COMPARATIVE EFFECTS OF VIRGINIAMYCIN, BETAINE, AND ELECTROLYTE ON COMPENSATORY GAIN AND THE GENERAL PERFORMANCE OF MALE BROILERS, EXPOSED TO HIGH AMBIENT TEMPERATURE STRESS

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CHAPTER I

INTRODUCTION

In the tropical countries ambient temperature and relative humidity vary with ecological zones. During summer elevated ambient temperature and relative humidity results in reduced poultry production, survivability, and resistance against several diseases. The growth of broilers in many geographic areas of the world is frequently complicated by mortality and production losses due to high ambient temperature.

During chronic heat stress, productivity of domestic animals is reduced by a complex array of physiological compensatory responses aimed at maintaining homeostasis. Commercial broilers as fast growing birds are more susceptible to various stresses in addition to ambient stresses. Fast growing animals are vulnerable of atmospheric stress because of their increased metabolic heat associates with their growth rate. A continuous increase in somatic growth and feather development, combined with an increase in environmental temperature produces excess body heat.

Reduced feed intake and performance, increased panting and water consumption and drooping wings characterize the behavioral response of poultry to remove excess deep body temperature. Poultry do not have the ability to sweat and must rely primarily upon panting (gular flutter) to remove surplus deep

body heat. Panting will commence approximately one half hour post high temperature stress.

The inhaled air is passed over the moist lining of the respiratory tract then enters the lungs and air sacs at a temperature lower than that of the body. Deep body heat is then removed as the bird exhales. Removal of body heat is also assisted by dilation in the peripheral blood vessels, which allow an increase in the flow of blood to the skin, wattles, comb and shanks from which heat is released.

The zone of thermal neutrality (comfort zone) for poultry is within the range of 14.5-25.5 ^{O}C (Freeman, 1966), and the chicken body temperature rises above normal when the environmental temperature rises to 30 ^{O}C or above (Romijn and Lockhorst,1966). Any variation in environmental temperature out of these limits will have an impact on productivity. Curtis (1981) pointed out at least four ways that environmental stress can influence the animal status. These include altering the internal functions, diverting nutrients, reducing productivity and impairing disease resistance.

Growth of 3-7 week- old broilers has been reported to be maximized at approximately 20 $^{\circ}$ C (Kleiber and Dougherty, 1934: Barott and Pringle, 1949, 1950: Ota and Garver; 1954; Prince et al., 1960; Deaton et al., 1968, 1978). McNaughton and Reece (1982) reported that the maximal performance of 23-48 day –old broilers achieved at 15.6 $^{\circ}$ C environment by feeding a high-energy diet (3375Kcal/Kg). Increasing dietary energy was found by to offset the decreased body weights of broilers at 29 $^{\circ}$ C Adams et al. (1962) and Dale and Fuller

(1980), especially with animal or vegetable fat in feed (Mickel berry et al., (1966). Feed conversion or feed efficiency of broilers was reduced for growing temperatures below 21° C (Olson et al., (1971): Deaton et al., (1973,1978). Hurwtiz et al (1980) found that maximum feed efficiency for broilers occurs at about 24 °C. Reece and Lott (1983), reported no difference in feed conversion between broilers grown at 21.1 and 26.7 °C, while Prince et al. (1965) reported a 12.5% increase in feed efficiency attributable to a temperature increase from 7.2 to 23.8 ° C.

Many studies have shown that high environmental temperature depressed body weight (Wilson, 1948,1949; Squib et al., 1959; Campas et al., 1962; Huston, 1965; Parker et al., 1972; Swian and Farrell, 1975; DeAlbuquerque et al., 1978; Vo et al.,1978; Henken et al, 1982). Kheireldin and Shaffner (1957) indicated that depression in growth was more pronounced during the first week of exposure, after which the treated birds started to catch up with their controls.

Ahmed et al., (1974) found that abruptly switched environmental temperatures (23 to 30° C) resulted in an immediate inverse change in feed intake for five-month old roosters. Broilers receiving 12 h of light only in the low temperature portion of cycle weigh more than those that receive it in the high portion (Deaton and Reece, 1970). When comparison is made between broilers reared under constant vs. cyclic temperatures, the temperature range of the cycle determines which will give the higher body weight gain, Deaton et al (1973).

Heat stress in addition to such obvious losses (Subbah Rao et al., 1969); Thaxton et al.,1970, 1973) has a very crucial influence on the reduction of immune status of animals which, not only makes birds more susceptible to disease, but also increases mortality and reduces productivity due to these diseases as well.

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CHAPTER II

LITRATURE OF REVIEW

INTRODUCTION

The interrelationship of animals with an existing environment has attracted scientist and industry for reasons. The responses that permit physiological functioning and survival of the animal in a stressful environment have been described by a variety of words such as adaptation acclimation acclimatization, habituation (Yousef1987).

ADAPTATION: Reduction of physiological strain produced by a stressful component of the total environment. This changes occurs in the lifetime of an organism or is the result of genetic selection in a species or subspecies over generations.

ACCLIMATION: A physiological change, occurring within the lifetime of an organism, which reduces the strain caused by the temporary stressful changes in particular climatic factors (Yousef, 1987).

ACCLIMATIZATION: A physiological change occurring within the lifetime of an organism, which reduces the strain caused by stressful changes in the natural climate (e.g. seasonal or geographical) stated by Yousef (1987)

ENVIRONMENT STRESS: Heat stress in poultry can result in heavy economic loss wherever it occurs, but especially when facilities, lack up-to date ventilation technologies. Both ambient temperature and relative humidity vary with

technologies. Both ambient temperature and relative humidity vary with ecological zone and season. During summer in tropical areas combined elevated relative humidity and ambient temperature can result in marked poultry production decline and subsequent shortage of animal protein. Heat stress therapeutics can focus on ventilation technique to lower effective ambient temperature or on method that enhance the birds ability to resist a given heat stress level.

The oxygen uptake and heat production of many birds vary with environmental temperature. The range of environmental temperature over which the oxygen up take remains essentially constant and is at its lowest level in thermoneutral zone. This is a range of air temperature defined by the upper and lower critical temperatures. The range of air temperatures over which birds are in a thermoneutral condition varies from a few ^{O} C in penguins in some small birds to 30^{O} C (Le Maho, 1983).

The heat production within the thermoneutral zone depends on the level of food intake prior to the measurement. The higher the level of food intake, the higher the heat production, and this effect may persist for some time after the diet has changed (Sturkie, 1986). At air temperatures higher than the upper critical temperature, heat production increases, usually as a result of an increased body temperature. The increased temperature of the tissues results in a generalized acceleration of chemical reaction and consequently in an increased oxygen requirement and heat production (Van't Hoff Arrhenius effect). It was proposed by Weather (1981), that the use of the slope of the increase in heat production

with increasing air temperature, above the upper critical temperature, as measure of the cost of thermoregulation in a hot environment. The coefficient of heat strain was greater for small birds than for large birds. The heat production also increased at air temperature below the lower critical temperature, but the mechanism in this instance is quite different.

The TN (thurmonutral) zone is defined as the zone between the higher and lower critical temperatures. Meltzer (1983) stated that the TN zone is inversely related to bird's age. Heat production (HP) is linearly related to caloric intake(Luiting, et al., 1990) and feed consumption, Van Kampen., (1977); Wiernusz et al.,(1991). Per unit body weight male broilers have a 24 % higher HP than females, Meltzer.(1983).

It is well evidenced that peripheral temperature receptors and temperature-sensitive neurons in the central nervous system are involved in the regulation of body temperature, heat production and heat loss in birds. Sturkie (1986) illustrated that when the domestic fowl is exposed to a cold environment, shivering can be detected before any change occurs in the deep-body temperature. This observation is consistent with the control of heat production by thermal receptors in birds that have been identified in the tongue, beak and bill, (Dawson, 1975) but there may well be others elsewhere. In fact, Necker (1977) has shown in the pigeon that feathered skin areas, particularly on the back, are very sensitive to changes of temperature. Their sensitivity was assessed in terms of the response evoked by heating and cooling the skin areas. The beak and un-feathered areas of the feet were relatively insensitive. It was also documented

that heat production may be influenced by changes in the temperature of thermo receptors in the central nervous system influenced by changes in deep-body temperature. Localized heating of the anterior hypothalmus-preoptic region of the brain of the house sparrow results in a diminution of heat production, whereas cooling the same region has the opposite effect.

MODULATING BIRD HEAT PRODUCTION :In modulating bird heat production (HP) and body temperature, thyroid hormones are involved (Yousef,1985).The size and histology of the thyroid changes with season ,(Wentworth et al.1986). Reinek et al (1945) has observed that, in young chicks of 2 weeks of age, the T4 secretion rate in summer was one-half that in winter. Seasonal profiles of circulating T4 and T3 in birds suggest that T4 seems to be associated with calorigenesis and lipogenesis, especially during migration (Chandola and Bhatt, 1982). Seasonal changes in extra thyroidal conversion of T4 to T3 may alter seasonal reproduction (Panthak and Cahndola, 1982; Cogburn and Freeman, 1984). In measuring seasonal effects, examination of changes in temperature, light, feed intake, reproductive cycle, and molt is necessary because they vary with the season (Wenthworh et al., 1986).

A decrease in thyroid size (Chiasson et al.,1979) and secretion with high environmental temperatures has been reported (Muller and Amezcua, 1959; Sathl and Turner, 1961; Huston et al., 1962; Cogburn and Harrison, 1980). Pituitary thyrotrophs are stimulated in Japanese quail by exposure to long daily photoperiods (Tixier Vidal and Assenmacher,1967) Assenmacher,1967) Kittok et al. (1982), observed increased sensible heat loss in adult chickens following

administration of triiodothryonine (T3) or thyroxine (T4), Bobek et al (1977) and Klandorf et al (1981) have suggested that oxygen consumption of chickens between 1-8 weeks of age is correlated with the circulating concentration of T3 but not T4 T3 is reported to be the metabolically active thyroid hormone and secretions of T3 are reported to be dependent on ambient temperature (Freeman, 1983).

At high ambient temperatures, basal heat production over shadowed by elevated HP with an increased respiration rate (Robertshaw, 1981). In contrast, at cold exposure, T3 secretion and heat production is increased (Kuhn and Nouwen,1978). Basal heat production decreases with T3 secretion, (Williamson et al., 1985; Mitchell et al., 1987). Modulating T3 secretion is a homeostatic mechanism used to reduce heat stress. Feeding T3 or T4, 6-8 weeks old broilers exposed to heat stress reduced survival time while thiouracil, a blocker of T3 secretion, enhanced bird survival time when exposed to similar heat stress (Fos,1980; May, 1982). Blood concentration of T3 and T4 are influenced by nutrient intake (Klandrof et al., 1981) raising the possibility that such responses observed in birds under heat stress may be related to feed consumption since during heat stress feed intake is reduced.

THERMOREGULATION: Thermoregulation is defined as the system by which animals maintain their body temperature. It involves a balance between heat gain and heat loss. Metabolic heat is necessary for maintenance, growth, and production. High activity of animals in respect to growth and exercise will correspond in more heat gain from metabolism when compared to lower rates of

activity. Thermoregulation is similar in birds and mammals. The plumage of birds has functions of flight and thermal insulation. The salt glands of some birds enable them to avoid many of the consequences of dehydration as a result of evaporative heat loss, but the absence of sweat glands in bird places the onus of evaporative cooling on their respiratory mechanism. The thermobalance of birds is determined by summing up the heat produced and heat lost. Avian species and mammals, are homeotherms and must, consequently, maintain deep body temperatures relatively constant over a wide range of ambient temperatures (Meltzer, 1987).

Under most practical conditions, there is a flow of heat from the bird to the environment by radiation, convection, conduction and water evaporation. The importance of these routes will vary with environmental conditions (Freeman, 1971). Thermobalance has been determined by Strike (1986) as follows.

$H = E \pm R \pm C \pm K \pm S$

H= Metabolic heat production,

E= Evaporative heat loss

R= Heat loss by radiation

C= Heat loss by convection

K= Heat loss by conduction

S= Body heat content

Where as:

(S= delta T x body mass x 3.5)

[S= heat content change (kJ), delta T= body temperature change (°C), and 3.5 = the mean specific heat, of the body tissues (kJ / kg. ° C)]. The amount of stored body heat, depends upon both body temperature and its specific heat. The quantity of heat gain or loss can be estimated as:

Very limited information about heat change measurements in the domestic fowl as influenced by environment is available. The content of stored body heat in birds is an important thermoregulatory mechanism, particularly during heat stress, where a rise in body temperature creates a temperature differential between the bird and the environment allowing heat loss from the body (Sturkie, 1986).

HEAT LOSS; Birds dissipate heat in attempt to maintain thermobalance for survival and production. Balancing heat loss against heat production controls the bird's body temperature. Heat stress occurs when the sum of [heat production] + [heat gain from the environment] becomes greater than the animal's ability to lose heat (Macleod et al 1993). In mild heat stress, during which fowls maintain first phase panting,(continuous rapid breathing), cardiac output is increased by 20-30 % from normal by increased heart rate (+15%) and stroke volume (+10%). Arterial pressure drops by 10 % and peripheral resistance decreases by 30%, (Frankel et al. 1962). The heat loss from the non-feathered limbs may reach up to 50% of total metabolic heat production (Steen and Steen, 1965). The thermally induced vasomotor changes in birds were characterized for the legs owing to their obvious importance in heat dissipation in these species, (Johansen and Millaard, 1973; Bernstein, 1974; Baudinette et al.,1976).

Nolan et al.(1978) observed that blood flow to the wattles of Roosters is increased by the release of the alpha-adrenergic tone. A 16.5% increase in oxygen consumption occurred in the hyperthermic animals representing both the energy cost of panting and the effect of the elevated body temperature (Wolfenson et al., 1981). The increase in oxygen consumption was small relative to the 60 % to 70 % increase found in the dog (Males and Dampney,1975). The 14 % increase in heart rate and the concomitant 10 % reduction in arterial blood pressure were typical for hyperthermic fowls (Frankel et al, 1962). Increased by 27 % in cardiac output was brought about by a 43.4 $^{\circ}$C temperature (Whittow et al., 1964). Wolfenson et al. (1981) was able to estimate the cardiac output in hyperthermic fowls to about 214 ml. Min-1. Kg –1, a 20 % increase above the control state. They further concluded that, in terms of the change in cardiac output during heat stress, the fowl seems to be in the intermediate range when its response is compared to the 2 % increase reported in sheep (Hales.,1973a), the 40 % increase in dogs(Hales and Dampney.,1975) and the 100 % increase in man (Rowell, 1974) under comparable body temperature elevations.

Blood flow to the upper respiratory tract, tongue, larynx and trachea increased during hyperthermia to 320-430 % of control levels, (Wolfensos et al.,1981). They demonstrated that hyperthermia did not induce a uniform response in all inner body organs. Kullmar et al. (1970) demonstrated that muscle blood flow was unaffected by thermal stimulation of the hypothalamus or the spinal cord. Blood flow in the cerebrum increased by 40 % during

hyperthermia, contrasting the reduction in blood flow to this organ in mammals during hyperthermia (Hales 1973c; Colton and Frankel, 1972).

SKIN: Heat loss from skin is known as sensible or direct heat loss. Skin temperature over un feathered area changes as a result of vasomotor function, over a wider range than in the feathered areas of the skin (Richards 1974). Richards (1971) observed that metatarsal skin temperature increased by 8 $^{\circ}$C, while in the feathered skin, an increase in air temperature from 20 to 30 $^{\circ}$C was shown to induce only a 2 $^{\circ}$C increase in skin temperature. Steen and Steen (1965) and Bausinette et al.(1976) stated that the role of the un feathered skin areas are for temperature regulation of the fowl. The isolative feather layer is not uniform; it is sparser over the ventral side of the main body and the wings (Lucas and Stettenheim 1972).

Wolfenson et al.(1981) stated that it is significant that the vascular responses over the body correspond to the distribution of insulation. Increase in blood flow over the skin of the back was only two fold, while found in the ventral side a 7- fold increase. He concluded that this would aid in the dissipation of heat with the spreading of wings as birds do during heat stress and probably assists in the warming of eggs during brooding.

The comb and wattles have an important role in the dissipation of heat in birds in which these organs are developed (Wolfensosn et al.,1981). During hyperthermia, blood flow to these organs was increased 4 and 2- folds respectively.

Heat loss varies tremendously with external factors such as air temperature and wind (Schmidt – Neilsen and Knut , 1997). Heat loss through radiation, convection and conduction may be heaped together as non-evaporative or sensible heat loss while heat loss through respiratory and coetaneous water evaporation may be referred to as evaporative or insensible heat loss. To evaporate water from the body needs great amounts of heat. One gram of water at room temperature to vapor at the same temperature requires 584 cal (Schmidt – Nielsen and Knut, 1997). The temperature range over which heat production is minimal described as the thermoneutral zone (TN). Bird heat production is linearly related to the deep body temperature (Van Kampen and Romijn, 1970; Farrel and Swain,1977) extending over a range of –5 to 40 $^{\circ}$C (Romijn and Vreugdenhil, 1969).The inverse relationship of heat production to ambient temperature (Van Kampen, 1974, 1981a; Williamson et al., 1986; Chwalinbog et al., 1985) may be attributed to reduced feed consumption at higher temperatures.

Chwalibog (1989) stated that broilers exposed to gradually increasing high ambient temperature had a decreasing oxygen consumption and carbon dioxide production, suggesting that reduced heat production during heat distress could be due to decreased gas exchange. Thermoregulation operates though modulation of heat production and or heat loss and the cardiovascular system may affect both processes by modulation of heat dissipation on the one hand and by oxygen transport on the other hand (Yahav et al.,1997). Plasma volume expansion was observed during the need for acute heat dissipation, such as

during a period of heat exposure in rats (Meiri et al., 1991) physical exercise in humans (Senay et al., 1976; Gillen et al. 1991), and heat exposure of chickens (Whittow et al,1964).

BY RADIATION: The amount of heat lost from the skin surface to the surrounding air by radiation depends on the differential between the two temperatures. When air temperature is low, heat loss by radiation is great. When air temperature is high, heat loss by radiation is low. At ambient temperatures that are optimum for the bird's well being, about 75% of the total heat lost form the skin is by radiation and is the major means of dissipation.

BY CONVECTION: When cool air comes in contact with the surface of the bird, the air is warmed and rises from the bird and cooler air moves in. Heat lost in this manner is termed convection. In the convection system of heat loss actual movement of molecules are involved. Air in contact with the skin warms up, becomes less dense, rises and replaced by cooler denser air. If the birds are exposed to moving air, or if the bird itself is actually moving through the air, considerably heat may be lost. If the air velocity is not too high, such forced convection is roughly proportional to the square of air velocity. Convective heat loss (CW/m^2) may be expressed simply as:

$$C= H_c (T_s-T_a.$$

Where H_c is the convective heat transfer coefficient ($W/m^2. {}^{O}C$) and incorporating dimensionless numbers describing the flow and thermal properties of the air and the size of and shape of the animal. T_s is the mean surface temperature and T_a is the air temperature (Sturkie,1986)

BY CONDUCTION: When the body surface of the bird comes in contact with any cooler surrounding object, such as the floor or soil, this type of minimal loss is known as conduction. Sturkie (1986) described that heat loss by conduction involves the transfer of energy from molecule to molecule but unlike convection, there is no actual gross translocation of molecules. The equation for heat transfer by conduction (K, in W/m^2)

$$K= h_k (T_s- T_a)$$

Where H_k is the conductive heat transfer coefficient (W/m^2. ^{O}C). The conductive heat transfer coefficient depends on the thermal conductivity of the medium to which heat is being lost such as air, nest materials, birds or water. It depends also on the thickness of the nest or of the boundary layer of air or water adjacent to the skin or feathers. The thickness of the boundary layer in turn varies with the roughness and shape of the animal's surface as well as with the velocity of the air or water movement adjacent to the animal and the size of the bird.

VAPORIZATION: Vaporization of moisture in the respiratory tract (insensible or indirect heat loss) process in which birds change liquid in to vapors in respiratory tract as a means of removing heat from the body begins when bird starts panting (vaporization of water through breathing) when room temperature rises and less sensible heat is lost from the body. Heat is necessary in changing water to vapor. At ambient temperature of 86 ^{o}F or above, the bird pants in an endeavor to cause more air to move through the respiratory system, because vaporization carries off more heat.

It is established that the higher the ambient temperature the faster the panting. If the inhaled air is completely saturated (has 100% relative humidity), it cannot absorb moisture in the respiratory tract, hence there can be no vaporization, and the bird has lost its last chance to survive. Unlike heat lost through the skin, heat lost by vaporization does not raise the room temperature. It does cause the birds to drink more water in order to prevent dehydration often resulting in wet droppings.

HEAT ACCLIMATION: Exposure of birds in cold climates birds tends to acclimate themselves to the cold environment. Many experiments show that cold acclimation occurs by increased heat production when birds were exposed to cold environment. Earlier studies provided very little evidence for no shivering thermo genesis, an increased heat production in the absence of shivering such as occurs in many mammals during acclimation to cold. In fact, birds do not appear to have brown fat, an important thermogenic tissue involved in no shivering thermo genesis in mammals.

Any bird during winter has the lower critical temperature shifted up word (Kendeigh et al., 1977; Rintamaki et al., 1983) and the upper critical temperature has diminished compared with birds under summer conditions. In addition, the slope of the relationship between heat production and air temperature is less,(Hissa and PaloKangas, 1970; Kendeigh et al,1970; Kendeigh et al.,1977).The phenomena is illustrated in the willow patrmigan, an arctic species, in which the lower critical temperature during summer was 7.7 ^{O}C and in the winter –6.3 ^{o}C. It was also observed that smaller birds do not rely on seasonal

changes in insulation to any great extent. Primary adaptation to cold is an enhanced ability to sustain elevated heat production for long periods (Marsh and Dawson, 1982; Dawson et al., 1983). Some birds experience an increased heat production within the thermoneutral zone during the cold season of the year (Kendeigh et al., 1977; Rinatamaki et al., 1983) a feature of the common redpoll.

There is an associated increase in thyroid activity, suggesting that the calorigenic effect of thyroid hormcnes is involved in the response. Bird's exposure to high temperature results in a diminution in heat production in several species of birds. In the domestic fowl and Japanese quail, it has been attributed to diminution in thyroid activity .The response to high temperature is suppressed if the temperature is allowed to fluctuate.

ABDOMINAL FAT & VISCERAL ORGANS: Yahav et al., (1996) demonstrated the linear relationship between abdominal fat and ambient temperature. Abdominal fat percentage was lower in birds exposed to high temperature except for females exposed to high temperatures, which had higher abdominal fat percentage than females exposed to high temperature in a low temperature environment. The percentage of abdominal fat of females was much higher in birds exposed to high temperature than birds exposed to low temperature. Sonaiya (1989) observed that heart and abdominal fat as percentages of body weight were significantly lower in chickens exposed to high temperatures at the age of 5 d, in comparison with unexposed birds.

Yahav et al (1996) observed no statistical difference in liver weights of exposed birds as compared with non-exposed birds. Deaton et al (1969)

reported that heart and liver weights were significantly reduced by constant high ambient temperature. A significant effect of temperature was observed on the unsaturated fatty acids, especially 18:1 (Sonaiya, 1988). At moderate temperature levels the correlation between temperature and total body fat content is positive (Kubena et al., 1972). Fisher (1984) observed a linear increase of 0.19 % total body fat per degree increase in temperature between 10 and 30 ^{O}C.

During heat stress the bird's susceptibility to pathogens was evaluated by Freeman, (1988). He stated that heat stress or water deprivation increases output of adreno corticotrophic hormone, which results in high level of corticosteroid hormone in birds. Carticosterone decreases the size of spleen, thymus and bursa of fibricius size and reduces circulating lymphocytes (Ben Nathan et al., 1976). It would be beneficial to supplement birds with antibiotics to reduce risk of disease susceptibility during heat stress. Plavnik and Hurwitz (1985) and Plavink et al. (1998) found a significant decrease in heart weights with increasing temperature above 25 ^{O}C, and liver weights were also decreased in chickens kept at 35 ^{O}C or at a cycling temperature. This may be due to a decrease in metabolic rate, which was observed by Yahav et al. (1998) in naked neck chickens exposed to similar environmental condition. The gizzard proportions were increased in males by high temperatures at the age of 34 days and in females at 54 days (Sonaiya, 1989).

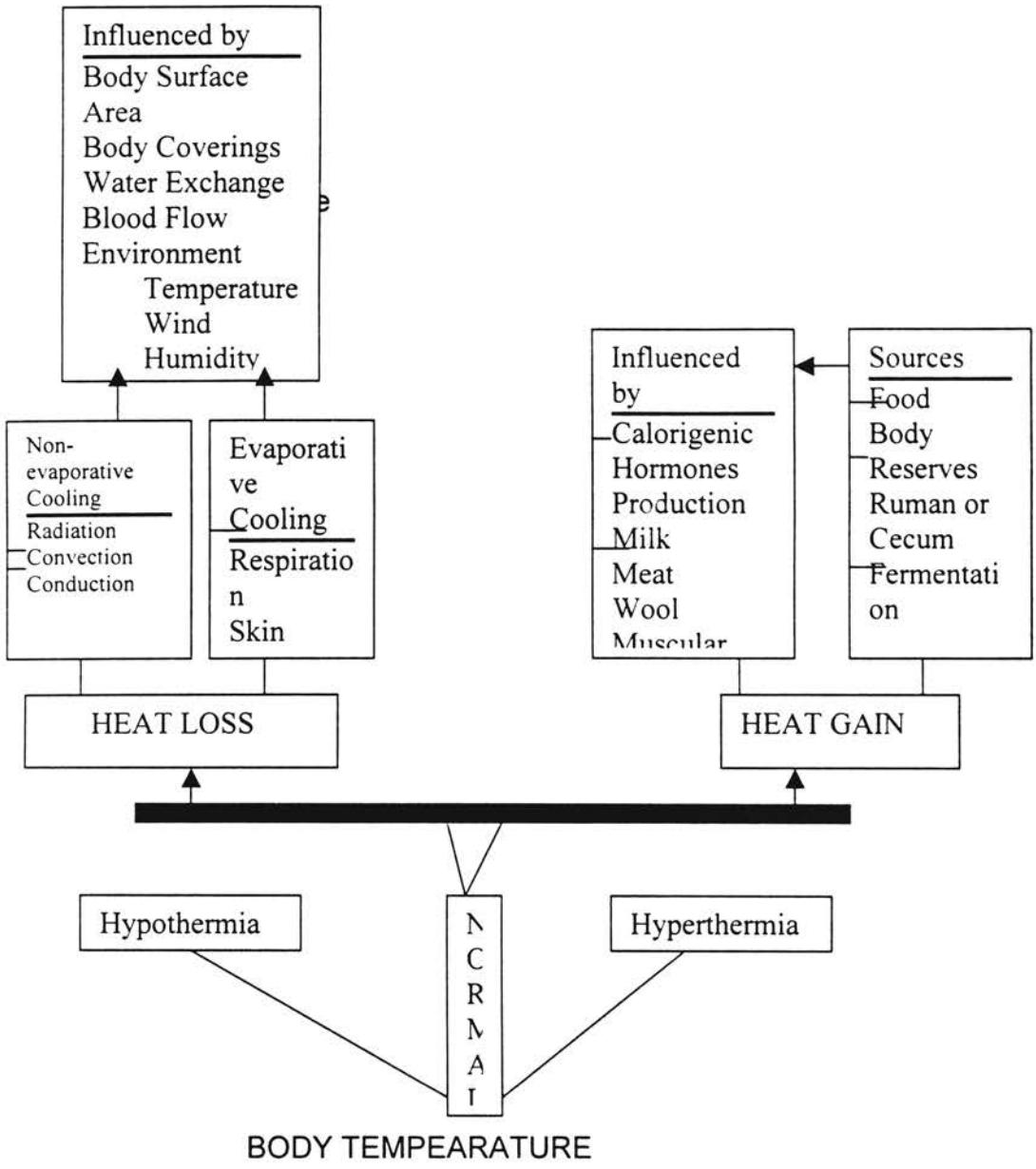
Heart weights as a proportion of body weight were observed highly reduced by high temperatures as compared with low temperature. Reduced liver

weight proportion of body weights of males were also observed at the age of 34 and 54 day but were higher in females exposed to high temperature at both ages (Sonaiya, 1989). Plavink et al. (1998) observed that relative abdominal fat pad size was lowest in birds kept at the 35 ^{O}C cyclic temperature and highest in those kept at 25 ^{O} C (Geraert et al.,1994).

BODY TEMPERATURE

During the body's metabolism processes heat is produced as a by- product. This process of heat production is not constant. It depends upon the feed intake, oxygen consumption and activity of the bird. Increase of any of these variables results in a higher heat production. Heat production of birds is most commonly computed from the measured oxygen consumption. If the bird is at rest, and if it is not growing or laying eggs, then almost all of the energy released in the tissues is in the form of heat. The energy is released by oxidative reactions. There is a direct connection between the amount of oxygen consumed by the bird and the amount of heat produced. If heat production is measured in a bird that is rested, awake, fasting and in the thermoneutral zone, the heat production is equal to the basal metabolic rate (Bligh and Johson, 1973). Misson (1974) found that several training session were necessary to accustom the domestic fowl to the experimental situation before basal value were achieved and depending on the size of the bird 24-49 hours fasting were necessary to reach a post-absorptive state. Heat produced in such deep-seated organs such as liver

must be transported to the skin surface or the mucosal linings of the upper respiratory tract before it can be lost to the environment.



A summary of the avenues of heat gain, and heat loss as related to homoeothermic in mammals from Yousef (1985a)

Birds vary enormously in their thermoregulatory capacities immediately after hatching, and they have been classified according to these and other capabilities (Nice, 1962). Domestic fowls are covered with feathers and are able to respond effectively to heat and cold. In contrast altricial birds, e.g. the passeriformes, are naked when hatched and have little ability to regulate their body temperature at air temperatures below 23 ^{O}C or above 40 ^{O}C. Other birds (semi precocial, semi altricia) are intermediate between precocial and altricial species in their thermoregulatory capacities. There is one absolute requirement to maintain constant temperature for a body; heat loss must exactly equal heat gain. For maintaining a constant body temperature the animal's body must lose heat at the same rate it is produced by a metabolic activity. Metabolic heat production can easily rise more than 10- fold with activity and, unless heat loss is increased in the same proportion, body temperature will rise rapidly. For the maintenance of body temperature birds need to evaporate water (panting) during high ambient temperature.

Body temperature will be raised when case of heat is not liberated. Variations in the heat of metabolism cause the fluctuation of body temperature of the chicken from 105 ^{O}F to 107 ^{O}F (average 106 ^{O} F body temperature). The heat produced by an animal must be transported to the surface before it can be transferred to the environment. Therefore, the surface of the organism must be at

a lower temperature than the inner parts. If the temperature were the same throughout, no heat could be transferred. Because of the temperature the cycle of organism cannot be uniform throughout the daily temperature pattern of many mammals and birds consistently follows the light cycle. When the towhee is kept in 12 hours of light it's body temperature follows a cycle synchronized with the light cycle. At a room temperature of 23 ^{O}C, the core temperature at night is about 39 ^{O}C and when the light comes on, it rapidly rises to nearly 42 ^{O}C. At different room temperatures (5 ^{O}C for example) the core temperature follows the same day – and- night cycle although it is, on the average, about 0.5 ^{O}C higher than the corresponding core temperature measured at 23 ^{O}C. Both the temperature cycle and the corresponding cycle in metabolic rate can be reversed by reversing the periods of light and dark (Schmidt – Nielsen and knut, 1997).

Deep or core body temperature of a mature chicken is generally higher than that of mammals, in the range of 41-42^{O}C vs. 38 ^{O} C (Freeman, 1965). Ensminger et al (1992) stated that deep body temperature varies between individuals; it is higher in small birds than large birds, higher in males than in females, higher in active birds than in inactive ones and higher in non- brooding than in brooding hens. Also, temperature rises with the presence of the food in the digestive tract, with increased activity, and with higher ambient temperature. Deep body temperature is highest in the morning and lowest in the evening (after three hours in darkness).

HEAT PRODUCTION ESTIMATION: Heat production can be estimated through indirect calorimeter methods. This method depends upon the quantification of

oxygen consumption and carbon dioxide production as described by Brouwer (1965).

HP = 16.18 x L oxygen consumed + 5.02 x L carbon dioxide produced.

HP = heat produced in k j, oxygen consumed in liters, carbon dioxide produced in liters. A correction is usually applied for nitrogen excretion since Rominjn and Lockhorst (1961,1966) stated that the error resulting from this omission is about 0.2 % and should not exceed 1.5 % even at a high rate of protein catabolism. Heat production measurement by indirect calorimeter has been used to determine feed energy availability for growth and maintenance (Shanoono and Brown,1969) as well as estimating the energy requirement under specific conditions (Burlacu et al.,1970a, b).

Bird's energy for maintenance is effected by environment temperature (Van Kammpen,1974; Farrell and Swain, 1977) nutrient deficiencies (Klieber, 1945) diseases (Sykes,1970) and the dietary ratio of protein to energy (Davidson et al,1968). Sonaiya (1989) observed that nitrogen retention was better under constant low temperature, but the energy was deposited preferentially into body fat. Maintenance requirement was lower under high temperatures. However the energy requirement for growth were lower at low ambient temperature. Animals have maximum energy utilization efficiencies for growth and productivity when heat losses associated with maintaining normal physiology function are low.

Variations exist in the metabolic rate between large and small birds, therefore heat production values are expressed per unit metabolic body weight

(kg BW.75). Luiting, (1990) to minimize variability and make values largely independent of body weight. Macleod et al (1993) have observed that heat production, both per bird and per unit of metabolic size (kg W0.75) was significantly affected by feeding regimen, but unaffected by genotype. Short and long term food restriction influences body temperature regulation in broiler breeders (Francis et al., 1991; Macleod and Hocking,1993; Macleod et al., 1993). These studies indicated that heat production was reduced by controlled feeding and that the rate of increase of rectal temperatures was reduced. Li et al. (1992), reported that the abdominal temperatures of laying hens varied little with either food intake or environmental temperature below 28 ^{O}C, while above this temperature abdominal temperatures increased with environmental temperature and quantity of food, indicating the heat load of high environmental temperatures.

