings of Tion *et al*. (1984). They reported that energy and protein variation of the diets did not significantly influence feed conversion efficiency. Contrary to this, many workers reported that feed efficiency increased with increase of protein (Gowda *et al*., 1976; Johri, 1977; Babu *et al*., 1986) and energy (Coon *et al*., 1981; Salmon *et al*., 1983).

The cumulative feed efficiency was practically similar upto fifth week of age, both in Period A and Period B even though at second week of age it was significantly better for birds in Period A. However, during sixth, seventh and eighth week of age, the efficiency was significantly better for those birds in Period B. The birds reared during Period B were passing through the late summer, consequently they had more comfortable micro environment and therefore better body weight as well as feed consumption resulting in better feed efficiency. Whereas birds in Period A were facing higher summer temperature during this phase of their life, therefore they were under thermal stress, consequently they have poorer body weight, low feed intake and hence poorer feed efficiency. The present findings agree with those reported by Hurwitz et al. (1980). They found that feed efficiency increased with temperature to reach a maximum at 27°C and then decreased between 27 and 34°C. Al-Fataftah (1987) also reported decrease in feed efficiency with increasing environmental temperature.

The absence of any significant difference in body weight, feed consumption and feed efficiency due to dietary treatments but at the same time significant impact due to periods suggest that the impact of temperature on broilers is direct and not through nutrition. The observations of Charles et al. (1981) is relevant. The absence in broilers of an interaction between temperature and nutrition contrasts impressively with the well-documented interaction in laying hens. They observed that in laying hens the decrease in energy intake as temperature is increased follows that of heat loss, but since nutrient requirement is independent of temperature, production depression also follows unless dietary nutrient content is increased in compensation. They further opined that such a compensation is ineffective in broilers. They surmised that in broilers the effect of temperature are specific and direct and not through nutrition. Cowan and Michie (1978) in their effort to reduce the growth rate depression by manipulating protein also felt that the temperature effects on broilers were independent and that there was no interaction between temperature and dietary nutrient concentration suggesting neuro-hormonal mediation. The larger size and weight and consequent reduction of surface area could undermine efficiency of sensible heat loss contributing to heat stress in broilers.

Processing yields and losses

The data on processing yields and losses presented in Table 11 revealed that the parameters tested were neither influenced by the dietary treatments nor by the periods. The present findings agree with the findings of

Kondra *et al*.(1962), Orr and Hunt (1984), Mahapatra *et al*. (1984), Babu *et al*. (1987), Shyam Sunder *et al*. (1988), Reddy (1989) and Satterlee *et al*. (1980).

Blood loss

Data presented in Table 11 revealed that per cent blood loss ranged from 3.79 to 4.63 with an overall mean of 4.21 during Period A and 3.98 during Period B. Mathur and Ahmed (1968) reported per cent blood loss of 4.44 in males and 4.23 in females. Shyam Sunder *et al*. (1988) reported blood loss of 3.94 to 4.88 per cent. Baghel and Pradhan (1989a) reported blood loss of 3.82 per cent in hot, 4.40 per cent in hot-humid and 3.58 per cent in cold season. The present findings are in close agreement with the findings of the above workers.

Feather loss

The mean per cent feather loss (Table 11) obtained in the present study is 4.22 during Period A and 4.76 in Period B. Benoff (1981) reported per cent feather loss in broilers as 5.40 per cent. Mathur and Ahmed (1968) reported per cent feather loss for male broilers as 4.33 and females as 5.86. The present finding is consistent with the findings of above workers.

Total loss

The per cent total loss ranged from 22.46 to 27.76 in the present study (Table 11). The overall mean per cent total loss for the Period A was 26.72 and for Period B was 23.45. The results obtained are in close agreement with the findings of following workers. Shyam Sunder *et al*. (1988) reported per cent total loss in broilers fed different levels of energy and protein in diets as ranged from 16.80 to 29.20. Rejikumar (1991) reported total loss of 27.24 per cent in broilers in summer in Kerala.

Eviscerated yield

The data on per cent eviscerated yield (Table 11) ranged from 66.69 to 72.74 with an overall mean of 67.84 for Period A and 71.66 for Period B. Shyam Sunder *et al*. (1988) reported eviscerated yield of 65.74 to 67.94 per cent in broilers fed different protein-energy diets. Jacob (1991) reported eviscerated yield of 68.03 per cent in broilers. The present findings are in close agreement with the findings of the above workers.

Giblet yield

The overall mean giblet yield for Period A was 5.44 per cent and for Period B was 4.89 per cent (Table 11). The mean per cent giblet yield ranged from 4.55 to 5.74. This findings are in agreement with the findings of Mahapatra et al. (1984), who reported that diet had no significant effect on giblet weight. Contrary to this, Shyam Sunder et al. (1988) reported that per cent giblet weight was inversely related to the level of dietary protein. Baghel and Pradhan (1989 b) reported that carcass traits and organ weights were infuenced by the energy level.

Ready-to-cook yield

The data on per cent ready to cook yield (Table 11) ranged from 72.24 to 77.54. The overall mean per cent for Period A was 73.28 and for Period B was 76.55. Shyam Sunder et al. (1988) reported total meat yield of 70.80 to 73.47 per cent in broilers fed different energy protein diets. Ready-to-cook yield of 72.75 to 78.17 per cent was reported by Reddy (1989) in broilers fed with different energy protein diets. The results obtained in the present study agree with those reported by above workers.

Abdominal fat

The per cent abdominal fat presented in Table 11 revealed that neither energy, protein nor periods influenced this parameter. The per cent abdominal fat ranged from 0.85 to 1.65 per cent. The overall mean per cent for Period A was 1.44 and for Period B was 1.21. Adams et al. (1962a) observed no significant difference in carcass fat content of broilers reared at 21°C and 29°C. Griffiths et al. (1977) reported that dietary energy concentration had no significant effect on abdominal fat pad size. Keshavarz and Fuller (1980) reported abdominal fat per cent of 1.01 in broilers reared at an atmospheric temperature of 23.9 to 35°C. Baghel and Pradhan (1989 a) reported abdominal fat loss of 1.99 per cent in hot, 1.35 per cent in hot-humid and 1.79 per cent in cold season. The results obtained in the present study are in close agreement with those reported by above workers. Contrary to the above findings, Hargis and Creger (1980), Jackson et al. (1982), Pesti (1983), Lawin et al. (1984) and Skinner et al. (1990) reported that abdominal fat can be altered by the manipulation of protein and energy. Although much has been learned about the effect of dietary factors on carcass composition it is as yet not possible to predict carcass composition accurately from the available knowledge of dietary factors. They surmised that factors as widely differing as amino acids, crude fibre, fat content, physical form of diet, interaction between sex, age, genotype and nutrition have an effect on fat deposition.

