INTERRELATIONSHIPS AMONG TRIIODOTHYRONINE (T3), ENERGY AND SEX ON NUTRITIONAL AND PHYSIOLOGICAL RESPONSES OF HEAT STRESSED BROILERS

By

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Abstract: *The objective of this work was to elucidate the impact of triiodothyronine hormone (T_3) in relation to the concentration of metabolizable energy (ME) and sex on growth performance, body temperature, respiration rate, carcass characteristics and meat chemical composition of heat stressed broilers at (35±2°C) during the day and (30±1°C) during night, and average 58±4% relative humidity for 6 weeks period. Total of 180 males and180 females, 21-d old Lohman broiler chicks were assigned to 2 levels (0, and 0.5 ppm T_3), and 3 levels of dietary metabolizable energy (3470, high; 2900, moderate; and 1760, low ME/kg) as well as sex. Thereby, there were 6 dietary treatments within each sex. Each treatment was replicated three times (10-broilers each), thus there were 30- broiler chicks/ treatment/sex. The experimental diets were iso-nitrogenous and met nutrient requirements of broilers (NRC, 1994). The experimental period was lasted from 21-42 d of age. The obtained results could be summarized as following:*

1- *Dietary supplementation with 0.5 ppm of T3 significantly ($P<0.05$) impaired growth by 8.3% and feed efficiency by 7.5%, while increased water intake by 2.04% and increased mortality rate of broilers by 141% over groups fed diets without T_3 supplementation.*

2- *Feeding high ME diet improved growth by 41.6, and 4.5%, feed efficiency by 74.1, 11.9, when compared with either the low or intermediate ME level, respectively. Meanwhile, this accompanied with negative impact ($P<0.05$) of increasing ME on feed intake. Also, Increased ME level also significantly ($P<0.05$) increased mortality rate.*

3- *A significant interaction between T_3 and ME on water intake was shown in which decreasing energy level increased water intake of broiler chicks fed on T_3-supplemented diet, while feeding intermediate ME level*

decreased water intake of broilers fed on diets without T_3 supplementation.

4- *Cloaca and skin temperatures as well as respiration rate measured at 6.00 am were significantly ($P<0.05$) increased by 0.58, 1.15, and 1.12 %, respectively, when the diet was supplemented with 0.5 ppm of T_3. Whereas this effect was diminished when the measurements were taken at 2.00 pm, except for respiration rate which remained significantly higher by 1.93%.*

5- *Feeding intermediate ME diet significantly ($P<0.01$) increased cloaca and skin temperatures compared with the low or the high ME diet, and had insignificant effect on respiration rate measured at 6.00 am. However feeding high ME diet increased cloaca and skin temperatures compared with the low and the intermediate ME level when measured at 2.00 pm, whereas greater value of respiration rate was obtained with the group fed on intermediate ME level.*

6- *Respiration rate exhibited a significant ($P<0.05$) relationship between ME and T_3, showing that increasing ME level in T_3-supplemented birds had little effect on respiration rate, however, feeding intermediate or high ME diet to T_3-unsupplemented group increased respiration rate by 7.2% for both groups.*

7- *Broilers fed on T3-supplemented diet had significantly lower weights of empty carcass, gizzard, wings, neck, back and thigh.*

8- *Feeding high ME diet significantly ($P<0.01$) increased dressing percentage, and weights of empty carcass, heart, liver, wings, abdominal fat, neck, back, breast and thigh when compared with either the intermediate or low ME diet.*

9- *Absolute weight of abdominal fat of T_3-supplemented group fed on low ME diet was 22.04% lower than that of the intermediate or the high ME diet, whereas low energy diet had only 2.82 and 9.52% less abdominal fat than either the intermediate or high energy diet of T3-unsupplemented group, respectively.*

10- *No significant impacts of dietary T_3 supplementation or sex on moisture, crude protein, fat and ash contents of skinless, boneless meat were noted. Dietary ME levels affected only moisture percentage of broiler meat.*

It is concluded that adding T3 hormone to broiler diets raised under high environmental temperature could not serve to alleviate the adverse

effect of heat stress on broiler growth and decreased feed efficiency, even negative impacts were shown. However, increasing energy level induced improvement in growth and feed efficiency. Meanwhile, no effect of T3 or energy or sex or the relationship among them was observed on chemical composition of broiler meat.

INTRODUCTION

Numerous studies have established the importance of the thyroid hormones in the metabolism of mammals and birds (McNicolas and McNabb, 1987; Cogburn *et al.* 1989a; Rosebrough, 1999; El-Deeb and Abou-Elmagd, 2001). While various methods are available for the induction of hypothyrodism and hyperthyrodism (Decuypere, *et al.*, 1987; Leclercq *et al.*, 1988; Cogburn *et al.*, 1989a; El-Husseiny *et al.*, 2000), relatively few studies were carried out to investigate the effects of these two statuses in relation to the energy concentration and sex on growth, metabolism and body composition of heat stressed broilers. Growth and thyroid hormones are two of the principal hormones responsible for the attainment of normal growth in birds. The beneficiary effects of these hormones on muscle protein synthesis and body fat are well evident. When chicks are rendered hypothyroid by either administration of antithyroid substances, surgical theyrodectomy, or radiothyroidectomy, reduction in body weight, (Mashaly *et al.*, 1983) and circulating concentrations of T_3 and T_4 (Rudas and Pethes, 1984) are observed; this is true with feeding thiouracial too. Snedecor (1971) indicated that feeding antithyroid substances for performing radiothyroidectomy reduced relative body weights of chickens. In the literature, there were contrary results for the effect of T3 on growth and feed utilization by broilers as for example, Tixier-Boichard *et al.* (1990) reported that body weight was significantly increased in dwarf males and decreased in normal females given T_3 supplemented diets. Leclercq *et al.* (1988) showed that dietary supplementation with T_3 did not influence growth rate, feed efficiency and body temperature. Also, Cogburn et al. (1989a) found that dietary 1 ppm of T3 did not affect growth, feed intake, and feed efficiency of broilers. On the other hand, T_3 decreased growth and fat deposition in broilers (Decuypere *et al.*, 1987, Elnager *et al.*, 2001), and growth, but not feed intake (Rosebrough *et al.*, 1992) and growth and feed intake without altering the feed efficiency (Rosebrough, 1999) growth (Scanes, 1987), growth and feed efficiency (May, 1980).

Heat stress reduces feed intake, growth rate, and feed utilization of chickens (Cowan and Michie, 1978; Cerniglia *et al.*, 1983; Sinurat and Balnave, 1985; Cahaner and Leenstra, 1992; El-Gendy and Washburn,

1995; Cooper and Washbrun, 1998; Yalcin *et al.*, 1998; 2001; Makled *et al.*, 2001; Deeb and Cahaner, 2001; El-Deeb and Abou-Elmagd, 2001; El-Husseiny *et al.*, 2000). There are, also, indications that thyroid function is altered at high temperature (Sinurat *et al.*, 1987; El-Deeb and Abou-Elmagd, 2001). Plasma concentrations of T_3 decreased when chickens exposed to high temperature in most (May and Lott, 1986; Freeman and Cogburn, 1983) but not all (Rudas and Pethes, 1980, 1984) studies. These changes reflect variations in feed intake (Moss and Balnave, 1978; Klandorf *et al.*, 1981), with energy intake appears to be the main factor regulating plasma T_3 (Sharp and Klandorf, 1985; Al-Harthi, 1997). On the other hand, the relationship between the amount of feed intake and digestive tract activity was previously reported (Duncan *et al.*, 1970; Boorman, 1973; Savory, 1980; Savory and Hodgkiss, 1984). Fetter and Carlson (1932) and Guyton (1987) concluded that as T3 increases motility of the digestive tract increases and this, in turn, induced greater appetite and feed intake. As mentioned above, T_3 decreases at high ambient temperature and this may explain, in partially, the longer time required for feed to pass through the digestive tract when the birds are kept at high temperature (Sleeth and Van Liere, 1937; Wilson *et al.*, 1980; Savory, 1986). Clarke and Hembree (1990) combined T_3 and dietary fat treatments to ascertain if the stimulatory effect of T_3 could be attenuated by dietary fat. They reported that dietary safflower oil competitively inhibited the stimulation of certain enzyme activities by T_3. It is interesting to note that later work indicated that T_3 inhibited lipogenesis in the chickens (Rosebrough *et al.*, 1992; Rosebrough, 1999).

Heat stress is usually regulated by manipulation of housing conditions, nutrition, or genetic makeup (Cerniglia at al., 1983; Daghir, 1995; Tegethoff and Hartung, 1996; Mendes *et al.*, 1997; Cooper and Washbrun, 1998; Makled *et al.* 2001). However, metabolizable energy requirements for maintenance decreases with reduced growth under high temperature, it increases with rises in the temperature between 28° and 30° C and thereafter till 36° C (Daghir, 1995). Dale and Fuller (1980) reported that under natural conditions, the growth depression caused by heat stress was less in chicks fed on high fat diets. Hurwitz *et al.* (1980) showed an increase in energy requirements at temperatures above 30° C, where an additional input of energy was necessary in order to release the obligatory heat generated by metabolism (Daghir, 1995). The effect of heat stress on nutrient utilization received greater attentions in the literature. Lei and Slinger (1970), Olson et al. (1972), and El-Husseiny and Creger (1980) concluded that different temperatures had no effect on metabolizable energy. Farrell and Swain (1977) found that the relationship between energy

retention and temperature was quadratic, with maximum retention occurred at 22 and 16° C. Whereas, the amount of protein retained was significantly lower at 35 and 30° C. Maximum fat balance was observed at 22 and 16° C, but declined both above and below these temperatures. Wallis and Balnave (1984) found that sex and environmental temperature had no major effects on ME. However, the influence of environmental temperature on amino acid digestibilities appeared to be sex-related, where decreased digestibilities of most amino acids at higher temperatures in female but not male birds were observed.