Wiernusz and Teeter et al.,(1993) observed that heat production and body temperature increased with food intake at 24 ^{O}C. They did not find any differences in body temperature between feeding levels at 35 ^{O}C, where heat production was increased with food intake. Teeter et al., (1987), observed that the amount of food intake did not consistently affect body temperature post feeding at 24 ^{O}C or 35 ^{O}C in broilers. Teeter et al., (1992), further observed the linearly increased rectal temperature of broilers with food intake at either 24^{O}C or 35^{O}C. Zhou and Yamamoto (1997), observed increased heat production with food intake (0,45 and 90 g) during each temperature period (28^{O}C, 32^{O}C and 36^{O}C), and also at 22 ^{O}C. prior to exposure. They further reported that heat

production (averaged for the last 2 h over all temperatures) was 2.8 KJ/ kg W 0.75 and higher at 90g feed intake than zero intake.

Heat production also increased with environmental temperature and was significantly higher at 36^{O}C than at 28 ^{O}C and 32^{O}C, but heat production decreased with exposure time when the birds were exposed to 28 ^{O}C and 32 ^{O}C, but increased at 36^{O}C. Zhou and Yamamoto et al., (1997), observed that abdominal temperature increased with food intake during each treatment temperature period (28^{O}C, 32^{O}C, 36^{O}C), and also at 22^{O}C (prior to exposure to the treatment temperature). Using the average value for the last 2 h of measurement at all environmental temperatures, there was a significant difference between adjacent food intakes when environmental temperatures increased causing abdominal temperatures to increased markedly. Using the means of abdominal temperatures at the same environmental temperature but different food intakes, abdominal temperature at ambient temperatures of 32 ^{O}C and 36 ^{O}C were 41.9 and 43.1 ^{O}C (Zhou and Yamamoto, 1997). Ke et al., (1992), observed 41.2 ^{O} C and 41.5 ^{O}C.

IMMUNITY: Ambient temperature is one of the factor, which influences on the body temperature. Body temperature is very crucial in respect of health and immunity but very little work has been done on body temperature and it's effect on disease resistance. Guyton (1975) illustrated that high body temperatures (approximately 106^{0} F) in human beings causes the parenchyma of many cell to begins to be damaged. The pathologic findings in a person who dies of hyperpyrexia are local hemorrhages and parenchymatous degeneration of cells

throughout the entire body. Exposure to high ambient temperature causes increasing body temperature. Thaxton et al. (1968) observed that high ambient temperature before primary antigenic challenge causes inhibition of the development of the primary immune response in young chicken. Edens et al.(1998) observed in a preliminary examination of poult Enteritis Syndrome in-infected birds separated from huddles, body temperature of those birds were depressed. Freeman, (1970,1971) illustrated that hypothyroidism is also associated with body temperature of birds and could be related with the condition that prevails in poult enteritis mortality syndrome. Body temperature depression associated with poult enteritis mortality syndrome reached a minimum level after 6 day of exposure. Depressed body temperature in the poult enteritis mortality syndrome-infected poults was accompanied by a highly significant depression in serum T3 and T4 concentration (Rachel et al.,1998).

May.(1989) established a well-known relationship between body temperature and levels of serum thyroid hormones in domestic poultry. Rachel et al. (1998) observed no depression in body temperature and thyroid serum concentrations in the experiment where birds were kept in controlled, apparently ideal environments closely resembling normal brooding temperature conditions. Scholes, et al. (1942) demonstrated resistance to Salmonella pullorum was positively correlated with the internal temperatures of chicks, regardless of whether differences in temperature results from environment or genetic manipulation

The concept of cold and hot virus was established on the bases of studies with in poliomyelitis (Dubes et al.,1956; Lwoff et al., 1960) Perol-Vauchez et al., (1961) in the infection of encephalomyocarditis and Prunet. (1964) as well as Asso. (1967) in the case of Foot and Mouth Disease Virus have shown that the multiplication of viruses was higher in high body temperatures then in low and depends on the pathogenicity of the strain .The more pathogenic a strain is the better is its capacity to develop at higher body temperatures .Gorhe et al. (1969) observed that the normal body temperature of adult mice (38 ^{O}C) was non-permissive for optimal production of RNA replicase from Foot and Mouth Disease Virus cold strain and was reflected by an efficient virus multiplication when temperature was lowered.

BLOOD CHEMISTRY: Donko (1989) stated that blood values of red cell counts, packed cell volumes, hemoglobin concentrations and plasma protein concentrations were reduced in birds raised at 30 ^{O}C and 35 ^{O}C when compare with birds raised at 20 ^{O}C and 35 ^{O}C ambient temperature. Glucose intake may influence blood viscosity, because blood is not only a medium for transporting nutrients, metabolic waste products, and gases around the body, but also plays an important role in the diffusion of body heat. However, problems associated with glucose running through water line include a variety of fermentation products (Zhou et al,1998). Zhou et al (1997b) found that whole blood viscosity (WBV) of broilers decreased significantly when they were exposed to a high ambient temperature. The decrease in WBV may be advantageous in reducing peripheral

resistance and the heat load, and increasing tissue perfusion and circulatory distribution, including the blood supply for surface heat exchange surface. Thermal conductivity of Skin increases linearly with rate of blood flow in skin (Ohara,1981).

Packed cell volume (PCV) was significantly higher at low constant temperatures (10 ^{O}C and 15 ^{O}C) and plasma volume was higher at high temperatures (30 ^{O}C and 35 ^{O}C) Yahav et al (1997) and Yahav et al (1996) noted that plasma T3 concentration decreased after a 24-h heat exposure at 5d of age, The reduced T3 concentration was maintained in the exposed groups as late as 21d of age but the difference between these and the control birds disappeared at 35d of age.

BODY COMPOSITION: Dietary studies assessing the effects of fat, protein, mineral and vitamins, especially vitamin C supplementation has achieved progress in alleviating the negative influences of heat stress (Kutlu and Forges,1993). Abasiekong (1989) reported that water addition to the diet in the ratio (food: water) of 3:1 increased the performance of broiler chicks under heat stress condition. Kutlu et al (1995b) reported that diets with more than 60% moisture increased performance of broilers and layers under heat stress conditions.

THERAPEUTIC ENHANCING OF HEAT STRESSED POULTRY PERFORMANCE: Under heat stress conditions facility management tools such as water spray for birds, feed restriction to reduce heat production, and more

space per birds attribute to minimizing mortality and production loss. It is known that birds subjected to hot ambient temperature characteristically reduce feed intake, growth rate, and feed efficiency, this presumable occurs to regulate the bird's heat dissipation. Gross (1983) suggested that stress which occurs early in life, while many systems of the chicks are still developing, may have a long-lasting impact and could possibly modify expression of their genetic potential. The growth rate of 4 to 8 wk old broiler chickens is maximal at environmental temperatures of 18 to 20 ^{O}C (Hurwitz et al., 1980) and declines progressively at higher temperatures (Yahav et al., 1996). Yahav et al (1996) observed that after the 24-h exposure to 36 ^{O} C body weights of the exposed chickens were significantly lower than that of the unexposed chickens. He further demonstrated that additional periods of high temperature during the 7th d after hatching further depressed weight gain in the conditioned chicks and was associated with a reduction in feed intake and feed efficiency.

Thermotolerance is over come, leading to marked mortality when temperatures exceeding 38 ^{O}C (Squibb and Wogan,1960). Yahav et al (1996) observed growth retardation after short-term exposure to heat stress during the 1st wk of age and marked mortality was observed at the age of 42 days when exposed to 35^{O}C. An increase in mortality has been shown in broilers exposed to prolonged periods of high temperature, especially after 4 wk of age (McDouglad and McQuistion, 1980). Charles (1986) recommended that the ambient temperature requirements, 31^{O}C during the first days of life gradually be declined to 21^{O}C at 21 day for maximum growth and high feed efficiency. Howlider and

Rose (1989) observed that birds at 31^{O}C ambient temperature took longer to reach a 2 kg body weight compared to 21 ^{O}C at the age of 21d.

Distress of birds during high ambient temperature causes the bird's heat content to shoot up, resulting in a reduced temperature gradient between the environment and bird's body. Because heat exchange disturbances inflict a stress, the bird's response to preserve homeostasis is natural. These responses result in a reduced feed consumption (Squibb et al. 1959; Adams et al. 1962;Teeter et al., 1985; Howlider and Rose1971) increased surface area by postural changes (Freeman,1971) increased urine production(Van Kampen,1981) and metabolic alterations to reduce heat production (Van Kampen,1977). Hyperthermia induced panting altars arterial carbon dioxide and bicarbonate precipitating respiratory alkalosis (Arad and Marder, 1983). Teeter et al. (1985) observed decrease feed consumption, growth rate and survivability. High environmental temperatures associated with relative humidity impede productivity and disease resistance in poultry.

Changes in environmental or body temperatures have striking effects on many physiological processes. Increases in temperature accelerate rates of oxygen consumption, Generally a rise of 10 ^{O}C in temperature causes the rate of oxygen consumption to increase by about two folds (Schmidt – Nielsen and Knut, 1997; Joiner and Huston,1957; Adams et al,1962; Reid et al, 1964; Godfrey and Winn,1965; Smith and Oliver,1971; Thaxton and Pardue,1984; Bottje and Harisson,1985). Pardue et al (1985) observed that cyclic high temperatures lead to increased mortality and reduce growth rates in

broilers. Washburn (1985) and Austic (1985) stated that heat stress adversely affects feed intake, body weight, egg production and livability in domestic birds. Teeter et al (1985) observed adverse effects of high rearing temperature on broiler performance including feed intake and weight gain reduction. Farrell and Swain (1977) observed that the metabolize-ability of the diet was reduced by high ambient temperature. Donoghue and Krueger et al (1990) stated that the deleterious effect of thermal stress on domestic hens creates a significant economic problem for poultry producers during the hot summer months by reducing weight gain. Heat stress along with a high relative humidity causes economic loss by increasing mortality and lowering production in broilers, layers and breeding flocks. Xin et al. (1994), reported that broilers are most susceptible to heat during the last 3 weeks of the growing period and that males are more affected than females.

FEED RESTRCTION: Al-Harthi and MacLeod (1996) demonstrated that apparent metabolize able energy intake was 25% lower ($P<0.05$) in the 30 ^{O}C and pair –fed birds than in the 20 ^{O}C control group. Ad libitum fed birds at 20 ^{O}C gained more weight than the 30 ^{O}C and pair fed groups. Heat production was greater in the 20 ^{O}C control group while the 20 ^{O}C pair fed birds had a higher heat production than birds on the same food intake kept at 30 ^{O}C.

Feed restriction can be vital in helping an animal to survive in an heat stress environment. Teeter et al (1992) suggested that when birds were precision fed graded amounts of feed (5 %, to 10 % body weight) they were observed to have a lower body temperature. Pierce (1980) mentioned with

drawing the feed in the morning so birds was fasted during the hottest part of the day. This practice has been relatively successful and is used routinely by many companies when there is a possibility that heat stress-related mortality might occur. Ross breeders Ltd recommended to alleviate the effect of heat stress, a special management method involving feed restriction or short term feed withdrawal during the hottest period of the day. Teeter et al.(1987) noted reduced mortality when chickens in wire-cage batteries were fasted prior to heat stress in an environmental chamber. Gross and Seigel (1980) observed that overheated or water deprived chicks had lowered stress responses when subsequently subjected to fasting. Several studies have been conducted to demonstrate efficacy to improve the livability, growth and feed efficiency of heat stressed chickens.

Growth restriction (due to feed restriction) induced changes in hormonal, McMurtry, et al (1988) and metabolic status, Rosebrough et al. (1986) and could modify the reaction of chicks to heat stress applied later in life by reducing heat production. May et al. , (1987); Arjona et al. (1988) and Quart et al (1989) did not observe any significant effect of short term fasting on bird's performance or carcass yield. Early growth restriction by feed restriction results in improved feed efficiency and a reduction in carcass fat in broiler chickens at marketing age, Plavnik and Hurwitz (1985, 1988); McMurtry et al., (1988).

During the early growth restriction period, maintenance energy requirements decrease, possibly due to a reduction in heat production, as observed in mammals but returns to normal upon re-feeding. Whitehead et al

(1984) showed higher mortality than their lean line counterparts, particularly when they were fed ad libitum. Macleod et al (1993) has observed that mature, ad libitum-fed fat line hens were observed panting even at the ambient temperature of 20 ^{O}C. The reduced mortality of fat birds when they were control-fed, may be associated with the lower heat production of control-fed birds, Macleod et al, (1978, 1979) and the related effect of short-term food withdrawal on heat tolerance, Francis et al. (1991). Macleod et al (1993) observed reduced heat production per bird in the feed restricted birds' compare with the ad libitum fed birds. Hocking et al. (1992), observed peak mortality in ad libitum-fed fat-line hens. They further noted that control feeding reduced plasma triglyceride concentrations to 32.3 mg/ ml in the fat line and 80.2 mg/ml in the lean line. Increased viscosity will lead to elevated resistance to blood flow, Chien.(1982). The effect will be greatest in the capillaries, which have the smallest diameter, Wells (1972). Increased resistance to blood flow leads to increased arterial blood pressure and this, in turn has long-term effects on heart ventricular function.

VIRGINIAMYCIN: Virginiamycin is an effective antibiotic against Gram positive microorganisms, (D.E. Somers and Van Dijck, 1955), and has been well documented to improve broiler growth rate and feed efficiency (Woodward et al., 1988; Harns et al., 1986; Mile, et al., 1978 as well as carcass yield, (Woodward et al., 1988; Lesson, 1984). The performance of broilers improve which fed diets containing VM when is associated with an increase in feed consumption,(Buresh et al., 1985a) ; Leeson 1984) and improved nutrient absorption efficiency,(Nelson et al .1963; March, et al ., 1984a; Miles and Harms, (1983). Enhanced

utilization of phosphorus, (Buresh et al., 1985b) and manganese (Henry et al., 1986), are also reported for birds consuming virginiamycin.

BETAINE: Betaine is a metabolite of choline that donates methyl groups to homocystein to form methionine, and also to the folate pool. Betaine is formed from choline and that growth responses obtained from betaine are due to its ability to provide methyl group. (Kidd et al., 997). Birds maintain the intracellular concentration of water that is crucial for homeostasis by osmoregulation. Osmoregulation is the ability of a cell to maintain its structure and funtin by regulation movement of water in and out of the cell (Kidd et al., 1997).The osmoprotective properties of betaine are well conserved in may forms of life, including bacteria (Chambers and Kunin, 1987), and animals (Law and Burg, 1991). Osmoprotective substances are used by bacterial cells to prevent dehydration when growing in concentrated solutions of glucose, sodium chloride or other salt. Betaine is the most important osmoprotective compound in bacteria, (Imhoff and Rodriguz- Valera, 1984) Betaine is known as to serve as an osmoprotectant in bacteria by replacing intracellular K and restoring the osmotic turgor without accumulation of K when the environmental salinity increased (Sutherland et al., 1986). Beneficial osmoprotective properties may be due to the dipolar zwitterin characteristics of betaine and its high solubility in water (Chambers and Kunin, 1985). The unique chemical properties of betaine play a key role in providing osmoprotective properties in microorganisms and these attributes have a parallel in more complex organism (Bagnasco et al., 1986). Saundreson and MacKinlay (1990) evaluated growth and hepatic enzymes in

male broiler chicks as influenced by dietary supplementation with combinations of methionine, betaine and choline. Betaine inclusion improved the growth of chicks fed a semi- purified diet,(McGinnis et al, 1942). Finkelstein et al. (1983) evaluated the effects of supplemental betaine and choline at dietary levels of 0.2 % on hepatic betaine-homocystine methyltransferase and found activity increased as dietary levels of betaine and choline increased.

ELECTROLYTES: Therapeutic applications to lessen the consequences of heat stress by electrolyte supplementation have been partially successful. These therapeutic applications have multiple modes of actions by improving acid base water and mineral balance simultaneously. Some ion effects are confounded with these responses making cause and affect evaluations a difficult task. During periods of high temperature, Iwasaki et al. (1997) observed that broilers consuming a 4% glucose –water solution ad libitum to 35 day of age, had a significantly lower mortality due to heat exposure and higher live weight gain than birds receiving tap water. Results from this study demonstrate that glucose has the potential to reduce economic losses during heat stress. Administration of glucose increases the neonatal chicken's body temperature when exposed to 21 ^{O}C, suggesting that carbohydrate metabolism is involved in the physiology of body temperature, Thaxton, et al., (1974). Zhou et al, (1998) observed increased live weight gain with 4% glucose treated water during heat stress. They further observed that feed and metabolic energy intake decreased significantly during the first 20-30 ^{O}C cycle period compared with 20 ^{O}C or the third 20-30 ^{O}C cycle

period in both experimental groups. Heat stressed birds exhibit increased potassium excretion,(Smith and Teeter 1987a).

Thaxton and Parkhurst (1976) have observed that newly hatched broilers, which receive 10% sucrose –water solution prior to placement of feed, exhibit numerical increase in body weight and lowe feed conversion ratios than birds that received only water prior to feed. Iwasaki et al. (1998), found that birds which received glucose –water solutions exhibited lower rectal temperatures than birds who received only water. Studies show sodium bicarbonate, potassium bicarbonate, calcium chloride and ammonium chloride helps to correct the acid-base imbalance of the blood, by counteracting the pH rise of respiratory alkalosis, (Macari et al. 1994).

Teeter et al. (1985) observed that birds show positive responses to the use of dietary supplements of $NaHCO_3$. Heat exposed birds may exhibit a reduction in the levels of plasma carbon dioxide and bicarbonate during heat stress panting and when not panting, Balnave and Gorman (1993). Teeter et al (1985) observed that the loss of bicarbonate ions during heat exposure may affect the blood pH and induce a nutritional requirement for bicarbonate in birds. Increasing dietary bicarbonate however may accentuate any respiratory alkalosis. Bonsembianate et al (1990) reported that supplementing the feed of 7-d-old turkeys with 5 g $NaHCO_3$/kg in the diet resulted in an improvement in growth, when temperatures ranged from 26 to 30 ^{O}C and RH (relative humidity) ranged from 75 to 90%. Sodium bicarbonate (6.3 grams) increased water intake and decreased mortality of heat stressed, finishing broilers, whereas 3.2 g

$NaHCO_3$/l had no beneficial effect. Belnave and Oliva (1991), working with finishing broilers at high temperatures (30 ^{O}C) found that diets supplemented with 16.8 g $NaHCO_3$/kg and in drinking water 5.6 g $NAHCO_3$/l produced a significant improvement in bird production response.

Maria et al.(1998) observed the difference in body weight gain between sexes when female birds increased weight gain when fed diets with 1.2 and 1.8% $NAHCO_3$ and finished 37.17 and 18.44% heavier than males. Potassium is the most abundant intracellular cation, and is involved in many metabolic activities, nerve impulse conduction, and excitation of muscle cells and regulation of cell volume. Heat stress depresses plasma K^+ concentrations in chickens (Huston, 1978; Ait-Boulahsen et al.1989) and enhances urinary K^+ excretion and reduces body K^+ retention (Deetz and Ringrose, 1976; Smith and Teeter, 1987), which leads to inadequate cellular K^+ status if an appropriate amount of K^+ is not provided. Dietary K^+ levels of 0.6 % for laying hens (Deetz and Ringrose, 1976) and 1.5 % for broiler chicks (Smith and Teeter,1987) are required to prevent of K^+ imbalance during chronic heat stress conditions, K^+ levels of 0.15 to 0.35% for hens and 3-6-wk- old broilers respectively, under normal conditions, are recommended by NRC (1984). Divergence of normal acid-base balance can negatively influenced the performance of bird productivity,(Mongin and Sauveur, 1977).

Application of carbonated water successfully reduced the respiratory alkalosis(Bottje and Harrison 1985). Teeter and Smith (1986) stated that blood pH and K^+ are dependent factors that affect acclimation to chronic

heat stress. Changes in blood acid-base balance associated with thermal polypnea have a profound influence on K^+ homeostasis due to the opposing movements of K^+ and H^+ ions into and out of cells (Tobin 1958) and to the renal competitive mechanism by which K^+ and H^+ ions are excreted, (Ofloff and Davidson, 1959).

Chickens have limitations in compensating for higher K^+ intake by increasing excretion or decreasing absorption (Kondo and Ross, 1962; Deetz and Ringrose, 1976). Addition KCl in drinking water increased plasma K^+ concentration (Abdellah et al.1995). Abdellah et al, (1995) observed that 0.9 % KCl may be an excessive level that overcomes the compensatory mechanisms of the body. Riely et al.(1976) demonstrated that inclusion of 0.75% and 1.00% of KCl resulted in an increase in ready to cook yield.

Babji et al (1982) reported that electrolyte administration up to 0.1 % improved weight gain and percentage carcass water uptake. Whiting et al (1991) reported that chilled carcass yield was significantly greater for the heat-stressed broilers than for the thermoneutral broilers. He further observed that oven-cooked fillet yield was significantly greater for the KCl and $NaHCO_3$ combination water treatments than for the KCl and $NAHCO_3$ treatments individually. Ali et al (1987) observed that magnesium aspartate hydrochloride (Mg-Asp-HCL) alleviated the immobilization, stress-induced increase in serum porlactin in young turkeys. This compound has been successfully administered to mammalian livestock to reduce the effects of stress(Schumm 1982, 1983; Kietzmann and Jablonski 1985). A single daily injection of 40 mg of Mg-Asp-HCL

reduced weight loss without affecting overall feed consumption because of the sedative affects of this compound (Donoghue et al 1990). Sedation of the hypothermic hen may decrease non-essential muscular activity and reduce total energy expenditure, resulting in a reduction in body weight loss.(Kaemmerre and Kietzmann 1984). in response to thermal stress (Edens and Siegel1975). The ability of Mg-Asp-HCL to attenuate an increase of these catabolic compounds could reduce energy expenditures further, resulting in less body weight loss during thermal stress.

The reduction in circulating magnesium concentrations may also promote weight loss in heat –stressed hens. Magnesium is an essential mineral required for the regulation of carbohydrate, protein, and lipid metabolism and the maintenance of normal health (Altura and Altura, 1984; Whang 1984; Littledike and Goff 1987; Shils, 1988). Soutyrine and Sams (1997) observed that a CO_2 treatment resulted in better viability, more water consumption and less feed efficiency than that of a KCl treatment.

HEMATOCRIT: Exposure to heat stress resulted in an irreversible decrease in blood hematocrit, Yahave et al. (1996). Several researchers have shown that the environmental temperature at which broiler is reared may influence hematocrit and hemoglobin values. Olson (1973) found that the number of erythrocytes in the domestic fowl increased during the winter. Huston (1960) reported and increase in erythrocyte concentration and hematocrit for birds reared at 21.1^{O}C.when compared to birds reared at 30.^{O}C. Huston (1956) observed that hmeatocrit values from birds reared at a constant temperature of 30. ^{O}C. Ere

significantly lower that birds reared at 8. ^{O}C and 19.O ^{O}C. No significant difference was fond between the hematocrit values from birds reared at 8.0^{O}C and 19.0 ^{O}C. Deaton et al. (1969a) reared birds at constant temperatures of 7.20, 15.60, 23.90 and 32.2 ^{O}C and observed that 8-week hematocrit and hemoglobin values were highest for the birds reared at 7.2 ^{O}C and lowest for the birds reared at 32.2 ^{O}C.

Deaton et al. (1969) reared chicks from 1 day to 56 days of age at constant temperatures of 7.2, 23.9 and 32.2 ^{O}C With the exception of the first week, birds reared at the 7.2 ^{O}C temperature had significantly higher hematocrit and hemoglobin values than the birds reared at 32.2^{O}C.there were not consistent significant differences in hematocrit or hemoglobin values for the birds reared at 23.9 ^{O}C and 32.2 ^{O}C. Washburn and Huston (1968) fed a synthetic milk diet with 3 levels of copper (Cu) and iron (fe) to chicks reared at temperatures of 8.0 , 19.0 and 30.0 ^{O}C. They reported a distinct effect of environmental temperature on all dietary regimes, but the effect was not clear- cut when examined within a dietary treatment.

VITAMINES: Coskun and kutlu (1997) showed that supplementation with ascorbic acid affected carcass yield while having effects on body weight gain, dry matter intake, dry matter conversion efficiency, carcass weight and abdominal fat pad weight. They further suggested that feeding broilers with ascorbic acid supplemented wet diets may help to prevent weight gain loss

induced by high environmental temperatures. Soutyrine and Sams (1997) did not observe any difference in heat stress resistance between male and females. MECHANICAL Reece and Deaton (19971a) noted that evaporative cooling is widely used in arid regions to reduce high summer temperatures, but that practice was not being used in more humid regions. The reluctance to use evaporative cooling in high humidity areas may be because it is generally recognized that excessive humidity in poultry house may result in decrease performance or production. They demonstrated that in areas of high relative humidity. It is possible to lower the high portion of a 24-hour temperature cycle from 37.8 to 24.4 ^{O}C with evaporative cooling.

The economic impact of heat stress is severe because poultry raised in tropical areas are exposed to high environment temperatures and relative humidity resulting in heavy mortality, morbidity, and reduction in production: reduced fertility, hatchability, disease resistance and increase in expensive measures to attempt to ventilate and cool birds.

COMPENSATORY GROWTH

GROWTH: Growth is defined as an increase in protein mass, mineral, water or fat. Ensminger (1992) has defined it as an increase in the size of bones, muscles, internal organs or other parts of the body. He further illustrated that growth is the normal process before hatching and after hatching until the bird reaches its full, mature size, is influenced primarily by nutrient intake. However Promeroy (1955) argued that this distinction is difficult to substantiate in practice

as fatty tissues perform needed functions other than just acting as an energy source. Subcutaneous tissue, for instance, has been implicated in thermoregulation of many animals, Blaxter and Rook (1953). Maynard (1947) stated a distinction between what he termed ' true growth' and extra fat deposition. He stated that true growth is characterized by an increase in protein mass, minerals, water and fat.

Early work on growth and development (Hammond 1932; Palsson and Verges 1952) led to the theory that growth occurred in waves and early maturing parts and tissues had priority over late maturing parts. According to this theory, feed restriction and re-feeding would affect various tissues differently. Little and Sandland (1975) observed that fat was the tissue most affected during loss. However others, Burton et al. (1974); Drew and Reid (1975) ; Bulter-Hogg (1984); Drouillard, et al. (1991), have demonstrated that loss of weight consists of protein, fat and water loss. These researchers further demonstrated that the extent of depletion is dependent on the severity and duration of feed restriction, maturity of the animal and diet.

COMPENSATORY GROWTH: Compensatory capabilities in livestock, plants, fish and humans have long been recognized. The term compensatory growth has been used to describe the accelerated or catch-up or make-up growth following a period of reduced feed consumption, which can be mediated by management. Washburn and Bondari (1978), have defined this term as a growth velocity above that of ad libitum fed control. Yu et al.(1991) defined compensatory growth as a rate of growth exceeding that normally observed in the same breed of chicken at

the same age. In order to achieve early growth retardation it is necessary to reduce nutrient intake by means of diet dilution, Leeson (1989); Leeson et al (1991).

Recent reports on food restriction during the following period in broilers indicate that restricting food intake lowers body weight, carcass fat, retards growth and improves feed efficiency. Boa- Ampsnsemetal (1991) ; Fontana et al., (1992); Yu et al., (1992) defined it as early feed restriction relying on the phenomenon called "compensatory" or " catch-up growth, which are used interchangeably. Acar et al (1995) illustrated that catch-up growth is defined as a recovery from a growth deficit resulting from a limited nutrient intake. Upon re-feeding, birds demonstrated catch-up growth however the important point is whether they are able to attain the same final body weight as controls at market age. Parder et al.(1963) illustrated the phenomenon of growth acceleration, which accompanied recovery after transient growth retardation produced by illness or starvation in young humans. They used the word catch-up growth, which become almost universally adopted by pediatricians. Osborne and Mendel (1941) employed an animal model for catch up growth to disprove a statement by Minot (1907) that the rate of growth depends on the degree of senescence. Their animals demonstrated catch-up growth even after they were prevented from growing by a variety of procedures for extended periods of time.

A set- point for normal body size for the age of an organism is implicit in the concept of control of catch-up growth, Prader et al. (1962); Tanner (1963); Prader (1978). The existence of a set point and its possible location in

the central nervous system has been tested in experiments in rats stunted by neonatal head-irradiation, Mosier and Jansons, (1967). Alterations in digestive and physiological functions may also be factors influencing the compensatory process. In the early stages of development animal growth results from hyperplasia (cell division) and hypertrophy (cell enlargement), while in later developmental stages the primary avenue for growth is hypertrophy, Enesco and Le Blond (1962).

As in the runt pig, born with fewer cells and still having fewer after growing to maturity (Widdowson, 1976), reducing the nutritional level during early, hyperplastic growth can inhibit compensatory growth so that mature size is reduced, even though form is maintained. Under nutrition of a similar severity and duration during the later hypertrophic growth stages when cell enlargement is dominant has no permanent effect on final size, McCance and Eiddowson (1962, 1974) ; Winick and Noble (1966). Bottomley and Lvey (1997) suggest growth depression results from the differential growth of various body components, namely decreased growth of soft tissues while bones and body organs, including the digestive tract, continue normal development. Hahn (1982) explained that after removal of a growth suppressor such as poor nutrition, animals have higher feed intakes than normal for their weight. It has been hypothesized that they then grow more rapidly because maintenance requirements are proportionally low, leaving more feed energy for growth. Higher efficiency of energy conversion resulting from changes in intermediary metabolism may also be an explanation.

The broad implications of research observations related to growth suppression and recovery led (Von Bertalanffy 1968) to the principle of equifinality for organisms realizing similar end points independent of initial conditions, time and perturbations in physiological processes. In nutritional tests, an extended duration or severity of restricted feeding can result in animals requiring a longer time to reach a given final weight after re- alimentation than full fed animals, Balnave (1973). They have shown that those animals are capable of normal catch-up growth acceleration following a fast however, catch-up growth brings the animal only to the stunted body size characteristic of the head-irradiation model, Mosier et al. (1983a). Irradiation of a narrow midline zone of the head produces the same degree of growth retardation as whole head irradiation with the same dose thus excluding the possibility that growth stunting of the head-irradiation rat is a non-specific effect of tissue damage, Mosier and Jansons (1970).

GROWTH HORMONES: Plasma growth hormone (GH) is increased in rats recovering from under nutrition prior to weaning (Sinha et al.1973) and after weaning (Moiser and Jansons 1976), cortisone treatment (Mosier and Jansons 1976) and hypothyroidism, Mosier et al.(1977). The results showed that rats recovering from under nutrition had a normal pulsatile pattern of GH secretion and that increased secretions of GH during catch-up growth after fasting took place during the environmental lights (Mosier et al. 1985b). Increased secretion of GH was also found in rats recovering from growth suppressive treatments with cortisone. In that experiment only the lights-on phase was studied. Mosier et al.

(1985b). David (1986) linked this finding with catch-up growth from GH secretion and supported the hypothesis that catch-up control is located in the central nervous system. Hughes (1982) summarized a series of investigations and concluded that the ability of an animal to achieve complete catch-up growth after under nutrition is dependent on the degree of the growth deficit, maturity of tissues at the time of the growth and the relationship of the growth to the timing of the peak growth velocity. Preece (1976) summarized evidence indication that failure of catch-up growth after glucocorticoid exposure is due to peripheral effect; i.e. effects on cartilage. Davis (1986) explained that different degrees of catch-up growth observed after cushing's syndrome or after glucocorticoid treatment may relate to differences in intensity and duration of glucocorticoid exposure, age and individual susceptibility. He further illustrated that the mechanism of growth retardation after neonatal head-irradiation is obscure. He concluded that set points might have been reset through radiation-induced damage of neural tissues.

Catch-up growth depends on the function of peripheral, as well as, central systems. Failure to catch-up growth may result from the failure of any of these systems. David (1986) concluded that catch growth control exists as evidenced by the fine-tuning of body size that occurs during growth recovery and its location in the central nervous system is suggested by its interaction with GH secretion and with environmental light and by findings in animal with growth stunting following head irradiation. The effects are partially evident in

fast growing strains of broilers, particularly males, from 4 weeks of age (Albers et al., 1990).

Hurwitz et al.(1980) demonstrated in a series of experiments that, under management systems lack of ventilation induces ascites. Shlosberg et al.(1989) observed that a mash feed, in contrast to a pelleted feed, could prevent a high incidence of ascites when given for the first 28 d of life. Albers et al.(1990) observed that birds receiving low energy through this feed at a time when feed intake per unit of metabolic weight is at its highest. Shlosberg et al.(1990) found that feeding mash compared with pellets, reduces ascites mortality by 1.1 % during the age of 29-46 days where as mortality from ascites was lowered compared with pellet feeding. Albers et al.(1990) stated that the efficacy of the various feed restriction regimens may have limits due to the fact that broilers have a maximum ratio of feed intake per unit of metabolic weight at 10 to 20 days of age. At that age broilers need maximum amounts of oxygen to metabolize feed, particularly fats. Therefore if uncontrolled feeding is permitted, they are prone to developing anozemia, thus starting the chain of physiopatholgical events leading to ascites. It is interesting that feed restriction leads to inhibition of adipocytes proliferation and decreased fat depots.

Shlos-Berg et al. (1991) demonstrated that slowing broiler growth through feed restriction will reduce the incidence of ascites induced by a cold environment while maintaining optimum body weight and feed conversion at market age. Arce et al. (1992) in their study were successful in reducing ascites through feed restriction in broiler chicks. Albers et al.(1990) observed the reduction of ascites

following restriction was significantly improved but less than that of ad libitum birds (Saleh et al., 1997). Boa-Ampnsen et al. (1991) reported that the full benefit of feed restriction would be realized by feeding on alternate days.

Benyi and Habi (1998) reported a lack of significant difference in feed efficiency among birds which were fed ad libitum those whose intake was quantitatively reduced by 15 % and those whose feeding time was reduced by 2 days /wk. They further suggested that the significantly better feed efficiency leading to the faster growth rate and thereby the heavier final body weight of birds whose feeding time was reduced by 2 days / week than those whose feed intake was reduced quantitatively by 30 % despite the slightly higher feed intake by birds on the 2 days /week reducing in feeding time, suggests that reducing food intake quantitatively by 30 % and a more severe effect on body weight, growth rate and food efficiency than reducing time by 2 days / week. Pokniak and Cornejo (1982) observed that the mean feed intake of 15 % feed restricted bird was higher than that of the control group where as the 30 % and 45 % feed restricted birds were lower than that of the control group. The Feed conversion efficiency was lower in the 45 % restriction group than that of the control, 30 % restriction, and 15 % restriction group respectively.