Plasma Protein

The data on mean plasma protein (g per cent) value presented in Table 12 showed that this parameter tested was neither influenced by the dietary treatments nor by the periods. Broilers fed with different dietary treatments had plasma protein value within a range of 3.29 to 3.41 g per cent. The plasma protein value for Period A was 3.36 and for Period B was 3.27 g per cent. Deaton *et al*. (1969) reported plasma protein level of 3.18 g/100 ml at a temperature of 32.2°C. Bartov *et al*. (1974) reported plasma protein levels of 3.54±0.24 g/100 ml in male and 3.73±0.36 g/100 ml in female broilers. Darshan *et al*. (1987) reported plasma protein value of 3.76 g/100 ml in males and 4.50 g/100 ml in females. The present findings are in close agreement with that of above workers. Contrary to the above findings Leveille and Sauberlich (1961) reported that serum protein was related to dietary protein level. Total serum protein increased from 2.33 g/100 ml at 10 per cent protein level to 3.06 g/100 ml at 25 per cent protein level.

Haemoglobin

The mean haemoglobin values(g per cent) for broilers reared during summer are presented in Table 13 and found that neither the dietary treatments nor the periods influenced this parameter. The mean haemoglobin value ranged from 9.52 to 9.74 g per cent for different dietary treatments. The overall mean values recorded for Period A was 9.68 and for Period B was 9.53 g per cent. Deaton et al.(1969) reported lower haemoglobin value (9.24g/100 ml) at 32.2°C than at 7.2°C (10.97g/100 ml) in male broilers. Birds reared at 23.9°C recorded haemoglobin value of 9.75 g/100 ml. Mean haemoglobin value of 9.62 g/100 ml was reported in broilers in summer by Nair (1983). The results of the present work agree well with that of above workers.

Body fat

The per cent body fat estimated as ether extract is presented in Table 14 and found that different dietary combinations or periods did not influence this parameter. The mean per cent body fat ranged from 34.91 to 36.85 in broilers fed different dietary combinations. The overall mean per cent body fat for Period A was 35.78 and for Period B it was 34.13. The above results are in accordance with the findings of Bartov et al. (1974), Nair (1983) and Babu et al. (1987). Nair (1983) reported that ambient temperature does not affect carcass composition. Bartov et al. (1974) reported that amount of carcass fat at 8 or 9 weeks of age was not affected by different calorie-protein ratios. Babu *et al*. (1987) reported that in broilers fed different energy-protein rations, carcass fat ranged from 30.22 to 46.76 per cent.

Liver fat

The per cent liver fat in broilers fed different experimental diets and reared during the two periods estimated as ether extract presented in Table 15 revealed that the dietary treatments did not influence this parameter. This finding is in agreement with the findings of Bartov *et al*. (1974). But it was observed that the liver fat content was significantly higher (24.11 per cent) for those birds reared in Period A, which reached their eighth week of age during peak summer, than those in Period B (22.41 per cent). The results are in accordance with the findings of Wolford (1971) and Kazuaki Takahashi *et al*. (1982) who found that environmental temperature influenced hepatic lipid deposition. Wolford (1971) reported that birds reared in cool environment (1.7°C) for 28 days significantly reduced liver lipid level (9.0 g Vs 24.3g/100 g wet liver weight) in comparison to those in a warm environment. Kazuaki Takahashi *et al*. (1982) reported significant increase in liver lipid in chicks reared at 23-35°C than those at 15-23°C.

<u>Fat-constants</u>

Data on mean Iodine Value and Saponification Value presented in Table 16 does not reveal any statistical significance between dietary treatments. Mean Iodine Value ranged from 70.64 to 76.99 with an overall mean of 73.74. This indicated that the fat contained more of unsaturated fatty acids.

The overall trend of the carcass fat to be similar to the derived dietary fat in both Iodine Value and fatty acid composition was reported by Mickelberry <u>et</u> <u>al</u>. (1966). They also reported that elevated temperature had no influence on Iodine Value. Bartov and Bornstein (1976) reported Iodine Value of abdominal fat as 70.70. The present findings agree with those reported by above workers. Contrary to the present findings they found that Iodine Value varied with the energy content of the diet.

In the present work Saponification Value ranged from 147.66 to 169.49 with an overall mean of 157.74 (Table 16). This indicate that abdominal fat contain more of long chain fatty acids. Since poultry body fat is derived from dietary fat as well as from liver lipogenesis, it is found that dietary constituents had a significant effect on the composition of body fat in broiler type chickens.

Mortality

The data on per cent mortality presented in Table 17 do not reveal any significant difference between dietary treatments. Similar findings were reported by Pesti and Fletcher (1983), Babu et al. (1986) and Reddy (1989). The overall per cent mortality during Period A was 7.20 and Period B was 6.88. Al-Fataftah (1987) reported that exposure of broilers to temperatures exceeding 29°C significantly increased mortality. Al-Ribdawi and Singh (1989) and Osman et al. (1989) reported higher mortality in higher atmospheric temperature. The main cause of death in the present work was due to outbreak of coccidiosis. Thaxton and Siegel (1970) suggested depression of secondary immunity by high environmental temperatures. Reid et al. (1976) reported that decrease intake of feed in summer lead to reduction in coccidiostat intake. This could also have contributed to the higher rate of mortality due to coccidiosis.

Summary

SUMMARY

An experiment was designed and conducted to establish the requirements of protein and energy for broilers during the summer season in the hot and humid atmosphere of Kerala. In Kerala, the day time temperature starts increasing from the month of February. Since broilers are marketed around 8 weeks of age, in order to make the two phases of growth of broilers namely starter and finisher phase coincide during the peak summer four trials were planned in a span of two years.