The present study was conducted to elucidate the impact of triiodothyronine hormone (T_3) in relation to the concentration of metabolizable energy and sex on growth performance, body temperature, respiration rate, carcass characteristics and meat chemical composition of broiler chicks raised under high ambient temperature at (35±2°C) during the day and (30±1 °C) during night, and average 58±4% relative humidity for 6 weeks period.

MATERIALS AND METHODS

General Management

A total number of 500 broiler chicks "Lohman flock" was raised at the Agricultural Research Station, Faculty of Meteorology Environmental and Arid Land Agriculture, King Abdulaziz University, Saudi Arabia during June and July months under hot ambient temperature (35±2°C) during the day and (30±1°C) during night the relative humidity averaged 58±4% for 6 weeks. Birds were fed on starter corn-soybean ration containing 23.3% CP, and 2930 kcal/kg ME (Table 1) for 3 weeks.

Experimental Design and Diets

At the end of 3-weeks period, 180 male and 180 female birds in similar weights were selected separately (based on comb size and general appearance) from 500 birds, and then divided randomly to thirty-six pens; each floor pen (1.5x 1.5 m) contained 10-broilers. Two levels (0, and/or 0.5 ppm), of triiodothyronine[1] (T3) hormone and 3 levels of metabolizable energy (high, 3470; moderate, 2900 and low, 1760 kcal ME /kg; Table 1) as well as sex were used. Also, MacLeod (1990) used similar ME value in the diets for broilers. Each treatment was replicated three times, thus there were

[1]A product Number T2752 (3, 3', 5-Triiodo-L-thyronine sodium salt) of Sigma Company, USA.

30- broiler chicks/treatment/sex. The experimental diets were iso-nitrogenous (20% CP) and meet nutrient requirements of NRC (1994), since they were formulated and fed from 21-42 d of age (experimental period).

Measurements

Birds were weighed individually at 28, 35 and 42 d of age. Feed intake was recorded at the same ages based on replicate, and then feed efficiency (g gain/g feed) was calculated. At the termination of the experiment, 12 birds/treatment/sex were randomly chosen, fasted overnight, weighed, slaughtered, bled, scalded, plucked and then eviscerated. Carcasses were drained for 10-min, weighed individually and then the abdominal fat was removed and weighed. Carcasses were cut into breasts and leg portions. The leg portion was obtained by cutting through the joint between the femur and the ileum bone of the pelvic girdle. The breast portion was obtained by cutting on each side of the vertebral column beginning at the midpoint of the sternal ribs until the breast portion was completely severed from the back portion. Parts from each carcass were weighed individually. Dressing was defined on the basis of the live body weight after starvation.

Four birds of each treatment of each sex were randomly selected and used for determination of the chemical composition of meat. The right side of each bird, breasts and thighs muscles were de-boned, mixed separately, homogenized, and then granddad to make 4 samples of meat/pen/sex/treatment, which gives in turn 12 samples of meat/treatment/sex. Boneless-skinless-meat samples were kept at -20° C prior to chemical analysis. Chemical analysis of meat sample was undertaken according to (AOAC, 1990). Meat sample was dried overnight at 100° C and then the dry matter content was determined. Nitrogen was determined by Kjeldahl method and meat protein was calculated by multiplying by 6.25. Fat content was determined using petroleum ether extract method. For ash analysis, meat samples were held overnight in a furnace at 550° C.

Bird's thermoregulation measurements such as water intake, cloacal and skin temperatures and the respiration rate were recorded. Three birds were randomly chosen from each replicate at 39, 40 and 41 d of age, for measuring cloacal and skin temperatures and respiration rate at 6.00 am and 2.00 pm. Cloacal temperature was measured using electronic thermometer with 0.1° C sensitivity.

Statistical Analyses

Data were analyzed using the General Linear Model (GLM) of SAS® (SAS Institute, 1985). The statistical model included main effects of T3, dietary energy level, and sex as well as the 2 and 3-way interactions of the main effects. Means difference at $P \leq 0.05$ was done using LSD. In the context, the effect of T_3, ME, and sex will be mentioned independent of each other.

RESULTS AND DISCUSSION

Growth Performance

Table (2) summarizes the effects of T_3 supplementation, different levels of ME and sex on growth performance of broilers. Dietary T_3 impaired body weight by 8.3% ($P<0.01$), feed efficiency by 7.5% ($P<0.01$), while increased water intake by 2.0% ($P<0.05$), and insignificantly reduced feed intake by 1.92%. It also noticed that dietary T3 increased mortality rate significantly. These results are in general agreement with those reported by Cogburn *et al.* (1989a), Rosebrough, (1999), El-Husseiny *et al.* (2000), and Elnagar *et al.* (2001), They showed that dietary T_3 supplementation impaired growth and feed efficiency of broilers, and this was accompanied by a marked depletion of body fat (May, 1982; Decuypere *et al.*, 1987). This might be due to the increase in metabolic rate of T_3-treated birds, and/or the decrease in plasma growth hormone (GH) in chickens (Harvey, 1983). Cogburn *et al.* (1986) indicated that 1 ppm supplementation of T_3 decreased plasma insulin and increased glucagon; the low insulin: glucagon ratio normally found in birds (Cogburn *et al.*, 1989a; b) indicates that their metabolism predominately operates in a catabolic mode (Hazelwood, 1984). The hyperthyroidism induced by dietary T_3 supplementation or iv injection increased plasma T_3 and decreased plasma T_4 (Cogburn *et al.*, 1986 &1989a;b; Rosebrough, 1999; El- Hussieny *et al.*, 2000). Plasma T_3 regulated the insulin: glucagen molar ratio and consequently fat deposition and/or lipid metabolism in broiler chicks, this might be due to the inhibitory effect of T_3 on the T_4 secretion of the thyroid gland (Cogburn *et al.*, 1989b; Rosebrough, 1999), and plasma growth hormone (Scanes, 1987, Donoghue *et al.*, 1990, Rosebrough *et al.*, 1992).

In the literature, there was conversely relationship between T_3 and growth hormone as for example Rosebrough *et al.* (1992) showed negative relationship whereas; Tixier-Biochard et al. (1990) reported positive one. The thyroid hormones appear to play an important role in the growth

process of chickens especially regulating secretion of GH from the pituitary gland and determining the molar ratio of Insulin: glucagon secreted by the pancreas. Cogbrun et al. (1989a). It should be mentioned however that the relationship between T3 and growth and feed efficiency are controversy in the literature, as for example, Tixier-Boichard *et al.* (1990) reported that body weight was significantly increased in dwarf males and decreased in normal females given T_3 supplemented diets. Leclercq *et al.* (1988) showed that dietary supplementation with T_3 did not influence growth rate, feed efficiency and body temperature. Also, Cogburn et al. (1989a) found that dietary 1 ppm of T3 did not affect growth, feed intake, and feed efficiency of broilers. On the other hand, T_3 decreased growth and fat deposition in broilers (Decuypere *et al.*, 1987), growth, but not feed intake (Rosebrough *et al.*, 1992) and growth and feed intake without altering the feed efficiency (Rosebrough, 1999), only growth (Scanes, 1987), and growth and feed efficiency (May, 1980).

Increasing dietary ME, significantly improved both weight gains ($P<0.01$), and feed utilization ($P<0.01$), while decreased feed and water intakes significantly. However, the improvement in feed utilization correlated with the contrary relationship between dietary ME and feed intake (Table 2). This finding is in agreement with that of Deaton *et al.* (1983), Macleod (1990), Yalcin *et al.* (1998), Attia *et al.* (1998), and Al-Batshan and Hussein (1999). In regard to the wide range of ME used herein, MacLeod (1990) fed also broiler chicks diets with similar ME (8, 13 and 15 MJ/kg) energy and protein (13 and 21% CP) concentration, and found that CP intake varied directly with dietary CP: ME ratio, indicating that control of energy intake took priority and that feed intake did not increase in order to enhance amino acid intake on low-CP diets. Mortality rate was significantly decreased when intermediate and low energy diets were fed, and this was correlated with the increasing in water intake of birds on low energy diet. The increase in water intakes of birds on low energy diet might be attributed to the increase in feed intake. The results, also, indicate that males were significantly 9.9% bigger, consumed 2.63% more feed, 6.3% more water, utilized the feed 5.3% more efficiently and exhibited insignificantly 33.3% higher mortality than females (Table 2).

There was a significant interaction between sex and ME which indicated that raising ME level from the low to the intermediate in female and male diets improved growth by 29.1 and 41.6%, respectively. Meanwhile, these responses were 5.9 and 3.3% when ME was further increased from the intermediate to the high level in female and male diets respectively (Table 3). This indicated that the relationship between growth

and dietary ME is different between female and male broilers. In this regard, Wallis and Balnave (1984) showed that the influence of environmental temperature on amino acid digestibilities appeared to be sex-related, there being decreased digestibilities of most amino acids at higher temperatures in female but not male birds.