ASCITES: Ascites is defined as an excessive accumulation of fluid in the abdominal cavity and accumulation of fluid around the hydro pericardium. Fast-growing breeds are more susceptible to a ascites due to their rapid growth and higher oxygen demand due to their metabolic rate. Ascites syndrome in broilers takes a very high toll in the industry during winter. The condition is prevalent in

ages of birds. This idea of feed restriction was initiated by Plavnik and Hurwitz (1985) not only to reduce the feed cost but also to reduce the amount of fat deposition at the marketing age. Dickerson (1978) suggested that the improvement in feed efficiency during re-alimentation is due, in part to improved metabolic efficiency associated with maintaining a smaller body.

This mechanism was demonstrated in the experiments of Zubair et al. (1994) by the ability of the feed restricted birds to exhibit a higher ME intake / BW .67 during the re-aliment period.

Compensatory growth with improved feed efficiency in early feed-restricted birds versus birds provided ad libitum access to feed has been found in market age. Broilers (Proudfoot et al.,1983; Pokniak et al., 1984; Plavnik and Hurwitz.,1985,1988,1989,1990 and Summers et al.,1990). Plavnik and Hurwitz et al. (1991) suggested that early feed restriction had advantages in improving feed conversion efficiency in male broilers and turkey poults. Sheila et al.(1993) found that feed restriction to 50 and 60 % of ad libitum during the 2nd week of life was found to have no adverse effects on feed: gain ratio at market age.

Fontana et al. (1992) observed that broilers that were subjected to feed restriction at an early age had significantly lower feed conversions at 28 d and 49 d of age than birds feed ad libitum. Jones et al. (1992) stated that after the commencement of the feed restriction at 7 d of age, the feed intake of the 4 d continuously restricted birds declined upon re-alimentation and was greater than the ad libitum fed birds. Bene et al.(1979) observed broiler feed intake to 85 % of that of ad libitum fed birds from 14 to 42 days of age. Feed intake by birds

account for 30 % of total energy expenditure. Zubair et al.(1994)reported that the weights of the pancreas and liver were significantly higher for the restricted birds compared with their ad libitum counterparts during re-alimentation.

Rosebrough et al.(1986)feed restricted male broiler chicks from 6 to 12 d of age and reported heavier weights for the livers of the restricted birds when compared with the controls on days 14, 16, and 18. Zubair et al., (1994) in his studies suggested that enlargement of the liver observed during re-feeding in these experiments was probably an adaptation to enable the birds to exhibit a higher rate of fat deposition. Fontana et al.(1993)observed that liver and gizzard weights were minimally affected by the feeding regimes. Pokniak and Cornejo (1982) illustrated that the liver weights (43.01 g), of 45 % feed restriction birds were higher than those of control birds (41.7), 30% feed restriction (39.9 g), and 15 % feed restriction birds (37.3 g).

Protein % was higher(72.8 %) in the 45 % feed restriction group compared with the 30 % feed restriction , control and 15 % feed restriction group, and Fat % was higher(17.9) in the livers of the 30 % group compared with control , 15 % and 45 % feed restriction group respectively. Digestive tract weights were higher (136.1 g) in the control group verses 126.2 in the 45 % feed restriction, 121.6 g in 15 % feed restriction and 116.4 g in 30 % feed restriction group. The fat % was 37.0 % higher in the 45 % and 30 % feed restriction group and 35.8 % in control and 33.3 % in 15 % feed restriction groups.

FEED INTA KE: Feed is the most expensive item in the broiler industry. Among different measures to reduce feed cost is to apply feed restriction in the early

feeding (Saleh et al., 1997). Allowing birds an unlimited supply of food can result in consumption in excess of the birds requirement for maintenance and production and the excess energy being converted into fat (Scott et al., 1969; Ross Breeders, 1978; Nesheim et al.,1979). Benyi and Habi (1998) reported that a 30% feed restriction resulted in less abdominal fat deposition than when there was a 15 % feed reduction, reduction of feeding time by 2 days /week or ad libitum feeding.

This resulted in a significantly higher abdominal fat observed in birds on ad libitum feeding than those on 30 % feed restriction. Plavnik and Hurwitz (1985) suggested that if energy consumption is severely limited for a short period of time early in life, a significant reduction in the size of the abdominal fat pad of broilers is attainable without retarding overall growth to 56 d of age.

VISCERAL ORGANS: The percentage of total heart weight relative to live body weight and right ventricle weight relative to total heart weight and right ventricle weight relative to body weight ratio were not affected by the early feed restriction programs from 1 to 21 d of age. Acar et al. (1995) Studying with other species showed higher fasting heat production and maintenance energy requirements during re-feeding that previously recorded during feed restriction, which was associated with 50% heavier weights for metabolically active tissues such as small intestine, pancreas and liver (Koong et al. 1982).

Spratt et al.(1990)reported in his studies with broiler breeders that the gut liver, and reproductive tracts which make up only 4 % of body weight

increased heat production until adipocyte hyperplasia recommences (Cartwright et al., 1986).

Plavnik and Hurwitz (1991) suggested that early feed restriction had advantages in reducing carcass fat in broilers. It was further observed that in chickens, regardless of sex, early feed restriction of varying severities resulted in a reduction in carcass fat at the marketing age of 7 to 8 weeks. Fontana et al. (1993) observed no significant differences in abdominal fat pad weights between broilers that were restricted and broilers that consumed feed ad libitum at 49 days but restricted broilers had significant heavier abdominal fat pad weights than unrestricted controls at 28 d of age. They further suggested that significantly higher lipogenic activity was found in restricted broilers when compared with controls at 28 d of age (unpublished data). Yu et al. (1990) observed that on a dry matter basis, total body fat decreased while total body protein increased as a result of restricted feeding.

Jones et al., (1992), did not observe any difference in total body fat, moisture, protein or ash content of the feed restricted and ad libitum fed birds, at the age of 70 d. They further observed that there were no differences in mean cell diameter or volume in the adipose tissue of the birds grown on the ad ibitum or food restricted. Bean et al.(1979) observed that feed restricted broilers increased abdominal fat weights compared with those of ad libitum fed birds.

Pinchasov and Jensen (1989) observed that abdominal fat deposition was generally less for the restricted birds but the difference was not significant. Abdominal fat content was not influenced significantly by restricted

urestricted controls from 21 to 56 days of age. Clavert et al. (1989) in his trial indicated that once ad libitum feeding resumed, early restricted and unrestricted broilers grew at similar rates.

Fonatana et al. (1992) observed that mean body weights were significantly lower for restricted broilers than for the group consuming feed ad libitum. Mollision et al. (1984) reported that restricted feed intake to 90% of that consumed by the controls reduced the percentage of abdominal fat and body weight of market age broilers. Pinchasov and Jensen (2989), Summers et al. (1990) and Yu et al. (1990) did not observe any difference in abdominal fat pad size between restricted and unrestricted broilers.

The data of Cartwright et al., (1986), suggested that the reduction in abdominal fat resulting from a corresponding reduction in the number of adipocytes induced by the early feed restriction. March et al. (1982) stated that a severe feed restriction led to the disappearance of a peak adipocytes lipid by translocation regardless of initial adipocytes size (Cartwight et al. 1986). This loss of lipid in small adipocytes may then lead to disappearance or loss of identity (March et al., 1984). Jones et al. (1992), explained that the success of a feed restriction program in reducing body fat and allowing full body weight recovery is du to the negative energy balance experienced by the broiler during the restriction phase. During this period the bird mobilizes stored energy and the resultant loss of body fat is accompanied by a decrease in average adipocyte size upon re-alimentation. Any surplus energy is reflected by the bird through

significant differences in carcass composition during and immediately after restriction.

Shapira et al. (1978) suggested that fasting, even for short periods depresses lipogenesis whilst re-feeding following a fast increases the rate of hepatic lipogenesis and carcass fat. Acar et al. (1995) observed that the proportion of abdominal fat pad relative to live weight was significantly reduced ($P<0.05$) in the feed restricted 7 to 14 d birds compared with feed restricted birds form 4 to 11 d of age. The percentage of abdominal fat pad was reduced in restricted birds as compared with ad libitum fed at 11 14 d of age.

Rosebrought et al. (1986) found that the activity of lipogenic enzymes were depressed during the period of restriction, peaked during the 1st wk of re-feeding, and declined gradually to levels below those of the control birds in subsequent weeks. Increase in growth rate through genetic selection and improved nutrition in broiler chickens has been associated with high body fat deposition. The periodic surge of substrate delivery to the liver simulates lipogenesis (Leveille and Hanson, 1965)

Simon and Rosselin (1979) and the periodic surge in the amount of fat available for storage also stimulated adipocyte proliferation, Ballam and March, (1979). Yu and Robinson (1992). Cabel and Waldroup (1988) reported that broilers subjected to early feed restriction from 6 to 12 or 6 to 18 days of age had reduced abdominal fat pads and lower body weights than unrestricted birds. Calvert et al. (1989) reported that broiler chicks fed 40 kcal per bird per day for 6 or 12 days had body weight gain.

Arafa et al. (1983) reported that energy restriction 10 d prior to slaughter caused suppressed weight gain as a result of poor feed efficiency. Pokniak and Cornejo (1982) reported that the mean body weights of the control group was higher than that of restricted group at the age of 56 days and the 15 % restricted group had higher body weight compare with 30% and 45 % feed restricted birds

ABDOMINAL FAT: Producing lean poultry meat to meet the demands of the consumer is a major objective of broiler farming. This objective has proven difficult to achieve as genetic selection for increased body weight has also resulted in a concurrent increase in carcass and abdominal fat. Many methods for reducing carcass fat in broilers have been tried by different researchers with varying degrees of success.

Physically restricting feed intake (Beane et al.,1979; Mollison et al., 1984) reducing the dietary calorie; protein ratio (Summers et al., 1965; Griffiths et al., 1977) chemically restricting feed intake by feeding glycolic acid (Fancher and Jensen, 1988).

Pinchasov and Jensen (1989) represent different methods that have been used to alter body composition. These methods have not been accepted commercially primarily because of the concomitant reduction in total body weight experienced with these procedures. In an earlier study by Griffiths et al. (1977) energy uptake was limited from 0 to 3 wk of age but did not affect subsequent abdominal fat pad size. Pokniak and Cornejo (1982) and Pokniak et al. (1984) limited feed intake from d 8 to 23 post hatching and they found

feed- restricted birds during the restriction period was 77 g per bird, which represents only 35% of the weight gained by the full-fed counterparts over the same time period. He further observed that feed restriction intake to 50 % resulted in approximately 40 % lowered daily heat production compared with the ad libitum broilers.

Plavnik and Hurwitz (1991) observed that in male turkeys, accelerated growth following feed restriction resulted in greater body weights, an effect which reached significance in milder restrictions. Due to accelerated growth, body weight, which had been retarded by feed restriction, reached (and in turkeys sometimes exceeded) that of the ad libitum fed birds several weeks later. Jones et al. (1992) stated that there was no influence of genotype on the ability of the bird to compensate body weight or on the effect of a feed restriction to reduce body fat. Farrell and Williams (1989) observed that the use of discontinuous feed restriction may also enhance body weight recovery. Jones et al.(1992) observed that the body weight of the birds fed on the 4 d restriction recovered so that at slaughter there were no differences in body weight between the ad libitum fed and 4 d restricted birds. The birds on the 6 d restriction treatment had significantly ($P < 0.05$) lower body weights at slaughter. Benyi and Habi (1998) reported that birds fed ad libitum grew faster and were therefore significantly heavier at the end of the investigation than birds on the restricted feeding regimens. He further reported that feed restriction by 70 %, 15%, and 2 days per wk resulted in reduced growth rates and final body weights.

Kwakkel et al.(1991) observed high mortality at low temperature when feed was restricted during the rearing period of layer pullets. Saleh et al.(1997) reported that restricted during the rearing period of layer pullets. Saleh et al. (1997) reported that restricted feeding during 7 to 14 d may improve feed conversion and reduce mortality of large males growth for further processing.

WEIGHT GAIN: The ability to manifest compensatory growth following a period of feed restriction is used in animal husbandry to improve performance (kuhn et al, 1996). A meat type-bird makes investments in supply organs such as the gastrointestinal tract and liver immediately hatching to direct growth into the rapid development demand organs such as muscles and feathers (Katanbaf et al., 1988) Sheila et al,. (1993) observed studied that feed restrictions of 50 to 65 % of ad libitum during the 2^{nd} wk of life was found to have no adverse effect on body weight

Maxwell et al. (1991) and Ye et al. (1990) reported that their birds failed to recover the weight loss during feed restriction and did not attain the same body weight as controls at 49 and 56 d of age, respectively. Broiler chicks subjected to a period of severe feed restriction for 6 d at the age of 1 wk will have regained their normal body weight following re-feeding by market age. This is achieved with a better-feed efficiency and accompanied by less carcass fat and a smaller abdominal fat pad (Plavnik and Hurwits, 1985; Plavnik et al., 1986). Acar et al. (1995) observed 7-14 d restricted broilers gained more ($P<.001$) weight than either the ad libitum birds. This is evidence that feed restrictions impacts the growth curve at numerous locations.

The exponential rare function also represents the normal response of animals to stresses i.e. the reaction is greatest when the stress is first applied with lessening effect as the stress progresses. This effectively puts a limit on the compensatory rate per day. Use of the exponential rate function also provides the compensation rate will reach the same value independent of whether a given cumulative stress is obtained from a single day with sever conditions of from consecutive days with moderate conditions (Hahan, 1982).

MORTALITY: Fontana et al. (1992) observed significant reductions in the rates of mortality in restricted broilers. Bowes et al (1998) and O'Sullivan et al. (1991) reported a lower rate of mortality caused by sudden death syndrome in broilers restricted to 75% of the feed intake of control birds from 5 to 39 days of age on an alternate-day feed restricted program similar to that used for broilers breeders. The rapid growth rate of modern broilers has been associated with high mortality and skeletal disorders, Robinson et al.,1992) and it has been suggested that a reduction in growth rate by limiting excesses in feed may ameliorate this problem (Edwards and Soensen, 1987). Hullan et al. (1980) and Julian et al (1984) reported that sudden death syndrome is associated with rapid grown broilers.

Therefore it can be said that reducing feed will affect the rate of mortality due to sudden death syndrome. Fantana et al. (1992) has shown that control males had a higher rate of mortality than males provided with an early feed restriction. Jones et al. (1992) observed that broiler chicks subjected to early-life feed restrictions become excitable after 2-3 d on the restriction regime

Chahil and Johnson (1974) observed the suppressed growth of Japanese quail during exposure to 37 ^{O}C for the period from 3 to 5 weeks of age but recovered by 10 weeks of age when the birds were returned to 21 ^{O}C. Hahn et al. (1974,1975) demonstrated that the existence of elevated air temperature " thresholds", above which growing animals were unable to fully compensate, whether in growth or feed conversion. A study of 3 week old chicks brooded at 36 ^{O}C for 2 weeks indicated recovery was not achieved by 19 weeks when egg production began and body weight was still less than controls at 79 weeks (Van Kampen,1980) however , sexual maturity was not delayed and the number of eggs in subsequent production to 79 weeks was not reduced. Hahn (1982) expressed that there is strong evidence of limits that growing animals fed ad libitum have a considerable ability to compensate for growth suppression occurring during exposure to adverse environments.

Exceeding the limits, which are inadequately defined at present, can result in performance penalties in terms of time to reach a given weight or weight at a given time. In the light of available evidence on thermal environment a basis for optimizing production resources while protecting livestock can be given. General recommendations can based on:

1. The animal beings ad-lib fed.

2.The average temperature not exceeding the threshold for failure or increased duration of compensation.

3. When adequate management flexibility exists to take advantage of compensatory performance.

A series of studies at the Missouri Climatic Laboratory with ad lib fed finishing hogs, cattle and broiler chickens indicated that the ability of growing animals to recover from adverse climates is considerable (Hahn et al., 1974,1975). These studies showed the animals were not only able to recover growth lost during a period of moderate heat stress but also able to convert feed to gain more efficiently after relief from heat stress than unstressed animals. Hahn et al. (1975.) exposed broilers to 30 ^{O}C for 10 days (day 11-21) of the experiment; Starting weights of 0.8 Kg at day 1 (with 23 ^{O}C before and after the heat treatment). The birds reached 2 kg live weight 1.5 days later than the control group kept at 23 ^{O}C continuously while the feed consumption for the treatment group was 0.87 Kg (26%) less than that of the controls, there were no differences in live weight between the two groups at17 days after removal of heat stress (when all birds averaged 2.05 Kg) however the feed consumption remained 1.05 kg (21%) less for the heat exposed birds than for the controls. In the study on pigs exposed to 30 ^{O}C for 17 days (days 14-31 of the experiment) starting weights of 30 kg at day 1 and 40 kg on day 14) reached 60 kg as rapidly as control pigs (on day 45), while consuming 14 Kg (12%) less feed than the controls (Hahn et al., 1975). The improved feed conversion persisted to the end of the experiment at the 75 Kg live weight. Drury and Siegel,(1966), observed related results in the growth rates of broiler chickens with increased air velocity at high air temperatures resulting in more rapid growth when the air temperature was subsequently reduced.

Cattle fed ad libitum (Fox, 1972) and Inaizumi; sheep (Drew and Reid,1975) and Turkeys (Auckland, 1972). Broilers and turkeys subjected to mild nutrient restriction that allowed for only 60 to 74% of normal growth showed final body weights that were greater than controls fed ad libitum (Plavnik and Hurwitz, 1991)

Gous (1977) demonstrated that the bird's ability to absorb some amino acid may be increased due to feed restriction. Plavnik and Hurwitz (1989) stated that requirements for all amino acids increase due to feed restriction by 10 to 20%.

ENIRONMENT STRESS: There is an impetus to grow and develop despite adverse environmental conditions (Robbins et al., 1928). Fouler (1976) illustrated that livestock are not merely an aggregation of predictable chemical reactions but highly developed survival kits for resisting environmental insults. As a result of the relatively stable homeostatic state which resists displacement from normal performance, the rate of growth changes with time an toward a smooth sigmoid curve Thompson (1942) termed this " an instance of that principle of continuity which is the foundation of all physical and natural science"

Potentially important factors in the expression of compensatory growth include stage of growth of the individual animal, severity and duration of the growth suppression imposed by environmental stresses and condition of the growth suppression imposed by environmental stresses and condition of animals prior to being stressed. Each of these factors contribute to the improved

feed conversion (feed/gain) during compensatory growth in dairy calves (Lortscher et al., 1973; and Drori et al., 1974);sheep (Hogg and Tulloh, 1979) and rabbits (Schlolaut and Lange, 1979) with part of the gain attributable to the rapid accumulation of body water after re-alimentation (Murray,1976). Successive nutritive restriction on rats indicated a lessening extant of compensatory growth with each restriction. Re alimentation episode, but a considerable portion of the decreasing recovery rate was a result of increasing body size (Szepersi and Epstein, 1977). Restricted postnatal growth, can also be compensated for by adequate nutrition as observed in the recovery ability of dairy calves subjected to under nutrition at 2, 3 or 4 months of age (Imaizumi, 1981). Forsum et al. (1981) and Plavnik and Hurwitz (1985) showed that maintenance energy requirements decreased considerably during feed restrictions.

The ability of animals to compensate in growth during re-alimentation following a period of under-nutrition has been demonstrated in poultry (Auckland and Morris, 1971; Plavnik et al., 1986; Plavnik and Hurwitz, 1991). It has also been demonstrated that the broilers, as well as other animals, are able to show compensatory growth response following food intake restriction (Washburn & Bodari, 1978; Pokniak et al., 1980). Early growth restriction induced by feed restriction in improved feed efficiency and lowered carcass fat at market age (Palvnik and Hurwitz, 1985, 1988; Mcmurty, et al., 1988). This suggests that more efficient protein use occurs in animals undergoing compensatory growth.

attracted most researchers in poultry because of its beneficial influence on birds in terms of growth and carcass composition.

Problems associated with fast growth rate in broilers are skeletal and metabolic disorders. Robinson et al.(1992) illustrated that studies on early feed restriction have the potential for correction of these conditions (Plavnik and Hurwitz, 1985, 1988 a, b, 1991; Jones and Farrel, 1992). Improvement in feed efficiency through feed restriction has been attributed in part to higher metabolic efficiency associated with maintaining a smaller body and a lower metabolic rate during early growth, Dikderson, (1978). Calorimetric studies conducted with broilers so far have shown no conclusive evidence of the role of metabolic heat production during and after early feed restriction on body composition and growth rate, Ones and Farrel (1992).

Decrease in maintenance energy requirement during feed restriction could possibly be due to a reduction in heat production as observed in mammals Forsum et al.(1981). It has been suggested by Plvanik and Hurwitz, (1985) and Jones and Farrell (1992) that food restrictions should provide the maintenance requirement for the growth of the bird during the restriction phase but Jones et al. (1992) has shown in his studies that body weight stasis was achieved in feed restricted birds with- out providing strictly defined maintenance requirements. Total cumulative feed energy for the total growth period to market weight was about the same or slightly to moderately increased for restricted fed, re- alimented cattle (Hironaka and Kozub, 1973; Meyer et al., 1965; Fox, 1972).

accelerated growth better describes the increase in growth rate upon re-feeding, because not all previously restricted birds exhibit complete compensatory growth during the re-feeding period. Gigor (1987) and Sejrsen(1982) emphasized the importance of nutrition in mammary development and subsequent lactation. During the compensatory growth period, animals exhibited greater daily body weight gain, increased appetite and nutrient utilization, reduced maintenance requirement (by depressing the basic metabolic rate), enhanced feed intake capacity, activated endocrine status, changes in the composition of body tissue gain, and improved overall efficiency when compared with conventionally fed animals during a similar period (Blum et al. 1985; Wilson and Osbourn, 1960).

Compensatory growth in female rats resulted in increased expression of milk protein genes due to increased mRNA transcription and increased protein synthesis and secretion of milk protein (Park et al. 1988). Baik et al. (1982), reported that compensatory growth increased milk production by 10%. Choi et al.(1998) observed that during 18-month study the body weight of Holstein heifers that were nourished under the rotating restriction and compensatory feeding system showed an incremental growth pattern. They also observed that, in protein synthesis, the test group produced 2.5 and 1.9 times higher protein levels than did the control group in mid and late pregnancy, respectively, and that the protein secretion of the test group was slightly higher (1.3 and 1.1 times) than that of the control group. Compensatory growth induced by an incremental nutrient regimen significantly enhances the efficiency of body growth and subsequent lactation performance, Choi et al. (1998). Feed restriction

Different techniques including regulating the photoperiod to induce changes in growth rates and fat deposition (Cave,1980). Robbins et al.(1984) exogenous thyroid hormone treatment to alter fat e deposition (May1980) and nutrient restriction to reduce the size of the abdominal fat pad and carcass fat at slaughter (Pokniak and Cornejo,1982; Arafa et al ,1983) has been investigated. The severity of nutrient restriction necessary to achieve a consistent reduction in abdominal fat deposition and subsequent compensatory growth requires the use of physical feed restriction (McMurty et al, 1988; Plavnik and Hurwitz, 1985,1988,1989; Plavnik et al., 1986). Jones et al. (1992), suggested that the use of quantitative food restriction in commercial practice may be limited because of broiler behavior and feed delivery problems. The use of discontinuous and dilution food restrictions were examined in an attempt to overcome these problems.

The method of intake restriction on broiler chicks by chemical means suggested by Fancher and Jensen (1988) demonstrated that glycolic acid (GA) depressed feed intake in broilers in a dose-dependent manner. Because GA is a natural organic acid present, although in small quantities in many foods and products. Harris and Richardson,(1980) suggested that it may serve as a useful anorectic compound for restricting feed in poultry production.

The primary benefit of early restriction programs is the monetary savings from improved feed efficiency (Proudfoot et al., 1983). Secondary benefits of early feed restriction programs include reduced sudden death syndrome (Mollison et al., 1984). Fontana et al., (1992) proposed that the term

OBESITY: Bohman (1955) explaining compensatory growth defined the term as rapid growth relative to age. In growing chickens for meat, a desirable feeding strategy would be to produce chickens with maximum lean body mass, minimum feed intake and maximum final body weight. However, at market age, broiler chickens may contain more body fat than body protein on dry weight basis, Leclercq and Whitehead (1988). Obesity in birds increases the incidence of reproductive failure and death due to impaired thermoregulation, Garlich (1979). Limiting nutrient intake during portions of the early growth phase has shown promise in limiting fat deposition in the broiler. One approach to control obesity is to limit feed intake. Limits in feed intake depressed growth in broiler chickens during the period of restriction, but the reduced growth may be compensated for upon re-feeding. Hence, compensatory growth is defined as the rate of growth exceeding that normally observed in the same breed of chicken at the same age (Yu et al. 1990).

Chickens are nibblers when feed is provided for ad libitum access, chickens eat small amounts at frequent interval, Masic et al. (1974). Meal frequency alters body enzymatic systems affecting carbohydrate metabolism, fat storage, and protein formation (Cohn,1963; Fabry and Tepperman,1970). Ragsdale (1934) reported that when put on a low plane of nutrition, physiological aging proceeds at a slower rate and, upon re-alimentation, such animals tend to grow at a rate appropriate to its physiological age rather than to its chronological age.

due to an early feed restriction. Feed restriction for the purpose of compensatory growth was shown not only beneficial for gain but also reduction of ascites incidence.

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CHAPTER III

SUPPLEMENTAL BETAINE, VITAMIN E, VITAMIN C AND ELECTROLYTES EFFECTS ON BROILER PERFORMENCE AND IMMUNITY RESPONSE DURING ELEVATED AMBIENT TEMPERATURE ESPOSURE

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ABSTRACT.

Following rearing to 18 days with and without 0.1% dietary betaine, 960 male Cobb X Cobb broilers were placed in a cycling ambient temperature (24-37^{O} C) also on day 18 the antibody titer against New Castle and Infectious bursal disease was determined. Betaine elevated ($p>0.05$) feed efficiency during the first 18 days. During the grower phase ration, supplementation included 315 g / 2000 lb of vitamin C (VC) and 15 IU (106.385 g / lb vitamin E (VE) while drinking water was fortified with two levels of electrolyte mixture electrolyte low EL(L), 0.16%) and high EL(h), 0.32%) as well as betaine (BE, 0.1%). Variables

monitored individual weight gain (WG), daily gain (DG) final body weight (FWT, feed consumption (FC), feed efficiency (FE), antibodies for new castle disease (NDT) and infectious bursal disease (IBDT), body temperature (BT), hematocrit, carcass composition. Supplementation of B numerically increased WG, DG, FWT and FE and enabled spleen and gall bladder weight retention during ambient temperature Thermoneutral birds exhibited ($p>0.05$) elevated weight gain percentage of final body weight and FC with EL, VC and BE. Supplementation of EL elevated ($p<0.05$) survivability and numerically improved by VC ($p>0.05$), BE ($p>0.05$), and VE ($p>0.05$) with 8 %, 0.9%, 7% and 4% livability. Body temperature at 35 and 41 days of age and mean body temperature was declined ($P <0.05$) for EL(l). Vitamin E and BE was also observed to protect mean body temperature from excessive rise. Body temperature BT35, BT41, MBT of thurmonutral birds declined ($p>0.05$) by EL (l), VC and elevated ($p>0.05$)by BE and VE. Vitamin C elevated ($p>0.05$) daily gain, FC and MF with and with out EL(l) or EL(h) of heat stressed birds. Electrolyte high level improved ($p<0.01$) FE of HS birds. New Castle disease titer (NDT) and IBDT were significantly ($p=0.01$) improved with VE, EL (l) of heat stressed and VNDT was improved with VE ($p<0.05$), BE ($p>0.05$) and VC ($p<0.05$) of thermoneutral birds. In conclusion, it can be suggested that betaine vitamin E, electrolyte and vitamin C supplementation have therapeutic effects on heat stress as well as shown beneficial response in thermonutrla birds.

(Key Words vitamins, electrolytes, betaine, broilers, ambient temperatures, heat stress)

INTRODUCTION

The adverse effect of elevated ambient temperature and relative humidity on growth, egg production, hatchability, fertility and immunity are well documented (Joiner and Huston, 1957; Adams et al., 1962; Reid et al: 1964; Godrey and Winn.,1965; Smith and Oliver.,1971; Thaxton and Pardue:, 1984., Bottje and Harrison, 1985). Pardue et al, (1985) observed that cyclic high temperature leads to increasing mortality and reducing growth rate in broilers. Washburn, (1985) and Austic, (1985) stated that heat stress adversely affects feed intake, body weight, egg production and livability in domestic birds. Teeter et al,(1985) observed adverse effects of high rearing temperature on broiler performance as reduced feed intake and weight gain. Donoghue and Krueger et al, (1990) stated that the deleterious affect of thermal stress on the domestic hen created a significant economic problems to poultry producers during the hot summer months.

Numerous compounds have been added to broiler feed and water in attempts to help alleviate the adverse effects of heat stress. Blood acid–base imbalances precipitated by respiratory alkalosis (Whiting and Andrews 1991) have bee treated in several ways. Odom and Harrison (1985) observed reduced amount of the bicarbonate ions were a major factor contributing to the reduction in shell quality under high ambient temperature conditions. Ferket and Qureshi (1992) illustrated that drinking water fortified (235 mg / l) with a vitamin pack (Vitamin A, D,E K, Roboflavin, pantothenic acid, niacine, B complex Thiamine, pyridoxine, biotin, folic acid,) increased performance of heat stressed birds.

Paul and Harrison (1995) observed dietary Ascorbic Acid to improve gain with no impact on feed intake or efficiency. They suggested that body energy used during heat stress was influenced by ascorbic acid, possibly through interactions with glucocoraticocids. Glazevrook and Thomson (1942) stated that ascorbic acid is carried in the blood stream specifically and is taken up by organs where transport mechanism are responsible for its accumulation within the cell. The adrenal and pituitary glands have the highest concentration of ascorbic acid per weight of tissue. The guinea pig fed higher level of vitamin C had significantly more vitamin E in their lungs and plasma than animals fed low dose of vitamin C .It was concluded that higher levels of vitamin C protected tissue levels of vitamin E. Since vitamin E can enhance both non specific and specific immune responses, it's protection by ascorbic acid indirectly can affect overall immune function.

Thaxton and Pardue (1984) suggested that supplementation of ascorbic acid 1000 mg /kg feed immediately after heat stress, reduced weight losses and improved weight gain for 10 days after heat exposure. Thaxton and Pardue (1984); Pardue et al (1985) observed that addition of ascorbic acid 1,000 mg /Kg in the feed reduced weight loss and mortality in birds up to 4 wk of age exposed to high temperatures. In contrast Freeman et al (1983) found no improvement in weight gain or survivability, when ascorbic acid was provided 1,000 mg /kg in the feed.

Sealock and Siberstem (1940) Sealock and Godland (1951) stated that ascorbic acid quantity synthesized by the animal should be sufficient for normal

growth and metabolism. Thornton (1961); Lyle and Moreng (1968), Freeman (1971), Siegel (1971,1984) found that under stressful conditions synthesized ascorbic acid was deficient for meeting physiological needs. Ascorbic acid could reduce the synthesis of glucocorticoids during heat stress, which increased through adrenal cortex. Effective glucocorticoids increase hepatic glycogen deposition and cause a modest hperglycemia.

Exposure to high ambient temperature before a primary antigenic challenge is reported to inhibit development of the primary immune response in young chickens (Thaxton et al., 1968). High primary immunity titers to sheep-red blood cells, bovine serum albumin, or polyvalent K Salmonella pullorum were developed in young chickens. These circulating antibody titers were depressed within 12 hours after 30 minutes exposure to temperatures of 41.7 ^{O}C to 43.3 ^{O}C (Thaxton et al., 1970). Siegal (1980) stated that several researchers showed suppressed level of antibodies in chickens against a variety of diseases exposed to environmental stress. Increase of important hormone (adrenal hormones) during general stress effects antibodies. Increase in chronic infections have been attributed to intensive production practices, because, not only do these practices seem to impose greater infection pressure on the population, but they also produce changes in the climatic and behavioral environment to which the birds are not genetically adapted (Biggs, 1977). Adrenal involvement in the immunity suppression of cell-mediated immunity by immobilization stress in mice has also been shown (Blecha et al., 1982). Heat stress lowers maternal acquired immunity

in calves (Scott et al., 1976) and cell mediated immunity in chicken (Regnier and Kalley, (1981).

Tengerdy .P (.1978), Nickel, C. F, (1979) and Axelord (1980) observed beneficiary effects of vitamin E on immune response and disease as well. Heinzerling et al.,(1974) and Ellis R. P. et al (1976) reported that supplementation of the vitamin E level higher than the recommended dosage enhanced immune responses and lead to increased disease resistance in several animal species. Tengerdy et al (1973) illustrated that supplementation of vitamin E either in diet or by peritoneal injection increased the number of antibody producing cells in chickens and mice. Jackson et al (1978) and Nickels (1979) demonstrated that passively transferred antibody levels were significantly increased in plasma of chickens when hens were fed high levels of vitamin E. They further reported that sufficient vitamin E could be transferred from the hen to chicks to stimulate the immune system in the chickens. Akramul Haq et al (1996) summarized that supplemental vitamin E alone or in combination with B-carotene fed to breeder birds enhanced lymphocyte function of day old chickens as measured by the blastogenic response and humoral immunity of the progeny. Sheila (1993) found that vitamin E supplementation during heat stress and transportation stress protected against the drop in egg production and egg weight.

Teeter et al (1985) observed that chronically heat stressed chicks exhibit a respiratory cycle with panting and non-panting phases. Blood pH of panting birds ($p < .05$) was elevated compared with non-panting birds. Correcting this

respiratory alkalosis by addition of NH_4Cl to the diet increased ($P<0.05$) live weight gain by 25 % for birds exposed to continuous 35 C. Teeter et al (1985,1990) stated that blood electrolyte balance in chickens altered during heat stress and supplementation of drinking water with potassium chloride has resulted in reduced mortality rates in heat-stressed broiler. Plasma Na and K were reduced ($p<0.05$) by HS whereas Cl was increase ($p<0.05$). Smith and Teeter (1987) suggested that blood pH and K are dependent factors that affect acclimation to chronic heat stress. Branton et al (1986) observed the affect of ammonium chloride and sodium bicarbonate solution on mortality was more directly related to the birds influence on water intake than to specific changes in blood pH.