In each trial the following energy-protein combinations at starter and subsequent finisher diets were tested in a completely randomised design.

Treatment	Starter	Finisher
Diet 1	22% CP:2900 Kcal ME/kg	19% CP:3000 Kcal ME/kg
Diet 2	24% CP:2900 Kcal ME/kg	19% CP:2900 Kcal ME/kg
Diet 3	26% CP:2900 Kcal ME/kg	19% CP:3000 Kcal ME/kg
Diet 4	26% CP:2900 Kcal ME/kg	19% CP:2900 Kcal ME/kg

Two hundred and forty one-day old broiler chicks were procured for each trial. Each treatment had three replicates of 20 chicks each. Trials corresponding to the same period for the two years were pooled and the results

were presented as Period A (started in early summer and ended in peak summer) and Period B (started in peak summer and ended in late summer).

The following parameters were recorded in all the four trials and the effects of nutrients on each of the parameters were studied.

1. Weekly body weight
2. Weekly body weight gain
3. Weekly feed consumption
4. Feed efficiency
5. Livability
6. Processing information at eighth week of age
7. Abdominal fat at eighth week
8. Body fat and liver fat at eighth week of age
9. Fat constants
   a. Saponification Value
   b. Iodine Value
10. Blood analysis at eighth week
    a. Plasma protein
    b. Haemoglobin
11. Climatic parameters

The results obtained during the course of the study are summarised in Table 18 and detailed as follows:

1. Mean weekly body-weight of chicks recorded from first week to sixth week of age did not reveal any significant difference between periods. Analysis of seventh and eighth weeks body weight revealed that the difference between periods was statistically significant ($P < 0.01$), while the difference among dietary treatments or interactions between diet x period were not significant. The trials that ended in peak summer (Period A) showed significantly ($P < 0.01$) lower mean body weight at eight week (1182.25 g) than the trials ended in late summer (Period B), which had a final body weight of 1408.39g. Dietary combinations of 22:2900 in the starter and 19:3000 in the finisher stage upto eighth week of age was found to be optimum for growth of broilers in summer months in Kerala.

2. The data on body weight gain revealed that this parameter were not influenced by the dietary treatments upto eighth weeks of age and by periods upto sixth week of age. Thereafter body weight gain was influenced by periods. Broilers reared during Period B showed higher body weight gain than Period A. Maximum body weight

gain was recorded at fifth week of age in both Period A (246.19 g) and in Period B (238.13 g). At seventh and eighth week of age, the trials that ended in March (Period A) recorded lower body weight gain than Period B.

3. Analysis of the data on feed consumption (g/bird/day) indicated that the dietary treatments did not influence feed consumption upto eighth week of age in both Period A and Period B. Analysis of data period wise, did not reveal significant difference upto sixth week of age. However, the magnitude of difference in daily feed consumption at seventh and eighth week of age between Period A and Period B was statistically ($P < 0.05$) significant. The trials that ended in peak summer (Period A) recorded lower feed consumption during seventh (91.03 g) and eighth week of age (83.33 g) than Period B, which had a feed consumption of 108.82 g during seventh week and 99.71 g during eighth week of age.

4. The data on mean cumulative feed efficiency of broilers fed different dietary treatments revealed that there was no significant difference between groups upto eighth week of age. Analysis of data period-wise revealed feed efficiency upto fifth week of age was not

affected barring second week and from sixth week onwards, Period B showed significantly ($P < 0.01$) better feed efficiency than Period A. At eighth week of age trials that ended in peak summer (Period A) had significantly ($P < 0.01$) poor feed efficiency (3.28) than that recorded during Period B (2.84).

5. Data on processing yield and losses did not reveal any significant difference between dietary treatments or periods. The overall mean per cent blood loss for the trials that ended in peak summer (Period A) was 4.21 and for the trials that ended in late summer (Period B) was 3.98.

   The overall mean per cent feather loss for Period A was 4.22 and for Period B was 4.76.

   It was found that the overall mean value for total loss 26.72 per cent during Period A and 23.45 per cent for Period B.

   The percentage eviscerated yield obtained was 67.84 during Period A and 71.54 during Period B.

   The overall giblet yield during Period A was 5.44 per cent and for Period B 4.89 per cent.

The mean per cent ready-to-cook yield was 73.28 during Period A and 76.55 per cent during Period B.

The mean abdominal fat per cent during Period A was 1.44 and during Period B, the overall mean value was 1.21.

6. The mean plasma protein value (g per cent) of broilers fed different levels of protein and energy did not reveal any significant difference among different diets or periods. The overall mean plasma protein value during Period A was 3.36 g per cent and during Period B 3.27 g per cent.

7. The mean haemoglobin value (g per cent) of broilers fed experimental diets at eight weeks of age did not reveal any significant difference among different diets or periods. The overall mean haemoglobin value during Period A was 9.68 and during Period B was 9.53 g per cent.

8. The per cent body fat estimated as ether extract during Period A was 35.90 and in Period B it was 35.89. Statistical analysis of the data on per cent body fat did not reveal any significant difference among dietary treatments or periods.

9. The per cent liver fat estimated as ether extract during Period A was 23.38 and in Period B 21.59. During Period B per cent liver fat was significantly ($P < 0.01$) lower than Period A.

10. The mean Iodine Value of abdominal fat of broilers fed diets 1, 2, 3 and 4 were 70.64, 73.47, 73.87 and 76.99 respectively with an overall mean of 73.74. Statistical analysis of the data did not reveal any significant difference between treatments.

11. The overall mean Saponification Value for broilers fed different dietary treatment was 157.74. The mean Saponification Value obtained for diets 1, 2, 3 and 4 were 165.83, 169.49, 147.66 and 147.96 respectively. Dietary treatments did not influence this parameter.

12. Per cent mortality during Period A was 7.29 and Period B was 6.88. Dietary treatments or periods did not influence this parameter.

13. The mean maximum temperature during the experimental period inside the experimental shed ranged from 29.0 to 38.0°C and the mean minimum temperature ranged from 23.34 to 28.50°C. The relative humidity ranged from 49.5 to 87.0 per cent.