There were no significant relationships among T3, ME, and sex on feed intake, feed efficiency and mortality rate (Table 3). The lack of significant interaction between ME and T_3 on growth performance recorded herein is in agreement with the finding of Ingram and Evans (1980), and Rosebrough *et al.* (1992) who indicated that dietary thyroid hormones may not alter growth and feed utilization if optimal dietary energy and protein range are utilized. Also in accordance with the present results, Rosebrough (1999) found that dietary fat level and T_3 did not interacted in growth performance of broiler chicks kept under normal environmental temperature, as T3 impaired growth and feed intake of all fat energy groups. In the present study, birds on low energy diet consumed less energy, but more protein than those either on the 3470 or 2900 kcal ME groups, even though T_3 did not improve growth rate and feedd utilization of low energy groups, nor of other calorific groups. It clear also those broilers fed on intermediate and low energy regimen consumed 8.4 and 24.8% more feed to compensate for the decrease in ME value and this is in agreement with the reports by Scott *et al.* (1982), and NRC (1994).

Also, there was a significant interaction between T_3 and ME on water intake revealing inverse relationship between energy level and water intake of broilers on T_3-supplemented diet, whereas feeding intermediate ME level decreased water intake of broilers fed on diet without T_3 supplementation (Table 3). The increase in water intakes of broilers fed on low ME regimen supplemented with T_3 may be due to release the obligatory heat generated by the catabolic action of T_3 as a result of feeding marginal energy level. In this regard, Sharp and Klandorf (1985), and Al-Harthi (1997) showed that energy intake appears to be the main factor regulating plasma T_3.

It was concluded that increasing energy level in the diets improved weight gains, and feed utilization of broiler chicks under high temperature in Saudi Arabia. Meanwhile, dietary T_3 supplementation had no beneficial effects, since negative responses were shown on growth performance and mortality rate.

Physiological Responses

Effects of T3 supplementation, ME concentration and sex on body and skin temperatures measured at 6.00 are presented in Table 4. Cloaca and skin temperatures as well as respiration rate were significantly increased by 0.58, 1.15, and 1.12 % respectively, in broilers fed on T3-diet compared with those on un-supplemented T3 (Table 4). This is partially constant with the results of Tixier-Biochard *et al.* (1990) who found that dietary T_3 increased rectal temperature of dwarf chciks but not of the normal broilers. Moreover, Müller and Seitz (1984) reported that hyperthyroidism increased metabolic rate, oxygen consumption and elevated respiratory ratio, as a result of increasing rate of energy expenditure. The lack of significant effects of T_3 supplementation on cloaca and skin temperature measured at 2.00 pm (Table 5), is in agreement with those reported by Touchburn *et al.* (1981), and Leclercq *et al.* (1988) who reported that T_3 supplementation did not affect body temperature of lean or fat lines of broiler chicks. The significant increases of 1.12, and 1.93% in respiration rate of T_3-supplemented birds observed at 6.00 am and 2.00 pm are in agreement with previous work. Since Newcomer (1976) and El-Husseiny *et al.* (2000) showed that T_3-fed broilers had significantly greater oxygen consumption than the control group which might reflect the increase in respiration rate. This probably induced an increase in the basal metabolic rate and/or heat production (Harvey, 1983; Hazelwood, 1984; Cogburn *et al.* 1989a), since birds drank more water (Table 2) to relief the metabolic heat production. It has been shown that increasing water intake apparently acted as a heat sink to lower body temperature (Smith and Teeter, 1989; Al-Harthi, 2001). Furthermore, Ismail-Beigi and Edelman (1970) reported that thyroid hormones stimulated oxygen consumption through an increase in Na^+, K^+-ATPase. It is clear that temperatures and respiration rate measured at 2.00 pm were higher than those measured at 6.00 am, this might be due to the increase in the environmental temperature and subsequently house temperature during the day.

Unexplained increase ($P<0.01$) in cloaca and skin temperature was shown of the intermediate ME level when compared with the low or the high ME diet measured at 6.00 am, meanwhile there was insignificant effect on respiration rate measured at 6.00 am (Table 4). On contrary, feeding high ME diet increased cloaca and skin temperatures compared with the low and the intermediate ME levels when measured at 2.00 pm, which might indicate an increase in metabolic heat production. Respiration rate was significantly higher with broilers fed on intermediate ME diet than those on either the low or the high ME regimen (Table 5). These results indicate that

the change in body temperature and respiration rate during the day tended to respond differently to ME level (Tables 4&5).

Results exhibited insignificant differences between male and female broilers in cloaca and skin temperatures as well as respiration rate (Tables 4&5), although there were significant differences between sex in weight gains and feed intake (Table 2). However, this could be explained by the increase in water intakes of males broiler compared with females and the effect of water intake on body temperature was evident previously (Smith and Teeter, 1989; Al-Harthi, 2001).

Only skin temperature exhibited a significant T_3 x ME interaction ($P<0.05$) when measured at 6.00 am (Table 6). Data revealed that feeding birds either intermediate or high ME diet without T_3 supplementation induced an increase in skin temperature by 1.9% compared with those on low energy diet.

There was a significant relationship ($P<0.05$) between sex and ME in respiration rate measured at 2.00 pm (Table 7). Results indicated that feeding either intermediate or high ME diet to broiler males increased respiration rate by 7.0 and 6.8%, and had little impact on female by 1.1 and 0.83%, respectively (Table 7). This indicated that respiration rate of female and male broiler chicks responded differently to ME content of the diet. This may be due to difference in body size, and thereby basal heat production as males had 9.9% bigger weights and eat 2.63% more feed.

Also, the relationship between ME and T_3 was significant ($P<0.05$), showing that increasing ME level in T_3-supplemented birds had little effect on respiration rate, however, feeding intermediate or high ME to T_3-unsupplemented birds increased respiration rate by 7.2% for both groups. It was cleared from Table (7) that males fed on low ME T_3 un-supplemented diet had significantly lower respiration rate than females on the same regimen or any other feeding regimen that indicating, sex, ME, and T_3 relationship ($P<0.01$).

Carcass Characteristics

Tables (8 and 9) present data of the mean effects of T_3, ME and sex on slaughter traits including edible parts weights and dressing percentage. Broilers fed on T_3-supplemented diet had significantly lower weights of gizzard, wings, neck (Table 8), back and thigh as well as empty carcass (Table 9). These decreases are expected and paralleled with the variation in growth and body weight between T_3 treatments (Tables 2; 8 and 9). Results

of the present work indicated that there were insignificant differences in the absolute weights of liver (Table 8), abdominal fat and breast, and dressing percentage (Table 9). These findings are in general agreement with those reported by El-Husseiny *et al.*, (2000), who showed a decrease in body weight and dressing percentages when T_3 was added to the basal broilers diet. This is also similar to the results of Rosebrough *et al.* (1997), and Cogburn *et al.* (1989a). Moreover, Clarke and Hembree (1990) reported that safflower oils (75% Linoleic acid) competitively inhibited the stimulation of certain enzyme activities by T_3. Rosebrough *et al.* (1992) and Rosebrough (1999) noted that T_3 inhibits Lipogenic enzyme activities in chickens and increased catabolic mode (Wilson *et al.*, 1983; Hazelwood, 1984). Leclercq *et al.* (1988), also, found that T_3 supplementation at 0.1 or 0.2 ppm tended to decrease abdominal fat proportion, but did not affect growth rate, and feed efficiency of lean or fat lines of broilers. In the present work expressing liver weight (2.0 vs. 2.1%) or abdominal fat (0.35 vs. 0.39%) as a proportional to live body weight elucidated little differences between T_3 groups. The differences in results between the present work and those of Leclercq *et al.* (1988) could be explained based on the differences in T_3 doses (0.5 vs. 0.1 or 0.2 ppm), strain of broilers, and the ambient temperature during the experimental course. It was, also, noticed that heart was enlarged ($P<0.01$) as absolute or relative weights to body weight due to feeding T_3 supplemented diet (Table 8); however, this could be explained by the greater activities of this organ, since the relationship between respiration rate and heart activity is well known.

Feeding high ME diet significantly ($P<0.01$) increased weight of heart, liver, wings, neck (Table 8), empty carcass weight, back, breast, thigh, abdominal fat as well as dressing percentage (Table 9) compared with either the intermediate or low ME diet. These differences in carcass yield were paralleled with that in live body weight. These results are in partial agreement with those reported by other investigators (Kassim and Suwanpradit,1996; Lei and Van Beek, 1997; Attia *et al.*, 1998; and Al-Batshan and Hussein, 1999). They concluded that increasing ME content of the diet exert a significant effect on most of the carcass parts and this paralleled with the variation in body weight. Gizzard weight was significantly higher in birds on the intermediate ME level than that either on the high or low ME level (Table 8). This is difficult to be explained based on differences in live body weight (Table 2), and/or dietary crude fibre contents among different ME groups (Table 1). The increase in absolute weight of abdominal fat of birds on high ME level (174 C:P ratio; Table 9) was constant with the previous results (Scott *et al.*, 1982; Deaton and Lott,

1985; Kassim and Suwanpradit, 1996; Lei and Van Beek, 1997; and Attia *et al.* 1998). They showed that increasing energy level in broiler diet increased abdominal fat, and this most likely was due to widening dietary protein: energy ratio (Leenstra, 1986; Leeson and Summers, 1990; Kassim and Suwanpradit, 1996). It should be mentioned, however, that increasing dietary ME level herein was accompanied with wendening C: P ratio since CP was kept constant among the experimental diets (Table 1).

Sex differences were clear in the weights of heart, wings (Table 8). empty carcass, back, and thigh (Table 9) in which male broilers had higher values than female ones. Meanwhile, weight of liver (Table 8) or abdominal fat (Table 9) was not significantly affected by sex differences, which disagree with previous reports (Cabel and Waldroup, 1991; Qota, 1994).