Teeter et al, (1985) stated that supplemented NH_4Cl and $NaHCO_3$ and KCL have all been observed to increase weight gain or survivability to various degrees. Husseny and Creger (1981) reported that broiler subjected to 32^{O} C environment for 42 days had lowered rates of Ca, Cu, Fe, K, Mg , Mn, Na , P, and Zn retention whereas Belay and Teeter (1992) reported reduced ($p<0.05$) mineral retention for K, P, S, Ha, Zn, Mo, Mn, Mg, and Cu during heat stress. Hest stressed birds had increased ($p<0.05$) excretion for urinary k, P, S, Na, Mg, Ca, and Mn whereas Zinc, Mo, Fe, and Cu were not affected (Belay and Teeter, 1992). Smith and Teeter (1987a) suggested that the negative K balance may be a consequence of respiratory alkalosis. Teeter, (1987) studied that ammonium chloride inclusion in broiler ration reduced the incidence of respiratory alkalosis

and enhance broiler growth rate combination of ammonium chloride and sodium bicarbonate did not have any significant effect on egg quality.

Betaine is a metabolite of choline that donates methyl groups to homocystein to form methionine, and also to the folate pool. Betaine is formed from choline and that growth responses obtained from betaine are due to its ability to provide methyl group. (Kidd et al., 997). Birds maintain the intracellular concentration of water that is crucial for homeostasis by osmoregulation. Osmoregulation is the ability of a cell to maintain its structure and funtin by regulation movement of water in and out of the cell (Kidd et al., 1997).The osmoprotective properties of betaine are well conserved in may forms of life, including bacteria (Chambers and Kunin, 1987), and animals (Law and Burg, 1991). Osmoprotective substances are used by bacterial cells to prevent dehydration when growing in concentrated solutions of glucose, sodium chloride or other salt. Betaine is the most important osmoprotective compound in bacteria, (Imhoff and Rodriguz- Valera, 1984) Betaine is known as to serve as an osmoprotectant in bacteria by replacing intracellular K and restoring the osmotic turgor without accumulation of K when the environmental salinity increased (Sutherland et al., 1986). Beneficial osmoprotective properties may be due to the dipolar zwitterin characteristics of betaine and its high solubility in water (Chambers and Kunin, 1985). The unique chemical properties of betaine play a key role in providing osmoprotective properties in microorganisms and these attributes have a parallel in more complex organism (Bagnasco et al., 1986). Saundreson and MacKinlay (1990) evaluated growth and hepatic enzymes in

male broiler chicks influenced by dietary supplementation of methionine, betaine and choline. Betaine supplementation improved the growth of chicks fed a semi-purified diet, (McGinnis et al, 1942). Finkelstein et al. (1983) evaluated supplemental betaine and choline at dietary levels of 0.2 % on hepatic betaine-homocystine methyltransferase activity increased as dietary levels of betaine and choline increased.

Although numerous research has been conducted on electrolytes vitamin E and ascorbic acid, but limited research has been carried out on the effect of dietary ascorbic acid associated with electrolytes and betaine on the performance as well as immunity response of broiler chickens, during heat stress.

Purpose of the said experiments was to determine, whether or not there was an affect of above treatments on the immunity response, general performance, blood chemistry, body composition and body temperature during heat stress and high relative humidity.

STATEMENT OF PROBLEMS

Poultry production in tropical areas is a negatively influenced by high ambient temperatures and relative humidity. Once the ambient temperature rises above thermal zone ventilation is needed to remove the sensible and latent heat produced by the birds. Birds in the high ambient temperature and relative humidity areas experienced sever panting in the attempts to find relief. The major environment stress factor is relative humidity, where as in Pakistan relative humidity is more than 80 % during the summer period, which causes a heavy

economic loss due to high mortality, decrease production, fertility and hatchability. It is also very important that 80 % of the poultry farms in Pakistan are with out electric power therefore impossible to maintain the proper ventilation or cooling the growing house to meet the ideal environment to achieve the maximum potential of the chicken

MATERIALS AND METHODS

Experiment 1.

Nine hundred and sixty male Cobb X Cobb broiler raised four floor pens (240 chicks per pen.) to three weeks of age. Birds were fed a corn-soybean starter diet (3150 Kcal M.E / Kg 23 % CP;Table 37) with betaine 0.1 % and with out betaine. Chicks were wing banded at the age of 10 day. Forty chicks were selected randomly at on day 18, and blood samples collected to determine antibody titers against the New Castle and Infectious bursal disease vaccination. New Castle vaccine (inactivated) was given during the blood collection on the first day of day18. On the 4^{th} week (22 d of age) following an overnight fasting, nine hundred and sixty chickens weighed and randomly, allotted to treatments were selected and transferred to in wire -floored grower batteries containing 61 x 92 – cm compartments hose in a two thermostatic and humidstatic controlled room. Under the facility it was continuous tungsent filament lighting,. Each treatment contained 16 replicates per treatment with six chicks per replicate per cage (48 chicks per treatment). Week 4 was utilized to adapt all birds to the grower ration (3170 Kcal M.E. / Kg 21 % CP: table 38). One room was maintained at 24 C while the heat stressed environment increased by 2 ^{O}C/ day

from 24 ^{O}C to 37 ^{O}C at 70 % relative humidity. Ambient temperature and relative humidity during the investigation was recorded with thermograph placed at the height of upper cages. Feed and water were continuously available.

Treatment 1 supplementation of dietary vitamin E (15.IU, 106.385 LB/2000 LB), treatment 2 dietary vitamin C (150ppm, 315g/2000LB), treatment 3 betaine 0.05 %, treatment 4 electrolytes low level, treatment 5 electrolytes high level drinking water were provided accordingly from 29th day of age till the termination of experiment at the age of 42 d (20 day in experiment). Feed and water were recorded when offered. Two birds from each replicate per treatment were randomly collected, for body temperature at the peak of heat stress (37 ^{O}C) at (noon) age of 35 and 41 d. Mortality was collected on daily bases and necropsy made for cause of death. Gall bladders weights of dead birds were also recorded to evaluate the effect of AT. At the termination of the experiment (42 day of age) final body weight, feed and water consumption were recorded accordingly.

Forty (N. D Vaccinated) birds were bled to collect blood for determination of antibody levels against New Castle disease and Infectious Bursal disease. Birds for processing were fasted for 12 hours and fasted body weights were recorded in the processing plant prior to sacrifice. Birds were weighed, hung on rail, electrically sunned, bled for 15 min. following severing of jugular and carotid veins, passed through a scalding vat, plucking machine, hand eviscerated, and carcass were weighed. In both experiments, dressing percentage was calculated as dressed carcass weight without the neck and giblets divided by live weight. Carcasses were weighed in air and water for computation of specific gravity

(Teeter and Smith, 1985). Immunity producer organs (spleen, bursa,) were hand removed and weighed.

Experiment 2.

Four hundred and eighty male Cobb X Cobb were used same as experiment 1.

Statistical Analysis

In both experiments the pen of chicks was used as experimental unit, and data was analyzed VC, VE, BE, EL, two- and three way interactions analyzed by using General Linear Models (GLM) procedure of SAS.

RESULTS

Experiment 1

Body weight gain

Final body weight (FW), weight gain (WG), daily weight gain (DG) and weight gain proportion of final body weight (PG) was not significantly influenced by EL (l), EL (h), VE, VC or BE (table 1) of heat stressed birds. Final weights of heat stressed birds were not effected with any treatment but were numerically higher (+0.5%) with EL (l), vitamin C (+0.13%), betaine (+1.2%), and with vitamin E (+1.23%) compared with control group. Two-way interactions of electrolyte X vitamin E and electrolyte X vitamin C resulted (table1) in a numerical decrease in final body weight compared with control groups. In two-way interactions of electrolyte and betaine FW increase by +3% with electrolyte (low) and betaine. Betaine combination with vitamin E

also numerically increased final weight +1.8% where as betaine and vitamin C increased final weight by 2.3%. Three-way interactions (EL (l) X BE X VC, +7%, EL (h) X BE X VC, 0.1%) numerically increased final body weight. Three-way interactions of EL (l) X BE X VE, EL (h) X BE X VE also improved final weight by 6.1% and 0.3% respectively.

Weight gain was numerically increased with the supplementation of EL (l), + 0.042%, EL (h), +2.5%, VC (+1.15%), VE (+1.23%) and BE(+1.2%). Two-way inter actions of EL X VE and EL X VC decreased weight gain where as two way interaction of EL (l) X BE, EL (h) X BE, BE X VE and BE X VC shown improved weight gain by +2%, +4.3%, +1.8%, +2.3% respectively compared with their control group. Three-way interactions of EL (l) X BE X VC, EL (h) X BE X VC, EL (l) X BE X VE, EL (h) X BE X VE were also numerically higher by +7.2%, +3.6, 5.1%, and 8.3 % respectively (Table 1).

Daily gain (table 1) of heat stress birds was numerically depressed with EL and VE where as increased with VC and BE by 0.80, 0.68% respectively. EL (l) X BE, BE X VC and BE X VC treatments shown increased daily gain by 2, 0.4, 1.5% respectively. EL (l) X BE X VC, EL (l) X BE X VE and EL (h) X BE X VE also improved daily gain by 7.2, 5.1, 0.3 % respectively compared with control group.

Percentage of weight gain (PG) was numerically decreased with EL, BE, VC and VE. EL (h) X BE interactions significantly decreased PG compared with control group. EL (l) X BE X VC increased PG by 0.15% numerically.

Feed consumption

Feed consumption (FC), and mean feed consumption (MF), (table 1) was significantly decreased with EL (l) and EL (h) and feed efficiency (FE) significantly improved with EL (l) 11% and EL (h) by 2%. VC treatment showed not significant but numerically increased FC (4%) and MF (4%), but decreased FE (2%) compared with control groups. BE decreased FC (5.8%), MF (5.6%) and increased FE (2.08%). VE also decreased FC (5.6%), MF (5.6%) and improved FE (6.1%). In Two-way interactions of EL (l) X VE and EL (h) X VE numerically decreased FC (15.7%, 12.6%) and MF (15%, 12%) and improved FE (15%, 4%). EL (l) X VC decreased FC (10%), ME (10%) and increased FE (7.9%).Two-way interactions EL X BE showed EL (l) and EL(h) X BE significantly decreased FC and MF yet did not significantly improve FE (16%, 8.7%). BE X VE and BE X VC also decreased FC (10.8%, 1.59%) and MF (108%, 1.9%) and increased FE (8.2%, 2%). In Three-way interaction of EL X BE X VC, EL (l) X BE X VC and EL (h) X BE X VC (not significant) decreased FC and MF (11%, 3%) but improved FE (17%, 4.6%). There-way interactions of EL (l) X BE X VE and EL(h) X BE X VE (not significantly) depressed FC and MF (17.1%,17.6%) and improved FE (16%, 8.7%).

Water consumption

Water consumption (WC), daily water (DW), water feed ratio (WF) and water to body weight gain ratio (WR) comprised in table 2 was not influenced by

any of treatments. A Trend of increasing WC, DW, WF and WR were observed. EL (l) and EL (h) increased WC (6%, 9%), WF (21%, 18%) and WR (13%, 11%) respectively. VC supplementation also increased WC, WF and WR (17%, 6%,9%). BE and VE also increased WC (17%, 7%), WF (7%, 6%) and WR (14%, 5%). BE combination with VC and two- way interactions of EL (l) X VE, EL (h) X VE, EL (l) X VC, EL (h) X VC, EL (l) X BE and EL (h) X BE numerically increased WC (32.0, 14.4, 20.5, 10.5, 15.0, 31.0, 36%), DW (15.0,14.3, 20.4, 10.0, 15.0, 31.0, 6.3 %), WF (13.4,19.0, 28.0, 27.1, 19.0, 32.0, 33 %) and WR (22.0,17.2, 21.7,16.0,17.1, 30.9, 36%). Three ways interaction of EL (l) X BE X VC, EL (h) X BE X VC, EL (l) X BE X VE and EL (h) X BE X VE showed an increase WC (40.55, 51.7, 27.8, 34%), DW (40, 51, 29, 33), WF (42, 41.9, 25, 40%) and WR (37.6, 51, 19, 35%)

Visceral weights

Gall bladder weight as a proportion of final body weight (GWP), spleen weight proportion of final body weight (SWP), bursa of fibricious weight proportion of final body weight (BRP) and dressing wastage weight proportion of 12 h fasted weight (PVS) are comprised in table 3. EL (l) and EL (h) reduced (not significant) the BWP (31%, 5%), SWP increased (16%), BRP increased (0. 7%) and PVS was increased ($p < 0.05$) by (2%) with EL(l). VC treatments decreased GWP, SWP, and PVS (5%, 9%, .4%). BE decreased GWP (5%) increased SWP (9%) and decreased PVS (0.4%). VE influenced

on GWP, SWP, BRP and PVS (+5%, 0, 0, -1%). Two-way interactions of EL (l) X VE, EL (h) X VE, EL (l) X VC, EL (h) X VC, EL (l) X BE, EL (h) X BE, BE X VE, BE EL (l) X VE, EL (h) X VE EL (l) X VE, EL (h) X VE EL (l) X VE, EL (h) X VE, BE X VE and BE X VC did not significantly effect GWP (+6.25,-12.5, -30, -15,-43, +15, -43, +5, -6,-7) SWP (+15, -9, -9, -9, +16, +9 +9, 0 %) BRP (0, 0,-13, -6, 0, 0, 0, 7%) and PVS(+2.4, -31, +3, -0.8, +1.7, -0.34, -1, -.6 %) respectively. Three-way interactions of EL (l) X BE X VC, EL (h) X BE X VC, EL (l) X BE X VE, EL (h) X BE X VE also showed a tendency to increase GWP (-50,-37, -40, -46 %) SWP (0, +9, +23, 0 %) BRP (+9, 0, 13, 13%) and PVS (+26,+3,+31,+17%) compared with the control of each group.

Immunity

Immunity against infectious of bursal disease(IBDT) and New Castle disease (NDT) (Table 4) were significantly influenced by EL, VC, VE, EL X VE, EL X BE and BE X VC. IBDT was improved ($P<0.05$) by EL (h) compared with control. VE and VC decreased the IBDT compared with control of each group. VE X EL in two-way interactions has significant immunity stimulating factor on BDT. Two-way interactions of EL X VC and EL X BE significantly decreased the BDT. Supplementation VC has showed improvement in BDT in two-way interactions BE X VC.

New castle titer (NDT) was significantly increased with the treatment VE compared with control and BE also increased NDT. In Two-way-interactions of BE X EL, electrolyte high with betaine significantly depressed NDT compared

with EL(l) X BE and EL(h) where as BE significantly increased NDT compared with EL(h) and EL (l) X BE. VC also showed immunity suppressive response of NDT compared with control.

Carcass composition

Fasted (12 h) body weight (BW) was not effected significantly by any of treatments but a trend of increasing BW was observed with VC, BE and VE, 0.5%, 0.5 %, 1.56 % respectively. EL (l) X VE, EL (l) X VC, EL (l) X BE, BE X VE and BE X VC also influenced increasing pattern of BW by 2.6, 0.7,1.6,2 and1%) respectively. EL (l) X BE X VC and EL (l) X BE X VE tended to increase BW 4.7 %, 5 %.

Hot weight (HW) was decreased with EL treatments and were increased with VC (.7%), BE (4.1%), VE (1.8%), EL (l) X VE (1.6%), E (l) X BE (1.6%), BE X VE (2%), EL(l) X BE X VC (4.7%) and EL (l) X BE X VE (5%). Chill weight, (CW) tended to increase with the VC (0.6%), BE (0.5%), VE (1.9%), EL (l) X VE (1.4%), EL (l) X BE (0.5%), BE X VE (2.3%), BE X VC (1%), EL (l) X BE X VC (2.6%), EL (l) X BE X VE (4.2%) treatments.

Specific gravity (SG) also increased with treatments EL (l) 0.4%, EL (h) 0.5%, VC (0.2%), BE (.2%), VE (0.1%), EL (l) X VE (0.3%), EL (h) X VC (1 %), EL(l) X BE (0.5%), EL (h) X BE (0.6%), BE X VE 0.2%), BE X VC (0.4%), EL (l) X BE X VC (0.8%), EL (h) X BE X VC (0.8%), EL (l) X BE X VE (0.4%) and EL (h) X BE X VE by 0.8%. Survivability ratio (SA) decreased with EL,

VC, BE increased with VE (1.1%).Two-way interaction of BE X VE also resulted in increased(0.2%) SA. Total yield (TY) was depressed numerically with EL and was improved with VC (0.36%), BE (8%), VE (1.1%), EL (l) X VE (18%), EL (h) X VE (10%), EL (l) X VC (13%), EL (h) X VC (3%), EL (l) X BE (27%), EL (h) X BE (16%), BE X VE (13%), BE X VC (8%), EL (l) X BE VC (26%), EL (h) X BE X VE (33%) and EL (h) X BE X VE (12%). Dressing percentage (DP) decreased significantly with EL (l) compared with control group. BE and VE increased DP by .05 and .4%. In Two-way interactions BE X VE and BE X VC improved DP by .4.0 and 0.6% respectively. Water absorption (WA) was lowest with the influence of EL, VC, BE but were higher with VE (0.9%). Influence of VE in two-way interaction produced a higher DP compared to treatments EL (h) X VE, EL (l), EL (h) and the control.

Survivability

Survivability (SR) shown in table 3 was significantly improved with EL (l) and EL (h) by 17%, 8% compared with control. VC, BE and VE improved SR by .9%, 7%, 4% compared with control. Two-way interactions of EL (l) X VE, EL (h) X VE, EL (l) X VC, EL (h) X VC, BE X EL (l), EL (h) X BE and BE X VE, BE X VC increased by 18.0,14.0,15.0, 5.0, 27.0,1.8,11.0, 8.0%). In three way-interactions of EL (l) X BE X VC and EL (h) X BE X VC improve (26%, 3%) respectively. Effect of EL (l) X BE X VE and EL (h) X BE X VE increase survivability 31% compared to control 17% (Table 3).

Body temperature

Body temperatures (Table 6) at the age of 35 d (BT35) 41 d (BT41) and mean body temperature (MBT) was significantly reduced by EI (l) 1%, .7%, .8% respectively compared with control. BE reduced BT35 significantly (.8%). VC showed an increase BT35, BT41 and MBT (0.3%). VE has shown decreased BT35 (1.1%), BT41 (0.14%) and MBT (0.6%). EL (l) X VE and EL (h) X BE decreased BT35 (1.8%, 2%) BT41 (0.7%,0.5%) and MBT (1.3%,1%). EL (l) X VC and EL (h) X VC affected BT35 (-.63%, -0.1%) BT41 (-0.4%, +0.4%) and MBT (-0.51, +0.4). EL (l) X BE and EL (h) X BE decreased BT35 (1%, .0.5%) BT41 (0.7%, 0.3%) and MBT (1%, 0.4%). BE X VE and BE X VC also decreased BT35 (1%, 3%) BT41 (0.3%, 0.1%) and MBT (0.7%, 0.2%). EL (l) X BE X VC decreased BT35 (0.6%) BT4 (0.6%) MBT (0.6%) and EL (h) X BE X VE increased BT35 (0.02%) BT41 (0.2%) MBT and (0.09%). EL (l) X BE X VE and EL (h) X BE X VE also decreased BT35 (2.7%, 2.3%) BT41 (1%) and MBT (1.8%) There were no significant main effect or interactions found with body temperatures however, trends were observed with treatments VC, BE X VC and EL (h) X VC increasing BT35, BT41 and MBT and BE, VE, EL X VE, EL (l) X VC, EL X BE, EL (l) X BE X VC and EL X BE X VE reducing BT35, BT41 and MBT.

Hematocrit

Average Hematocrit (Table 7) was not influenced significantly by any of treatments but was numerically increased by treatments, EL (l) 2.9%, EL(h) 2.2%, EL(l) X VE(1.%), EL(h) X VC (1%), EL(l) X BE (1.7%), EL(h) X BE X VC (.9%), and EL(h) X BE X VE(1.7%). Treatments VC (1.9%), BE (1%), VE(1.4%) ,

EL(l) X VC (1.53%), EL(h) X BE (0.67%), VE X BE (2.8%), BE X VC (3.2%), El(l) X BE X VC (3.42) and EL(h) X BE X VE (4%) reduced AHC not significantly.

Serum chemistry

Serum chemistries comprised in Table 8 showed significant effect of electrolyte on triglyceride (TR) and EL (l) indicates significantly high value of trigyceride compare with control group not with EL (h). In three ways-interactions of EL X BE X VE electrolyte high combination with vitamin E showed significant high level of triglyceride in serum compared with electrolyte high and control group. Vitamin C responded in decreasing TR by (10%) where as vitamin E and betaine increased TR by 4.5% and 6 % respectively. Electrolyte, Vitamin E and Betaine interactions enhanced TR by (20%), EL (l) X VC by (3%), EL (h) X VC by (7%), EL (l) X BE by (28%), EL (h) X BE by (14%), BE X VE by (10%), EL (l) X BE X VC (14%) and EL (h) X BE VC by (3%).

Chloride (CL) was not effected significantly by any treatment but was elicited with supplementation of electrolyte low (0.6%), electrolyte high level (3.1%) vitamin E (1.8%) betaine (5%) electrolyte low level combination with vitamin E (1%), electrolyte high level combination with vitamin E (7%), electrolyte low level combination with betaine (8%), electrolyte high level combination with betaine (10%), betaine combination with vitamin E (7%), electrolyte low combination with betaine and vitamin E (5%) and electrolyte high level combination with vitamin E (10%).

Magnesium (Mg) was not significantly affected by treatments. It was observed that EL (h), BE, VE, EL (h) X VE, EL (h) X VC , EL (l) X BE, EL (h) X BE, BE X

VE, EL (l) X BE X VE , EL (h) X BE X VE enhanced by 0.7, 7%, 2.1%, 9%, 0.6%, 7%, 7%, 9%, 3%, 6% respectively. Uric acid (UR) was elicited with the supplementation of EL (l) by 6% , EL(h) by 17%, BE by 7%, EL (h) X VE by (20%), EL(h) X VC by (19%), EL (h(X BE by (35%), BE X VE by (4%), EL (h) X BE X VC by (39%) and EL(h) X BE X VE by (43%). Albumin (AL) was increased with EL (h) by 9%, BE by (4%), VE by (1%), EL (h) X VE (12%), EL (h) X VC (10%), EL (l) X BE by (6%), EL (h) X BE by (14%), BE X VE (5%), EL (h) X BE X VC by (20%) and EL (h) X BE X VE (15%). Calcium (Ca) level in serum was higher with supplementation of EL (h) by 1.3%, BE (5 %), EL (l) X BE (.06%), EL (h) X BE (16%), BE X VE (3%), EL (h) X BE X VC (8%), EL (l) X BE X VE (3%) and EL (h) X BE X VE (18%) compared with their control groups. Remaining treatments responded to decrease Ca level in serum. Phosphate (Phos) level in serum was enhanced by supplementation of EL (h) by 1%, BE by 2%, VE by 1%, EL (l) X VE by 3%, EL (l) X BE by 8%, EL (h) X BE by 2.7%, BE X VE by 2.7%, EL (l) X BW X VE by 7% and EL (h) X BE X VE by 6%. Sodium (Na) was increased with EL (l) by 2%, EL (h) by 4%, BE by 5%, VE by 1%, EL (l) X VE by 1%, EL (h) X VE by 8%, EL (h) X VC by 1%, EL (l) X BE by 8%, EL (h) X BE by 11%, BE X VE by 6%, BE X VC by 3%, EL (h) X BE VC by 7%, EL (l) X BE X VE by 4%, and EL (h) X VE X BE by 12%. Potassium level was increased with supplementation of EL (l) by 3%, BE by 4%, VE by 6%, EL (l) X VE 8%, EL (h) X VE by 5%, BE X VE by 10%, EL (l) X BE X VE by 17% and EL(h) X BE VE by 9%.

Total Yield:

Total yield (sale able product) were segregated in to low yield (LY), medium yield (MY), and high yield (HY) to examine the influence of yield on different variables. It was observed (Table 9) that LY resulted significantly high FC and MF and HY resulted significantly low FC whereas HY was the result of significantly high FE. There were significant effects (table 10) of dressing wastage percentage of body weight (PVS), survivability (SR), dressing percentage (DP), body temperature (BT35) and mean body temperature (MBT) on total yield. High yield was shown the effect of low PVS, high SR, DP, low BT35 and MBT. Table 11 shows significant differences of high BW, HW and CW on HY. There were no significant influence of total yield on serum chemistry but (Table 12) low levels of Mg, AL, Na and TR were seen in HY whereas high level of CL, Mg, Ca, Na, K and TR resulted in MY. High level of UR and AL responded with LY.

Correlation

Positive correlation (significant) of FC and MF with BT35, BT41and MBT was observed (table 13) indicating high body temperature is related with high FC and MF. A negative correlation was seen with survivability and body temperature at all age indicating high body temperature influence mortality. High BT41 was negatively (significant) correlated with FW, WG, DG. A high water temperature (WT) caused a high (significant) feed and water ratio (Table 13). Body temperature (BT35) was negatively correlated (significant) with FE, TY, water

absorption (WA), and bursal weight (Table 14). Body temperature (BT41) significantly decreased AHC, TY, WA and BR. A significant positive correlation was observed with MBT and FE, AHC, WA and BR where as WT significantly reduced BR (Table 14). Spleen weight percentage (SWP) and (SW) spleen weight was significantly reduced by BT35 and MBT (table 15). Body temperature (BT35) BT41, BTW and WT were not significantly correlated with serum chemistry (Table 16). Triglyceride (TR) significantly increased the SWP, SW (Table 17) and WR (water gain ratio) and water feed ratio (Table 18) whereas Ca and PHO increased (significant) water WA (Table 17). Bursal disease titer (BDT) has increasing response (significant) with Ca, and K. Average hematocrit was positively correlated with TR, Al, PHO, Na and K (table 19).

Experiment 2

Body weight gain

Final body weight (FW), weight gain (WG), daily gain (DG), percentage of gain (PG), feed consumption (FC), mean feed consumption (MF), and gain to feed ratio (FE) of thermoneutral birds (Table 20) were not effected significantly by treatments. Final weight was depressed by EL, BE, VE but was increased (1%) with the supplementation of VC. Weight gain was depressed with EL and VE and were improved with VC (2%), BE (0.7%) and BE X VC (2.9%). Daily gain was improved with VC (2.2%), BE (0.8%), BE X VC (2.9%) and decreased with EL level and VE concentration. Percentage of gain was numerically increased with EL (l) 3.5%, EL (h) 5.8%, VC 3.3%, BE 3.2%, VE 1.3%, BE X VC 6.5% and BE X VE 4.5%.

Feed consumption.

Feed consumption (FC), mean feed consumption (MF) and feed efficiency (Table 20) was not influenced by any treatment significantly. Feed consumption and mean feed consumption was improved with supplementation of EL (I) by 14%, EL (h) by 18%, VC by 10%, BE by 14%, VE by 2.2 %, BE X VC 22%, and BE X VE by 16%. Feed efficiency was numerically decreased with supplementation of EL (I) 9%, EL (h) 7%, VC 4%, BE 4%, BE X VC 8%, and BE X VE by 4%.

Water consumption

Water consumption (WC), daily water consumption (DW), water to body weight gain ratio (WR) and water feed ratio (WF) were not influenced by any of treatment. WC and DW was increased with all treatments, EL (I) by 38%, 37% EL (h) by 28%, VC 5%, BE by 21%, VE by 11%, BE X VC by 25%, BE X VE by 31%. Water gain ratio was also increased with supplementation of EL (I) by 44%, EL (h) by 33%, VC by 4%, BE 14%, VE 11%, BE X VC 20%, BE X VE by 30% compared with control groups. Water feed ratio was increased with EL (I), EL (h), BE, VE BE X VE by 22%, 96%, 18%, 24% and was decreased with VC by 37%, and BE X VC 32 %.

Immunity

New castle disease titer (NDT) was improved significantly with VE (3%) and VC (2.8%) but no significant improvement was observed with EL (I) +18%, EL (H) +4%, BE +13%. Infectious of bursal disease titer (Table 22) was depressed with all treatments.

Survivability

There were no effect of treatments on survivability however all treatments tended to depress survivability.(Table 23)

Carcass composition

Carcass composition comprised in Table 23 showed no significant improvement in any variables with any treatment. There were many observations indicating improvements in carcass compositions. Total yield (TY) was depressed with EL, VC, VE, BE X VC, BE X VE but was improved with BE (3%). Survivability ratio improved with EL (l) by 1%, EL (h) by 7%, BE by 5%, BE X VE by 3% and was depressed with supplementation of VC, VE and BE X VC. Dressing percentage (DP) was improved with EL (l) by 1%, EL (h) by 0.2%, BE by .5%, BE X VC by 0.58%, BE X VE 0.4% and depressed with VE. Twelve hours fasted body weight (BW), improved with EL (h) by 0.88%, BE by 4%, BE X VC by 0.24%, BE X VE by 0.18% and decreased EL (l) and VE. Specific gravity (SG) tended to increase with supplementation of EL (l) by 0.3%, VC by 0.38%, BE by 0.6%, BE X VC by 11% whereas EL (h) and VE showed negative influence on SG. Hot weight (HW) was improved with EL (h) by 0.3%, BE by 5%, BE X VC by 1%, BE X VE 1% and were depressed with EL (l), VC and VE compared with their control group. Chill weight (CW) was improved with EL (h) by 1%, BE (4%), BE X VC (0.7%), BE X VE (0.4%) and decreased with VC and VE. Percentage of dressing wastage (PVS) was low with EL, VC, BE, BE X VC, BE X VE and was high with VE (3%). Water absorption (WA), spleen weigh as a percentage of BW (SWP) and bursal weight as a percentage of body weight

(BRP) were not influenced by any treatment (Table 24). With supplementation of EL (l), VC, BE, VE, BE X VC BE X VE less WA and was high with EL (h) by 3%, compared with control. Spleen weight as a percentage of body weight (SPW) showed an increasing pattern with EL (l) and EL (h) by 14% and 7%, other treatments showed decreasing pattern of SWP. Bursal weight as a percentage of body weight (BRP) was higher with EL (h) by 20%, VC (11%), VE (5%) and was lower with BE, and BE X VE compared with control groups.

Body temperature

Body temperature at the age of 35 d (BT35), 41 d (BT 41) and mean body temperature (MBT) comprised in table 25 indicates no significant effect of treatments. BT 35 was low with EL (l) 0.6%, EL (h) 0.09%, VC (0.3%), VE (0.07%) and was higher with BE (0.3%) and BE X VE 0.2%. BT 41, lower with EL (h) 0.2%, VC (3%) and was higher with EL (l) 0.2%, BE (0.3%), VE (0.43%) BE X VC (0.1%) and BE X VE 0.7%. MBT was higher with BE (0.3%), VE (0.2%), BE X VC (0.07%), BE X VE (0.5%) and lower with EL (l) 0.2%, EL (h) 0.1% and VC (0.3%).

Serum chemistry

Serum chemistry comprised in Table 26 shows a significant effect of increasing EL (h) on uric acid (UR) compared with control and EL (l). Vitamin C and BE tended to decrease UR not significantly whereas VE increased UR Two way-interactions of BE X VC showed significantly decreased (42%) UR compared with control VC and BE. Two way-interaction of BE X VE was also significantly influenced the level of UR which showed the lowest concentration

(25%) UR level. Chloride (CL) was not significantly influenced with any treatment but was increased with EL (h) by 3%, BE by 15 %, VE by 7%, BE X VC by 0.7%, BE X VC by 11% and decreased with EL (l) and VC. Magnesium (Mg) concentration was decreased with the supplementation of EL (l) and VC and were decreased concentration and were increased with the supplementation of EL (h) 8%, BE 2%, VE 0.7%, BE X VC 11%, BE X VE 8%. Albumin (AL) was increased with EL (l) by 2%, EL (h) by 12%, BE by 4%, VE by 20%, BE X VC by 4%, BE X VE by 23% and decreased with the supplementation of VC compared with control group. Calcium (Ca) was decreased with EL, VC, VE and was increased with BE, BE X VC, BE X VE by 10%, 2%, 9% respectively compared with control group. Phosphorus (PHO) was higher in birds, which were supplemented with EL (h) 8%, BE by 4%, VE by 7%, BE X VE by 11%. Phosphors decreased with EL (l), VC, and BE X VC. Sodium (Na) was lower in birds given EL (l), VC, BE X VC treatments and higher EL (h) 5%, BE 2%, VE 9% and BE X VE 10%. Potassium (K) concentration was lower when given EL (l) and VC and was higher with treatments EL(h) by 3%, BE 1%, BE X VE by 10%. Potassium was significantly increased with VE (15%) compared with control. Triglyceride (TR) was lower in birds with EL (l) and VC treatments and was higher with EL (h) by 3%, BE by 6%, BE X VC by 8%, BE X VE by 41%.Triglyceride was significantly increased with VE (37%) compared with control.

Total yield

Total yield was divided into low yield (LY) medium yield (MY) and high yield (HY) to determine effects of different variables. Chill weight (CW), water temperature (WT), spleen weight percentage of fasted body weight (SWP), bursa weight percentage of body weight (BRP), survivability (SR), dressing wastage as a percentage of body weight (PVS), survivability ratio (SA), dressing percentage (PD) and specific gravity (SG) comprised (Table 27) indicates that high CW was the effect HY ($p<0.0001$) where as low CW for LY and medium CW for MY. High, low and medium HY shows high WT with HY and low WT with low WT. Those broilers with a HY had a higher survivability than those birds with a LY. Dressing wastage as a percentage of body weight PVS, SA and PD were significantly effected by the HY, LY and MY yet did not significantly effect SG.

There was no significant effect of yield on average hematocrit (AHC), body temperature age d 35 (BT35), d 41(BT41), and mean body temperature (MBT) (Table 28). It is important to point out that HY, MY and LY have high, medium and low level of AHC. Body temperature effects showed that low medium and high HY has low medium and high BT41 and MBT respectively but BT35 was high with LY medium with MY and low with HY.

Serum chemistry effect on total yield (Table 29) indicated that total yield has significant effects on uric acid (UR). Level of UR was significantly higher in HY compared with MY but not with LY. Chloride was higher in HY and LY compared with MY. It was observed that Mg, AL, PHOS and Na was less in MY compared with HY and LY. Concentration of Ca and TR were of higher in LY and compared to HY.

Correlation

A significant positive relationship of FE and negative relationship of PG, FC, and MF was found with BT35, BT41 and MBT. FW has showed significant positive relation ship with BT41 and MBT but not with BT35. No significant relation ship of water temperature (WT) was observed with any of variables (Table30). There was not any significant correlation of WG, DW, DG, WC, WG and WF with BT35, BT41, MBT and WT.