From the overall results of the study it is concluded that commercial broilers grown in the climatic condition of Kerala, requires 22 per cent crude protein and 2900 Kcal ME/kg in the starter and 19 per cent crude protein and 3000 Kcal ME/kg in the finisher diets. Manipulation of dietary protein and/or energy have little avail in containing the poor growth rate in broilers observed during summer. The physiological mechanism for poor growth rate in broiler chicken could be other than poor feed consumption during summer which warrants further detailed study.

Table 18. Consolidated performance of broilers fed experimental diets upto 8 weeks of age.

Parameters	Periods	Treatments D1	D2	D3	D4	Overall mean
Body weight at 8 weeks (g)	A	1167.03	1208.88	1184.57	1168.52	1182.25[a]
	B	1397.22	1423.56	1472.21	1340.56	1408.39[b]
Feed consumption (g)	A	3932.89	3856.32	3861.70	3867.80	3879.68
	B	4037.97	3957.50	3871.91	4075.30	3985.67
Feed efficiency	A	3.37	3.19	3.26	3.31	3.28[a]
	B	2.89	2.78	2.63	3.04	2.84[b]
R-to-C Yield (%)	A	72.43	73.75	74.69	72.24	73.28
	B	76.49	76.08	77.54	76.10	76.55
Abdominal fat (%)	A	1.65	1.48	1.40	1.23	1.44
	B	1.59	1.17	1.21	0.85	1.21
Plasma protein (g%)	A	3.28	3.40	3.44	3.30	3.36
	B	3.25	3.41	3.22	3.26	3.27
Haemoglobin (g%)	A	9.84	9.87	9.41	9.60	9.68
	B	9.43	9.61	9.64	9.45	9.53
Body fat (%)	A	36.43	36.57	35.24	35.35	35.90
	B	38.86	33.95	36.59	34.15	35.89
Liver fat (%)	A	23.12	22.58	23.71	24.11	23.38[a]
	B	21.00	21.26	21.57	22.54	21.59[b]
Mortality (%)	A	7.50	8.33	7.50	5.83	7.29
	B	7.50	5.00	4.17	10.83	6.88

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Appendix i. Mean weekly body weight(g) of broilers fed experimental diets from 0-8 weeks.

FIRST TRIAL

Treatments	Age in Weeks								
	0	1	2	3	4	5	6	7	8
D1	43.50[a] ±0.34	77.03[a] ±1.41	148.03[a] ±3.92	274.30[ab] ±8.13	430.17[bc] ±11.69	610.25[ab] ±14.79	759.92[a] ±20.93	859.81[a] ±24.64	1003.02[ab] ±29.19
D2	43.30[a] ±0.34	74.47[a] ±1.30	137.56[a] ±3.39	256.76[b] ±7.02	409.40[c] ±11.49	592.76[b] ±15.75	763.60[a] ±21.13	922.41[a] ±23.12	1082.04[a] ±29.49
D3	43.73[a] ±0.33	77.93[a] ±1.32	149.43[a] ±3.31	284.13[a] ±8.10	452.54[ab] ±10.51	626.86[ab] ±14.64	768.88[a] ±19.77	844.26[a] ±26.92	970.00[b] ±32.07
D4	43.20[a] ±0.30	77.40[a] ±1.23	143.27[a] ±3.38	289.20[a] ±7.10	466.00[a] ±8.74	634.33[a] ±12.23	773.83[a] ±19.69	840.18[a] ±24.94	967.04[b] ±30.26
Means for diets	43.43 ±0.12	76.71 ±0.77	144.57 ±2.68	276.10 ±7.15	439.53 ±12.47	616.05 ±9.25	766.56 ±3.04	866.67 ±19.06	1005.52 ±26.78

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

Appendix ii. Mean weekly body weight(g) of broilers fed experimental diets from 0-8 weeks.

SECOND TRIAL

Treatments	Age in Weeks 0	1	2	3	4	5	6	7	8
D1	38.47^{a} ±0.31	88.97^{a} ±1.40	167.25^{a} ±3.72	316.50^{a} ±7.53	507.92^{a} ±11.56	775.25^{a} ±17.70	964.41^{a} ±18.09	1245.93^{a} ±24.47	1492.94^{a} ±33.24
D2	38.87^{a} ±0.34	86.92^{a} ±1.25	174.83^{a} ±3.23	332.50^{ab} ±5.76	543.83^{b} ±7.74	821.50^{b} ±9.45	993.67^{a} ±17.44	1228.79^{a} ±28.71	1432.94^{a} ±37.75
D3	38.73^{a} ±0.32	90.37^{a} ±1.37	180.50^{a} ±4.20	345.67^{b} ±7.91	561.83^{b} ±11.51	831.27^{b} ±16.25	1011.70^{a} ±20.82	1304.07^{a} ±27.14	1517.93^{a} ±33.10
D4	38.37^{a} ±0.34	87.33^{a} ±1.07	178.25^{a} ±3.09	337.67^{b} ±6.87	548.25^{b} ±9.00	777.00^{a} ±13.17	829.83^{b} ±20.89	1085.84^{b} ±33.89	1273.65^{b} ±45.62
Mean for diets	38.61 ±0.12	88.40 ±0.79	175.21 ±2.90	333.09 ±6.16	540.46 ±11.50	801.55 ±14.65	965.65 ±26.16	1216.16 ±46.33	1429.37 ±54.88

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

Appendix iii. Mean weekly body weight (g) of broilers fed experimental diets from 0-8 weeks.

THIRD TRIAL

Treat-ments	Age in Weeks								
	0	1	2	3	4	5	6	7	8
D1	42.98^{a} ±0.37	96.52^{a} ±1.19	204.27^{a} ±2.68	346.75^{a} ±4.48	545.08^{a} ±8.28	841.17^{a} ±11.65	1079.50^{a} ±14.36	1233.33^{a} ±20.84	1331.03^{a} ±22.31
D2	43.30^{a} ±0.45	100.20^{a} ±1.11	207.03^{a} ±2.71	372.00^{bc} ±5.36	600.37^{bc} ±8.76	927.00^{b} ±11.62	1179.83^{b} ±19.03	1302.71^{b} ±21.43	1335.71^{a} ±24.38
D3	43.50^{a} ±0.52	97.67^{a} ±1.44	213.43^{a} ±2.88	380.33^{c} ±5.52	608.58^{c} ±7.61	931.33^{b} ±10.79	1182.20^{b} ±16.36	1338.48^{b} ±19.58	1399.14^{a} ±22.56
D4	43.03^{a} ±0.38	97.23^{a} ±1.17	205.97^{a} ±2.73	360.92^{ab} ±5.59	582.25^{b} ±9.55	904.08^{b} ±13.37	1159.49^{b} ±16.90	1298.64^{b} ±20.16	1370.00^{a} ±19.62
Means for diets	43.20 ±0.12	97.91 ±0.80	207.68 ±2.00	365.00 ±7.27	584.07 ±14.11	900.90 ±20.79	1150.26 ±24.13	1293.29 ±21.90	1358.97 ±15.96

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

Appendix iv. Mean weekly body weight (g) of broilers fed experimental diets from 0-8 weeks.