There were significant interrelationships ($P<0.05$. $P<0.01$, $P<0.05$; $P<0.05$) between ME and T_3 in heart, liver, wings (Table 10) and abdominal fat (Table 11), respectively. Results indicated that increasing ME level for T_3-supplemented diet linearly increased absolute weights of heart and liver (Table 10), while there was no response of feeding high ME diet over intermediate ME of groups fed on the T_3-unsupplemented diet. Weight of abdominal fat of T_3-supplemented group fed on low ME diet was 22.04% lower than those of the intermediate or the high ME diet (Table 11). Whereas group fed on low energy diet had only 2.90 and 10.53% less abdominal fat than those either on the intermediate or on the high-energy diet of T3-unsupplemented group (Table 11). This indicates that T_3 modified energy metabolism in T_3-treated birds. This is in general agreement with the results reported by Leclercq *et al.* (1988), Rosebrough et al. (1992), and Elnagar *et al.* (2001). They found that T_3 supplementation either at 0.1 or 0.2 ppm tended to decrease abdominal fat proportion. Similar findings were noted with wings weights. However, later study by Rosebrough (1999) indicated that fat level in isocaloric diets did not interacted with T_3 in lipogenesis and the activity of lipogenic enzyme.

Body Composition

Results presented in Table (12) show the main effects of T_3 concentrations, ME levels and sex on chemical composition of skinless boneless meat. There were no significant impacts of dietary T_3 supplementation on moisture, crude protein, fat and ash contents of meat of broilers. Similar results were recently reported by Hussieny *et al.* (2000) who showed that dietary T_3 supplementation had no effects on protein and fat contents of liver. However, Decuypere *et al.* (1987) and Rosebrough *et*

al. (1992) showed that T_3 decreased lipiogensis and abdominal fat. Moreover, Rosebrough (1999) noted that T_3 inhibits Lipogenic enzyme activities in chickens as well as increased catabolic mode (Wilson *et al.*, 1983; Hazelwood, 1984). Similarly, Cogburn *et al.* (1989a), and Elnagar *et al.* (2001), also, stated that growth rate, feed efficiency and body composition of chickens were dramatically altered by changes in thyroid activity.

Dietary ME levels affected only moisture percentage of broiler's meat (Table 12). Feeding high dietary ME level increased protein and fat percentages of broiler meat insignificantly. These results are in partial agreement with those reported by Qota (1994) and Kassim and Suwanpradit (1996) who showed that increasing dietary ME level resulted in an increase in fat content of breast and thigh meat, with the most fat in the thigh meat.

There were no significant differences in meat chemical composition between male and female broiler chicks raised under high ambient temperature (Table 12). These results are contradictory to those reported by Jackson *et al.* (1982), and Qota (1994) who found that male broiler chicks had more tissue protein and less tissue fat than female broilers raised under normal ambient temperature. There were no significant interrelationships between, T_3 and sex and/or ME and between sex and ME on chemical composition of broiler meat (Table 13).

From the foregoing discussion, It could be concluded that increasing energy level (the level used in this work) in broiler diets raised under high ambient temperature in Saudi Arabia induced an improvement in growth and feed efficiency, and had no negative effect on chemical composition of broiler meat. However, there was a negative effect of triiodothyronine hormone (T3) (the concentration used in this work) on feed utilization expressed as growth and/or efficiency.

Table (1): Composition and calculated analysis of the experimental diets

Ingredients, %	Pre-experimental diet – 2930	Energy level in the experimental diet 3470	2900	1760
Yellow corn	58.55	64.9815	46.1419	6.1815
Wheat bran	0.00	0.0	24.8271	71.3705
Soybean meal (48% CP)	35.12	18.8589	14.2016	14.3445
Fish meal (65% CP)	2.0	8.0	8.0	2.0
Limestone	0.92	1.0374	1.0568	1.5582
DiCa phosphate	1.57	0.6366	0.5176	1.0024
Vit+Min mix	0.5	0.5	0.5	0.5
NaCl	0.3	0.3	0.3	0.3
DL-methionine	0.20	0.1524	0.2371	0.4379
L-lysine HCl	0.00	0.0121	0.0479	0.135
Corn oil	0.67	5.3511	4.0	2.0
Choline chloride	0.10	0.10	0.10	0.10
Coccidostatic	0.07	0.07	0.07	0.07
Total	100.0	100.0	100.0	100.0
Calculated values				
ME kcal/kg	2930	3470	2900	1760
Crude protein,%	23.31	20.0	20.0	20.0
C:P ratio	125.7	173.5	145.0	88.0
Methionine,%	0.56	0.55	0.55	0.55
TSAA,%	0.92	0.86	0.86	0.92
Lysine,%	1.28	1.14	1.14	1.14
Ca,%	0.92	0.89	0.89	0.89
Available P, %	0.44	0.41	0.41	0.41
Crude fat,	6.13	8.41	7.05	4.66
Linoleic acid	3.28	4.62	3.84	2.60
Crude fibre	2.47	2.25	4.38	8.56

Vitamins and minerals mixture provide per kilogram of diet. vitamin A (as all-trans-retinyl acetate). 12000 IU, vitamin E (all rac-α-tocopheryl acetate), 10 IU; k_3 3mg, Vit.D_3, 2200 ICU; riboflavin, 10 mg, Ca pantothenate,10 mg; niacin, 20 mg, choline chloride, 500 mg; vitamin B_{12}, 10µg; vitamin B_6, 1.5 mg, thiamine (as thiamine mononitrate); 2.2 mg; folic acid, 1 mg, D-biotin, 50µg. Trace mineral (milligrams per kilogram of diet) : Mn, 55; Zn, 50; Fe, 30;Cu, 10; Se, .1 and Ethoxyquin 3mg.

Table (2): Mean effects of triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on performance of heat stressed broilers of 6 week-old

Treatments	Criteria				
	Weight gains (g/bird/d)	Feed intake (g/bird/d)	Feed efficiency (g gain/ g food)	Water intake, (L)	Mortality, %
T_3 ppm					
0.0	46.80[a]	118.89	0.40[a]	0.49[b]	3.9[b]
0.5	42.91[b]	116.61	0.37[b]	0.50[a]	9.4[a]
ME kcal/g					
3.47	50.52[a]	106.00[b]	0.47[a]	0.48[b]	14.0[a]
2.90	48.35[b]	114.92[b]	0.42[b]	0.48[b]	4.0[b]
1.76	35.69[c]	132.33[a]	0.27[b]	0.52[a]	2.0[b]
Sex					
Male	46.97[a]	119.28[a]	0.40[a]	0.51[a]	8.0
Female	42.74[b]	116.22[b]	0.38[b]	0.48[b]	6.0
Pooled SEM	2.96	2.98	0.016	0.0109	0.25
Probabilities					
T_3	0.01	NS	0.05	0.05	0.05
ME	0.01	0.01	0.01	0.01	0.01
Sex	0.01	0.05	0.05	0.05	NS

[a-c] means within the same column within the same treatment not bearing similar superscripts are significantly different ($P<0.05$) based on LSD Test for mean differences.

Table (3): The interaction effects among triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on performance of heat stressed broilers of 6 week- old

Treatments	Criteria				
	Weight gains (g/bird/ d)	Feed intake (g/bird/d)	Feed efficiency (g gain/ g food)	Water Intake (L)	Mortality, %
T_3 (ppm) X Sex					
T_3 (0.0) X Female	44.72	116.89	0.39	0.48	1.0
T_3 (0.5) X Female	40.76	115.56	0.36	0.49	10.0
T_3 (0.0) X Male	48.88	120.89	0.41	0.50	7.0
T_3 (0.5) X Male	45.05	117.67	0.39	0.52	9.0
Sex X ME kcal/g					
Female X 3.47	47.92	105.33	0.45	0.46	10.0
Female X 2.90	45.25	110.67	0.41	0.48	3.0
Female X 1.76	35.06	132.67	0.26	0.52	3.0
Male X 3.47	53.13	106.67	0.50	0.50	18.0
Male X2.90	51.44	119.17	0.43	0.49	5.0.
Male X 1.76	36.33	132.00	0.28	0.53	0.0
T_3 (ppm) X ME kcal/g					
T_3 (0.0) X 3.47	52.09	105.00	0.49	0.49	10.0
T_3 (0.0) X 2.90	51.40	118.83	0.43	0.47	2.0
T_3 (0.0) X 1.76	36.92	132.83	0.28	0.50	0.0
T_3 (0.5) X 3.47	48.95	107.00	0.46	0.48	18.0
T_3 (0.5) X 2.90	45.29	111.00	0.41	0.50	7.0
T_3 (0.5) X 1.76	34.47	131.83	0.26	0.54	3.0
Sex ME X T_3 X					
3.47X T_3 (0.0)X Female	50.40	103.67	0.49	0.46	3.0
2.90X T_3 (0.0)X Female	48.50	114.00	0.43	0.47	0.0
1.76X T_3 (0.0)X Female	35.26	133.00	0.27	0.50	0.0
3.47X T_3 (0.5)X Female	45.43	107.00	0.42	0.47	17.0
2.90X T_3 (0.5)X Female	41.99	107.33	0.39	0.48	7.0
1.76X T_3 (0.5)X Female	34.86	132.33	0.26	0.53	7.0
3.47X T_3 (0.0)X Male	53.78	106.33	0.50	0.52	17.0
2.90X T_3 (0.0)X Male	54.29	123.67	0.44	0.47	3.0
1.76X T_3 (0.0)X Male	38.57	132.67	0.29	0.50	0.0
3.47X T_3 (0.5)X Male	52.48	107.00	0.49	0.48	20.0
2.90X T_3 (0.5)X Male	48.0	114.67	0.42	0.51	7.0
1.76X T_3 (0.5)X Male	34.08	131.33	0.26	0.56	0.0
Pooled SEM	2.96	2.98	0.016	0.0109	0.25
Probabilities					
T_3 X Sex	NS	NS	NS	NS	NS
Sex X ME	0.05	NS	NS	NS	NS
T_3 X ME	NS	NS	NS	0.05	NS
ME X T_3 X Sex	NS	NS	NS	NS	NS

Table (4): Mean effects of triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on cloaca temperature °C, skin temperature °C, and respiration rate of heat stressed broilers measured at 6.00 am

Treatments	Criteria		
	Cloaca temperature ,	Skin temperature	Respiration rate
T_3 ppm			
0.0	41.21[b]	39.93[b]	40.22[b]
0.5	41.45[a]	40.39[a]	40.67[a]
ME kcal/g			
3.47	41.39[b]	40.16[b]	40.58
2.90	41.49[a]	40.46[a]	40.58
1.76	41.11[b]	39.85[b]	40.17
Sex			
Male	41.35	40.16	40.46
Female	41.31	40.16	40.43
Pooled SEM	0.20	0.26	0.38
Probabilities			
T_3	0.05	0.01	0.05
ME	0.05	0.01	NS
Sex	NS	NS	NS

[a-b] means within the same column within the same treatment not bearing similar superscripts are significantly different ($P<0.05$) based on LSD Test for mean differences.