Survivability (SR) was positively correlated (highly significant) with BT41 and MBT (table 31). Survivability ratio (SA) was negatively and significantly correlated with MBT but no significant correlation was seen with BT35 and BT41 (Table 31). Total yield (TY) was (significantly) positively correlated with BT41. No significant correlation ship of SW, CW, VS, GW, SG, WA and BR are seen with BT35, BT41 and MBT. (Table 31)

Immunity of New Castle disease (NDT), infectious of bursal disease (IBDT) and average hematocrit (AHC) is comprised in table 32. Titer of NDT and AHC were not significantly correlated with BT35, BT41and MBT. Water temperature and IBDT was (significantly) positively correlated with BT41. No significant correlation of serum chemistry was observed with BT35, BT41 and MBT (Table 33).

Dressing percentage (DP) was found positively correlated with magnesium (Mg) whereas bursal weight (BR) and survivability ratio (SA) were negatively and significantly correlated with potassium (K) Table 34. No significant

correlation between SG,T Y, WA, SW, CW, WW and VS and CL, Mg, TR, UR, AL, Ca, PHOS and Na were observed (Table 34).

There were not any significant correlation of FW, WG, WC, DW, DG, PG, WG, WF, FC, MF, FE and FE with CL, Mg, TR, UR, AL, Ca, PHOS, K and Na except FW and K which were significantly correlated (Table 35). There were no significant relation of NDT, BDT and AHC with CL, Mg, TR, UR, ALB, Ca, PHOS, K and Na (Table 36).

DISCUSSION

Betaine (0.1%) has increased final body weight, body weight gain, daily gain, and feed efficiency when exposed to 24-35^{O} C. Birds raised in 24^{O} C environment increased weight gain, daily gain, percentage of gain, feed consumption and mean feed consumption. Results of (Mathew et al. 1997) dose not support our results increased weight gain and feed consumption of thermoneutral birds because of their birds age (5- 14 d) but he found increased feed intake with the addition of 0.5% betaine. Addition of 0.04% betaine did not significantly effects weight gain but the feed conversion efficiency (Schutte et al., 1997). Elevated feed efficiency agreed with the result of Teeter and Belay (1999) with the supplementation of betaine 0.1 %. This impact of improved FE could be because of water balance. Mathew et al, (2000) observed tendency of decreasing average daily gain with the supplementation of betaine via feed. They concluded on the basis of their findings that betaine is just as likely to give

positive or negative growth response. There is lack of research regarding betaine efficacy during heat stress. Interaction of electrolyte and betaine has significantly decreased percentage of gain, feed consumption and mean feed consumption of heat-exposed birds. Betaine increased numerically water consumption, daily water consumption, feed to water ratio and water to weight gain ratio in both experiments. Carcass compositions were also improved with the addition of betaine as well as New Castle disease titer. It was very interesting observation that betaine decreased body temperature in heat exposed birds and increased body temperature in thermoneutral. Early biochemical studies led to the conclusion that betaine improves growth because of its ability to donate methyl groups. Decreased feed consumption in heat stress environment causes birds to decrease their growth rate. Supplementation of betaine through drinking water provides methyl groups to compensate growth because of decreased methyl due to low feed intake due to high ambient temperature. Birds maintain the intracellular concentration of water that is crucial for homeostasis by osmoregulation, the ability of a cell to maintain its structure and function by regulating movement of water in and out of the cell (Kidd, et al., 1997). Water is the major component of animal body vital for survival (Dick, 1979). Betaine is also well known as a osmoprotective due to the dipolar zwitterions characteristics and its high solubility (Chambers and Kunin., 1985). In mammalian cells the common inorganic intracellular osmolytes are potassium, magnesium and phosphate. Common organic osmolytes include methylated amines e g, Betaine, (Bagnasco et al., 1986; Wunz and Wright, 1993). These osmolytes protect cells

from environments with high levels of sodium chloride (Yancey et al., 1989). Our result indicates high level of serum chloride, sodium and magnesium by the treatment of betaine in both experiments.

Vitamin C (VC) has no significant effect on FW, WG, DG, PG, FC, ME, MF and FE in environment temperatures. Vitamin C showed numerical increasing FW (1.2%), DG (0.8%), FC (4%), MF (4%) exposed to heat stress. Final weight (1%), WG (2%), DG(2.2%), PG(3.3%), FC(10%) and MF(10%) was increased in thermoneutral birds by VC. Water consumption, DW and WR was not significantly increased due to heat stress. Spleen weight as a percentage of body weight (SWP) was decreased in heat stress and thermoneutral birds whereas BRP was increased only in thurmonutral birds. Carcass composition was not effected with supplemented VC in heat stressed birds but BW, HW, CW, SG and TY were increased numerically. Thermoneutral birds did not show any of significant effect with supplementation of VC but PD and SG numerically increased whereas TY, SA, BW, HW, CW and PVS were numerically decreased. Body temperatures BT35, BT41 but MBT were increased with the addition of VC compared with control group in thermoneutral and were increased in heat stressed birds. AHC of heat stressed birds were decreased with VC supplementation in heat stress. Survivability was not affected with VC but slightly (0.9%) improved in heat stress birds compared with control groups. There were not significant effect of VC on immunity in heat stressed birds but new castle disease titer was significantly improved with VC of thermoneutral birds. Serum chemistry has also no significant effect with VC of stressed birds.

Our results regarding mortality was agreed with Stillborn et al (1988) in which he did not observe significant effect on survivability, weight gain, feed efficiency during heat stress with the supplementation of VC (1000 ppm). Glic (1963); Reid et al (1964), and Adams and Rogler (1968) found that VC incorporated in broilers diets in amount ranging from 0.005 to 0.15% did not influence feed efficiency of weight gain. Pardue et al., (1985) has demonstrated no effect of VC (1000mg .Kg) on broiler growth. Inclusion of VC at .005 and .08% of broiler diets had no significant effect of 4-wk and 8-wk body weights. Our result with the inclusion of 0.04 % VC has the same result. Chickens synthesize VC primarily in the kidney (Roy and Guha, 1958). The quantity synthesized should be sufficient for normal growth and metabolism (Sealock and Silberstein, 1940; Sealock and Goodland, 1951) but under stressful conditions synthesized VC might not meet physiological needs (Thornton, 1961; Seigal, 1971; Horning et al., 1984). VC could reduce the synthesis of glucocorticoids during heat stress (Thanxton and Pardue, 1984) as plasma corticosteroid levels are significantly greater of heat stressed non-supplemented chicks than for VC supplemented, heat stressed chicks (Pardue et al., 1985b). Thus VC supplementation during heat stress could be beneficial to growth in broilers, as heat-induced increases in corticosteroids (Siegel et al, 1984) may cause an increased degradation of tissue proteins (Frankel et al., 1967, 1970)

VE improved numerically FW (+6%), FE (+6.1%) WC (+17%), DW (+7.8%), WF (+ 6%), WR (+5%), GWP (+5%), SR (+4%) NDT (+18%, p= 0.04), BW (+1.56%), HW (+1.8%), CW (+1.9%), SG (+0.11%), SA (+1.1%), TY (+5.1%),

DP (+0.4%), WA (+0.9%) in heat stress birds. Serum chemistry results indicated increasing pattern of CL (+ 1.8%), Mg (+2.1%), TR (+4.5%), AL (+1%), Phos (+1%), Na (+1.5%) and K(+6.2%) with supplementation of VE in heat stressed birds. Vitamin E supplementation effected PG (+1.3%) FC (+2.2%), MF (+2.2%), WC(+11%), DW(+11%), WR (+14%),WF (+18%),SR(-3%), NDT (+30%, $P< 0.05$), PVS(+3%), CL (+ 7%), Mg (+0.7%), UR (+8%),TR (+37%, $p<0.001$), AL (+20%), Phos (+6.8%), Na (+9%) and K(+15%,$p<0.05$) in thurmonutral reared birds. Body temperatures (BT35)-.07%), BT41+0.43% MBT +0.2% in thurmonutral and BT35 (-1.1%), BT41 (-0.14%), MBT (-0.6%) in heat stress with the supplementation of VE. VE improved survivability by 4 % in the heat stress birds not in thermoneutral birds. Our result agreed with the result of Jackson et al (1978) in which they found reduced mortality with the supplementation of VE.

There is very little work on effect of VE on chickens exposed to heat stress. Body weight gain and feed conversion of heat stressed birds were significantly improved (1-21d) with the supplementation of vitamins A, B, E and D (Ferket and Qureshi, 1992). New Castle disease titers in both experiments were significantly improved with supplementation of VE. It is agreed with the finding of Gore and Qureshi (1997) and Erf et al., (1998) in which they observed immunity stimulation of Newcastle disease with supplementation of vitamin E. Effects of VE appear to be influenced by several factors including age and dietary levels of vitamin E (Gore and Qureshi, 1997, Erf et al., 1998). The immunological responses of different commercial nuclear broiler lines to two dietary levels of

vitamin E after maturity of the immune system was investigate and observed that dietary VE affected total antibody levels (low> high vitamin E) Gore and Qureshi, ,(1997); Erf et al., (1998).

It is well established that heat stress can lead to a reduction in the birds' defense mechanism or to a relative state of immunosuppression (Thaxton and Seigal., 1970).It is also accepted that any type of stress can lead to over production of oxygen free radicals OH and O2 (Slater, 1984). Free radicals can cause metabolic disturbance and cell injury in many ways. A reactive free radical formed close to DNA may produce a change in the molecular structure resulting in a mutation of cytotoxicity (Collins et al 1994) and cause profound changes in enzyme activities. Reactive free radicals may also damage cells by lipid peroxidation of polyunsaturated fatty acids (PUFAs), by far, the most important damage produced by free radicals in the animal (Halliwell and Gutteridge, 1989). Increased oxidative stress and liver lipid peroxidation were observed in chickens fed on diet rich in PUFAs and the condition was made worse then the birds were fed on a vitamin E-deficient diet (Fuhrmann and Sallmann, 1995). Bollengier et al (1998) explained that vitamin E through its intra-membrane antioxidant properties may protect tissue membranes from lipid peroxidation caused tissue membranes fro lipid peroxidation caused by free radicals attack. It could, therefore, reduce the associated loss of integrity of function of cell membranes and associated increased cellular permeability and play a role in alleviating the effect of heat stress in chickens.

Serum level of TR was significantly increased in thermoneutral birds and numerically increased in heat stress birds agreed with the data of Bollengier-lee, (1985) in which TR was significantly greatest with the supplementation of VE in heat stress chicks. Addition of VE 500 mg / Kg reduced significantly the detrimental effect of chronic heat stress. Rats treated with dehydroepiandrosterone to induce hepatic oxidative injury, vitamin E prevented the associated rise in specific antioxident enzymes and markers of cellular damage (McIntosh et al., 1993). Loss of membrane integrity can be implicated in a reduction in the formation of ATP and decline in cellular metabolism during stress. This damage can be particularly serious in organs such as muscle and liver because of their high metabolic activity (Fowler.,1990).

Feed consumption and MF was reduced (significantly) with supplementation of EL (l) and EL (h) -15%, 4.5% respectively but FE was significantly high (+11%, $p<.001$) with EL(l) in heat stressed birds. Final body weight was numerically higher (+0.54%, 1.7%) by El (l) compared with control and El (h) respectively. Weight gain, DG and PG were reduced with EL (l) 0.54%, 0.04%, 0.63% and EH (h) 2.5%, 2.6%, 1.56% compared with control group. Final weight, WG, DG, and FE of thermoneutral birds with addition of EL was reduced (not significantly) by 5.5%, 0.7%, 5.8%, 8.6 %. Feed consumption was increased by 18% with EL (h), 14% with EL(l), PG by 5.8% with EL(h) and 3.4% with EL (l) of thermoneutral birds. Mean feed consumption (ME) was increased by 6.23 % with EL (h), 3.06% with (EL(l), 18.7% with EL(h), 14% with EL(l), 5.5% EL(h) and 14%

with EL(l) respectively of heat stressed birds. Water consumption of heat stressed birds was improved with the supplementation of EL (l) and EL (h) by 6% and 9%. Daily water was higher 9%, 6% with EL (l) and EL (h), WF and WR were also improved by 21% and 11% with EL (l) and 21%, 13% with the treatment of EL(h). WC, DW, WR and WF were increased with EL but not significantly in experiment 1.

It was observed in heat stress birds that body weight and gain were negatively influenced with the supplementation of electrolyte high level where as the same treatment and same level was shown useful in thermoneutral birds regarding final weight; weight gain, daily gain, feed consumption, mean feed consumption and feed efficiency, fasted (12 h) body weight and survivability was better compared with electrolyte low level in thurmonutral. Water consumption was higher in heat stress birds and was lowest in thurmonutral birds with supplementation of electrolyte low level compared with control. Potassium (K^+) level in serum indicates that electrolytes given at high level followed by more drinking water retained low level of potassium (5.42 mmol/l) compared with control (5.62 mmol/l) and electrolyte low level group (5.62 mmol/l) of heat stressed birds where as potassium status in thermoneutral birds was 6.67 mmol/l with electrolyte high level, 6.16 mmol/l with electrolyte low level and 6.47 mmol/ l in control group. Urinary potassium excretion increases during alkalosis of mammalian species (Harper et al., 1977). The decline in hydrogen ion concentration within the renal tubular cells causes secretion of K^+ to increase because of competition between hydrogen and potassium ions for re absorption

in the distal tubule. Kohne and Jones (1975a) exposed turkeys to acute hyperthermia and observed that birds developed a profound alkalosis and increased plasma potassium concentration. In contrast, Huston (1978) subjected female chickens to 8, 9, and 30 ^{O}C and observed an inverse relationship between ambient temperature and blood K^{+} concentration. Our result agrees with Huston (1978) of decreased K^{+} plasma concentration of heat stress birds compared with thermoneutral group. It indicates that low level of potassium could be because of more water excretion due to more water intake during heat stress and due to the development of anorexia. Hayat and Brake (1999) observed the significant reduction in plasma potassium and increased plasma chloride in the anorexic birds. Teeter et al (1990) observed 64% water excretion during heat stress. Water imbalance believed to be one of the major causes of growth depression. Hayat et al.,(1999) observed high mortality with high level of sodium bicarbonate (8 to 10g / liter water). He further observed that higher the sodium bicarbonate level (2 to 10 g / liter of drinking water) lower the body weight gain during heat stress.

Our electrolyte treatment was pack of electrolytes thus individual electrolyte effect is not possible to discuss. Our result agreed with the result of Hayat et al (1999) in which they did not find any significant effect of different level of sodium bicarbonate on body weight gain, feed consumption and feed conversion ratio but some numerical improvement same as in our result. Our results of improved water intake and water feed ratio also agreed with Hayat et al (1999) with the supplementation of sodium bicarbonate during heat stress ($31^{0}C$).

Our results confirm the earlier report of Balnave and Oliva (1991) that sodium bicarbonate added to the drinking water improves feed efficiency but not weight gain and feed consumption. This disagreement may be because of their experiment conducted at 30 ^{O}C compared with our experiment of 37^{O} C. Electrolyte given at a low level shows a heavier final body weight (FW) and 11% better feed efficiency compared with control group in heat stress where as 14% feed consumption and 3% more gain percentage in thurmonutral birds.

Two way interactions of electrolyte and betaine showed in Table 1 indicated significant decreasing influence on percentage of gain, feed consumption and mean feed consumption with electrolyte high level and betaine compare with control group of birds. It may be due the level of electrolyte, which can not be corrected with the combination of betaine. Electrolyte low level combination with betaine showed positive response on broiler performance in heat stressed birds No literature is available of electrolyte and betaine combination to verify our results. Wasting dressing percentage (skin, visceral organs, neck, feathers, legs, etc) were significantly more (2.5%) in heat stressed birds compared with control group which indicates more weight of wastage been achieved with this treatment. It may be weight of visceral organs or skin, feathers, neck or legs.

Although Hematocrit (Table 7) values were not significantly influence with any of treatments in experiment 1, electrolytes given increased hematocit values. Hematocrit may be influenced by environment temperature (Olson., 1937). Huston (1960) reported an increase in erythrocyte concentration and hematocrit for birds reared at 21.1^{O}C compared to birds reared at 30.0 ^{O}C. Electrolyte

influence on hematocrit value is not clear but significantly positive relationship of Na and K with hematocrit (Table 19) indicates that hematocrit is dependent on plasma electrolyte and metabolite concentration (TR, AL, Phos, Na and K in particular). Electrolyte low resulted in AHC= 31.72, Na =135.37, K=5.83, whereas Electrolyte low level significantly increased the plasma concentration of TR and numerically of AL, Na, K and phosphate.

Body temperatures of heat stressed birds (table 6) and thermonutrla birds (table 25) indicate significantly decreased BT35, BT41 and MBT with electrolyte low level and with betaine of BT35 in heat stressed birds. It is very interesting that vitamin C supplementation increased body temperatures of heat stressed birds and decreased of thermoneutral birds. Betaine was responsible for increasing body temperatures of thermoneutral and decreasing in heat stressed birds. Vitamin E supplementation decreased heat stressed body temperature and increased of thermoneutral bird's body temperature. When vitamin C combined with electrolyte low level it decreases body temperature of heat stressed birds and increases BT41 and MBT of heat stressed birds. Combination of vitamin C with betaine increased body temperature of heat stressed birds and thermoneutral both whereas vitamin C alone decreased body temperature of thermoneutral birds. Vitamin E in combination with betaine decreased body temperature of heat stressed birds and increased body temperature of thermoneutral birds. Our result regarding body temperature of 41 d age agrees with Myers (1974) of increased body temperature with supplementation of sodium on thermoneutral birds where as Edens (1976) did not observe any

significant difference of thermoneutral birds with the treatment of Na. Edens (1976) found significant increased body temperature with the intravenous injection of Na (after 30 minutes) in heat stressed birds. Eden (1976) illustrated that Na and Ca cations affect body temperature regulations in the chicken, but the effects appeared to be dependent upon environmental temperature.

Body temperatures were negatively correlated with plasma electrolyte and with some metabolites (UR, TR, PHO and Ca). Edens (1976) results agrees with our result of increasing body temperature decreased plasma calcium and phosphate. Body temperature age 41 d was negatively correlated with final weight, weight gain, daily gain, feed efficiency and was positively with feed consumption and mean feed consumption. Thermoneutral birds were negatively and significantly correlated with gain, feed consumption and efficiency. This result agrees with the result of Cooper et al (1998) for weight gain not feed consumption and feed efficiency of heat stressed birds even weight gain and feed consumption of thermonutrla birds not agrees with present study. This difference of observations may be due to their short time of data (35 d to 42 d of age) compared to our length of experiment (22 to 42 d of age).

New Castle disease titer was significantly decreased with the supplementation of vitamin C and with EL X BE but was numerically increased with VE and BE X VE of heat stressed birds but was improved in significantly with supplementation of vitamin C and vitamin E. Infectious of bursal disease titer was significantly improved with electrolyte low level, betaine, vitamin E and vitamin C of heat stressed birds and was numerically decreased with electrolyte,

vitamin C and improved with betaine of thermonutrla birds. There are many studies regarding immunity depression due to high environmental temperature (Siegal et al., 1980: Subha Rao et al., 1969. Thaxton et al, 1968 ;: Thaxton et al, 1973). Our observation of immunity suppression in heat stress compare to thurmonutral agrees with above author's findings. Sell et al., (1992) suggested that diets containing fortified levels of protein or essential amino acids, energy and vitamins can stimulate significant compensatory growth in flock affected by severe enteritis. Immunity stimulation of New castle disease through vitamin C in thermonutrla agrees with the suggestion of Gross (1992). Enhanced immunity of NDT with the supplementation of Vitamin E in heat stress also agrees with results of Franchini,(1990) and McIlroy et al (1993).

Total yield (table 9) was significantly affected by feed consumption, mean feed consumption, and feed efficiency. High yield was significantly improved with high feed efficiency but feed consumption and mean feed consumption was significantly higher in low yield compared with high yield and medium yield of heat stressed birds. Improved feed efficiency in heat stressed birds was due to electrolyte, betaine and vitamin E. There was no significant effect of yield (table 27) on live performance of weight and water consumption of thermonutrla birds.

Body weight (12 h fasted) hot weight and chill weight, dressing wastage, survivability, and dressing percentage significantly improved the high yield compared with medium yield and low yield of heat stressed birds. Chill weight, survivability, dressing wastage, survivability ratio and dressing percentage were significantly influenced on yield. Cumulative effect of electrolyte, betaine, vitamin

C and vitamin E on general performance resulted on total yield of heat stress and thermoneutral birds. In conclusion on the basis of data presented it could be drawn that about treatment could be helpful tool for optimum growth from environmental affected birds and protection against the detrimental effects of different diseases.

Research question

Different levels of electrolyte pack, vitamin C combination with vitamin E to examine immunity status and general performance of heat stressed broiler could be included for future research

TABLE 1. Effect of electrolyte (EL), betaine (BE), vitamin C (VC) and vitamin (VE) on final body weight (FW), weight gain (WG), daily gain (DG), percentage weight gain (PG), feed consumption (FC), mean feed consumption (MF), feed efficiency (FE) of male broilers exposed to 37° C age 22 to 42 d

Treatment		FW(g)	WG(g)	DG(g)	PG(%)	FC(g)	MF(g)	FE(g:g)
Main effects[#]	**EL**							
	Control	2023	1380.94	69.04	68.23	3135.60[a]	157.68[a]	0.45[c]
	EL (l)	2034	1380.36	69.01	67.81	2724.28[b]	136.21[c]	0.51[a]
	EL (h)	1999	1345.79	67.28	67.18	2999.59[a]	149.97[ab]	0.46[bc]
	VC							
	Control	2007	1363.51	68.17	67.89	2899.61	144.93	0.48
	VC	2030	1347.56	68.72	67.59	3019.71	150.98	0.47
	BE							
	Control	2006	1364.37	68.21	67.95	3046.45	152.32	0.47
	BE	2031	1373.69	68.68	67.54	2871.87	143.59	0.48
	VE							
	Control	2013	1370.96	68.54	68.06	3043.45	152.17	0.46
	VE	2025	1367.10	68.35	67.42	2874.86	143.74	0.49
Interactions[#]	**EL x VE**							
	Control	2026	1392.01	69.60	68.72	3228.10	161.40	0.45
	VE	2020	1369.87	68.49	67.75	3079.10	153.95	0.46
	EL (l)	1992	1346.98	67.34	67.56	2726.45	136.32	0.50
	EL (l) x VE	2076	1413.74	70.68	68.05	2722.11	136.10	0.53
	EL (h)	2021	1373.89	68.69	67.89	3175.81	158.79	0.45
	EL (h) x VE	1977	1317.69	65.88	66.47	2823.37	141.16	0.47
	EL x VC							
	Control	2007	1370.32	68.51	68.30	3061.03	153.05	0.47
	VC	2039	1391.56	69.57	68.17	3246.18	162.30	0.46
	EL (l)	2021	1358.55	67.92	67.47	2697.00	134.85	0.51
	EL (l) x VC	2056	1402.17	70.1	68.15	2751.56	137.57	0.51
	EL (h)	2002	1361.65	68.08	67.91	2937.80	146.89	0.48
	EL (h) x VC	1996	1329.93	66.49	66.46	3061.38	153.06	0.44

TABLE 1. Effect of electrolyte (EL), betaine (BE), vitamin C (VC) and vitamin (VE) on final body weight (FW), weight gain (WG), daily gain (DG), percentage weight gain (PG), feed consumption (FC), mean feed consumption (MF), feed efficiency (FE) of male broilers exposed to 37° C age 22 to 42 d (continue)

Treatments	FW(g)	WG(g)	DG(g)	PG(%)	FC(g)	MF(g)	FE(g:g)
EL x BE							
Control	2012	1392.33	69.61	69.19^{a}	3520.86^{a}	176.04^{a}	0.42
BE	2034	1369.55	68.47	67.28^{b}	2786.34^{bcde}	139.31^{bcd}	0.49
EL	1993	1340.49	67.02	67.21^{b}	2602.45^{e}	130.12^{d}	0.53
EL (l) x BE	2075	1420.23	71.01	68.41^{ab}	2846.11^{bcd}	142.30^{bcd}	0.50
EL (h)	2014	1360.29	68.01	67.44^{ab}	3016.03b	150.80^{b}	0.46
EL (h) x BE	1984	1331.29	66.56	66.92^{b}	2983.15bc	149.15^{bc}	0.46
BE x VE							
Control	2003	1368.19	68.40	68.30	3194.49	159.72	0.45
VE	2010	1360.55	68.02	67.60	2898.41	144.92	0.48
BE	2023	1373.72	68.68	67.82	2892.42	144.62	0.48
VE x BE	2039	1373.65	68.68	67.25	2851.32	142.56	0.49
BE x VC							
Control	2005	1369.76	68.48	68.32	2929.59	146.47	0.48
VC	2008	1358.98	67.94	67.57	3163.30	158.16	0.45
BE	2010	1357.25	67.86	67.47	2867.63	143.38	0.48
BE x VC	2053	1390.13	69.50	67.61	2876.11	143.80	0.49
EL x BE x VC							
Cont	1984	1371.77	68.58	69.20	3146.65	157.33	0.44
VC	2040	1412.90	70.64	69.17	3895.08	194.75	0.39
BE	2030	1368.87	68.44	67.03	2975.40	148.77	0.46
BE x VC	2037	1370.22	68.51	67.17	2597.27	129.86	0.52
EL (l)	2009	1355.05	67.75	67.42	2502.40	125.12	0.55
EL (l) x VC	1977	1325.92	66.28	66.99	2702.50	135.12	0.50
EL (l) x BE	2016	1362.04	68.10	67.51	2891.60	144.58	0.48
EL (l) x BE x VC	2135	1478.42	73.92	69.31	2800.62	140.03	0.53
EL (h)	2022	1382.46	69.12	68.33	3139.73	156.98	0.46
EL (h) x VC	2007	1338.12	66.90	66.56	2892.33	144.61	0.46
EL (h) x BE	1983	1340.83	67.04	67.49	2735.87	136.79	0.49
EL (h) x BE x VC	1986	1321.74	66.08	66.35	3230.44	161.52	0.42

TABLE 1. Effect of electrolyte (EL), betaine (BE), vitamin C (VC) and vitamin (VE) on final body weight (FW), weight gain (WG), daily gain (DG), percentage weight gain (PG), feed consumption (FC), mean feed consumption (MF), feed efficiency (FE) of male broilers exposed to 37° C age 22 to 42 d (continue)

Treatments		FW(g)	WG(g)	DG(g)	PG(%)	FC(g)	MF(g)	FE(g:g)
	EL x BE x VE							
	Cont	2010	1402.09	70.10	69.81	3559.06	177.95	0.42
	VE	2014	1382.58	69.12	68.57	3482.67	174.13	0.42
	BE	2041	1381.93	69.09	67.63	2897.13	144.85	0.48
	BE x VE	2026	1357.17	67.85	66.93	2675.54	133.77	0.51
	EL (l)	1975	1331.63	66.58	67.37	2709.60	135.48	0.49
	EL (l) x VE	2011	1349.35	67.46	67.05	2495.29	124.76	0.56
	EL (l) x BE	2009	1362.33	68.11	67.76	2743.30	137.16	0.50
	EL (l) x BE x VE	2142	1478.13	73.90	69.06	2948.92	147.44	0.50
	EL (h)	2022	1370.87	68.54	67.71	3314.80	165.74	0.44
	EL (h) x VE	2006	1349.72	67.48	67.71	2717.26	135.86	0.48
	EL (h) x BE	2021	1376.91	68.84	68.07	3036.82	151.84	0.46
	EL (h) x BE x VE	1948	1285.66	64.28	65.77	2929.49	146.47	0.46
ANOVA	DF	Significant						
EL	2	n.s	n.s	n.s	n.s	**	**	**
VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL X VE	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x VC	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE	2	n.s	n.s	n.s	*	*	*	n.s
BE x VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE x VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE x VC	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE x VE	3	n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant,*p< 0.05, **p <.00, a-c Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05) #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 2. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on water consumption (WC), daily water (DW), water feed ratio (WF), water :gain ratio(WR), of male broilers exposed to 37° C age 22 to 42 d

Treatment		WC(l)	DW(ml)	WF(g:g)	WR(%)
Main effects#	**EL**				
	Control	7.42	278.51	1.87	3.86
	EL(l)	7.95	298.16	2.37	4.44
	EL(h)	8.21	308.14	2.30	4.37
	VC				
	Control	7.53	282.40	2.10	4.02
	VC	8.19	307.40	2.25	4.43
	BE				
	Control	7.13	267.47	2.09	3.90
	BE	8.59	322.40	2.26	4.55
	VE				
	Control	7.54	283.04	2.11	4.11
	VE	8.18	306.83	2.25	4.34
Interactions#	**EL x VE**				
	Control	6.80	255.17	1.85	3.56
	VE	8.04	301.85	1.88	4.17
	EL(l)	7.95	298.35	2.45	4.58
	EL(l)x VE	7.94	297.96	2.28	4.30
	EL(h)	7.88	295.60	2.02	4.19
	EL (h) x VE	8.55	320.68	2.58	4.55
	EL x VC				
	Control	7.59	284.86	1.88	4.01
	VC	7.25	272.16	1.85	3.72
	EL(l)	7.47	280.27	2.15	4.08
	EL(l) x VC	8.48	316.05	2.58	4.80
	EL(h)	7.52	282.07	2.27	3.96
	EL(h) x VC	8.91	334.21	2.32	4.78
	EL x BE				
	Control	5.43	203.90	1.53	2.93
	BE	9.41	353.12	2.20	4.79
	EL	8.01	300.39	2.47	4.65
	EL(l) x BE	7.89	295.93	2.27	4.24
	EL(h)	7.95	298.12	2.29	4.13
	EL(h) x BE	8.48	318.16	2.31	4.61
	BE x VE				
	Control	6.84	256.70	1.98	3.79
	VE	7.41	278.24	2.21	4.01
	BE	8.25	309.38	2.23	4.43
	VE x BE	8.94	335.42	2.29	4.67
	BE x VC				
	Control	6.96	261.15	2.00	3.69
	VC	7.30	273.78	2.19	4.12
	BE	8.09	303.64	2.20	4.35
	BE x VC	9.09	341.17	2.31	4.75

TABLE 2. Effect of electrolyte(EL), betaine (BE), vitamin C (VC) and vitamin (VE) on water consumption (WC), daily water (DW), water feed ratio (WF), water ;gain ratio(WR), of male broilers exposed to 37° C age 22 to 42 d (continue)

Treatments	**El x BE x VC**	WC(l)	DW(ml)	WF(g:g)	WR(%)
	Cont	4.98	186.91	1.42	2.73
	VC	5.89	220.89	1.64	3.14
	BE	10.20	382.81	2.35	5.29
	BE x VC	8.62	323.43	2.06	4.29
	EL(l)	7.53	282.42	2.21	4.07
	EL(l) x VC	8.48	318.35	2.72	5.23
	EL(l) x BE	7.41	278.12	2.09	4.10
	EL(l) x BE x VC	8.36	313.75	2.45	4.37
	EL(h)	8.37	314.41	2.37	4.28
	EL(h) x VC	7.52	282.10	2.20	3.98
	EL(h) x BE	6.66	250.00	2.17	3.64
	EL(h) x BE x VC	10.30	386.32	2.44	5.59
	El x BE x VE				
	Cont	5.54	208.00	1.54	3.01
	VE	5.32	199.84	1.52	2.86
	BE	8.06	302.34	2.16	4.11
	BE x VE	10.77	403.90	2.25	5.48
	EL(l)	7.81	292.96	2.42	4.59
	EL(l) x VE	8.20	307.81	2.52	4.71
	EL(l) x BE	8.10	303.75	2.49	4.58
	EL(l) x BE x VE	7.68	288.12	2.05	3.90
	EL(h)	7.17	269.14	1.98	3.78
	EL(h) x VE	8.72	327.10	2.59	4.48
	EL(h) x BE	8.58	322.07	2.05	4.60
	EL(h) x BE x VE	8.38	314.25	2.57	4.63
ANOVA	DF	Significant			
EL	2	n.s	n.s	n.s	n.s
VC	1	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s
EL X VE	2	n.s	n.s	n.s	n.s
EL x VC	2	n.s	n.s	n.s	n.s
EL x BE	2	n.s	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s	n.s
3.86BE x VC	1	n.s	n.s	n.s	n.s
EL .x BE x VC	2	n.s	n.s	n.s	n.s
EL x BE x VE	3	n.s	n.s	n.s	n.s

n.s=not significant, #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 3. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) gall bladder final body weight ratio(GWP), spleen weight body weight ratio(SWP), bursa of fibricious weight body weight ratio(BRP), dressing wastage weight body weight ratio (PVS), survivability(SR) of male broilers exposed to 37° C age 22 to 42 d

Treatment		GWP	SWP	BRP	PVS	SR
Main effects#	**EL**					
	Control	0.19	0.10	0.14	28.43[b]	72.16[b]
	EL(l)	0.13	0.12	0.14	29.18[a]	86.86[a]
	EL(h)	0.18	0.10	0.15	28.53[ab]	79.16[a]
	VC					
	Control	0.17	0.11	0.14	28.77	79.16
	VC	0.16	0.10	0.14	28.66	79.86
	BE					
	Control	0.17	0.10	0.14	28.78	76.33
	BE	0.16	0.11	0.14	28.68	82.63
	VE					
	Control	0.16	0.11	0.14	28.88	77.89
	VE	0.17	0.11	0.14	28.58	81.13
Interactions#	**EL x VE**					
	Control	0.16	0.11	0.14	28.27	70.13
	VE	0.21	0.10	0.14	28.60	75.69
	EL(l)	0.11	0.11	0.13	29.39	86.80
	EL(l)x VE	0.15	0.13	0.14	28.97	86.11
	EL(h)	0.21	0.11	0.15	28.88	76.73
	EL (h) x VE	0.14	0.10	0.14	28.18	81.59
	EL x VC					
	Control	0.20	0.11	0.15	28.50	75.00
	VC	0.17	0.10	0.13	28.37	70.83
	EL(l)	0.12	0.13	0.14	28.99	84.37
	EL(l) x VC	0.14	0.10	0.13	29.37	88.54
	EL(h)	0.19	0.11	0.14	28.81	78.12
	EL(h) x VC	0.17	0.10	0.14	28.25	80.20
	EL x BE					
	Control	0.16	0.10	0.14	28.79	63.88
	BE	0.21	0.11	0.13	28.07	81.94
	EL	0.16	0.11	0.13	29.07	85.41
	EL(l) x BE	0.09	0.12	0.14	29.29	87.50
	EL(h)	0.19	0.10	0.15	28.36	79.86
	EL(h) x BE	0.17	0.11	0.14	28.69	78.47
	BE x VE					
	Control	0.15	0.10	0.14	29.06	75.00
	VE	0.19	0.10	0.14	28.43	77.77
	BE	0.17	0.12	0.14	28.63	80.78
	VE x BE	0.14	0.11	0.14	28.73	84.49
	BE x VC					
	Control	0.14	0.10	0.15	28.50	77.77
	VC	0.20	0.10	0.13	28.99	75.00
	BE	0.19	0.12	0.14	29.04	80.55
	BE x VC	0.13	0.10	0.14	28.33	84.72