FOURTH TRIAL

Treat-ments	Age in Weeks								
	0	1	2	3	4	5	6	7	8
D1	38.07^{a} ±0.37	79.83^{a} ±1.07	162.50^{a} ±2.97	288.52^{a} ±5.18	440.33^{a} ±8.32	625.50^{a} ±11.96	881.67^{a} ±17.77	1094.67^{a} ±21.35	1301.50^{a} ±26.39
D2	38.23^{a} ±0.38	86.00^{b} ±1.29	174.67^{b} ±2.99	329.83^{b} ±7.43	530.17^{b} ±11.20	769.17^{b} ±14.65	1052.17^{b} ±18.10	1241.17^{b} ±19.76	1414.17^{b} ±23.10
D3	38.33^{a} ±0.38	83.60^{b} ±1.43	183.33^{b} ±3.17	333.92^{b} ±7.18	533.73^{b} ±12.05	750.52^{b} ±15.80	1013.68^{b} ±23.23	1245.26^{b} ±30.76	1426.49^{b} ±35.93
D4	38.03^{a} ±0.35	86.87^{b} ±1.43	177.80^{b} ±4.16	326.00^{b} ±8.55	530.51^{b} ±12.13	751.02^{b} ±16.66	1024.24^{b} ±23.70	1219.49^{b} ±30.65	1407.46^{b} ±39.13
Mean for diets	38.17 ±0.07	84.08 ±1.57	174.58 ±4.41	319.57 ±10.47	508.69 ±22.80	724.05 ±33.14	992.94 ±37.97	1200.15 ±35.61	1387.41 ±28.90

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

Appendix v. Mean weekly body weight gain(g) of broilers as influenced by experimental diets upto 8 weeks of age.

FIRST TRIAL

Treatments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	33.63^{a} ±2.36	70.50^{a} ±4.66	126.30^{ab} ±7.96	154.20^{a} ±8.95	175.25^{a} ±9.57	151.78^{a} ±13.36	102.87^{a} ±24.46	143.58^{ab} ±21.89
D2	31.17^{a} ±2.12	62.81^{a} ±3.92	118.07^{a} ±7.16	152.67^{a} ±9.34	183.36^{a} ±10.83	166.32^{a} ±15.87	153.24^{b} ±21.58	164.62^{a} ±18.40
D3	34.20^{a} ±2.09	71.27^{a} ±3.87	134.80^{a} ±9.33	165.66^{ab} ±7.30	174.32^{a} ±11.31	138.79^{a} ±20.05	62.68^{c} ±27.63	118.30^{b} ±20.33
D4	34.18^{a} ±1.86	67.58^{a} ±4.26	144.27^{c} ±7.58	176.80^{b} ±5.33	168.42^{a} ±11.85	140.68^{a} ±21.36	67.05^{ac} ±23.69	114.26^{b} ±22.22
Mean for diets	33.30 ±0.72	68.04 ±1.92	130.86 ±5.63	162.33 ±5.63	175.34 ±3.07	149.39 ±6.33	96.46 ±20.95	135.19 ±11.76

Means bearing the same superscript within the same column do not differ significantly (P<0.05).

Appendix vi. Mean weekly body weight gain(g) of broilers as influenced by experimental diets upto 8 weeks of age.

SECOND TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	50.50[a] ±2.37	78.28[b] ±4.95	149.25[a] ±7.97	191.42[a] ±10.85	267.33[a] ±12.81	180.59[a] ±17.94	272.41[a] ±18.69	241.76[a] ±30.04
D2	48.05[a] ±2.15	87.92[a] ±4.14	157.67[a] ±6.65	211.33[b] ±6.59	277.67[a] ±8.74	171.50[a] ±20.70	226.72[b] ±25.73	192.78[ab] ±23.39
D3	51.50[a] ±2.09	90.13[a] ±5.04	165.17[a] ±7.55	216.17[b] ±8.46	267.46[a] ±10.60	180.44[a] ±17.19	293.72[a] ±18.81	214.14[ab] ±37.76
D4	48.97[a] ±1.80	90.92[a] ±4.79	159.42[a] ±8.95	210.58[b] ±7.66	228.75[b] ±14.32	115.33[b] ±23.54	188.70[b] ±32.35	168.36[b] ±32.43
Mean for diets	49.76 ±0.73	86.81 ±2.91	157.88 ±3.29	207.38 ±5.46	260.30 ±10.79	161.97 ±15.69	245.39 ±23.50	204.26 ±15.61

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

Appendix vii. Mean weekly body weight gain(g) of broilers as influenced by experimental diets upto 8 weeks of age.

THIRD TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	53.53[a] ±1.14	107.75[a] ±1.93	143.48[c] ±3.09	197.33[a] ±4.79	296.08[a] ±5.86	238.33[a] ±10.18	157.17[a] ±12.93	86.03[a] ±10.31
D3	56.90[a] ±0.99	106.83[a] ±2.19	164.97[a] ±3.48	229.20[b] ±4.94	326.63[b] ±5.88	253.39[a] ±12.79	122.88[a] ±10.34	43.57[a] ±14.17
D3	54.17[a] ±1.24	115.43[b] ±2.02	167.23[b] ±3.37	228.42[b] ±3.99	325.25[b] ±5.91	252.03[a] ±8.66	157.97[a] ±8.80	59.82[a] ±13.36
D4	54.20[a] ±1.09	108.73[a] ±2.21	155.05[b] ±3.59	221.33[b] ±5.01	320.17[b] ±7.37	259.92[a] ±8.43	137.08[a] ±10.68	71.53[a] ±10.40
Mean for diets	54.70 ±0.75	109.69 ±1.95	157.68 ±5.42	219.07 ±7.46	317.03 ±7.12	250.92 ±4.54	143.78 ±8.48	65.24 ±8.99

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

Appendix viii. Mean weekly body weight gain(g) of broilers as influenced by experimental diets upto 8 weeks of age.