Table (5): Mean effects of triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on cloaca temperature °C, skin temperature °C, and respiration rate of heat stressed broilers measured at 2.00 pm

Treatments	Criteria		
	Cloaca temperature,	Skin temperature	Respiration rate
T_3 ppm			
0.0	42.66	41.85	59.46[b]
0.5	42.79	42.02	60.61[a]
ME kcal/g			
3.47	42.96[a]	42.20[a]	60.72[b]
2.90	42.85[b]	42.01[b]	60.86[a]
1.76	42.37[b]	41.60[b]	58.53[b]
Sex			
Male	42.76	42.01	59.69
Female	42.69	41.86	60.39
Pooled SEM	0.21	0.20	1.00
Probabilities			
T_3	NS	NS	0.05
ME	0.01	0.01	0.01
Sex	NS	NS	NS

[a-b] means within the same column within the same treatment not bearing similar superscripts are significantly different ($P<0.05$) based on LSD Test for mean differences.

Table (6): The interaction effects among triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on cloaca temperature °C, skin temperature °C, and respiration rate of heat stressed broilers measured at 6.00 am

Treatments	Criteria		
	Cloaca temperature	Skin temperature	Respiration rate
T_3 (ppm) X Sex			
T_3 (0.0) X Female	41.23	39.95	40.26
T_3 (0.5) X Female	41.40	40.36	40.59
T_3 (0.0) X Male	41.20	39.90	40.19
T_3 (0.5) X Male	41.50	40.42	40.74
Sex X ME kcal/g			
Female X 3.47	41.38	40.16	40.67
Female X 2.90	41.43	40.46	40.50
Female X 1.76	41.12	39.86	40.11
Male X 3.47	41.41	40.17	40.50
Male X2.90	41.54	40.47	40.67
Male X 1.76	41.10	39.84	40.22
T_3 (ppm) X ME kcal/g			
T_3 (0.0) X 3.47	41.43	40.18	40.50
T_3 (0.0) X 2.90	41.29	40.16	40.28
T_3 (0.0) X 1.76	40.91	39.43	39.89
T_3 (0.5) X 3.47	41.36	40.14	40.67
T_3 (0.5) X 2.90	41.69	40.77	40.89
T_3 (0.5) X 1.76	41.31	40.27	40.44
Sex X T_3 X ME			
3.47X T_3 (0.0)X Female	41.43	40.16	40.78
2.90X T_3 (0.0)X Female	41.28	40.20	40.22
1.76X T_3 (0.0)X Female	40.97	39.49	39.78
3.47X T_3 (0.5)X Female	41.33	40.16	40.56
2.90X T_3 (0.5)X Female	41.59	40.71	40.78
1.76X T_3 (0.5)X Female	41.27	40.22	40.44
3.47X T_3 (0.0)X Male	41.43	40.21	40.22
2.90X T_3 (0.0)X Male	41.30	40.12	40.33
1.76X T_3 (0.0)X Male	40.86	39.38	40.00
3.47X T_3 (0.5)X Male	41.38	40.13	40.78
2.90X T_3 (0.5)X Male	41.79	40.82	41.00
1.76X T_3 (0.5)X Male	41.34	40.31	40.44
Pooled SEM	0.20	0.26	0.38
Probabilities			
T_3 X Sex	NS	NS	NS
Sex X ME	NS	NS	NS
T_3 X ME	NS	0.05	NS
MEX X T_3 X Sex	NS	NS	NS

Table (7): The interaction effects among triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on cloaca temperature °C, skin temperature °C, and respiration rate of heat stressed broilers measured at 2.00 pm

Treatments	Criteria		
	Cloaca temperature	Skin temperature	Respiration rate
T_3 (ppm) X Sex			
T_3 (0.0) X Female	42.59	41.77	60.33
T_3 (0.5) X Female	42.79	41.96	60.44
T_3 (0.0) X Male	42.74	41.93	58.59
T_3 (0.5) X Male	42.79	42.09	60.78
Sex X ME kcal/g			
Female X 3.47	42.92	42.03	60.50
Female X 2.90	42.73	41.95	60.67
Female X 1.76	42.42	41.62	60.00
Male X 3.47	43.06	42.38	60.94
Male X2.90	42.96	42.06	61.06
Male X 1.76	42.32	41.58	57.06
T_3 (ppm) X ME kcal/g			
T_3 (0.0) X 3.47	42.77	42.09	60.83
T_3 (0.0) X 2.90	42.92	41.94	60.83
T_3 (0.0) X 1.76	42.31	41.51	56.72
T_3 (0.5) X 3.47	43.16	42.31	60.61
T_3 (0.5) X 2.90	42.77	42.07	60.89
T_3 (0.5) X 1.76	42.44	41.69	60.33
Sex X T_3 X ME			
3.47X T_3 (0.0)X Female	42.64	41.88	60.33
2.90X T_3 (0.0)X Female	42.69	41.89	60.67
1.76X T_3 (0.0)X Female	42.44	41.56	60.00
3.47X T_3 (0.5)X Female	43.19	42.18	60.67
2.90X T_3 (0.5)X Female	42.78	42.01	60.67
1.76X T_3 (0.5)X Female	42.40	41.68	60.00
3.47X T_3 (0.0)X Male	42.89	42.31	61.33
2.90X T_3 (0.0)X Male	43.16	42.00	61.00
1.76X T_3 (0.0)X Male	42.17	41.47	53.44
3.47X T_3 (0.5)X Male	43.12	42.44	60.56
2.90X T_3 (0.5)X Male	42.77	42.12	61.11
1.76X T_3 (0.5)X Male	42.48	41.70	60.67
Pooled SEM	0.21	0.20	1.00
Probabilities			
T_3 X Sex	NS	NS	NS
Sex X ME	NS	NS	0.05
T_3 X ME	NS	NS	0.05
MEX T_3 X Sex	NS	NS	0.01

Table (8): Main effects of triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on body organs and some carcass parts of heat stressed broilers

Treatments	Criteria, weight (g)					
	Body weight	Heart	Gizzard	Liver	Wings	Neck
***T_3* ppm**						
0.0	1608.2[a]	6.95[b]	39.9[a]	32.1	148.4[a]	66.8[a]
0.5	1508.7[b]	7.99[a]	34.3[b]	31.9	139.9[b]	60.0[b]
ME kcal/g						
3.47	1681.3[a]	8.24[a]	37.5[b]	35.3[a]	153.5[a]	71.2[a]
2.90	1615.9[b]	8.07[b]	38.6[a]	32.7[b]	150.5[b]	67.3[b]
1.76	1378.1[b]	6.10[b]	35.2[b]	27.9[b]	128.4[b]	51.7[b]
Sex						
Male	1614.4[a]	7.90[a]	37.6	32.6	147.1[a]	64.5[a]
Female	1502.6[b]	7.04[b]	36.6	31.4	141.2[b]	62.3[b]
Pooled SEM	48.4	0.40	0.98	1.55	4.80	3.68
Probabilities						
T_3	0.01	0.01	0.05	NS	0.01	0.01
ME	0.01	0.01	0.01	0.01	0.01	0.01
Sex	0.05	0.05	NS	NS	0.05	NS

[a-b] means within the same column within the same treatment not bearing similar superscripts are signifcantly different.

Table (9): Main effects of triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on carcass yield and abdominal fat of heat stressed broilers

Treatments	Criteria, weight (g)					
	Dressing (%)	Empty carcass	Back	Breast	Thigh	Abdominal fat
***T_3* ppm**						
0.0	65.9	1061.4[a]	236.6[a]	308.0	368.5[a]	5.76
0.5	65.8	994.3[b]	216.0[b]	297.7	340.7[b]	5.81
ME kcal/g						
3.47	67.3[a]	1131.2[a]	257.2[a]	331.2[a]	389.3[a]	6.17[a]
2.90	66.4[b]	1072.9[b]	233.1[b]	314.8[b]	374.5[b]	5.60[b]
1.76	63.9[b]	879.5[b]	188.6[b]	262.6[b]	299.9[b]	5.20[b]
Sex						
Male	65.5	1059.3[a]	232.1[a]	306.2	373.8[a]	5.79
Female	65.5	996.4[b]	220.5[b]	299.5	335.3[b]	5.78
Pooled SEM	2.78	32.6	9.68	12.3	11.3	0.34
Probabilities						
T_3	NS	0.01	0.01	NS	0.01	NS
ME	0.01	0.01	0.01	0.01	0.01	0.01
Sex	NS	0.05	0.05	NS	0.05	NS

[a-b] means within the same column within the same treatment not bearing similar superscripts are signifcantly different.