TABLE 3. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) gall bladder final body weight ratio(GWP), spleen weight body weight ratio(SWP), bursa of fibricious weight body weight ratio(BRP), dressing wastage weight body weight ratio (PVS), survivability(SR) of male broilers exposed to 37° C age 22 to 42 d(continue)

	El x BE x VC	GWP	SWP	BRP	PVS	SR
	Cont	0.16	0.10	0.15	28.27	70.83
	VC	0.15	0.10	0.13	29.23	56.94
	BE	0.23	0.12	0.14	28.72	79.16
	BE x VC	0.20	0.10	0.12	27.42	84.72
	EL(l)	0.13	0.12	0.15	28.76	89.58
	EL(l) x VC	0.20	0.11	0.11	29.38	81.25
	EL(l) x BE	0.11	0.14	0.13	29.29	79.16
	EL(l) x BE x VC	0.08	0.10	0.16	29.35	95.83
	EL(h)	0.14	0.10	0.14	28.46	72.91
	EL(h) x VC	0.23	0.10	0.15	28.27	86.80
	EL(h) x BE	0.23	0.12	0.14	29.16	83.33
	EL(h) x BE x VC	0.10	0.11	0.15	28.23	73.61
	El x BE x VE					
	Cont	0.15	0.10	0.13	28.30	62.50
	VE	0.16	0.09	0.15	29.29	65.27
	BE	0.17	0.11	0.14	28.24	77.77
	BE x VE	0.26	0.11	0.12	27.90	86.11
	EL(l)	0.12	0.11	0.13	29.67	90.27
	EL(l) x VE	0.21	0.12	0.12	28.48	80.55
	EL(l) x BE	0.10	0.11	0.14	29.11	83.33
	EL(l) x BE x VE	0.09	0.13	0.15	29.46	91.66
	EL(h)	0.17	0.10	0.15	29.21	72.22
	EL(h) x VE	0.20	0.10	0.14	27.52	87.50
	EL(h) x BE	0.26	0.09	0.14	28.54	81.25
	EL(h) x BE x VE	0.08	0.10	0.15	28.84	75.69
ANOVA	DF	Significant				
EL	2	n.s	n.s	n.s	*	*
VC	1	n.s	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s	n.s
EL X VE	2	n.s	n.s	n.s	n.s	n.s
EL x VC	2	n.s	n.s	n.s	n.s	n.s
EL x BE	2	n.s	n.s	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s	n.s	n.s
BE x VC	1	n.s	n.s	n.s	n.s	n.s
EL x BE x VC	2	n.s	n.s	n.s	n.s	n.s
EL x BE x VE	3	n.s	n.s	n.s	n.s	n.s

n.s=not significant,*p< 0.05, $^{a-b}$ Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05) #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 4. Effect of electrolyte(EL), betaine (BE), vitamin C (VC) and vitamin (VE) infectious bursal disease titer (BDT) and new castle disease titer (NDT) of male broilers exposed to 37° C age 47 d

Treatment		BDT	NDT
Main effects#	**EL**		
	Control	-0.0004[b]	1.28
	EL(l)	-0.0033[ab]	0.93
	EL(h)	-0.0034[a]	0.90
	VC		
	Control	-0.0026	1.13[a]
	VC	-0.0015	0.94[b]
	BE		
	Control	-0.0013	0.98
	BE	-0.0029	1.09
	VE		
	Control	-0.0035	0.93[b]
	VE	-0.0006	1.14[a]
Interactions#	**EL x VE**		
	Control	-0.0036[b]	1.03
	VE	0.0045[a]	1.52
	EL(l)	-0.0046[b]	0.93
	EL(l)x VE	-0.0021[b]	0.93
	EL(h)	-0.0025[b]	0.83
	EL (h) x VE	-0.0043[b]	0.96
	EL x VC		
	Control	0.0033[a]	1.08
	VC	-0.0024[bc]	1.47
	EL(l)	-0.0076[d]	1.16
	EL(l) x VC	0.0008[ab]	0.70
	EL(h)	-0.0037[bc]	1.14
	EL(h) x VC	-0.0032[bcd]	0.65
	EL x BE		
	Control	0.0035[a]	1.21[a]
	BE	-0.0026[b]	1.35[a]
	EL	-0.0039[b]	1.02[a]
	EL(l) x BE	-0.0028[b]	0.84[b]
	EL(h)	-0.0037[b]	0.70[b]
	EL(h) x BE	-0.0031[b]	1.09[a]
	BE x VE		
	Control	-0.0029	0.75
	VE	0.0002	1.20
	BE	-0.0041	1.11
	VE x BE	-0.0016	1.07
	BE x VC		
	Control	-0.0037[b]	1.08
	VC	0.0009[a]	0.87
	BE	-0.0016[ab]	1.17
	BE x VC	-0.0041[ab]	1.01

TABLE 4. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE)) infectious bursal disease titer (BDT) and new castle disease titer (NDT) of male broilers exposed to 37° C age 42 d(continue)

Treatment		BDT	NDT
	El x BE x VC		
	Cont	0.0057	n.e
	VC	0.0013	n.e
	BE	0.0008	n.e
	BE x VC	-0.0061	n.e
	EL(l)	-0.0061	n.e
	EL(l) x VC	-0.0131	n.e
	EL(l) x BE	0.0052	n.e
	EL(l) x BE x VC	-0.0021	n.e
	EL(h)	-0.0035	n.e
	EL(h) x VC	-0.0038	n.e
	EL(h) x BE	-0.0036	n.e
	EL(h) x BE x VC	-0.0035	n.e
	El x BE x VE		n.e
	Cont	-0.0025	n.e
	VE	0.0096	n.e
	BE	-0.0047	n.e
	BE x VE	-0.0005	n.e
	EL(l)	-0.0062	n.e
	EL(l) x VE	-0.0015	n.e
	EL(l) x BE	-0.0029	n.e
	EL(l) x BE x VE	-0.0027	n.e
	EL(h)	-0.0001	n.e
	EL(h) x VE	-0.0073	n.e
	EL(h) x BE	-0.0049	n.e
	EL(h) x BE x VE	-0.0014	n.e
EL	2	***	n.s
VC	1	n.s	*
BE	1	n.s	n.s
VE	1	n.s	*
EL X VE	2	*	n.s
EL x VC	2	**	n.s
EL x BE	2	**	*
BE x VE	1	n.s	n.s
BE x VC	1	**	n.e
EL x BE x VC	2	n.s	n.e
EL x BE x VE	3	n.s	n.e

n.e=not estimated, .n.s=not significant,*p< 0.05, **p <.001, [a-d] Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05), #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 5. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on 12 hours fasting body weight(BW), hot weight (HW), chill weight(CW), specific gravity (SG), survivability ratio (SA), total yield (TY), dressing percentage(DP), and water absorb (WA) of male broilers exposed to 37° C age 22 to 42 d

Treatment		BW(g)	HW(g)	CW(g)	SG	SA	TY(g)	DP	WA(g)
Main effects#	**EL**								
	Control	2095.54	1500	1549	1.043	1.035	6790	73.96[a]	49.97
	EL(l)	2064.00	1484	1529	1.048	1.030	7908	72.97[b]	44.79
	EL(h)	2064.56	1475	1519	1.046	1.033	7175	73.57[ab]	43.47
	VC								
	Control	2078.60	1481	1528	1.045	1.036	7277	73.50	47.14
	VC	2091.46	1492	1537	1.047	1.030	7304	73.50	45.02
	BE								
	Control	2079.87	1482	1529	1.045	1.036	6967	73.48	46.38
	BE	2090.19	1490	1536	1.047	1.029	7614	73.52	45.77
	VE								
	Control	2068.62	1472	1518	1.045	1.027	7099	73.33	45.88
	VE	2101.44	1500	1547	1.046	1.038	7483	73.62	46.28
Interactions#	**EL x VE**								
	Control	2098.69	1505	1551	1.043	1.033	6591	73.93	46.00[ab]
	VE	2092.38	1494	1548	1.043	1.035	6989	73.99	53.95[a]
	EL(l)	2037.14	1439	1484	1.047	1.022	7725	72.88	45.47[ab]
	EL(l)x VE	2152.85	1529	1573	1.048	1.037	8091	73.03	44.10[ab]
	EL(h)	2070.02	1472	1519	1.046	1.023	6980	73.35	46.12[ab]
	EL (h) x VE	2059.10	1478	1519	1.047	1.043	7369	73.75	40.79[b]
	EL x VC								
	Control	2091.73	1496	1546	1.044	1.043	7016	73.90	49.89
	VC	2099.34	1503	1553	1.042	1.028	6564	74.02	50.06
	EL(l)	2083.35	1479	1526	1.045	1.035	7713	73.24	46.47
	EL(l) x VC	2106.64	1488	1531	1.051	1.024	8103	72.70	43.10
	EL(h)	2060.70	1467	1512	1.045	1.030	7103	73.36	45.06
	EL(h) x VC	2068.41	1484	1526	1.048	1.037	7246	73.77	41.89

TABLE 5. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on 12 hours fasting body weight(BW), hot weight (HW), chill weight(CW), specific gravity (SG), survivability ratio (SA), total yield (TY), dressing percentage(DP), and water absorb (WA) of male broilers exposed to 37° C age 22 to 42 d(continue)

Treatment	BW(g)	HW(g)	CW(g)	SG	SA	TY(g)	DP	WA(g)
EL x BE								
Control	2085.29	1486	1536	1.043	1.037	5889	73.56	49.08
BE	2105.79	1513	1564	1.044	1.034	7691	74.36	50.87
EL	2070.12	1468	1514	1.048	1.038	7734	73.13	45.83
EL(l) x BE	2119.87	1499	1543	1.048	1.021	8081	72.80	43.75
EL(h)	2084.20	1493	1537	1.044	1.034	7279	73.75	44.25
EL(h) x BE	2044.91	1458	1501	1.049	1.032	7070	73.33	42.70
BE x VE								
Control	2076.88	1474	1520	1.045	1.037	6838	73.15	45.99
VE	2082.86	1491	1538	1.045	1.035	7097	73.81	46.78
BE	2060.36	1470	1516	1.045	1.017	7359	73.59	45.77
VE x BE	2120.02	1510	1556	1.047	1.041	7869	73.44	45.78
BE x VC								
Control	2049.45	1465	1512	1.045	1.023	7076	73.76	46.46
VC	2110.29	1499	1545	1.045	1.050	6895	73.20	46.31
BE	2107.75	1496	1544	1.044	1.040	7478	73.24	47.82
BE x VC	2072.63	1484	1528	1.049	1.009	7750	73.79	43.72
El x BE x VC								
Cont	2047.72	1470	1519	1.044	1.034	6532	74.15	49.56
VC	2122.85	1502	1551	1.041	1.040	5245	72.96	48.60
BE	2135.75	1522	1572	1.045	1.052	7499	73.65	50.29
BE x VC	2075.83	1504	1556	1.043	1.016	7883	75.07	51.52
EL(l)	2075.45	1478	1524	1.045	1.033	8159	73.40	45.29
EL(l) x VC	2064.79	1458	1504	1.050	1.043	7310	72.85	46.37
EL(l) x BE	2091.25	1481	1528	1.044	1.037	7267	73.07	47.66
EL(l) x BE x VC	2148.50	1518	1558	1.052	1.006	8895	72.54	39.83
EL(h)	2025.16	1448	1493	1.045	1.001	6537	73.72	44.54
EL(h) x VC	2143.25	1537	1581	1.043	1.067	8021	73.79	43.95
EL(h) x BE	2096.25	1485	1531	1.045	1.058	7669	73.01	45.58
EL(h) x BE x VC	1993.58	1430	1470	1.052	1.006	6471	73.76	39.83

TABLE 5. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on 12 hours fasting body weight(BW), hot weight (HW), chill weight(CW), specific gravity (SG), survivability ratio (SA), total yield (TY), dressing percentage(DP), and water absorb (WA) of male broilers exposed to 37° C age 22 to 42 d(continue)

Treatment		BW(g)	HW(g)	CW(g)	SG	SA	TY(g)	DP	WA(g)
	EI x BE x VE								
	Cont	2100.02	1506	1548	1.043	1.045	5875	73.70	42.22
	VE	2070.56	1467	1523	1.042	1.029	5903	73.41	55.93
	BE	2097.37	1504	1554	1.044	1.027	7307	74.15	49.77
	BE x VE	2114.20	1522	1574	1.043	1.041	8074	74.56	51.97
	EL(l)	2063.58	1452	1499	1.047	1.044	8107	72.56	46.04
	EL(l) x VE	2076.66	1484	1530	1.049	1.031	7361	73.70	45.62
	EL(l) x BE	2010.70	1425	1470	1.048	1.000	7342	73.12	44.91
	EL(l) x BE x VE	2229.04	1574	1616	1.048	1.042	8820	72.48	42.58
	EL(h)	2067.04	1463	1513	1.045	1.022	6532	73.19	49.70
	EL(h) x VE	2101.37	1522	1561	1.043	1.047	8025	74.32	38.79
	EL(h) x BE	2016.83	1481	1524	1.046	1.025	7428	73.51	42.65
	EL(h) x BE x VE	2073.00	1434	1477	1.051	1.040	6712	73.26	42.79
ANOVA	DF	Significant							
EL	2		n.s	n.s	n.s	n.s	n.s	*	n.s
VC	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s
VE	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL X VE	2		n.s	n.s	n.s	n.s	n.s	n.s	*
EL x VC	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE x VE	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE x VC	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE x VC	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE x VE	3		n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant,*p< 0.05, [a b] Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05)
#=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 6. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on body temperature at the age o f 35 d (BT35), body temperature at the age of 41 d (BT41) and mean body temperature (MBT). Of male broilers exposed to 37° C

Treatment		BT35 °C	BT41 °C	MBT °C
Main effects#	**EL**			
	Control	42.86[a]	42.60[a]	42.73[a]
	EL(l)	42.40[b]	42.30[b]	42.35[b]
	EL(h)	42.62[ab]	42.53[ab]	42.57[ab]
	VC			
	Control	42.54	42.41	42.48
	VC	42.71	42.53	42.62
	BE			
	Control	42.65[a]	42.51	42.58
	BE	42.20[b]	42.44	42.52
	VE			
	Control	42.87	42.50	42.68
	VE	42.39	42.44	42.42
Interactions#	**EL x VE**			
	Control	43.08	42.65	42.86
	VE	42.65	42.54	42.60
	EL(l)	42.53	42.24	42.38
	EL(l)x VE	42.27	42.35	42.31
	EL(h)	42.99	42.62	42.81
	EL (h) x VE	42.25	42.43	42.34
	EL x VC			
	Control	42.73	42.38	42.56
	VC	43.00	42.81	42.90
	EL(l)	42.34	42.37	42.35
	EL(l) x VC	42.46	42.23	42.34
	EL(h)	42.56	42.49	42.53
	EL(h) x VC	42.68	42.56	42.62
	EL x BE			
	Control	42.84	42.54	42.69
	BE	42.89	42.65	42.77
	EL	42.49	42.35	42.42
	EL(l) x BE	42.31	42.24	42.27
	EL(h)	42.63	42.63	42.63
	EL(h) x BE	42.61	42.42	42.52
	BE x VE			
	Control	42.87	42.47	42.67
	VE	42.44	42.55	42.49
	BE	42.86	42.54	42.70
	VE x BE	42.34	42.34	42.34
	BE x VC			
	Control	42.50	42.39	42.45
	VC	42.81	42.62	42.71
	BE	42.59	42.43	42.51
	BE x VC	42.62	42.44	42.53

TABLE 6. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on body temperature at the age o f 35 d (BT35), body temperature at the age of 41 d (BT41) and mean body temperature (MBT). Of male broilers exposed to 37° C (continue)

Treatments		BT35 °C	BT41 °C	MBT °C
	El x BE x VC			
	Cont	42.60	42.38	42.49
	VC	43.08	42.70	42.89
	BE	42.86	42.39	42.63
	BE x VC	42.91	42.92	42.92
	EL(l)	42.40	42.38	42.39
	EL(l) x VC	42.59	42.33	42.46
	EL(l) x BE	42.28	42.35	42.32
	EL(l) x BE x VC	42.33	42.12	42.23
	EL(h)	42.52	42.42	42.47
	EL(h) x VC	42.75	42.84	42.79
	EL(h) x BE	42.61	42.56	42.59
	EL(h) x BE x VC	42.61	42.28	42.45
	El x BE x VE			
	Cont	43.18	42.65	42.92
	VE	42.50	42.42	42.46
	BE	42.98	42.64	42.81
	BE x VE	42.79	42.67	42.73
	EL(l)	42.49	42.24	42.37
	EL(l) x VE	42.49	42.47	42.48
	EL(l) x BE	42.56	42.24	42.40
	EL(l) x BE x VE	42.05	42.24	42.15
	EL(h)	42.93	42.52	42.72
	EL(h) x VE	42.33	42.75	42.54
	EL(h) x BE	43.05	42.72	42.89
	EL(h) x BE x VE	42.17	42.12	42.15
ANOVA	DF	Significant		
EL	2	*	*	*
VC	1	n.s	n.s	n.s
BE	1	*	n.s	n.s
VE	1	n.s	n.s	n.s
EL X VE	2	n.s	n.s	n.s
EL x VC	2	n.s	n.s	n.s
EL x BE	2	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s
BE x VC	1	n.s	n.s	n.s
EL x BE x VC	2	n.s	n.s	n.s
EL x BE x VE	3	n.s	n.s	n.s

n.s=not significant,*p< 0.05, $^{a-b}$ Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05), #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 7. Effect of electrolyte (EL), betaine(BE), vitamin C (VC) and vitamin (VE) on average hematocrit (AHC) of male broilers exposed to 37° C age 22 to 42 d

Treatment		AHC
Main effects#	**EL**	
	Control	30.82
	EL(l)	31.72
	EL(h)	31.52
	VC	
	Control	31.53
	VC	30.94
	BE	
	Control	31.41
	BE	31.02
	VE	
	Control	31.45
	VE	31.01
Interactions#	**EL x VE**	
	Control	31.14
	VE	30.50
	EL(l)	31.77
	EL(l)x VE	31.68
	EL(h)	31.45
	EL (h) x VE	30.85
	EL x VC	
	Control	31.31
	VC	30.33
	EL(l)	32.62
	EL(l) x VC	30.83
	EL(h)	30.65
	EL(h) x VC	31.65
	EL x BE	
	Control	31.08
	BE	30.57
	EL	31.83
	EL(l) x BE	31.62
	EL(h)	31.43
	EL(h) x BE	30.87
	BE x VE	
	Control	31.55
	VE	31.35
	BE	31.36
	VE x BE	30.68
	BE x VC	
	Control	31.25
	VC	31.64
	BE	31.81
	BE x VC	30.23

TABLE 7. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on average hematocrit (AHC) of male broilers exposed to 37° C age 22 to 42 d (continue)

	El x BE x VC	AHC
	Cont	30.98
	VC	31.17
	BE	31.64
	BE x VC	29.49
	EL(l)	31.95
	EL(l) x VC	31.70
	EL(l) x BE	33.29
	EL(l) x BE x VC	29.95
	EL(h)	30.81
	EL(h) x VC	32.06
	EL(h) x BE	31.50
	EL(h) x BE x VC	31.25
	El x BE x VE	
	Cont	31.36
	VE	30.80
	BE	30.92
	BE x VE	30.21
	EL(l)	32.00
	EL(l) x VE	31.66
	EL(l) x BE	31.54
	EL(l) x BE x VE	31.70
	EL(h)	31.29
	EL(h) x VE	31.58
	EL(h) x BE	31.62
	EL(h) x BE x VE	30.12

ANOVA	DF	Significant
EL	2	n.s
VC	1	n.s
BE	1	n.s
VE	1	n.s
EL X VE	2	n.s
EL x VC	2	n.s
EL x BE	2	n.s
BE x VE	1	n.s
BE x VC	1	n.s
EL x BE x VC	2	n.s
EL x BE x VE	3	n.s

n.s=not significant, #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 8. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on serum chloride mmol/l ,(CL), magnesium, meq/l(Mg), triglyceride, mg/dl,(TR), uric acid, mg/dl, (UR), albumin , g/dl,(AL), calcium, mg/dl,(Ca), phosphorus mg/dl, (Phos), sodium, mmol/l,(Na), potassium ,mmol/l, (K), of male broilers exposed to 37° C age 42 d

Treatment		CL	Mg	UR	TR	AL	Ca	Phos	Na	K
Main effects#	**EL**									
	Control	102.70	1.40	2.48	29.99[b]	0.96	6.47	5.13	132.49	5.62
	EL(l)	103.29	1.40	2.66	36.56[a]	0.98	6.42	5.18	135.37	5.83
	EL(h)	106.07	1.41	3.00	33.96[ab]	1.05	6.56	5.03	138.57	5.42
	VC									
	Control	109.51	1.47	2.88	34.87	1.04	6.91	5.41	141.33	5.92
	VC	98.53	1.34	2.55	32.14	0.95	6.06	4.83	129.62	5.32
	BE									
	Control	100.97	1.35	2.61	32.38	0.98	6.29	5.06	131.73	5.50
	BE	107.07	1.46	2.82	34.63	1.02	6.67	5.17	139.22	5.74
	VE									
	Control	103.11	1.39	2.75	32.74	0.99	6.57	5.09	134.45	5.44
	VE	104.93	1.42	2.68	34.27	1.00	6.40	5.14	136.50	5.80
Interactions#	**EL x VE**									
	Control	100.02	1.41	2.63	29.29	0.99	6.33	4.97	130.04	5.38
	VE	105.38	1.39	2.32	30.68	0.92	6.60	5.30	134.93	5.86
	EL(l)	104.61	1.47	2.91	37.72	1.01	6.67	5.19	138.68	5.78
	EL(l)x VE	101.67	1.32	2.42	35.40	0.95	6.17	5.17	132.06	5.86
	EL(h)	104.40	1.27	2.71	31.21	0.97	6.69	5.10	134.63	5.17
	EL (h) x VE	107.75	1.55	3.30	36.71	1.13	6.43	4.97	142.51	5.67
	EL x VC									
	Control	106.12	1.44	2.45	32.49	0.96	6.63	5.19	136.41	6.01
	VC	99.28	1.36	2.50	24.48	0.95	6.31	5.08	128.57	5.23
	EL(l)	113.21	1.60	3.24	39.42	1.13	7.29	5.86	148.31	6.33
	EL(l) x VC	93.37	1.20	2.09	33.71	0.83	5.55	4.50	122.43	5.30
	EL(h)	109.20	1.38	2.95	32.70	1.04	6.82	5.17	139.27	5.41
	EL(h) x VC	102.95	1.45	3.05	35.22	1.07	6.31	4.89	137.87	5.43

TABLE 8. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on serum chloride mmol/l ,(CL), magnesium, meq/l(Mg), triglyceride, mg/dl,(TR), uric acid, mg/dl, (UR), albumin , g/dl,(AL), calcium, mg/dl,(Ca), phosphorus mg/dl, (Phos), sodium, mmol/l,(Na), potassium ,mmol/l, (K), of male broilers exposed to 37° C age 42 (continue)

	CL	Mg	UR	TR	AL	Ca	Phos	Na	K
EL x BE									
Control	96.51	1.34	2.33	27.94	0.92	6.31	5.03	125.77	5.96
BE	108.89	1.46	2.63	32.04	0.99	6.63	5.23	139.20	5.65
EL	101.58	1.35	3.09	33.82	0.98	6.49	5.19	134.00	5.69
EL(l) x BE	105.00	1.45	2.24	39.31	0.98	6.35	5.17	136.75	5.95
EL(h)	104.81	1.37	2.40	35.39	1.03	6.08	4.95	135.41	5.23
EL(h) x BE	107.33	1.45	3.60	32.54	1.08	7.05	5.12	141.72	5.62
BE x VE									
Control	100.00	1.30	2.80	31.41	0.96	6.46	5.02	129.90	5.27
VE	101.94	1.41	2.42	33.36	0.99	6.13	5.09	133.55	5.73
BE	106.22	1.47	2.70	34.08	1.02	6.67	5.15	139.00	5.62
VE x BE	107.92	1.44	2.94	35.18	1.01	6.68	5.19	139.45	5.86
BE x VC									
Control	110.14	1.45	2.83	33.45	1.03	6.97	5.49	141.55	5.92
VC	91.80	1.26	2.39	31.31	0.92	5.62	4.70	121.90	5.08
BE	108.88	1.50	2.93	36.29	1.05	6.85	5.38	141.10	5.91
BE x VC	105.26	1.42	2.71	32.96	0.98	6.50	4.95	137.35	5.56
El x BE x VC									
Cont	104.20	1.51	2.43	31.12	0.91	6.62	5.14	134.37	6.24
VC	88.82	1.17	2.22	24.76	0.94	6.00	4.93	117.17	4.95
BE	108.05	1.38	2.46	33.87	1.01	6.63	5.23	138.45	5.78
BE x VC	109.05	1.55	2.79	30.20	0.96	6.63	5.23	139.96	5.52
EL(l)	113.90	1.58	3.32	36.57	1.11	7.50	5.95	149.62	6.37
EL(l) x VC	89.27	1.11	2.86	31.07	0.84	5.49	4.44	118.37	5.01
EL(l) x BE	112.52	1.61	3.16	42.27	1.15	7.08	5.76	147.00	6.30
EL(l) x BE x VC	97.47	1.29	1.32	36.35	0.82	5.61	4.57	126.50	5.60
EL(h)	112.31	1.26	2.72	32.66	1.07	6.79	5.16	140.66	5.16
EL(h) x VC	97.31	1.49	2.08	38.12	0.98	5.37	4.74	130.16	5.30
EL(h) x BE	106.08	1.50	3.18	32.75	1.00	6.85	5.18	137.87	5.66
EL(h) x BE x VC	108.58	1.40	4.02	32.33	1.15	7.25	5.05	145.58	5.57

TABLE 8. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on serum chloride mmol/l ,(CL), magnesium, meq/l(Mg), triglyceride, mg/dl,(TR), uric acid, mg/dl, (UR), albumin , g/dl,(AL), calcium, mg/dl,(Ca), phosphorus mg/dl, (Phos), sodium, mmol/l,(Na), potassium ,mmol/l, (K), of male broilers exposed to 37° C age 42 (continue)

Treatments		CL	Mg	UR	TR	AL	Ca	Phos	Na	K
	El x BE x VE									
	Cont	96.52	1.36	2.60	27.76^{cd}	0.97	5.96	4.78	125.34	5.14
	VE	96.50	1.32	2.05	28.11^{abcd}	0.88	6.66	5.29	126.20	6.03
	BE	103.52	1.47	2.66	30.83^{abcd}	1.00	6.71	5.16	134.74	5.61
	BE x VE	114.26	1.46	2.59	33.2^{abcd}	.97	6.55	5.31	143.67	5.68
	EL(l)	101.68	1.45	3.00	39.50^{ab}	0.98	6.84	5.24	135.62	5.89
	EL(l) x VE	101.48	1.24	3.19	28.15^{abcd}	0.98	6.14	5.14	132.37	5.48
	EL(l) x BE	108.14	1.50	2.83	35.95^{abc}	1.04	6.50	5.14	141.75	5.67
	EL(l) x BE x VE	101.85	1.41	1.65	42.66^{ab}	0.93	6.18	5.19	131.75	6.23
	EL(h)	101.80	1.10	2.79	26.97^{cd}	0.92	6.59	5.05	128.75	4.78
	EL(h) x VE	107.83	1.65	2.02	43.81^{a}	1.13	5.57	4.85	142.08	5.68
	EL(h) x BE	107.00	1.45	2.62	35.45^{abc}	1.01	6.80	5.15	140.52	5.57
	EL(h) x BE x VE	107.66	1.45	4.58	29.62^{abcd}	1.14	7.30	5.08	142.93	5.67
ANOVA	DF	Signifi								
EL	2	n.s	n.s	n.s	**	n.s	n.s	n.s	n.s	n.s
VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL X VE	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x VC	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE x VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE x VC	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
EL x BE x VE	3	n.s	n.s	n.s	**	n.s	n.s	n.s	n.s	n.s

n.s=not significant,*p< 0.05, **p <.001, $^{a-d}$ Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05), #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 9. Effect of final body weight (FW) , weight gain (WG), daily gain (DG), feed consumption (FC), mean feed consumption (MF), feed efficiency (FE), water feed ratio)WF), water temperature (WT), water consumption (WC), daily water (DW), water weight gain ratio(WR), on low yield(LY), medium yield (MY), and high yield of male broilers exposed to 37° C age 22 to 42 d

S.O.V	FW(g)	WG(g)	DG(g)	FC(g)	MF(g)	FE(g)	WF(g:g)	WT°C	WC(l)	DW(g)	WR(g:g)
LY	2005	1369	68.49	3334[a]	166.74[a]	0.42[b]	1.36	34.72	5.06	190	2.80
MY	2025	1377	68.87	2749[b]	137.46[b]	0.50[ab]	2.14	34.32	7.63	286	4.13
HY	2056	1407	70.35	2691[b]	134.46[b]	0.52[a]	2.98	33.62	10.72	402	5.61
ANOVA	DF	Signifi									
Yield	2	N.S	N.S	*	*	*	N.S	N.S	N.S	N.S	N.S

n.s=not significant,*p<.0001 [a-b] Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05)

TABLE 10. Effect of low yield (LY), medium yield (MY), and high yield (HY) on dressing wastage weight body weight ratio (PVS), survivability (SR),dressing percentage(DP), body temperature at the age of 35 d, (BT35), body temperature at the age of 41 d(BT 41) and mean body temperature (MBT), of male broilers exposed to 37° C age 22 to 42 d

S.O.V		PVS	SR	DP	BT35	BT41	MBT
LY		29.13^{a}	60.31^{c}	73.20^{a}	42.81^{a}	42.51	42.66^{a}
MY		29.23^{a}	87.01^{b}	73.01^{b}	42.57^{ab}	42.34	42.45^{b}
HY		28.14^{b}	99.47^{a}	73.99^{a}	42.39^{b}	42.27	42.33^{b}
ANOVA	DF	Significant					
Yield	2	*	***	**	*	n.s	*

n.s=not significant,*p< 0.05, **p <.001.***p<.0001, $^{a-b}$ Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05)

TABLE 11. Effect on low yield (LY), medium yield (MY), and high yield (HY), on twelve hours fasting body weight (BW), specific gravity(SG), hot weight(HW), chill weight(CW), water absorb (WA), and average hematocit (AHC), of male broilers exposed to 37° C age 22 to 42 d

S.O.V		BW(g)	SG	HW(g)	CW(g)	WA(g)	AHC
LY		2033[b]	1.045	1454.54[b]	1501.72[b]	47.15[ab]	31.69
MY		2047[b]	1.046	1468.38[b]	1514.10[b]	45.72[b]	31.89
HY		2211[a]	1.045	1521.94[a]	1570.55[a]	48.61[a]	32.41
ANOVA	DF	significant					
Yield	2	**	n.s	**	**	n.s	n.s

n.s=not significant,*p< 0.05, **p <.0001. [a-b] Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05)

TABLE 12. Effect on low yield(LY), medium yield (MY), and high yield (HY), on chloride(CL), magnesium(Mg), uric acid(UR),albumin(AL), calcium(Ca), phosphorus (Phos), sodium (Na), potassium(K), triglyceride (TR), body temperature at the age of 35 d, (BT35), body temperature at the age of 41 d(BT 41)and mean body temperature of male broilers exposed to 37° C age 22 to 42 d

S.O.V		CL	Mg	UR	AL	Ca	PHOS	Na	K	TR
LY		103.41	1.42	2.89	1.01	6.47	5.05	135.54	5.63	32.95
MY		104.39	1.43	2.37	0.98	6.66	5.17	135.70	5.70	33.68
HY		104.09	1.40	2.86	0.95	6.52	5.20	132.52	5.65	30.71
ANOVA	DF	significant								
Yield	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant,

TABLE 13. Correlation between final body weight (FW) , weight gain (WG), water consumption (WC), daily water daily(DW), daily gain(DG), gain proportion of final body weight(PG), water and weight gain ratio (WR), water feed ratio (WF),feed consumption(FC), mean feed consumption(MF), and survive ability (SR) and body temperature age 35 d(BT35) , body temperature age 41 d (BT41) mean body temperature (MBT), water temperature(WT) of male broilers exposed to 37° C age 22 to 42 d

	FW	WG	WC	DW	DG	PG	WR	WF	FC	MF	SR
BT35	-0.04	-0.07	-0.04	-0.04	-0.07	-0.07	-0.04	-0.06	0.25**	0.25**	-0.27***
BT41	-0.16*	-0.18*	-0.11	-0.11	-0.18*	-0.12	-0.10	-0.11	0.17*	0.17*	-0.17*
MBT	-0.11	-0.14	-0.08	-0.08	-0.14	-0.11	-0.08	-0.09	0.24**	0.24**	-0.26***
WT	-0.05	-0.09	0.41	0.41	-0.09	-0.16	0.42	0.56**	-0.12	-0.12	-0.32

,*p< 0.05, **p <.001. ***p<.0001

TABLE 14. Correlation between gallbladder weight (GW) , feed efficiency (FE), new castle disease titer(NDT), infectious bursal disease titer (BDT),average hematocrit (AHC), specific gravity(SG) , dressing percentage (DP), survive ability ratio(SA), total yield (TY), water absorb(WA), bursal weight (BR), and body temperature age 35 d(BT35) , body temperature age 41 d(BT41) mean body temperature (MBT), water temperature(WT) of male broilers exposed to 37° C age 22 to 42 d

	GW	FE	NDT	BDT	AHC	SG	DP	SA	TY	WA	BR
BT35	0.08	-0.24**	-0.19	-0.08	-0.13	0.04	0.03	0.02	-0.27***	-0.18*	-0.26***
BT41	0.01	-0.22	0.18	0.01	-0.19*	0.19	-0.00	0.01	-0.20**	-0.25**	-0.36***
MBT	0.06	-0.27***	-0.03	-0.04	-0.18*	0.08	0.02	0.02	-0.02	-0.25**	-0.36***
WT	-0.98	0.11	0.27	-0.13	-0.02	0.12	-0.08	-0.20	-0.44*	-0.28	-0.10

*p< 0.05, **p <.001. ***p<.0001

TABLE 15. Correlation between spleen weight percentage of body weight (SWP), spleen weight(SW) chill weight (CW), water weight (WW), dressing wastage(VS), dressing wastage proportion of body weight ,(PV), and body temperature age 36(BT35) , body temperature(BT41) mean body temperature (MBT), water temperature(WT) of male broilers exposed to 37°C age 22 to 42 d

	SWP	SW	CW	WW	VS	PVS
BT35	-0.14*	-0.15*	0.00	0.05	-0.05	-0.09
BT41	-0.12	-0.14	-0.06	0.08	-0.11	-0.07
MBT	-0.17*	-0.17*	-0.03	0.07	-0.09	-0.09
WT	-0.35	-0.36	-0.18	-0.04	-0.18	0.01

*p< 0.05,

TABLE 16. Correlation between chloride ,(CL), magnesium(Mg), triglyceride,,(TR), uric acid,, (UR), albumin ,(AL),calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K), and body temperature age 36(BT35) , body temperature(BT41) mean body temperature (MBT), water temperature(WT) of male broilers exposed to 37° C age 22 to 42 d

	CL	Mg	TR	UR	ALB	Ca	PHO	Na	K
BT35	-0.01	-0.02	-0.05	-0.00	0.08	-0.07	-0.09	0.00	-0.05
BT41	-0.03	-0.05	0.03	0.06	0.01	-0.02	-0.11	-0.00	-0.07
MBT	-0.03	-0.04	-0.01	0.03	0.05	-0.05	-0.12	0.00	-0.07
WT	-0.26	-0.27	-0.13	-0.47	-0.21	-0.27	-0.41	-0.21	-0.31

TABLE 17. Correlation between specific gravity(SG), dressing percentage (DP), survivability ratio (SA), total yield (TY), bursa weight (BR), water absorb (WA), spleen weight (SW), spleen percentage of body weight(SWP), chill weight (CW), water weight (WW), dressing wastage (VS), percentage of dressing wastage(PVS) and chloride ,(CL), magnesium, (Mg), triglyceride,,(TR), uric acid,, (UR), albumin ,(AL),calcium, (Ca), phosphate, (Phos), sodium, (Na), potassium , (K) of male broilers exposed to 37° C age 22 to 42 d

	SG	DP	SA	TY	BR	WA	SW	SWP	CW	WW	VS	PVS
CL	0.04	0.02	-0.07	-0.01	-0.02	0.12	0.12	0.14	-0.04	0.00	-0.03	0.02
Mg	0.02	0.01	0.03	-0.01	0.02	0.10	0.10	0.09	0.02	0.03	0.04	0.02
TR	0.03	-0.08	0.01	-0.00	0.02	-0.00	0.26**	0.27**	-0.02	0.00	0.04	0.09
UR	0.06	0.03	-0.02	-0.09	-0.02	0.06	0.15	0.15	0.01	0.06	-0.00	-0.02
AL	0.05	0.00	0.05	-0.06	-0.04	0.10	0.14	0.12	0.06	0.07	0.09	0.02
Ca	0.03	-0.03	0.01	0.02	0.01	0.17*	0.09	0.09	-0.02	0.01	0.05	0.09
PHO	-0.02	0.01	0.03	-0.01	0.09	0.14*	0.10	0.10	0.02	-0.00	0.05	0.04
Na	0.05	0.01	-0.05	-0.03	-0.02	0.09	0.14	015	-0.03	0.01	-0.02	0.02
K	0.05	0.08	0.03	-0.00	-0.02	0.15	0.17	016	0.05	0.07	0.01	-0.03

,*p< 0.05, **p <.001.