FOURTH TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	41.77^{a} ±1.01	82.62^{a} ±2.54	126.02^{a} ±3.49	151.82^{a} ±4.40	185.17^{c} ±5.95	256.17^{a} ±9.09	213.00^{ab} ±9.46	206.83^{a} ±9.24
D2	47.77^{b} ±1.27	88.70^{ab} ±2.32	154.83^{b} ±5.22	200.33^{b} ±5.14	238.67^{b} ±6.57	283.00^{a} ±9.81	187.33^{a} ±10.39	173.00^{a} ±10.79
D3	45.27^{b} ±1.20	99.73^{c} ±2.75	150.75^{b} ±5.01	200.25^{b} ±6.10	219.48^{a} ±6.66	265.96^{a} ±9.24	231.58^{b} ±12.00	181.23^{a} ±9.80
D4	48.67^{b} ±1.42	91.00^{b} ±3.21	148.20^{b} ±5.44	207.46^{b} ±6.32	220.51^{ab} ±7.08	271.53^{a} ±9.89	195.25^{a} ±12.34	185.09^{a} ±12.12
Mean for diets	45.87 ±1.54	90.51 ±3.54	144.95 ±6.46	189.97 ±12.85	215.96 ±11.17	269.17 ±5.60	206.79 ±9.85	186.54 ±7.22

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

Appendix ix. Mean feed consumption(g)/bird/day of broilers fed experimental diets upto 8 weeks of age.

FIRST TRIAL

Treat-ments	Age in Weeks 1	2	3	4	5	6	7	8
D1	13.61	21.93	43.81	57.86	64.76	74.50	84.42	84.64
D2	12.50	19.94	43.70	63.92	69.82	81.90	84.90	82.35
D3	12.50	21.79	43.57	56.84	68.88	79.42	66.84	83.33
D4	14.17	20.79	46.90	59.52	67.14	80.15	71.28	85.33
Mean for diets	13.20 $\pm$0.42	21.11 $\pm$0.47	44.50 $\pm$0.80	59.54 $\pm$1.56	67.65 $\pm$1.11	78.99 $\pm$1.59	76.88 $\pm$4.60	83.91 $\pm$0.67

Appendix x. Mean feed consumption(g)/bird/day of broilers fed experimental diets upto 8 weeks of age.

SECOND TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	17.22^{a}	37.86^{b}	46.43^{a}	54.52^{a}	84.52^{ab}	86.64^{a}	116.89^{a}	93.76^{a}
D2	16.94^{a}	37.86^{b}	41.67^{a}	57.86^{a}	86.48^{a}	84.64^{a}	112.34^{a}	87.79^{a}
D3	15.81^{a}	32.62^{a}	44.76^{a}	64.50^{a}	81.19^{b}	85.14^{a}	112.24^{a}	94.21^{a}
D4	16.94^{a}	31.67^{a}	45.95^{a}	55.24^{a}	81.43^{b}	84.05^{a}	95.86^{a}	77.38^{a}
Mean for diets	16.73 $\pm$0.31	35.00 $\pm$1.66	44.70 $\pm$1.07	58.03 $\pm$2.27	83.41 $\pm$1.27	85.12 $\pm$0.55	109.33 $\pm$4.62	88.29 $\pm$3.92

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

Appendix xi. Mean feed consumption(g)/bird/day of broilers fed experimental diets upto 8 weeks of age.

THIRD TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	17.14^{ab}	36.91^{a}	57.38^{a}	88.33^{a}	112.91^{a}	124.28^{a}	106.19^{a}	78.33^{a}
D2	19.52^{c}	41.43^{a}	60.71^{a}	87.86^{a}	107.38^{a}	125.35^{a}	92.27^{a}	85.38^{a}
D3	18.57^{ac}	40.48^{a}	57.14^{a}	84.52^{a}	106.67^{a}	124.41^{a}	107.06^{a}	86.30^{a}
D4	16.91^{b}	40.71^{a}	49.76^{a}	91.19^{a}	106.67^{a}	129.35^{a}	115.18^{a}	80.90^{a}
Mean for diets	18.04 $\pm$0.62	39.88 $\pm$1.01	56.25 $\pm$2.31	87.98 $\pm$1.37	108.41 $\pm$1.51	125.85 $\pm$1.19	115.51 $\pm$6.39	82.73 $\pm$1.88

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

Appendix xii. Mean feed consumption(g)/bird/day of broilers fed experimental diets upto 8 weeks of age.

FOURTH TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	19.29^{a}	32.14^{a}	42.86^{a}	61.90^{a}	77.38^{a}	80.95^{a}	102.38^{a}	110.00^{a}
D2	19.29^{a}	33.81^{a}	42.86^{a}	80.00^{b}	77.12^{a}	77.86^{a}	108.33^{a}	106.43^{a}
D3	18.57^{a}	32.38^{a}	43.81^{a}	69.01^{ab}	72.67^{a}	85.64^{a}	112.56^{a}	114.19^{a}
D4	19.28^{a}	34.05^{a}	43.33^{a}	71.15^{ab}	68.12^{a}	83.82^{a}	109.91^{a}	113.90^{a}
Mean for diets	19.11 ±0.18	33.10 ±0.49	43.22 ±0.23	70.52 ±3.73	73.82 ±2.19	82.07 ±1.70	108.30 ±2.16	111.13 ±1.83

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

Appendix xiii. Mean weekly cumulative feed efficiency of broilers fed experimental diets upto 8 weeks of age.