Table (10): The interaction effects among triiodothyronine (T_3), dietary metabolizable energy level (ME) and\or sex on body organs and some carcass parts of heat stressed broilers

Treatments	Criteria, weight (g)					
	Body weight	Heart	Gizzard	Liver	Wings	Neck
T_3 (ppm) X Sex						
T_3 (0.0) X Female	1551.8	6.33	38.0	30.9	146.5	65.8
T_3 (0.5) X Female	1453.4	7.76	35.1	31.9	135.8	58.8
T_3 (0.0) X Male	1664.7	7.57	41.7	33.2	150.2	67.7
T_3 (0.5) X Male	1564.0	8.23	33.6	31.9	144.0	61.2
Sex X ME kcal/g						
Female X 3.47	1617.0	7.67	35.8	35.4	151.0	71.1
Female X 2.90	1541.4	7.60	38.5	31.6	144.9	65.4
Female X 1.76	1349.3	5.85	35.5	27.3	127.5	50.3
Male X 3.47	1745.6	8.81	39.2	35.3	156.0	71.2
Male X2.90	1690.4	8.54	38.7	33.8	156.0	69.2
Male X 1.76	1407.0	6.35	35.0	28.6	129.4	53.0
T_3 (ppm) X ME kcal/g						
T_3 (0.0) X 3.47	1693.7	7.18	39.1	32.4	153.5	75.6
T_3 (0.0) X 2.90	1689.6	7.73	42.3	33.9	155.0	69.0
T_3 (0.0) X 1.76	1441.4	5.94	38.2	29.9	136.6	55.7
T_3 (0.5) X 3.47	1669.0	9.31	35.9	38.3	153.5	66.7
T_3 (0.5) X 2.90	1542.2	8.41	34.9	31.4	145.9	65.7
T_3 (0.5) X 1.76	1314.9	6.3	32.2	26.0	120.3	47.6
ME kcal/g X T_3 X Sex						
3.47X T_3 (0.0)X Female	1647.5	6.83	36.4	31.9	154.0	77.0
2.90X T_3 (0.0)X Female	1627.7	6.91	40.5	32.3	148.5	66.7
1.76X T_3 (0.0)X Female	1380.2	5.24	37.2	28.6	137.0	53.8
3.47X T_3 (0.5)X Female	1586.6	8.52	35.2	38.9	148.1	65.2
2.90X T_3 (0.5)X Female	1455.2	8.29	36.4	30.8	141.3	64.2
1.76X T_3 (0.5)X Female	1318.3	6.47	33.8	25.9	117.9	46.9
3.47X T_3 (0.0)X Male	1739.9	7.53	41.7	32.8	153.0	74.3
2.90X T_3 (0.0)X Male	1751.6	8.55	44.1	35.6	161.5	71.2
1.76X T_3 (0.0)X Male	1502.6	6.63	39.3	31.2	161.5	57.6
3.47X T_3 (0.5)X Male	1751.3	10.10	36.7	37.7	159.0	68.1
2.90X T_3 (0.5)X Male	1629.3	8.53	33.4	32.0	150.5	67.2
1.76X T_3 (0.5)X Male	1311.4	6.07	30.7	26.0	122.6	48.4
Pooled SEM	48.4	0.40	0.98	1.55	4.80	3.68
Probabilities						
T_3 X Sex	NS	NS	NS	NS	NS	NS
Sex X ME	NS	NS	NS	NS	NS	NS
T_3 X ME	NS	0.05	NS	0.01	0.05	NS
MEX T_3 X Sex	NS	NS	NS	NS	NS	NS

Table (11): The interaction effects among triiodothyronine (T_3), dietary metabolizable energy level (ME) and\or sex on carcass yield and abdominal fat of heat stressed broilers

Treatments	Criteria, weight (g)					
	Dressing. %	Empty Carcass	Back	Breast	Thigh	Abdominal fat
T_3 (ppm) X Sex						
T_3 (0.0) X Female	66.5	1033.7	232.3	304.7	350.4	5.92
T_3 (0.5) X Female	65.9	959.1	208.7	294.4	320.3	5.63
T_3 (0.0) X Male	65.4	1089.1	241.0	311.4	386.5	5.59
T_3 (0.5) X Male	65.6	1029.5	223.2	301.8	361.1	5.99
Sex X ME kcal/g						
Female X 3.47	67.7	1093.5	248.0	325.7	368.9	6.28
Female X 2.90	66.8	1028.2	223.8	310.3	349.1	5.75
Female X 1.76	64.3	867.6	189.7	262.5	287.9	5.30
Male X 3.47	66.9	1168.9	266.4	336.7	409.8	6.06
Male X2.90	66.1	1117.6	242.3	319.3	400.0	6.22
Male X 1.76	63.5	891.4	187.5	262.7	311.8	5.10
T_3 (ppm) X ME kcal/g						
T_3 (0.0) X 3.47	67.8	1148.0	264.0	327.5	403.2	6.09
T_3 (0.0) X 2.90	66.0	1115.1	246.3	324.4	389.4	5.67
T_3 (0.0) X 1.76	64.1	921.1	199.6	272.2	312.8	5.51
T_3 (0.5) X 3.47	66.8	1114.3	250.4	334.9	375.5	6.26
T_3 (0.5) X 2.90	66.9	1030.7	219.8	305.3	359.6	6.30
T_3 (0.5) X 1.76	63.7	837.9	177.6	253.0	287.0	4.88
ME kcal/g X T_3 (ppm) X Sex						
3.47X T_3 (0.0)X Female	68.2	1123.7	258.5	322.7	388.7	6.58
2.90X T_3 (0.0)X Female	66.3	1078.4	237.6	328.0	364.4	5.63
1.76X T_3 (0.0)X Female	65.2	899.1	200.7	263.3	297.9	5.55
3.47X T_3 (0.5)X Female	67.1	1063.2	237.4	328.6	349.1	5.98
2.90X T_3 (0.5)X Female	67.2	977.9	210.1	292.7	333.8	5.88
1.76X T_3 (0.5)X Female	63.4	836.2	178.6	261.7	277.9	5.04
3.47X T_3 (0.0)X Male	67.4	1172.3	269.4	332.3	417.6	5.59
2.90X T_3 (0.0)X Male	65.7	1151.8	255.1	320.8	414.5	5.71
1.76X T_3 (0.0)X Male	63.0	943.2	198.4	281.1	327.6	5.48
3.47X T_3 (0.5)X Male	66.5	1165.4	263.4	341.1	401.9	6.53
2.90X T_3 (0.5)X Male	66.5	1083.5	229.6	317.9	385.5	6.73
1.76X T_3 (0.5)X Male	63.9	839.6	176.6	244.3	296.0	4.72
Pooled SEM	2.78	32.6	9.68	12.3	11.3	0.34
Probabilities						
T_3 X Sex	NS	NS	NS	NS	NS	NS
Sex X ME	NS	NS	NS	NS	NS	NS
T_3 X ME	NS	NS	NS	NS	NS	0.05
SEX X T_3 X ME	NS	NS	NS	NS	NS	NS

Table (12): Main effects of triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on chemical composition of skinless boneless meat of heat stressed broilers

Treatments	Criteria, %			
	Moisture	Crude protein	Fat	Ash
***T_3* ppm**				
0.0	73.47	77.90	15.86	3.01
0.5	73.42	77.97	15.81	3.06
ME kcal/g				
3.47	72.99[b]	78.38	16.01	2.90
2.90	73.24[b]	77.85	16.06	3.05
1.76	74.12[a]	77.59	15.45	3.15
Sex				
Male	73.44	78.14	15.66	3.03
Female	73.46	77.74	16.02	3.04
Pooled SEM	0.71	1.68	2.23	0.28
Probabilities				
T_3	NS	NS	NS	NS
ME	0.01	NS	NS	NS
Sex	NS	NS	NS	NS

[a-b] means within the same column within the same treatments not bearing similar superscripts are significantly different ($P<0.05$) based on LSD Test for mean differences.