TABLE 18. Correlation between final body weight (FW) , weight gain (WG), water consumption(WC), daily water(DW), daily gain (DG), weight gain ratio of final body weight (PG), water and gain ratio(WR), water feed ratio,(WF), feed consumption (FC), mean feed consumption (MF), survive ability(SR), and chloride ,(CL), magnesium(Mg), triglyceride,,(TR), uric acid,, (UR), albumin ,(AL),calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K) of male broilers exposed to 37° C age 22 to 42 d

	FW	WG	WC	DW	DG	PG	WR	WF	FC	MF	SR
CL	0.02	-0.02	-0.03	-0.03	-0.02	-0.07	-0.04	-0.04	-0.08	-0.08	0.00
Mg	-0.01	-0.06	-0.01	-0.01	-0.06	-0.10	-0.02	-0.01	-0.09	-0.09	-0.25
TRI	-0.04	-0.10	-0.18	-0.18	-0.10	-0.13	-0.01*	-0.19*	-0.04	-0.04	-0.00
URI	0.05	0.01	-0.03	-0.03	0.01	-0.05	-0.03	-0.04	-0.01	-0.01	-0.10
ALB	0.03	-0.01	-0.11	-0.11	-0.01	-0.08	-0.12	-0.12	-0.01	-0.01	-0.08
Ca	-0.04	-0.05	-0.08	-0.08	-0.05	-0.04	-0.09	-0.08	-0.11	-0.11	0.01
PHO	-0.01	-0.07	-0.09	-0.09	-0.07	-0.11	-0.10	-0.10	-0.09	-0.09	-0.03
Na	0.00	-0.03	-0.08	-0.08	-0.03	-0.06	-0.09	-0.09	-0.09	-0.09	-0.07
K	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	-0.08	-0.08	-0.05

,*p< 0.05,

TABLE 19. Correlation between gallbladder weight(GW), feed efficiency (FE), new castle disease titer(NDT), infectious bursal disease titer(BDT), average hematocrit(AHC) and chloride ,(CL), magnesium(Mg), triglyceride ,(TR), uric acid,, (UR), albumin ,(AL),calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K) of male broilers exposed to 37° C
age 22 to 42 d

	GW	FE	NDT	BDT	AHC
CL	-0.23	0.07	0.05	0.04	0.13
Mg	-0.22	0.04	0.02	0.11	0.15
TR	-0.10	-0.04	-0.04	0.13	0.23**
UR	-0.17	-0.00	-0.02	-0.02	0.00
AL	-0.22	0.00	-0.09	0.10	0.24**
Ca	-0.22	0.09	0.09	0.22*	0.14
PHO	-0.07	0.08	0.04	0.14	0.25**
Na	-0.17	0.07	0.03	0.11	0.18*
K	-0.11	0.07	0.03	0.26**	0.16*

,*p< 0.05, **p <.001.

TABLE 20. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on final body weight (FW), weight gain(WG), daily gain (DG), percentage weight gain (PG), feed consumption(FC), mean feed consumption(MF), feed efficiency (FE) on male broilers age 22-42 d.

Treatment		FW(g)	WG(g)	DG(g)	PG	FC(g)	MF(g)	FE(g:g)
Main effects#	**EL**							
	Control	2134.76	1491.59	74.57	69.90	2985.80	149.29	0.51
	EL(l)	2045.34	1463.84	73.19	72.44	3469.20	173.46	0.46
	EL(h)	2032.07	1478.71	73.93	74.23	3673.18	183.65	0.47
	VC							
	Control	2045.24	1461.82	73.09	70.98	3195.76	159.78	0.49
	VC	2066.22	1494.27	74.71	73.46	3556.36	177.81	0.47
	BE							
	Control	2082.24	1473.11	73.65	71.04	3115.00	155.75	0.49
	BE	2059.22	1482.98	74.14	73.40	3637.13	181.85	0.47
	VE							
	Control	2087.77	1481.50	74.07	71.72	3337.20	166.86	0.48
	VE	2053.70	1474.59	73.72	72.72	3414.92	170.74	0.48
Interactions#	**BE x VC**							
	Control	2081.94	1455.47	72.77	70.05	2988.06	149.40	0.50
	VC	2082.54	1490.76	74.53	72.02	3241.93	162.09	0.49
	BE	2068.54	1468.18	73.40	71.91	3403.47	170.17	0.48
	BE x VC	2049.90	1497.78	74.88	74.89	3870.78	193.53	0.46
	BE x VE							
	Control	2120.90	1474.47	73.73	70.25	3018.39	150.91	0.49
	VE	2062.59	1471.75	73.58	71.82	3211.60	160.58	0.49
	BE	2073.64	1488.53	74.42	73.18	3656.01	182.80	0.47
	BE x VE	2044.81	1477.42	73.87	73.62	3618.24	180.91	0.47
ANOVA	DF	Significant						
EL	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE X VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant ,*p< 0.05, **p <.001.

[a-b] Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05)

#=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 21. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on water consumption (WC), daily water (DW), water gain ratio(WR), water feed ratio(WF), of male broilers age 22-42 d.

Treatment		WC(l)	DW(ml)	WR(g:g)	WF
Main effects#	**EL**				
	Control	5.9	224.00	2.95	0.91
	EL(l)	9.5	356.56	5.27	1.17
	EL(h)	8.2	307.88	4.42	2.38
	VC				
	Control	7.67	287.87	4.13	1.83
	VC	8.11	304.42	4.30	1.14
	BE				
	Control	6.96	261.13	3.84	1.45
	BE	8.83	331.15	4.59	1.52
	VE				
	Control	7.43	278.98	3.90	1.34
	VE	8.35	313.13	4.53	1.64
Interactions#	**BE x VC**				
	Control	6.79	254.77	3.72	1.86
	VC	7.13	267.50	3.97	1.03
	BE	8.55	320.97	4.53	1.80
	BE x VC	9.10	341.34	4.64	1.25
	BE x VE				
	Control	6.05	227.20	3.14	1.19
	VE	7.86	295.07	4.54	1.70
	BE	8.82	330.76	4.65	1.48
	BE x VE	8.84	331.54	4.52	1.57
ANOVA	DF	Significant			
EL	2	n.s	n.s	n.s	n.s
VC	1	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s
BE X VC	1	n.s	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s	n.s

n.s=not significant, #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 22. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on new castle disease titer (NDT) and infectious of bursal disease titer(BDT) of male broilers age 22- 42 d.

Treatment		NDT	BDT
Main effects#	**EL**		
	Control	1.30	0.006
	EL(l)	1.66	0.005
	EL(h)	1.36	0.002
	VC		
	Control	1.21[b]	0.006
	VC	1.67[a]	0.003
	BE		
	Control	1.34	0.003
	BE	1.54	0.006
	VE		
	Control	1.19[b]	0.006
	VE	1.70[a]	0.003
ANOVA	DF	significant	
EL	2	n.s	n.s
VC	1	*	n.s
BE	1	n.s	n.s
VE	1	*	n.s

n.s=not significant ,*p <.001. [a-b] Means with in a column with unlike superscripts under common subheading differ significantly($p<0.05$), #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 23. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on total yield (TY), survive ability ratio (SA) dressing percentage(DP), 12 hour fasting body weight (BW), specific gravity (SG), hot weight(HW), chill weight (CW), survive ability(SR), dressing wastage percentage (PVS) of male broilers age 22-42

Treatment		TY(g)	SA	PD	BW(g)	SG	HW(g)	CW(g)	SR	PVS
Main effects#	**EL**									
	Control	8424.26	0.98	72.62	2093.95	1.047	1479.75	1521.09	92.10	29.35
	EL(l)	7153.82	0.99	73.97	2006.09	1.050	1448.66	1485.25	78.14	27.86
	EL(h)	8192.73	1.06	72.77	2112.62	1.045	1493.41	1537.35	84.08	29.31
	VC									
	Control	8249.43	1.02	73.11	2110.78	1.045	1499.96	1543.56	87.36	28.96
	VC	7600.44	0.99	73.14	2031.00	1.049	1447.93	1485.56	82.18	28.72
	BE									
	Control	7805.59	0.98	72.92	2028.36	1.044	1436.55	1480.31	86.85	29.22
	BE	8044.29	1.04	73.32	2113.41	1.051	1511.33	1548.81	82.69	28.45
	VE									
	Control	8210.28	1.02	73.16	2111.51	1.048	1504.16	1545.51	86.42	28.80
	VE	7639.59	1.00	73.09	2030.27	1.047	1443.72	1483.61	83.12	28.88
Interactions#	**BE x VC**									
	Control	8387.16	1.01	72.96	2115.26	1.043	1497.13	1543.64	89.79	29.23
	VC	7224.01	0.94	72.89	1941.46	1.044	1375.97	1416.99	83.91	29.22
	BE	8111.69	1.03	73.26	2106.29	1.047	1502.79	1543.49	84.94	28.68
	BE x VC	7976.88	1.05	73.39	2120.53	1.054	1519.88	1554.13	80.45	28.22
	BE x VE									
	Control	8422.78	1.00	72.74	2106.48	1.046	1491.86	1533.15	91.19	29.22
	VE	7188.39	0.95	73.11	1950.25	1.041	1381.24	1427.48	82.51	29.24
	BE	7997.79	1.04	73.58	2116.53	1.049	1516.46	1557.87	81.65	28.38
	BE x VE	8090.79	1.04	73.06	2110.28	1.052	1506.21	1539.78	83.73	28.52
ANOVA	DF	Significant								
EL	2	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE X VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant , #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 24. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on water absorb(WA), spleen weight percentage(SWP), bursa weight percentage(BRP), on male broilers age 22-42 d

Treatment		WA(g)	SWP(g)	BRP(g)
Main effects#	**EL**			
	Control	41.34	0.12	0.16
	EL(l)	36.58	0.14	0.20
	EL(h)	43.92	0.13	0.16
	VC			
	Control	43.06	0.13	0.16
	VC	37.62	0.13	0.18
	BE			
	Control	43.76	0.14	0.18
	BE	37.47	0.12	0.17
	VE			
	Control	41.34	0.13	0.17
	VE	39.88	0.13	0.18
Interactions#	**BE x VC**			
	Control	46.51	0.12	0.17
	VC	41.01	0.15	0.19
	BE	40.69	0.14	0.16
	BE x VC	34.24	0.11	0.17
	BE x VE			
	Control	41.28	0.12	0.17
	VE	46.24	0.15	0.19
	BE	41.40	0.13	0.18
	BE x VE	33.53	0.11	0.16
ANOVA	DF	Significant		
EL	2	n.s	n.s	n.s
VC	1	n.s	n.s	n.s
BE	1	n.s	n.s	n.s
VE	1	n.s	n.s	n.s
BE X VC	1	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s

n.s=not significant, #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 25. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on body temperature age 35 d (BT35), body temperature age 41 d(BT41), mean body temperature(MB) of male broilers age 42d.

Treatment		BT35°C	BT41 °C	MBT °C
Main effects#	**EL**			
	Control	41.24	41.57	41.41
	EL(l)	40.96	41.67	41.32
	EL(h)	41.20	41.46	41.33
	VC			
	Control	41.21	41.58	41.39
	VC	41.06	41.55	41.31
	BE			
	Control	41.07	41.52	41.29
	BE	41.20	41.62	41.41
	VE			
	Control	41.15	41.48	41.31
	VE	41.12	41.66	41.39
Interactions#	**BE x VC**			
	Control	41.16	41.53	41.35
	VC	40.95	41.50	41.24
	BE	41.25	41.63	41.44
	BE x VC	41.16	41.60	41.38
	BE x VE			
	Control	41.13	41.40	41.27
	VE	41.00	41.63	41.32
	BE	41.17	41.55	41.36
	BE x VE	41.24	41.69	41.46
ANOVA	DF	significant		
EL	2	n.s	n.s	n.s
VC	1	n.s	n.s	n.s
BE	1	n.s	n.s	n.s
VE	1	n.s	n.s	n.s
BE X VC	1	n.s	n.s	n.s
BE x VE	1	n.s	n.s	n.s

n.s=not significant, #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 26. Effect of electrolyte(EL), betaine(BE), vitamin C (VC) and vitamin (VE) on serum chloride mmol/l ,(CL), magnesium, meq/l(Mg),, uric acid, mg/dl, (UR), albumin , g/dl,(AL), calcium, mg/dl,(Ca), phosphorus mg/dl, (Phos), sodium, mmol/l,(Na), potassium ,mmol/l, (K), triglyceride, mg/dl,(TR),of male broilers age 42 d

Treatment		CL	Mg	UR	AL	Ca	PH O	Na	K	TR
Main effects#	**EL**									
	Control	115.56	1.56	2.82^{b}	1.15	7.07	5.37	148.69	6.47	45.45
	EL(l)	107.15	1.52	4.18^{ab}	1.18	6.05	5.22	130.78	6.16	40.95
	EL(h)	119.35	1.68	4.51^{a}	1.32	6.51	5.85	157.97	6.67	47.20
	VC									
	Control	116.68	1.68	4.10	1.22	6.81	5.65	148.93	6.45	45.00
	VC	111.36	1.57	3.57	1.21	6.27	5.31	142.70	6.42	44.08
	BE									
	Control	110.95	1.52	4.41	1.19	6.19	5.35	144.37	6.40	42.00
	BE	117.09	1.56	3.23	1.24	6.90	5.61	147.26	6.47	47.08
	VE									
	Control	110.00	1.58	3.67	1.08	6.57	5.29	138.87	5.91^{b}	34.29^{b}
	VE	118.04	1.59	4.00	1.35	6.51	5.67	152.75	6.96^{a}	54.79^{a}
Interactions	**BE x VC**									
	Control	114.66	1.59	4.04^{ab}	1.17	6.94	5.54	148.87	6.45	43.25
	VC	107.25	1.45	4.84^{a}	1.20	5.43	5.17	139.92	6.34	40.75
	BE	118.70	1.61	4.16^{ab}	1.27	6.68	5.75	149.04	6.44	46.75
	BE x VC	115.48	1.69	2.31^{c}	1.22	7.11	5.46	145.48	6.50	47.41
	BE x VE									
	Control	108.16	1.49	3.44^{bc}	1.06	6.47	5.09	138.07	6.06	35.83
	VE	113.75	1.56	5.43^{a}	1.32	6.90	5.62	150.67	6.74	48.16
	BE	111.84	1.68	3.90^{ab}	1.11	6.68	5.49	139.67	5.75	32.75
	BE x VE	122.34	1.62	2.57^{bc}	1.38	7.11	5.72	154.84	7.19	61.41
ANOVA	DF	Sign								
EL	2	n.s	n.s	*	n.s	n.s	n.s	n.s	n.s	n.s
VC	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
BE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VE	1	n.s	n.s	n.s	n.s	n.s	n.s	n.s	*	**
BE X VC	1	n.s	n.s	*	n.s	n.s	n.s	n.s	n.s	n.s
BE x VE	1	n.s	n.s	*	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant, $^{a-c}$ Means with in a column with unlike superscripts under common subheading differ significantly($p<0.05$), #=main effect values and / or interaction represent least square means averaged over treatments not listed within category.

TABLE 27. Effect of low yield(LY), medium yield (MY), and high yield (HY), on chill weight (CW), water temperature (WT),percentage of spleen weight(SWP), bursa weight percentage (BRP), survive ability(SR), dressing wastage percentage(PVS), survive ability ratio(SA), dressing percentage (PD), and specific gravity(SG), of male broilers age 22 to 42 d

S.O.V		CW (g)	WT	SWP	BRP	SR	PVS	SA	PD	SG
LY		1483.00^{b}	40.19	0.13^{a}	0.18	66^{a}	30.67^{a}	0.96^{c}	71.36^{c}	1.050
MY		1497.47^{b}	42.41	0.12^{b}	0.16	88^{b}	29.69^{a}	0.98^{bc}	72.45^{bc}	1.046
HY		1638.24^{a}	45.33	0.13^{a}	0.16	100^{c}	28.76^{b}	1.00^{a}	73.24^{a}	1.046
ANOVA	DF	Signific								
Yield	2	***	n.s	*	n.s	***	**	*	*	n.s

n.s=not significant **p<.05,***p<.001,****p <.0001, $^{a-c}$ Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05)

TABLE 28. Effect of low yield(LY), medium yield (MY), and high yield (HY), on average hematocrit (AHC), body temperature age 35 (BT35) , and body temperature age41(BT41) and mean body temperature (MBT), of male broilers age 22 to 42 d

S.O.V		AHC	BT35^{O}C	BT41 ^{O}C	MBT ^{O}C
LY		30.50	41.29	41.23	41.26
MY		31.50	41.25	41.42	41.33
HY		34.10	41.18	41.53	41.35
ANOVA	DF	Significant			
Yield	2	n.s	n.s	n.s	n.s

n.s=not significant

TABLE 29. Effect of low yield(LY), medium yield (MY), and high yield (HY), on chloride ,(CL), magnesium(Mg), uric acid,, (UR, albumin ,(AL),calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K),) triglyceride,,(TR), of male broilers age 22 to 42 d

S.O.V		CL	Mg	UR	AL	Ca	PHOS	Na	K	TR
LY		116.05	1.61	3.87^{ab}	1.20	7.83	5.67	156.59	6.08	51.50
MY		111.72	1.52	2.60^{b}	1.09	7.07	5.19	143.46	6.00	40.84
HY		116.86	1.68	3.87^{a}	1.12	6.83	5.61	149.52	6.51	36.36
ANOVA	DF	Significant								
Yield	2	n.s	n.s	*	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant *p<.05, $^{a-b}$ Means with in a column with unlike superscripts under common subheading differ significantly(p<0.05)

TABLE 30 Correlation between final body weight (FW), weight gain (WG),), daily gain(DG),) gain proportion of final body weight(PG), water consumption (WC),water and weight gain ratio (WG), water feed ratio (WF),feed consumption(FC), mean feed consumption(MF), and body temperature age 36(BT35) , body temperature(BT41) mean body temperature (MBT), water temperature(WT) of male broilers age 22 to 42 d

	FW	WG	DW	DG	PG	WC	WG	WF	FC	MF	FE
BT35	0.06	-0.19	0.08	-0.19	-0.25*	0.08	0.08	0.09	-0.25*	-0.25*	0.24*
BT41	0.29**	-0.03	-0.08	-0.03	-0.33**	-0.08	-0.8	-0.08	-0.31**	-0.31**	0.31**
MBT	0.22*	-0.14	0.00	-0.1	-0.37***	0.00	0.00	0.01	-0.37***	-0.36**	0.35**
WT	-0.11	-0.11	0.29	-0.11	-0.09	0.29	0.24	0.37	-0.33	-0.33	0.22

p<.05,*p<.001,****p <.0001

TABLE 31 Correlation between spleen weight (SW),chill weight (CW), dressing wastage(VS), survive ability(SR),gall bladder weight(GW), specific gravity (SG),dressing percentage(PD), survive ability ratio(SA), total yield(TY), water absorb(WA), bursa weight(BR), and body temperature age 35 d(BT35) , body temperature age 41d(BT41) mean body temperature (MBT), water temperature(WT) of male broilers age 22 to 42 d

	SW	CW	VS	SR	GW	SG	PD	SA	TY	WA	BR
BT35	-0.14	-0.18	-0.13	0.16	0.43	-0.02	-0.14	-0.19	-0.00	-0.10	0.12
BT41	-0.00	0.05	-0.16	0.33**	0.32	0.15	0.12	-0.18	0.28*	-0.06	0.06
MBT	-0.13	-0.08	-0.1	0.32**	0.41	0.08	-0.02	-0.25*	0.16	-0.11	0.12
WA	-0.1	-0.2	0.39	-0.28	0.31	0.50	-0.27	0.19	-0.34	0.06	-0.24

**p<.05,*p<.001,

TABLE 32. Correlation between new castle disease titer(NDT), bursal disease titer(BDT), average hematocrit (AHC), and body temperature age 35 d(BT35) , body temperature age 41 d(BT41) mean body temperature (MBT), water temperature(WT) of male broilers age 22 to 42 d

	NDT	BDT	AHC
BT35	0.07	0.05	0.04
BT41	0.36	0.23*	-0.16
MBT	0.35	0.18	-0.10
WT	0.25	0.20	-0.98

*p<.05

TABLE 33. Correlation between chloride, (CL), magnesium (Mg),) triglyceride,(TR), uric acid,, (UR,) albumin ,(AL),calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K), and body temperature age 36 d(BT35) , body temperature age 41d (BT41) mean body temperature (MBT), of male broilers age 22 to 42 d

	Cl	Mg	TR	UR	AL	Ca	Phos	Na	K
BT35	-0.21	-0.35	-0.17	-0.09	-0.14	-0.23	-0.20	-0.05	-0.31
BT41	-0.23	0.20	-0.01	0.29	0.13	-0.16	0.12	0.07	0.02
MBT	-0.15	-0.07	-0.12	0.16	0.00	-0.27	0.03	-0.17	-0.17

TABLE 34. Correlation between specific gravity(SG), dressing percentage(DP), survive ability ratio(SA), total yield(TY), water absorb(WA), bursal weight(BR), spleen weight(SP), chill weight(CW), water weight(WW), dressing wastage(VS), and chloride ,(CL), magnesium(Mg),) triglyceride,,(TR), uric acid,, (UR,) albumin ,(AL), calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K), of male broilers age 22 to 42 d

	SG	DP	SA	TY	WA	BR	SW	CW	WW	VS
CL	0.10	0.28	-0.12	0.03	0.17	-0.22	-0.10	0.14	0.16	-0.23
Mg	0.10	0.38*	0.02	0.16	0.20	-0.18	-0.31	0.25	0.22	-0.34
TR	0.29	-0.17	-0.34	-0.32	-0.01	-0.23	0.32	0.25	-0.25	0.17
UR	-0.00	0.41	0.24	0.35	0.27	0.03	-0.25	0.35	0.04	-0.36
AL	-0.00	0.30	-0.14	-0.08	0.19	-0.20	-0.10	0.05	0.01	-0.24
Ca	0.05	0.17	-0.11	-0.21	0.27	-0.06	-0.23	0.05	0.07	0.73
PHOS	0.33	0.23	-0.25	-0.02	0.01	-0.05	-0.09	0.01	0.32	-0.24
Na	0.06	0.26	-0.03	-0.00	0.17	-0.22	-0.15	0.14	0.10	-0.21
K	0.17	0.04	-0.39*	0.03	0.03	-0.39*	0.09	-0.13	0.10	-0.15

*p<.05

TABLE 35. Correlation between final weight(FW), weight gain(WG),water consumption (WC), daily water(DW), daily gain(DG), gain percentage(DG), water and gain ratio(WG), water feed ratio(WF), feed consumption(FC), mean feed consumption(MF), feed efficiency (FE),survivability(SR), and chloride ,(CL), magnesium(Mg),) triglyceride,,(TR), uric acid,, (UR,) albumin ,(AL),calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K), of male broilers age 22 to 42 d

	FW	WG	WC	DW	DG	PG	WG	WF	FC	MF	FE	SR
CL	0.37	0.26	0.11	0.11	0.26	-0.14	0.11	0.11	0.18	0.18	0.07	-0.07
Mg	0.33	0.18	0.07	0.07	0.18	-0.26	0.07	0.07	0.03	0.03	0.14	-0.10
TR	0.12	0.05	0.17	0.17	0.05	-0.15	0.18	0.17	-0.09	-0.09	0.15	0.01
UR	0.13	0.02	0.16	0.16	0.02	-0.23	0.16	0.16	0.01	0.01	-0.00	-0.01
AL	0.22	0.12	0.18	0.18	0.12	-0.18	0.18	0.18	-0.11	-0.11	0.25	-0.04
Ca	0.21	0.11	0.23	0.23	0.11	-0.18	0.23	0.23	0.17	0.17	-0.08	-0.2
PHOS	0.36	0.24	0.23	0.23	0.24	-0.16	0.23	0.23	0.04	0.04	0.21	-0.02
Na	0.22	0.14	0.19	0.19	0.14	-0.15	0.19	0.19	0.16	0.16	-0.05	-0.06
K	0.38*	0.30	0.07	0.07	0.30	-0.05	0.07	0.07	-0.01	-0.01	0.33	0.18

*p<.05.

TABLE 36. Correlation between new castle disease titer(NDT), bursal disease titer(BDT), average hematocrit(AHC), and chloride ,(CL), magnesium(Mg),) triglyceride,,(TR), uric acid,, (UR,) albumin ,(AL),calcium, (Ca), phosphorus, (Phos), sodium, (Na), potassium , (K), of male broilers age 22 to 42 d

	NDT	BDT	AHC
CL	0.16	0.04	-0.15
Mg	0.11	0.02	-0.29
TRIG	0.57	0.14	-0.29
URIC	0.51	-0.02	0.41
ALB	0.31	-0.05	-0.17
Ca	0.35	-0.14	-0.43
PHOS	0.84	0.01	-0.20
Na	0.12	-0.01	-0.00
K	-0.06	0.10	-0.17

Table 37 Starter Ration

Ingredient	%
Corn	51.623
Soybean	37
Meat and bone	3
Fat	6
Salt	0.23
Vitamin mix	0.05
Trace minerals	0.1
Methionine	0.1
Deflorinated phosphate	1.4
Calcium carbonate	0.36
Choline	0.05
Copper	0.03
Ethoxy	0.01
Selenium	0.06
M.E	3150 Kcal/Kg
C.P	23

Table 38 Grower Ration

Ingredient	%
Corn	61.39
Soybean	31
Fat	4.7
Salt	0.252
Vitamine mixe	0.05
Trace minerals	0.1
Methionine	0.1
Deflorinated phosphate	1.298
Calcium carbonate	1.02
Choline	0.05
Copper	0.03
Ethoxy	0.01
Selenium	0.01
M.E	3170 Kcal/Kg
C.P	21

Table 39. Electrolyte composition

Ingredients	Electrolyte (h) g/46 l water	Electrolyte(l) g/46 l water
Potassium Bicarb	126.50	63.26
Potassium Sulfate	49.00	24.5
Sodium Bicarb	43.12	21.6
Dextrose	13.28	6.64
Zinc Chelate	2.160	1.1
Manganese Sulfate	0.49	0.45
Copper Sulfate	1.28	0.24

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CHAPTER IV

Examination of Effects of Supplementation of Electrolytes and Betaine on Body Temperature and Performance in Virginiamycin–fed Male Broilers; Fed and Fasted, When Exposed to Heat Stress

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ABSTRACT Seven hundred and twenty male broilers, fed diets with and without virginiamycin (20ppm), were raised in broiler pens to age seven weeks. At that time birds in each treatments were pooled then randomly assigned to battery cages in a 37^{O} C environment. Five treatments, 24 replicates per treatment administered for a period of three days; were supplemented with either electrolytes (EL), betaine0 .05% (BL), EL X BL, or EL X BH (betaine 0.1%) while one served as a control. All supplemented were administered through drinking water. Each replicate or cage was comprised of six birds; three birds, painted for identification, with a history of being fed VM and three birds that had not been fed VM. Twelve replicates per treatment (360 birds) were fasted; another twelve replicates per treatment (360 birds) were offered ad libitum finisher feed (3170 Kcal M.E / Kg. 21% CP). Daily survivability for the first 24 h (S24), second 24 h (S48), third 24 h (S72), as well as mean survivability at 48 and 72 h (S1 and S)

were calculated. Weight difference (WD), daily weight difference (DWD), percentage of weight difference (PWD), final body weight (FW), feed consumption (FC), mean feed consumption (MF), FC as a ratio of FW (PF), water consumption for 4 days (WC), daily water consumption (DW), daily dead weight (DWT1, DWT2, DWT3), and body temperature (BT) were also determined. All above variables were used to examine the effect among treatments for fed (FED) and fasted (FAST) birds as well as any VM effect. All statistically analysis utilized PROC GLM. Body temperatures of BL and FED birds were high ($p < 0.05$) when compared with EL X BL and FAST. Mean feed consumption of EL X BL birds was higher ($p < 0.05$) compared with control. Daily water and WC of FED birds were more ($p<0.05$) relative to FAST birds. Weight difference (birds showed weight loss) was low ($p < 0.05$) for BL compared with control. Weight difference, PWD, and DWD were all low ($p < 0.05$) of VM relative to control and FAST verses control of VM and FED. Survivability 48 was low ($p < 0.05$) compared with control, while S72 was high ($p < 0.05$) compared with EL X BL. Survivability 24 and S1 were high ($p < 0.05$) for birds with a VM history compared with control. Survivability 72, S1, and S were high ($p < 0.05$) for FAST birds compared with FED. Dead weight of second day was lowest ($p < 0.05$) of BL compared with EL. Fasted bird's DW2 was lower ($p < 0.05$) compared with FED. In conclusion on the basis of data achieved with this experiment suggests that VM history, FAST, EL and BE can be beneficial tools to get more productivity and survivability during heat stress.

(Key words virginiamycin, betaine, electrolyte, heat stress, body temperature, fasting)

INTRODUCTION

High ambient temperature is a major limiting factor of broiler production in tropical and subtropical regions. The depression of broiler performance due to high ambient temperature cannot be fully compensated for by management practices especially in hot-climate developing countries. Limited capital is available to reduce the heat in chicken houses (Mathur and Horst, 1989; Cahner, 1990).

Birds are able to adapt the process of adjustment to increasing the external physical environmental temperature increase it s tolerance. Teeter et al (1985) observed chronically thermo stressed chicks exhibit a respiratory cycle with panting and non-panting phase. Thus the bird that has developed a tolerance to high temperatures can alter its heat output when hyperthermal rises begin (Elaroussi, 1987). Hutchinson and Sykes (1953) were able to increase the tolerance of birds to high temperature by exposing them for up to 4 h daily to 37^{O} C during a period of 24 successive days.

A heat stress response of elevated body temperature was observed this elevation followed by increased mortality. Mortality is associated with an inability to regulate body temperature under heat stress conditions (Keshavaraz and McDougald, 1981). Body temperature may also been indicator of metabolism with greater heat production resulting during period of increased body temperature. It was observed that a adult fowl's body temperature normally falls within the range of 41 to 42^{o} C a significantly increased body temperature is observed when environmental temperatures increase significantly ((Donkoh,

1989). Wilson (1948) observed that the individual variation in body temperature was greater at higher ambient temperatures.

Virginiamycin is an effective antibiotic against gram-positive microorganisms (DE Somers and Van Dijck, 1955) it has been well documented as improving broiler growth rate and feed efficiency (Woodward et al., 1988, Harms et al., 1986; Miles, et al., 1978) as well as carcass yield (Woodward et al., 1988; Lesson, 1984). Improved performance in broilers feed consumption (Buresh et al., 1985a; Leeson 1984) and nutrient absorption efficiency (Nelson et al., 1963; March, et al., 1984; Miles and Harms, 1983) was observed with the supplementation of virginiamycin in feed. Enhanced utilization of phosphorus(Buresh et al., 1985b) and manganese (Henry et al., 1986) was seen in birds consuming virginiamycin.