FIRST TRIAL

Treatments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	1.06± 0.10	1.59± 0.06	1.98± 0.07	2.23± 0.04	2.30± 0.09	2.57± 0.21	3.24± 0.27	3.42± 0.24
D2	0.90± 0.07	1.52± 0.12	2.03± 0.17	2.38± 0.18	2.47± 0.17	2.71± 0.15	3.01± 0.09	3.09± 0.07
D3	0.96± 0.08	1.52± 0.02	1.87± 0.02	2.05± 0.02	2.28± 0.07	2.62± 0.10	3.17± 0.03	3.36± 0.04
D4	1.10± 0.05	1.61± 0.01	1.96± 0.02	2.09± 0.05	2.28± 0.02	2.63± 0.10	3.15± 0.13	3.45± 0.60
Mean for diets	1.01± 0.05	1.56± 0.02	1.96± 0.03	2.19± 0.07	2.33± 0.05	2.63± 0.03	3.14± 0.05	3.33± 0.08

Appendix xiv. Mean weekly cumulative feed efficiency of broilers fed experimental diets upto 8 weeks of age.

SECOND TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	1.16^{a} ±0.03	2.20^{a} ±0.04	2.23^{a} ±0.03	2.52^{a} ±0.38	2.17^{a} ±0.03	2.41^{ab} ±0.04	2.71^{ab} ±0.12	2.94^{a} ±0.22
D2	1.17^{a} ±0.05	2.10^{ab} ±0.08	1.98^{a} ±0.10	1.98^{a} ±0.04	2.02^{a} ±0.03	2.27^{a} ±0.03	2.54^{a} ±0.16	2.86^{a} ±0.13
D3	1.05^{a} ±0.06	1.81^{b} ±0.18	1.59^{b} ±0.20	1.94^{a} ±0.07	2.21^{a} ±0.28	2.24^{a} ±0.08	2.34^{a} ±0.04	2.51^{a} ±0.06
D4	1.16^{a} ±0.01	1.81^{b} ±0.01	1.92^{ab} ±0.06	1.97^{a} ±0.03	2.12^{a} ±0.04	2.51^{b} ±0.09	2.88^{a} ±0.20	3.13^{a} ±0.28
Mean for diets	1.14 ±0.03	1.98 ±0.10	1.93 ±0.13	2.10 ±0.14	2.13 ±0.04	2.36 ±0.06	2.62 ±0.12	2.86 ±0.13

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

Appendix xv. Mean weekly cumulative feed efficiency of broilers fed experimental diets upto 8 weeks of age.

THIRD TRIAL

Treatments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	1.24± 0.03	1.85± 0.09	2.24± 0.09	2.57± 0.09	2.60± 0.08	2.83± 0.04	3.09± 0.10	3.32± 0.10
D2	1.36± 0.02	2.06± 0.08	2.30± 0.10	2.44± 0.07	2.39± 0.05	2.61± 0.02	2.92± 0.06	3.28± 0.07
D3	1.33± 0.06	1.94± 0.04	2.10± 0.05	2.31± 0.31	2.31± 0.09	2.54± 0.10	2.88± 0.20	3.16± 0.18
D4	1.27± 0.06	1.95± 0.02	2.08± 1.20	2.34± 0.06	2.34± 0.04	2.84± 0.21	2.94± 0.12	3.17± 0.12
Mean for diets	1.30± 0.03	1.95± 0.04	2.18± 0.05	2.42± 0.06	2.41± 0.07	2.73± 0.06	2.96± 0.05	3.23± 0.04

Appendix xvi. Mean weekly cumulative feed efficiency of broilers fed experimental diets upto 8 weeks of age.

FOURTH TRIAL

Treat-ments	Age in Weeks							
	1	2	3	4	5	6	7	8
D1	1.69^{a} ±0.06	2.22^{a} ±0.16	2.29^{a} ±0.07	2.49^{a} ±0.11	2.62^{a} ±0.07	2.50^{a} ±0.08	2.67^{a} ±0.05	2.84^{a} ±0.06
D2	1.57^{a} ±0.08	2.13^{a} ±0.06	2.04^{b} ±0.04	2.32^{a} ±0.07	2.30^{b} ±0.02	2.20^{a} ±0.04	2.48^{a} ±0.02	2.70^{a} ±0.04
D3	1.56^{a} ±0.04	1.95^{a} ±0.02	1.99^{b} ±0.03	2.17^{a} ±0.01	2.25^{b} ±0.01	2.29^{a} ±0.03	2.50^{a} ±0.04	2.74^{a} ±0.06
D4	1.55^{a} ±0.02	2.10^{a} ±0.06	2.08^{b} ±0.05	2.29^{a} ±0.10	2.26^{b} ±0.10	2.24^{a} ±0.11	2.52^{a} ±0.11	2.96^{a} ±0.14
Mean for diets	1.59 ±0.03	2.10 ±0.06	2.10 ±0.07	2.32 ±0.07	2.36 ±0.09	2.31 ±0.07	2.54 ±0.04	2.81 ±0.06

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

Appendix xvii. Mean processing yield and losses of broilers fed experimental diets at 8 weeks of age.

FIRST TRIAL

Observations	Treatments D1	D2	D3	D4	Mean for diets
Starved body weight(g)	1025.56±39.62	1202.22±60.53	1111.11±50.32	1078.89±31.60	1104.44±7.06
Blood loss(%)	4.37±0.45	4.09±0.46	3.50±0.40	3.59±0.28	3.89±0.21
Feather loss (%)	3.91±0.27	3.87±0.33	4.09±0.42	4.04±0.24	3.98±0.05
Total loss (%)	29.53±1.37	26.88±1.10	25.17±0.82	27.88±1.54	27.37±0.91
Eviscerated yield (%)	64.01±1.43	67.19±1.27	68.75±0.87	65.81±1.44	66.44±1.01
Giblet yield(%)	6.46±0.28	5.93±0.22	6.07±0.18	6.31±0.29	6.19±0.12
R-to-C yield (%)	70.47±1.37	73.12±1.10	74.82±0.82	72.12±1.54	72.63±0.91
Abdominal fat(%)	1.68±0.15	1.64±0.18	1.67±0.20	1.38±0.18	1.59±0.07

Appendix xviii. Mean processing yield and losses of broilers fed experimental diets at 8 weeks of age.