Table (13): The interaction effects among triiodothyronine (T_3), dietary metabolizable energy level (ME) and sex on chemical composition of skinless boneless meat of heat stressed broilers

Treatments	Criteria, %			
	Moisture	Crude protein	Fat	Ash
T_3 (ppm) X Sex				
T_3 (0.0) X Female	73.51	77.63	16.12	2.97
T_3 (0.5) X Female	73.40	77.86	15.91	3.11
T_3 (0.0) X Male	73.44	78.18	15.60	3.04
T_3 (0.5) X Male	73.45	78.09	15.71	3.02
Sex X ME kcal/g				
Female X 3.47	72.83	78.14	16.23	2.82
Female X 2.90	73.64	77.65	16.23	3.08
Female X 1.76	73.90	77.43	15.59	3.21
Male X 3.47	73.14	78.61	15.78	2.98
Male X2.90	72.85	78.05	15.88	3.01
Male X 1.76	74.34	77.75	15.31	3.10
T_3 (ppm) X ME kcal/g				
T_3 (0.0) X 3.47	73.18	78.35	16.04	2.89
T_3 (0.0) X 2.90	73.26	77.55	16.35	2.99
T_3 (0.0) X 1.76	73.98	77.82	15.20	3.14
T_3 (0.5) X 3.47	72.80	78.40	15.98	2.91
T_3 (0.5) X 2.90	73.23	78.16	15.77	3.10
T_3 (0.5) X 1.76	74.25	78.16	15.77	3.10
ME kcal/g X T_3 X Sex				
3.47X T_3 (0.0)X Female	73.03	78.13	16.11	2.79
2.90X T_3 (0.0)X Female	73.75	77.08	16.97	2.93
1.76X T_3 (0.0)X Female	73.75	77.66	15.28	3.19
3.47X T_3 (0.5)X Female	72.64	78.15	16.35	2.85
2.90X T_3 (0.5)X Female	73.53	78.21	15.49	3.24
1.76X T_3 (0.5)X Female	74.05	77.20	15.90	3.23
3.47X T_3 (0.0)X Male	73.33	78.56	15.96	2.99
2.90X T_3 (0.0)X Male	72.77	78.01	15.72	3.06
1.76X T_3 (0.0)X Male	74.21	77.98	15.13	3.08
3.47X T_3 (0.5)X Male	72.96	78.66	15.60	2.97
2.90X T_3 (0.5)X Male	72.92	78.10	16.04	2.96
1.76X T_3 (0.5)X Male	74.46	77.51	15.49	3.11
Pooled SEM	0.71	1.68	2.23	0.28
Probabilities				
T_3 X Sex	NS	NS	NS	NS
Sex X ME	NS	NS	NS	NS
T_3 X ME	NS	NS	NS	NS
SEX X T_3 X ME	NS	NS	NS	NS

REFERNCES

Al-Batshan, H. A.; and Hussein, E. O. S. (1999). *Performance and carcass composition of broilers under heat stress:1: The effect of dietary energy and protein. Asian-Australasian J. of Animal Sci. 12:914-922.*

Al-Harthi, M. A. (1997). *The effects of high ambient temperature on energy expenditure, utilisation and partition in the domestic fowl. Ph.D. Thesis, Faculty of Science and Engineering, School of Agriculture, The university of Edinburgh, UK.*

Al-Harthi, M. A. (2001). *Relieving the adverse effects of heat stress on broilers performance by dietary sodium chloride. Egyptain Poult. Sci. 21: 1139-1152.*

Association of Official Analytical Chemists (A. O. A. C.) (1990). *Methods of Analysis. 15th Ed., Arlington, USA.*

Attia, Y. A.; Nawar, M. E.; Osman, Mona; and Abd El -Hady, Salwa, B. (1998). *Optimum levels of metabolizable energy and crude protein in the rations for Avian-34 broiler chicks. in : Proc. 10 th Conf. of The Egyptian Society of Animal Production, Assiut University, Egypt.*

Boorman, K. N. (1973). *Physiological mechanisms of food intake control in the domestic fowl, in: Swan, H. and Lewis, D. (Eds) Nutrition Conference for Feed Manufacturers, 7: 107-126 (London, Butterworths).*

Cabel, M. C.; and Waldroup, P. W. (1991). *Effect of dietary protein level and length of feeding on performance and abdominal fat content of broiler chickens. Poult. Sci. 70:1550-1558.*

Cahaner, A.; and Leenstra, F. R. (1992). *Effect of high temperature on growth and efficiency of male and female broilers from lines selected for high weight gain, favorable feed conversion and high or low fat content. Poult. Sci. 71:1237-1250.*

Cerniglia, G. J.; Herbert, J. A.; and Watts, A. B. (1983). *The effect of constant ambient temperature and ration on the performance of sexed broilers. Poult. Sci. 62:746-756.*

Clarke, S. D.; and Hembree, J. (1990). *Inhibition of triiodothyrionine's induction of rat liver lipogenic enzymes by dietary fat. J. Nutr. 120:625-630.*

Cogburn, L. A.; Liou, S. S.; Alfonso, C. P.; McMuinness, M. C.; and McMurtry, J. P. (1989a). *Dietary thyrotropin-releasing hormone stimulates growth rate and increases the insulin:glucagon molar ratio of broiler chickens. Proc. Soc. Exp. Biol. Med. 192:127-137.*

Cogburn, L. A.; Liou, S. S.; Rand, A. L.; and McMurtry, J. P. (1989b). *Growth, metabolic and endocrine responses of broiler cockerels given daily injections of natural or biosynthetic chicken growth hormone. J. Nutr. 119:1213-1222.*

Cogburn, L. A.; Liou, S. S.; and McMutry, S. (1986). *Plasma levels of insulin and glucagon in broiler chickens fed thyroid active substance. Poult. Sci. 65 (Supple 1):81 (Abstr.)*

Cooper, M. A.; and Washbrun, K.W. (1998). *The relationships of body weight, feed consumption, and feed utilization in broilers under heat stress. Poult. Sci. 77:237-242.*

Cowan, P. J.; and Michie, W. (1978). *Environmental temperature and choice feeding of the broiler. Br. J. Nutr. 40:311-315.*

Daghir, N. J. (1995). *Poultry production in hot climates. Ed. N. J. Daghir, CAB International.*

Dale, N. M.; and Fuller, H. L. (1980). *Effect of diet composition on feed intake and growth of chicks under heat stress. II. Constant Versus cycling temperatures. Poult. Sci. 59:1434-1440.*

Deaton, J. W.; and Lott, B. D. (1985). *Age and dietary energy effect on broiler abdominal fat deposition. Poult. Sci. 64:2161-2164.*

Deaton, J. W.; McNaughton, L.; and Lott, B. D. (1983). *The effect of dietary energy level and broiler body weight on abdominal fat. Poult. Sci. 62:2394-2397.*

Decuypere, E.; Buyse, J.; Scanes, C. G.; Huyberchts, L.; and Kuhn, E. R. (1987). *Effects of hyper- or hypothyroid status on growth, adiposity and levels of growth hormone, somatomedin c and thyroid metabolism in broiler chickens. Repod. Nutr. Develop. 27:555-565.*

Deeb, N.; and Cahaner, A. (2001). *Genotype-by-environment interaction with broiler genotypes differing in growth rate :2. The effect of high ambient temperature on dwarf versus normal broilers. Poult. Sci. 80:541-548.*

Donoghue, D. J.; Preez, F. M.: Diamante, B. S. A.; and Scanes, C. G. (1990). *Influence of catecholamines, prostaglandins and thyroid*

hormones on growth hormone secretion by chciken pituitary cells in vitro. Dom. Anim. Endo. 7:35-42.

Duncan, I. J. H.; Horne, A. R.; Hughes, B. O.; and Wood-Gush, D. G. M. (1970). *The pattern of food intake in female Brown Leghorn fowls as recorded in a Skinner box. Animal Behaviour, 18:245-255.*

El-Deeb, M. A.; and Abou- Elmagd, A. (2001). *Effect of cyclic heat stress on voluntary water consumption, efficiency of feed utilization and thyroid activity of broiler chicks. Egypt. Poult. Sci. 21:811-831.*

El-Gendy, E. A.; and Washburn, K. W. (1995). *Genetic variation in body temperature and its response to short-term acute heat stress in broilers. Poult. Sci. 74:225-230.*

El-Husseiny, O.; Arafa, Sohier A.; Hashish, Samia, A.; and Madian, A. H. H. (2000). *Response of broiler performance to tri-iodothyrionine (T_3), thyroxine (T_4), iodocasein and thiouracil supplemented diets. Egypt. Poult. Sci. 20:347-371.*

El-Husseiny, O.; and Creger, C. R. (1980). *The effect of ambient temperature on carcass energy gain in chickens. Poult. Sci. 59:2307-2311.*

Elnagar, Samar, El-Sebai; and Abaza, M. (2001). *Manipulation of thyroidal activity in broiler chicks:1. Birds performance, physiological and biochemical observations. Egypt. Poult. Sci. 21:1101-1119.*

Farrell, D. J.; and Swain, S. (1977). *Effects of temperature treatments on the energy and nitrogen metabolism of fed chickens. Br. Poult. Sci. 18:735-748.*

Fetter, D.; and Carlson, A. J. (1932). *The effect of experimental hyperthyroidism on gastro-intestinal motility. American Journal of Physiology, 101: 598-604.*

Freeman, R. M.; and Cogburn, L. A. (1983). *Response of daily thyroid rhythms to cyclic temperature. Poult. Sci. 62 (Suppl. 1):1425 (Abstr.)*

Guyton, A. C. (1987). *Human Physiology and Mechanisms of Disease, (Philadelphia. Saunders).*

Harvey, S. (1983). *Thyroid hormones inhibit growth hormone secretion in domestic fowl (Gallus demostica). J. Endocrinol., 98:129-135.*

Hazelwood, R. L. (1984). *Pancreatic hormones, insulin/ glucagon molar ratios, and somatostatin as determinants of avian carbohydrate metabolism. J. Exp. Zool 232:647-652.*

Hurwitz, S.; Weiselberg, N.; Eisner, U.; Bartov, I.; Riesenfield, G.; Shariet, M.; Nir, A.; and Bornstein, S. (1980). *The energy requirements and performance of growing chickens and turkeys as affected by environmental temperature. Poult. Sci. 59:2290-2299.*

Ingram, D. L.; and Evans, S. E. (1980). *Dependence of thyroxine utilization rate on dietary composition. Br. J. Nutr. 43:525-531.*

Ismail-Beigi, F.; and Edelman, I. S. (1970). *Mechanism of thyroid calorigenesis :Role of active sodium transport. Proceedings of the National Academy of Science , USA 67, 1071-1078.*