SECOND TRIAL

Observations	Treatments				Mean for diets
	D1	D2	D3	D4	
Starved body weight(g)	1472.22±52.38	1349.44±125.77	1613.89±87.70	1302.78±74.69	1434.58±69.64
Blood loss(%)	3.94±0.19	4.15±0.30	3.47±0.17	4.07±0.17	3.91±0.15
Feather loss (%)	4.46±0.27	3.94±0.18	4.36±0.27	4.33±0.18	4.27±0.11
Total loss (%)	22.41±1.37	23.06±1.28	21.57±1.16	23.40±0.84	22.61±0.40
Eviscerated yield (%)	72.77±1.41	71.75±1.49	73.48±1.16	71.07±0.82	72.27±0.54
Giblet yield(%)	4.82±0.26	5.19±0.28	4.95±0.22	5.53±0.24	5.12±0.16
R-to-C yield (%)	77.59±1.37	76.94±1.28	78.43±1.16	76.60±0.84	77.39±0.40
Abdominal fat(%)	1.70±0.23	1.24±0.16	1.25±0.16	0.75±0.12	1.24±0.19

Appendix xix. Mean processing yield and losses of broilers fed experimental diets at 8 weeks of age.

THIRD TRIAL

Observations	Treatments				Mean for diets
	D1	D2	D3	D4	
Starved body weight(g)	1356.67±37.68	1417.78±55.65	1388.89±41.28	1425.56±38.37	1397.23±15.65
Blood loss(%)	4.89±0.36	4.41±0.21	4.50±0.31	4.28±0.26	4.52±0.13
Feather loss (%)	4.70±0.30	4.63±0.29	3.99±0.34	4.49±0.42	4.45±0.16
Total loss (%)	25.60±1.38	25.61±0.70	25.44±0.85	27.63±0.95	26.07±0.52
Eviscerated yield (%)	69.39±1.36	69.86±0.67	70.00±1.22	67.72±0.67	69.24±0.56
Giblet yield(%)	5.01±0.13	4.53±0.21	4.56±0.16	4.65±0.14	4.69±0.11
R-to-C yield (%)	74.40±1.37	74.39±0.70	74.56±1.20	72.37±0.64	73.93±0.53
Abdominal fat(%)	1.61±0.26	1.31±0.25	1.12±0.13	1.07±0.16	1.28±0.12

Appendix xx. Mean processing yield and losses of broilers fed experimental diets at 8 weeks of age.

FOURTH TRIAL

Observations	Treatments D1	D2	D3	D4	Mean for diets
Starved body weight(g)	1471.11±51.57	1510.00±27.59	1614.44±48.68	1561.11±32.47	1539.17±31.13
Blood loss(%)	4.15±0.27	3.79±0.28	4.12±0.37	4.21±0.21	4.07±0.09
Feather loss (%)	5.26±0.39	5.49±0.54	4.83±0.64	5.34±0.57	5.23±0.14
Total loss (%)	24.61±0.86	24.78±0.75	23.35±1.21	24.41±0.71	24.29±0.32
Eviscerated yield (%)	71.11±0.94	70.43±0.83	72.00±1.43	70.67±0.69	71.05±0.35
Giblet yield(%)	4.28±0.45	4.79±0.17	4.65±0.16	4.92±0.12	4.66±0.14
R-to-C yield (%)	75.39±0.86	75.22±0.75	76.65±1.36	75.59±0.68	75.71±0.30
Abdominal fat(%)	1.49±0.13	1.09±0.12	1.17±0.25	0.98±0.21	1.18±0.18

REQUIREMENTS OF PROTEIN AND ENERGY FOR BROILERS DURING SUMMER SEASON

By

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of
the requirement for the degree

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ABSTRACT

An experiment was designed and conducted to establish the requirements of protein and energy for broilers during the summer season in the hot and humid atmosphere of Kerala. Four trials were conducted in a span of two years. In each trial the following energy-protein combinations at starter, and subsequent finisher diets were tested in a completely randomised design.

Treatment	Starter	Finisher
Diet 1	22% CP:2900 Kcal ME/kg	19% CP:3000 Kcal ME/kg
Diet 2	24% CP:2900 Kcal ME/kg	19% CP:2900 Kcal ME/kg
Diet 3	26% CP:2900 Kcal ME/kg	19% CP:3000 Kcal ME/kg
Diet 4	26% CP:2900 Kcal ME/kg	19% CP:2900 Kcal ME/kg

Trials corresponding to the same period for the two years were pooled and the results were presented as Period A (started in early summer and ended in peak summer) and Period B (started in peak summer and ended in late summer). Except for the difference in nutrient intake, all the management practices followed were uniform for the different trials and treatment groups. Feed and water were given *ad lib*. The chicks were fed with starter diet upto six weeks of age and finisher diet upto eighth week of age.

Results of the study revealed that body weight at eighth week of age was not influenced by different energy protein levels in the diet during both Period A and Period B. But difference between periods was statistically ($P < 0.01$) significant. Broiler chicks reared during Period A showed significantly lower mean body weight at eight week than Period B. Dietary combination of 22:2900 in the starter and 19:3000 in the finisher stage upto eight weeks of age was found to be optimum for growth of broilers in summer months in Kerala.

Body weight gain was not influenced by the dietary treatments and by periods upto sixth week of age. Thereafter body weight gain was influenced by season. Broiler chicks reared during Period B showed higher body weight gain than Period A. Maximum body weight gain was recorded at fifth week of age in both Period A and Period B.

Feed consumption was not affected by dietary treatments in both Period A and Period B, but was significantly affected by periods at seventh and eighth week of age. Feed efficiency was also not affected by different dietary treatments upto eight weeks of age. Broiler chicks reared during Period A showed poorer feed efficiency from sixth week onwards.

Processing yields and losses, per cent abdominal fat and per cent body fat were not affected by dietary treatments or periods. Bio-chemical parameters like haemoglobin value and plasma protein value (g per cent) were not affected by different dietary treatments or periods. Per cent liver fat estimated as ether extract was significantly lower ($P < 0.01$) during Period B than Period A. Fat constants such as Iodine Value and Saponification Value were not affected by different energy protein levels of the diet. Mortality was not affected by different dietary treatments or periods.

From the overall results of the study it is concluded that commercial broilers grown in the climatic condition of Kerala, require 22 per cent crude protein and 2900 Kcal ME/kg in the starter diet coupled with 19 per cent crude protein and 3000 Kcal ME/kg in the finisher diets. Manipulation of dietary protein and/or energy has little effect in alleviating poor growth rate in broilers observed during summer.