Jackson, S.; Summers, J. D.; and Leeson, S. (1982). *Effect of dietary protein and energy on broiler carcass composition and efficiency of nutrient utilization. Poult. Sci. 61:2224-2231.*

Kassim, H.; and Suwanpradit, S. (1996). *The effects of energy levels on the carcass composition of the broilers. Asian J. Animal Sic. 9:331-335.*

Klandorf, H.; Sharp, P. J.; and Macleod, M. G. (1981). *The relationship between heat production and concentration of plasma thyroid hormones in the domestic hen. Gen. Comp. Endoncrinol. 45:513-520.*

Leclercq, B.; Guy, G.; and Rudeaux, F. (1988). *Thyroid hormones in genetically lean or fat chickens: effects of age and tri-iodothyrionine supplementation. Reprod. Nutr. Develop., 28(4A) 931-937.*

Leenstra, F. R. (1986). *Effect of age, sex, genotype and environment on fat deposition in broiler chicks, A review. World's Poult. Sci. J., 42:12-25.*

Leeson, S.; and Summers, J. D. (1990). *Commercial Poultry Nutrition, 1st edn. University Books. P.O. Box 1326, Guelph, Ontario, NIH 6 N8, Canada.*

Lei, K. Y.; and Slinger, S. J. (1970). *Energy utilization in the chick in relation to certain environmental stresses. Can. J. Anim. Sci. 50:285-292.*

Lei, S.; and Van Beek, G. (1997). *Influence of activity and dietary energy on broiler performance, carcass yield and sensory quality. Br. Poult. Sci. 38:183-189.*

MacLeod, M. G. (1990). *Energy and nitrogen intake, expenditure and retention at 20 in growing fowl given diets with a wide range of energy and protein contents. Bri. J. Nutr. 64:625-637.*

Makled, M. N.; El-Deeb, Mariam, A.; and Abdallah, N. H. (2001). *Effect of protein level, energy level, and season on performance of growing indigenous naked neck (Sharkasi) chickens. Egypt. Poult. Sci. 21:27-52.*

Mashaly, M. S.; Youtz, M. S. L.; and Wideman, R. F. (1983). *Hypothyroidism and antibody productions in immature male chickens. Immuni. Comm. 12:551-563.*

May, J. D. (1980). *Effect of dietary thyroid hormones on growth and feed efficiency of broilers. Poult. Sci 59:888-892.*

May, J. D. (1982). *Effect of dietary thyroid hormones on serum hormone concentration, growth, and body composition of chickens. In: Avian Endocrinology: Practical and Theoretical Implications. Lubbock: Texas Tech. Press. PP:185-192.*

May, J. D.; and Lott, B. D. (1986). *Effect of acclimation and heat stress on thyroid hormone concentration. Poult. Sci. 65:1211-1213.*

McNicolas, M. J.; and McNabb, F. M. A. (1987) *Influence of dietary iodine availability. J. Exp. Zool. 244:263-268.*

Mendes, A. A.; Watkins, S. E.; England, J. A.; Saleh, E. A.; Waldroup, A. L.; Waldroup, P.W. (1997). *Influence of dietary lysine levels and arginine :lysine ratios on performance of broilers exposed to heat or cold stress during the period of three to six weeks of age. Poult. Sci. 76:472-481.*

Moss, B.; and Balnave, D. (1978). *The influence of elevated environmental temperature and nutrient intake on thyroid status and hepatic enzyme activity in immature chicks. Comp. Biochem. Physiol. 60B:157-161.*

Müller, M. J.; and Seitz, H. J. (1984). *Thyroid hormone action on intermediary metabolism. Klin Wochenschr, 62:11-18.*

National Research Council (NRC), (1994). *Nutrient Requirements of Poultry. 9th Ed., National Academy Press. Washington, DC., USA.*

Newcomer, W.S. (1976). *Thyroxine and tri-iodothyrionine in blood after ingestion of iodinated casein by chicks. Poult. Sci. 55:60-69.*

Olson, D. W.; Sunde, M. L.; and Bird, H .R. (1972). *The effect of temperature on metabolizable energy determination and utilization by the growing chick. Poult. Sci. 51:1915-1922.*

Qota, E. M. A. (1994). *Effect of feeding system on poultry productivity under Egyptian farm conditions. M.Sc. Thesis. Faculty of Agriculture, Mansoura University.*

Rosebrough, R.W., (1999). *Dietary fat and Tri-iodothyrionine (T_3) interactions in the broiler chicken. Int. J. Vitam. Nutr. RES. 69:292-298.*

Rosebrough, R.W.; McMurty, J. P.; and Vasilatos-Younken, R. (1992). *Lipid metabolism in liver explants from hyper-thyroid chickens. Br. J. Nutr. 68:667-676.*

Rosebrough, R.W.; Mitchell, A. D.; and McMurty, J. P. (1997). *Carry over effects of dietary crude protein and tri-iodothyrionine (T_3) in broiler chickens. Br. J. Nutr. 75:573-581.*

Rudas, P.; and Pethes, G. (1980). *Effect of cold and warm exposure on Thyroxine metabolism in the chick (the regulatory role of the periphery) In" Recent advances of Avian endocrinology." Eds. G. P. Pethes, P. Peczely, and P. Rudas) PP. 269-279.*

Rudas, P.; and Pethes, G. (1984). *The importance of the peripheral thyroid hormone deiodination in adaptation to ambient temperature in the chicken (Gallus domesticus). Comp. Biochem Physiol. 77A:567-571.*

SAS Institute, (1985). *SAS- User's Guide: Statistics. Version 5th Ed., SAS Institute Inc., Cary, NC., USA.*

Savory, C. J. (1980). *Meal occurrence in Japanese quail in relation to particle size and nutrient density. Animal Behaviour, 28: 160-171.*

Savory, C. J. (1986). *Influence of ambient temperature on feeding activity parameters and divestive function in domestic fowls. Physiology and Behaviour, 38: 353-357.*

Savory, C. J.; and Hodgkiss, J. P. (1984). *Influence of vagotomy in domestic fowls on feeding activity, food passage, digestibility and satiety effects of two peptides. Physiology and Behaviour, 33: 937-944.*

Scanes, C. G., (1987). *The physiology of growth, growth hormone, and other growth factors in poultry. Critical Reviews of Poultry Biology, 1:51-105.*

Scott, M. L.; Nesheim, M. C.; and Young, R. J. (1982). *Nutrition of the Chicken, 3 rd edn., M.L. Scott & Associates, Ithaca, NY, USA.*

Sharp, P. J.; and Klandorf, H. (1985). *Enviromental and physiological factors controlling thyroid function in Galliformes. In " The Endocrine System and its Environment". Eds. Follett, B. K., Ishii, S. and Chandole, A.) PP. 175-188. Springer –Verlag:Berlin.*

Sinurat, A. P.; and Balnave, D. (1985). *Effect of dietary amino acids and metabolizable energy on the performance of broilers kept at high temperature. Br. Poult. Sci. 26:117-128.*

Sinurat, A. P.; Balnave, D.; and McDowell, G. H. (1987). *Growth performance and concentration of thyroid hormones and growth hormone in plasma of broilers at high temperatures. Aust. J. Biol. Sci. 40:443-450.*

Sleeth, C. K.; and Van Liere, E. J. (1937). *The effect of environmental temperature on the emptying time of the stomach. American Journal of Physiology, 118: 272-275.*

Smith, M. O.; and Teeter, R. G. (1989). *Effects of sodium and potassium salts on gain, water consumption, and body temperature of 4 to 7 week-old heat stressed broilers. Nutrition Reports International 40:161-169.*

Snedecor, G. Q. (1971). *Response of normal and Goitrogenic-fed cockerels to different environmental temperatures. Poult. Sci. 50:237-243.*

Tegethoff, V.; and Hartung, J. (1996). *Animal housing climatic quality in various harmful conditions in broiler production to avoid heat stress in summer. Dtsch Tierarztl Wochenschr 103:87-91.*

Tixier-Boichard , M.; Decuypere, E.; Huybrechts, L.; Kuhn, E.; and Merat, R. (1990). *Effects of dietary T3 on growth parameters and hormone levels in normal and sex-linked dwarf chickens. Dom. Anim. Endo. 7:573-585.*

Touchburn, S. P.; Simon, J.; and Leclercq, B. (1981). *Evidence of a glucose insulin imbalance and effect of dietary protein and energy level in chicken selected for high abdominal fat content. J. Nutr. 11:325-335.*

Wallis, I. R.; and Balnave, D. (1984). *The influence of environmental temperature, age and sex on the digestibility of amino acids in growing broiler chickens. Br. Poult. Sci. 25:401-407.*

Wilson, H. R.; Boone, M. A.; Arafa , A. S.; and Janky, D. M. (1983). *Abdominal fat pad reduction in broiler with thyroactive iodinated casein. Poult. Sci. 62:811-818.*

Wilson, E. K.; Pierson, F. W.; Hester, P. Y.; Adams, R. L.; and Stadelman, W. J. (1980). *The effects of high environmental temperature on food passage time and performance traits of White Pekin ducks. Poultry Science, 59:2322-2330.*

Yalcin, S.; Ozkan, S., Acikgoz; and Ozkan, K. (1998). *Influence of dietary energy on bird performance, carcass parts yields and nutrient composition of breast meat of heterozygous naked neck broilers reared at natural optimum and summer temperature. Br Poult. Sci. 39:633-638.*

Yalcin, S.; Turkmut, S.; and Siegel, P. B. (2001). *Response of heat stress in commercial and local broiler stocks 2. Developmental of Bilateral traits. Br. Poult. Sci. 42:153-160.*