Betaine is a metabolite of choline that donates methyl groups to homocystein to form methionine, and also to the folate pool. Betaine is formed from choline and that growth responses obtained from betaine are due to its ability to provide methyl group. (Kidd et al., 997). Birds maintain the intracellular concentration of water that is crucial for homeostasis by osmoregulation. Osmoregulation is the ability of a cell to maintain its structure and function by regulation movement of water in and out of the cell (Kidd et al., 1997). The osmoprotective properties of betaine are well conserved in may forms of life, including bacteria (Chambers and Kunin, 1987), and animals (Law and Burg, 1991).

Osmoprotective substances are used by bacterial cells to prevent dehydration when growing in concentrated solutions of glucose, sodium chloride or other salt. Betaine is the most important osmoprotective compound in bacteria, (Imhoff and Rodriguz- Valera, 1984) Betaine is known as to serve as an osmoprotectant in bacteria by replacing intracellular K and restoring the osmotic turgor without accumulation of K when the environmental salinity increased (Sutherland et al., 1986). Beneficial osmoprotective properties may be due to the dipolar zwitterin characteristics of betaine and its high solubility in water (Chambers and Kunin, 1985). The unique chemical properties of betaine play a key role in providing osmoprotective properties in microorganisms and these attributes have a parallel in more complex organism (Bagnasco et al., 1986). Saundreson and MacKinlay (1990) evaluated growth and hepatic enzymes in male broiler chicks as influenced by dietary supplementation with combinations of methionine, betaine and choline. Betaine inclusion improved the growth of chicks fed a semi- purified diet (McGinnis et al., 1942). Finkelstein et al. (1983) evaluated that supplemental betaine and choline at dietary levels of 0.2 % on hepatic betaine-homocystine methyltransferase activity increased as dietary levels of betaine and choline increased.

Therapeutic applications of electrolytes to lessen the consequences of heat stress have been partially successful in chickens. These therapeutic applications have multiple actions that improve acid base water and mineral balances simultaneously. Previous research has demonstrated that heat stressed birds exhibit increased potassium excretion (Smith and Teeter, 1987a).

Teeter et al. (1985,1990) stated that blood electrolyte balance in chickens altered during heat stress and that supplementation of drinking water with potassium chloride has resulted in reduced mortality rates in heat-stressed broilers. Smith and Teeter (1987) suggested that blood pH and K are dependent factors that affect acclimation to chronic heat stress. Branton et al (1986) observed that the affects of ammonium chloride and sodium bicarbonate solution on mortality are more directly related their influence on water intake than to specific changes in blood pH.

Teeter et al. (1985) stated that supplemented NH_4CL and $NaHCO_3$ and Kcl have all been observed to increase weight gain or survivability to various degrees. Husseiny and Creger (1981) reported that broilers subjected to a 32° C environment for 42 days had lowered rates of Ca, Cu, Fe, K, Mg, Mn, Na, P, and Zn retention. Smith and Teeter (1987a) suggested that the negative K balance might be a consequence of respiratory alkalosis. Ali Zulfiquar et al. (1994) did not observe any significant effect on any parameter with supplementation of $NaHCo_3$. Nor did a combination ammonium chloride and sodium bicarbonate have any significant effect on egg quality.

Objective of this study was to examine the carry over effect of pre fed Virginiamycin supplemented with electrolyte and betaine on survivability and body temperature of fed and fasted birds when exposed to heat stress.

MATERIALS AND METHODS

Seven hundred twenty Cobb X Cobb male broilers were raised in floor pens that were covered with four inches of wood shavings. Each pen contained two feeders and a tube drinker with nipples. At age 14 days birds were wing banded, daily and weekly recorded of body weight, feed intake, and mortality were record on prescribed data capture forms. Birds were fed with and with out virginiamycin, 20ppm (VM20) from the day after hatching through seven week age. Feed and water were provided ad libitum. Birds were offered starter feed (1397 Kcal/LB M.E, 22.6% CP table 11) from day old to 4 weeks of age then finisher feed (1466 Kcal M.E / LB. 17% CP table 11) through 7 weeks of age. Birds from each group were pooled from fed and not fed VM, the floor pens at the age of seven weeks and were moved into the battery house where ambient temperature was set at 37° C during daytime and 24° C during nighttime. Five treatments, 24 replicates per treatment were administered via the drinking water. Four consisted of supplementation with electrolytes (EL), betaine 0.05%(BL), EL X BL, or EL X BH (betaine 0.1%) for a period of three days; the fifth group was control group. Each replicate or cage was comprised of six birds; three birds that had been fed VM and three birds that had not been fed VM. Virginiamycin-fed birds were painted for identification. Twelve replicates per treatment (360 birds) were without feed and the other 12 replicates (360 birds) were offered ad libitum finisher feed. All on-feed birds were fed finisher diet (3170 Kcal/ Kg M.E., 21% CP) before and after placement in the battery house for the experimental period. Daily survivability for the first 24 h (S24), the second 24 h (S48), the third 24 h (S72), and the mean survivability at 48 (S1) and 72 h (S) were calculated. Weight

difference (WD), daily weight difference (DWD), percentage of weight difference (PWD), final body weight (FW), feed consumption (FC), mean feed consumption (MF), FC ratio of final body weight (PF), water consumption (WC), daily water consumption (DW), daily dead weights (DWT1, DWT2, DWT3), and body temperature (BT) were determined. All above variables were used to examine the effect of treatments of fed (FED) verses fasted (FAST) birds, as well as VM effects.

RESULTS

Feed consumption

Feed consumption (FC) and feed consumption percentage of final body weight (PF) (Table 1) among treatments were not significant. However mean feed consumption (MF) was higher ($p>0.05$) with EL X BL (28%) compared with EL X BH and control. Treatment increased ($p>0.05$) FC with EL, BL, EL X BL, and EL X BH compared with the control group. Feed consumption percentage of final body weight (PF) was elevated ($p>0.05$) with EL, BL, EL X BL, and with EL X BH compared with the control group.

Water consumption

Daily water (DW) consumption and total water consumption (WC), comprised (Table 2) showed no significant ($p>0.05$) effect of treatments. Water consumption and DW was more ($p=0.005$) of FED birds compared with FAST birds consumption. Electrolytes supplementation of FAST birds reduced ($p>0.05$) DW and WC compared to FAST control birds whereas EL increased ($p>0.05$)

DW in FED birds compared with FED control birds. Betaine low level increased ($p>0.05$) DW in FAST birds and FED birds compare to control birds. Electrolytes combined with BL decreased ($p>0.05$) DW in FAST birds but increased ($p>0.05$) DW in FED birds. Fasted birds responded to EL X BH with a decreasing ($p>0.05$) DW.

Body weight.

Weight difference (Table 3) which compared the beginning and ending weights for changes seen over the three-day heat stress period, was negative (weight loss) with all treatments under main effects. Betaine low level responded with a lower ($p>0.05$) WD compared with control WD. Percentage of weight difference (PWD) was not influenced ($p>0.05$) by all treatments; however BL supplementation yielded lower PWD ($p>0.05$) compared with EL, control, EL X BL, and EL X BH. The DWD was lower ($p>0.05$) with BL compared with control birds. Electrolytes alone, EL X BL, and EL X BH resulted in a reduced ($p>0.05$) DWD. Birds pre-fed VM had significantly lower ($p=0.03$, 0.02, and 0.03) WD, PWD, and DWD compared with control group. Fed birds WD, PWD, and DWD were significantly ($p=0.0001$) lower when compared with control birds

Two-way interactions of TRT X VM were not significant ($p>0.05$) showed in (Table 3). Numerical comparisons showed that VM with supplementation of EL, BL, EL X BL and EL X BH supplementation lest less ($p>0.05$) weight compared birds with FED VM alone. Overall it was found that birds pre-fed VM

combined with EL during the three days of heat stress lost less ($p>0.05$) weight compared with the other combinations BL, EL X BL, and EL X BH.

None of the two-way interactions of treatments and feeding level (FED and FAST) were significant. However treatments with FED birds tended towards a weight loss pattern except for BL with a WD of +28g, PWD of +1g, DWD of +1.6 g and EL X BH with WD of 0.5g, PWD of 0.03 %, and DWD of 0.06g which showed weight gain instead of weight loss. Supplementation with EL resulted in a loss of 26 g (WD) in FED birds compared with the FED control groups lost of 57g. The supplementation of EL the values for PWD, WD, and DWD were lower (p.0.05) than the control FED birds. Fasted birds supplemented with EL, BL, EL X BL, and EL X BH loss less ($p>0.05$) weight during the heat stress period when compared with FAST birds.

Examination of three-way interactions of TRT X FED X VM showed no significant ($p>0.05$) effects for WD, PWD and DWD (Table 3). Virginiamycin improved ($p>0.05$) protection from weight losses during heat stress for fasted birds; the WD (38 g) PWD (1.76 %) and DWD (2.1 g) less than fasted birds. Electrolytes supplementation to fasted birds pre-fed VM resulted in lower ($p>0.05$) WD, PWD, and DWD whereas BL X VM X FAS, EL X BL X VM X FAST, and EL X BH X VM X FAST, interactions resulted in higher ($p>0.05$) weight losses when compared with VM X FAST birds. Weight gain was observed with supplementation of EL by 28 g, and with BL (50 g) in fed birds pre-fed VM. Treatments EL X BL X FED and EL X BH X FED lost less ($p>0.05$) weight than that of fed birds pre-fed VM.

Final weight

Final weight (table 4) indicates main effects ($p>0.05$) of treatments. Electrolyte supplementation showed highest ($P>0.05$) final weight (FW) compared with EL combined with BL. Betaine low level showed more ($p>0.05$) final weight compared with control. Virginiamycin- fed birds showed significantly ($p=0.03$) higher FW (1.03%) compared with control group. The fed group also had a significantly ($p=0.0001$) higher FW when compared with the FAST group.

Final weight in the treat X VM show EL X VM with a 3.1%, BL X VM with a 2.2%, EL X BL X VM with 2.35% and EL X BH X VM with a 1.8% higher than that of control birds; however non of these interactions were significant ($p<0.05$).

Interactions in the treat X FED improved ($p>0.05$) 0.4% FW of FAST birds with supplementation of EL whereas BL, EL X BL, EL X BH reduced ($p>0.05$) FW of FAST birds compared with FAST control group. Electrolytes improved ($p>0.05$) FW (2.3%), BL (3.2%), EL X BL (0.7%), and EL X BH (1.2%) more of fed birds relative to fed control. Treatment X FED X VM did not influence significantly ($p>0.05$) on FW but VM (1.7%), EL X VM (1.4%). ELX BL X VM (2.3%) and EL X BH XVM (1%) increased ($p>0.05$) FW of FAST birds compared with FAST control. Final weight with VM (0.2%), EL X VM (4.6%), BL X VM (4.6%), EL X BL X VM (2.3%) and EL X BH X VM (2.6%) of fed birds was more ($p>0.05$) than fed control.

Body temperatures

Under main effect (table 4) BT reflects a not significant ($p>0.05$) effect between two treatments with supplementation of BL showing a high ($p>0.05$) BT compared with EL X BL for a difference of 0.7 %. There was no significant in BT between bird's pre-fed VM and control birds. However BT was significantly ($p=0.0001$) higher (2.6%) in FED birds compared with FAST birds.

No significant in two-way interactions on BR were found. Numerically the EL X VM and BL X VM birds showed increased ($p>0.05$) BT, while EL X BL X VM and EL X BH X VM showed reduced ($p>0.05$) BT when compared with control birds. Other numerical difference seen, when compared control bird values, were EL increased ($p>0.05$) BT of both FAST and FED birds, BL increased ($p>0.05$) fed BT and did not effect FAST, BT. Electrolytes X BL decreased ($p>0.05$) BT of FED and did not change FAST birds BT. Electrolytes X BL decreased ($p>0.05$) FAST, BT and increased FED compared with control birds.

In three-way interactions of treat X FED X VM increased ($p>0.05$) BT of FED birds and decreased ($p>0.05$) BT of FAST birds. Electrolytes X VM did not change BT of FAST birds but increased ($p>0.05$) BT of FED birds. Betaine low-level with VM and BL with EL and VM increased ($P>0.05$) BT of FED and FAST bird's BT. Electrolytes X BH X VM decreased ($P>0.05$) BT of FAST birds and increased BT of FED birds compared with control group.

Survivability

Survivability data during the three days heat stress period was collected on Table 5 as survivability of first 24 hours (S24), second 24 h (S48), thirds 24 h

(S72), survivability of first 48 h (S1) and survivability of 72 h (S). Survivability (S24) was higher ($p>0.05$) with EL and EL X BL by 2% when compared with control birds and was low ($p>0.05$) by 1% with EL X BH. Survivability 48 (S48) was lower ($p>0.05$) with ELX BH compared with control of treatments. Survivability72 was improved ($p>0.05$) by 2% and decreased ($p>0.05$) with EL X BL by 4% compared with control. Survivability1 was decreased ($p>0.01$) with all treatments except EL X BL, which increased ($p>0.01$) S1 by 2%. Survivability (S) did not influence by any treatment. Virginiamycin significantly ($p=0.03$) improved S24 by 6%, reduced ($p>0.05$) S48 and surv72 but improved ($p=0.02$) S1 by 4% and S by 2%.($P>0.05$)

Survivability24 and S48 were higher ($p>0.05$) respectively of FAST birds whereas S72, S1, and S were significantly higher ($P<0.004$) of FAST birds compared with FED birds. Survivability24 was improved ($p>0.05$) with EL X VM. BL X VM by 6% EL X BL XVM improved ($p>0.05$) by 7% and EL X BH XVM by 9% compared with control group. Survivability72 and S48 were decreased ($p>0.05$).

In two-way interaction of treat X VM all survivability except S72 was improved ($P>0.05$) with EL X BH compared with all interactions in this group. Survivability (S1) was better ($p>0.05$) with EL X VM by 2% BL X VM by 4% EL X BL X VM by 6% compared with controls. In two-way interactions (table 5) of treatments X FED, S24 of fed birds were improved ($p>0.05$) with EL by 2% compared with fed control. BL improved S24, S1 and S of FAST birds and with EL X BL improved ($p>0.05$) by 2% of FAST birds compared with FAST control

group. Surviability24 of fed birds was depressed (p>0.05) with BL by 3%, improved (p>0.05) by 2% with EL X BL, and with EL X BH improved (p>0.05) by 2%. Survivability 48 of FAST birds were decreased with EL, BL, and EL X BH and also fed birds Surv48 were decreased with BL and ELX BH. Survivability (S72) of FAST birds was 100% with EL, BL and decreased with EL X BH.

Survivability1 (table 5) of FAST birds was more (p>0.05) with BL and was less (p>0.05) with EL X BH. Fed birds S1 were decreased (P>0.05) with EL by 3% BL by 4% and EL X BH by 1%. Survivability of FAST birds was decreased (P>0.05) with EL X BL by 4%, EL X BH by 15%, and was increased (p>0.05) with BL by 2%. Survivability of fed birds was decreased (P>0.05) EL X BL and EL X BH by 2%. In three-way interaction (table 5) of treatments X VM X FED showed no significant (P>0.05) effects. Survivability 24 of FAST birds with VM X EL improved (P>0.05) by 3% with VM X BL and with EL X VM X BL and EL X VM X BH improved (P>0.05) by 9%. Fed bird's S24 was increased (p>0.05) with VM X EL by 3% with EL X VM by 9% BL XVM by 3% with BL X EL X VM by 6% and with EL X BH X VM by 9%. Survivability 48 was decreased (p>0.05) with VM X FED, EL X FED, EL X VM X FED, BL X FAST, BL X FED, BL X VM X FED, and EL X BL X VM X FED, EL X BH X VM X FED and with BL X VM X EL X FAST. Survivability 72 was 100% with VM X FAST, BL X VM X FAST, and EL X BL X VM X FAST. Survivability was improved (p>0.05) of FAST birds by 6% with EL, EL X VM by 3%, BL X VM by 9% compared with control birds.

Dead weight

A significant ($p<0.05$) effect of dad birds body weight summarized in table 6, is seen on dead weight day two (DW2) with EL supplementation 9% more compared to BL and BL X EL. Virginiamycin DW2 was numerically higher ($p>0.05$) than its control. Fed birds showed a significantly ($p<0.05$) higher DW 2 (2.3%) compared with FAST birds. Dead weight day one (DW1) was 3% more ($p>0.05$) with EL compared with control. Dead weight (DW1) was 1.2% less ($p>0.05$) with VM compared with control. Dead weights, DW 1 and DW3 of fed birds were more ($p>0.05$) than FAST birds. Dead weight (DW3) of VM birds was 3.5% less ($p>0.05$) than control of VM. Dead weight (DW3) was 0.07% more with BL compared with control.

Correlation

Correlation of fed birds table 7 showed positively correlation between FC and WD, PWD, DWD, FW, DW2 and positive correlation of DW1 and DW3. Mean feed consumption correlation with WD, PWD, and DWD was positive whereas was positive with FW, DW1, DW2 and DW3. Body temperature was positively correlated with WD, PWD, DWD, FW and DW2. Survivability 48 and FW were positively correlated. Survivability 24, S48, S72, S1 and S positively correlated with WD, PWD, DWD, FW, DW1, DW2 and DW3. Table 8 comprised of correlation showed FC and MF, positive relationship with all survivability. Water consumption and DW were negatively correlated with Surv48, Surv1, and Surv. Body temperature was negatively correlated with Surv72, Surv1, and Surv and negatively correlated with Surv24 and Surv48. Body temperature correlation (table 9) with FC, DW, WD was positive with MF.

DISCUSSION

Main objective of this study was to examine the carry- over effects of VM (pre-fed) on various factors with survivability and body temperature being examined in male broilers during three days of heat stress. Each cage has 3 birds that had been pre-fed VM and three birds without VM pre-feeding since feed and water during the heat stress period was offered on a cage basis, feed and water consumption was not included to determine VM effects. Feed consumption (Table 1) with supplementation of EL and BL was greater ($p>0.05$) compared with control group. Electrolytes combination with BL resulted decreasing feed intake. Mean feed consumption was significantly high with EL X BL compared with control and EL X BH. It is interesting that FC was very low in the EL X BL treatment, while MF was highest ($p>0.05$) with the same treatment. This is due to variation in degree of mortality in this treatment. Electrolytes increased water consumption (Table 2) of FED birds but decreased water intake in FAST birds. Betaine low-level supplementation increased ($p>0.05$) water intake in FAST birds and decreased water intake in FED birds. It was reversed with EL supplementation. Although water intake of FAST birds were decreased with EL and increased with BL FED birds water intake was increased with EL and decreased with BL. A combination of EL with BL and BH decreased ($p>0.05$) water intake in FAST birds and increased ($p>0.050$ water intake in fed birds.

The adverse effect on weight differences (Table 3) was decreased with EL, BL, EL X BL and EL X BH of heat stress. Virginiamycin protected the weight loss in heat stress birds by 12%; this is very important economically for the

poultry industry. Supplementation with BL in VM birds showed 37 % more protection against weight losses with EL supplementation no protection against weight loss in VM birds was seen. Betaine low level X EL supplementation in VM birds reduced weight losses by 14%. This indicates a synergism between VM and Betaine and VM combined with betaine and electrolytes. Electrolyte and betaine supplementation also showed a positive response in protecting body weight from the adverse effects of heat stress.

Reduced fasted and fed birds body weight (Table 3) indicate the positive influence of supplementation with EL, BL, EL X BL, EL X BH. All treatments showed either numerically lower or higher weight losses; however betaine both with and without electrolytes, actually effected a ($p>0.05$) weight gain. Virginiamycin with EL and betaine showed weight gain of fed birds. Virginiamycin in FAST birds reduced ($p<0.05$) weight losses by 12%.

Final weight (Table 4) was increased ($p>0.05$) with EL compared with EL X BL and EL X BH. Betaine low level showed a increased FW but EL X BL resulted in a decreased FW. Final weight of VM birds was higher ($p<0.05$) by 2.5% than control of VM. Virginiamycin X EL and VM X BL increased ($p>0.05$) FW compared with treatments without VM and with EL and BL. Final weight of BL (fed) birds was higher ($p>0.05$) than all other treatments of FED birds in TRT X VM group. Fasted bird's FW was higher ($p>0.05$) with VM and with supplementation of EL while with BH was less ($p>0.05$) than seen in VM birds. Electrolytes increased ($p>0.05$) the FW of FAST birds but BL X EL and BH X EL reduced ($p>0.05$) the FW of FAST birds.

Body temperature (Table 4) has no significant ($p>0.05$) effect of treatments and EL X BL birds has lowest ($p>0.05$) body temperature (BT) when compared with BL. Treatment with electrolyte and betaine resulted in a high ($p>0.05$) BT compared with control birds: however the treatment combination of EL X BL resulted in a lower BT compared with control. To maintain a constant BT an animal's body must lose heat at the same rate it is produced by metabolic activity. Birds need to evaporate water (panting) during high ambient temperature to maintain body temperature. Correlation between BT water consumption and feed consumption (Table 9) shows a positive relationship. Teeter et al.(1987b) showed increasing water consumption helps to combat heat stress by acting as a heat sink for broiler body heat.

Birds pre-fed VM did not show any difference in BT compared to pre-fed VM but with the supplementation of EL X BL and EL X BH, BT was decreased ($p>0.05$) and was increased with EL or BL. Fed birds BT was significantly($P<0.05$) higher than FAST birds. Treatment electrolytes increased BT in both FED and FAST birds compared to control of FED and FAST birds. BL increased the BT of fed birds only. Fasted birds pre-fed VM decreased ($p>0.05$) the BT and increased ($p>0.05$) BT of FED birds. Virginiamycin birds showed decreased ($p>0.05$) BT of FAST birds when supplemented with EL. Electrolytes increased ($p>0.05$) BT in both FED and FAST birds whereas BL decreased ($p>0.0$) BT of FAST birds and increased ($p>0.05$) BT of FED birds. Body temperature of FAST birds was less ($p<0.05$) than that of fed birds because of more energy retention of body for maintenance of fed birds compared with FAST birds.

Wiernusz and Teeter (1993) explained that the increased heat production associated with metabolism is more pronounced during heat stress. Any factor which increased heat production of heat exposed birds such as food metabolism (MacLeord et al., 1979; Wiernusz and Teeter, 1993) will resulted in the increasing heat load of birds. Wiernusz and Teeter (1995) observed low body temperatures of FAST birds pre exposed to heat stress. A virginiamycin carry over effect resulted in increased ($p>0.05$) body temperature in FED birds and decreased BT of FAST birds in this study may be related with enhanced increased dietary ME. Nelson et al. (1963) reported that VM increases dietary ME of fed birds. Virginiamycin efficacy also been reported to be more pronounced in turkeys (March et al., 1978) and broilers (Buresh et al., 1984) fed low caloric density diets. Increased AME in broilers with Virginiamycin supplementation has been attributed to improve dietary fat retention (Bartov, 1992). On the basis of VM capability of increasing BT in fed birds it could be suggested that VM enhancement of energy retention exists even after withdrawal from feed.

Early biochemical studies on betaine revealed that a betaine related growth response was obtained due to its ability to provide methyl groups to homocystine to form methionine (Kidd et al 1997). Betaine is synthesized from choline by choline oxidase and it can donate methyl groups to homocystine to form methionine (Kidd et al., 1997). Physiologically betaine is one of several compounds used by cells to regulate osmotic pressure. Among the potential

benefits of its inclusion in poultry feeds are sparing choline, carcass fat reduction and aiding cell osmoregulation.

It was also observed that betaine can sometime spare methionine since betaine provides methyl groups for methionine regeneration (Kidd et al., 1997). Stekol et al. (1953) reported that in chicks betaine methylates homocystine to methionine approximately three times more efficiently than that choline. This difference in efficiency may be due to inefficiencies in the metabolic conversion of choline to betaine. Choline must be transported from the cytosol into the mitochondria where it is oxidized into betaine, and then betaine is transports to the cytosol where it can function as a methyl donor (Mann et al., 1938). Besides a possible methionine sparing effect, betaine may also affect lipid metabolism by stimulating the oxidative catabolism of fatty acids via its role in carnithine synthesis. Thus betaine may a potential for reduced carcass fatness in commercial production (Schutte et al.,1997). Pesti et al (1980) hypothesized that broiler growth can be impeded by insufficient numbers of metabolically active labile methyl donors rather than by methionine. His hypothesis was supported by feeding trials where improved growth and feed efficiency was seen with betaine-supplemented feed

Schutte et al. (1996), observed that inclusion of betaine at 0.04 % drinking water did not significantly affect body weight gain, whereas said trial had shown the same trend with the inclusion of betaine at 0.05 % through drinking water. Mathews et al. (1995) reported that no significant was found with betaine at 0.1% on weight gain. Although there was no influence seen on weight gain with

betaine on because of the short term of the current trial but betaine reduce ($p>0.05$) the adverse effect of heat stress on weight loss with supplementation of betaine 0.05% in drinking water.

Virginiamycin is an effective antibiotic against Gram-positive microorganisms (De Sommer and Van Dijck, 1995) and has been shown to improve broiler growth rats and feed efficiency (March et al., 1984, 1978; Miles et al., 1984b; Harms et al., 1986, 1983; Woodward et al., 1988). Lesson et al. (1984) reported improved performance in broilers fed diets containing VM. Virginiamycin is also associated with increased feed consumption and nutrient absorption efficiency (Nelson et al., 963; March et al., 1981). The improved nutrient absorption may be related to reduced intestinal mass and mucousal membrane thickness (King, 1974; Solca et al., 1980) as improved yield has been attributed to reduced intestinal tract weight (Izat et al., 1989; Salmon and Stevens, 1990; Henry et al., 1986). Nelson et al. (1963) reported that improved chick growth with VM supplementation is associated with reduced intestinal weight and increased dietary ME_n.

Virginiamycin efficacy reported to be more pronounced in turkeys (March et al., 1978) and broilers (Buresh et al., 1984) fed low caloric density diets. The increased AME_n in broilers with VM supplementation has been attributed to improved dietary fat retention (Bartov, 1992). The influence of VM on net energy efficiency is yet unknown. Weight differences seen in the current trial (Table 3) agree with the result seen previously with 15 ppm VM supplementation in diets fed to broilers exposed to high environmental temperatures, where increased

weight gain were seen with 20 ppm VM fortification reduced mortality and increased saleable carcass was seen (Belay and Teeter, 1994). Our study of the VM (20 ppm) carry- over effect was very promising in heat stressed birds by its protection of weight loss, body temperatures, final body weight and survivability.

Electrolyte supplementation has been reported to be important in maintaining acid-base balance and it has been suggested that at high temperatures broilers have a dietary requirement for bicarbonate (Teeter, et al.,1985; Teeter et al., 1986; Balnave and Gorman, 1993). Beneficial responses to sodium bicarbonate (Hayat et al., 1999; Teeter et al., 1985; Balnave et al., 1993; Maria et al., 1998; Macari et al., 1994; Edence et al., 1976; Whiting et al., 1991[1]) potassium bicarbonate (Hayat et al., 1999: Teeter et al., 1985; Balnave et al., 1993;Maria et al., 1998; Macari et al., 1994; Teeter et al., 1986), potassium chloride (Abdellah et al., 1995; Macari et al., 1994; Whiting et al., 1991[1;] Teeter et al., 1986; Smith, 1994; Smith et al., 1987,1989, 1992) and sodium chloride (Smith, 1994; Smith et al., 1987,1989, 1992) supplementation in the diet or drinking water were observed in heat stressed birds.

Hayat et al. (1999) observed increasing water intake with the supplementation of sodium bicarbonate at different dosage in drinking water, whereas our observations showed decreasing water intake with the electrolyte pack. Sodium bicarbonate was 0.06 g / l in our present study, whereas their minimum dosage was 2 grams per liter water. Supplementation of potassium bicarbonate has been shown to reduce overall body weight gain and significantly increase over all feed conversion ratio (Hayat et al., 1999). Body weight gain was

not affected by dietary sodium bicarbonate (Bottje and Harrison, 1985; Maria et al., 1998) but was influenced positively (Teeter et al., 1985; Balnave and Oliva, 1991; Balnave and Gorman, 1993). It has also been shown that supplementation of potassium chloride at 0.6%, 0.9% and 0.8% reduced the weight loss of heat-stressed birds (Abdellah et al., 1995).

Adding KCL to broiler drinking water linearly increased weight gain of thermo stressed chicks (Teeter and Smith, 1986). Increased water intake and body weight gain has been observed as a result of NaCl addition to the drinking water (Smith and Teeter, 1989). Overall broiler production was not improved with the supplementation of electrolytes, 0.5% KCl and 0.5% NaHCO3, (Whiting et al., 1991)

All survivability (S24, S48, S72, S1 and S) was higher in fed birds relative to FAST birds. Results in the study agree with the result of Teeter et al. (1996) that implementing a fasting technique improves survivability during heat stress. Teeter et al. (1996) explained that fasting time is essential for the feed to clear the bird's digestive tract and reduce substrate availability. They further suggested that a bird's ability to tolerate heat distress increased with a longer fasting duration up to 24h. Fasted birds increasing ($p<0.05$) survivability pattern on daily basis seen in the present study supports their conclusion that survivability related to the fasting period. The survivability of fed birds on a daily basis was higher ($p>0.05$) on the second day (S48) relative to S24 demonstrates the acclimation effect on heat stressed-birds. Mortality associated with heat stress has been

found to normally decline with repeated exposure to heat stress (Teeter and Belay, 1996).

High mortality has been observed with the supplementation of sodium bicarbonate in birds receiving 8 to 10 grams / l drinking water (Hayat et al., 1999). Overall improved survivability associated with low-level supplementation of sodium bicarbonate agrees with the results of Branton et al. (1986) and Balnave and Oliva (1991). Braton et al. (1986) found reduced mortality in heat-stressed birds with the supplementation of 3.6 g of sodium bicarbonate in drinking water. Abdellah et al. (1995) observed that potassium chloride supplementation in the drinking water was reduced the mortality of broilers exposed to $37^{O}C$. Since a mixed pack of electrolytes was used to examine the therapeutic effect of heat stressed birds in present study, comparison with previous individual electrolyte studies is not possible. However in general electrolyte supplementation results in improved survivability and reduced weight losses due to heat stress.

The carry- over effect of VM on S24 and S1 were significantly ($p>0.05$) higher compared to control group. Survivability 48, S72 was numerically low and S was higher ($p>0.05$) with VM. Two-way interactions of treatments and three-way interactions of treat X FED X VM generally increased the survivability. Virginiamycin influence on survivability in FAST birds was 100% in all survivability categories. Teeter et al. (1996) finding support the present results where increasing survivability in heat-distress birds was seen with the addition of VM at 15 and 20 mg kg^{-1}. Virginiamycin (20ppm) fortification was found to have

no effect on primary titer, IbM and IgG, despite improved survivability in birds housed in a the thermoneutral environment (Belay et al., 1992b). Belay and Teeter (1994) reported better survivability with 15 ppm VM for chicks raised in mild cold stress. Milles et al. (1984) and Proudfoot et al. (1990) did not observe any significant effect of VM on survivability of thermoneutral birds.

Survivability with supplementation of VM 30 mg / kg that was numerically more compared with 11 mg /kg, 22 mg /kg and control has been seen in male and female turkeys in thermoneutral environments (Waibel et al, 1991). Salmon et al. (1990) observed no VM effects on the survivability of poults. Virginiamycin effects on a bird's survivability during heat stress were indeed marked at the 20 mg Kg^{-1} level, presumably due to reduced immune challenge and heat production (Teeter et al., 1996). Although there is not any direct evidence regarding carry over effects of VM on broilers survivability, it can be inferred on the basis of our present data that there is a potential carry-over effect of improved survivability in heat stressed birds that have been per-fed VM.

Supplementation of betaine had not influence on survivability as a main effect in the current study. Augustine et al. (1997) did not find any significant effect of betaine on survivability of in a thermoneutral environment. There was no significant ($p>0.05$) effect of betaine seen in FED and FAST bird during the current study. Fasted birds S4, S1 and S were improved ($p>0.05$) with betaine compared with control group. Fed birds survivability was reduced, however not significantly ($p>0.05$). Improved survivability could be explained by the relationship between treatments and water intake. Betaine increased ($p>0.05$)

the water intake of FAST birds compared with FAST control group. Fed birds water intake was depressed ($p>0.05$) with betaine relatively with fed control. The accumulation of betaine protects the cells from osmotic stress and allows then to continue regular metabolic activities in conditions that would normally inactivate the cell (Rudolph et al., (1986; Petronini et al., 1992; Ko et al., 1994). This osmoprotection occurs in animals with accumulated betaine through choline oxidation and through synthesis from betaine added to the feed (Virtanen, 1995). In mammals betaine is well documented for its ability to help cells tolerate osmotic stress that occurs as a result of the production of hyperosmotic urine (Bagnasco et al., 1986). Improved water retention is especially very crucial for heat exposed birds and would be expected to be beneficially associated with survival under heat stress conditions where water balance is adversely impacted (Teeter el al., 1996).

Two-way interactions of VM X EL, BE X VM, and BE X VM X EL which improved S24 and S1 indicates that a more positive response is seen with VM in combination with other supplements. In combination with BE and EL, the carry-over effects of VM on survivability were positive. VM in combination with EL and BE in fed and FAST birds showed more survivability compared with EL and BE alone. It can be suggested on the basis interactions seen that even after withdrawal of VM there could be a strong effect on survivability. That Virginiamycin, with or without electrolyte or betaine supplementations improved the survivability of heat-stressed birds is an indication that VM residues in the body are available for synergistic activity.

In conclusion virginiamycin (pre-fed), electrolyte and betaine supplementation can help to protect the adverse affects of heat stress in birds with a significant effect on economic benefits. Further interesting studies may examine the pre-fed effect in a thermoneutral environment as well as determine the break-point of a pre fed virginiamycin effect on general performance of broilers at high and low environmental temperature.

Table.1. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation on feed consumption (FC), mean feed consumption (MF) and percentage of feed consumption (PF) of male broilers age 49-52 d exposed to temperature 37^{O} C for three days.

Treatment			FC (g)	MF(g)	PF
Main effect	1	Control	651	52	46
	2	EL	722	71	54
	3	BL	718	54	51
	4	EL X BL	621	73	55
	5	EL X BH	670	53	49
	df=4	Significant	n.s	n.s	n.s

Treatment 1=control; Treatment 2= Electrolyte (EL); Treatment 3= Betaine 0.05%(BL); Treatment 4= ELX BL; Treatment 5= EL x BH(betaine 0.1%).

Table.2. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation on water consumption (WC) daily water (DW) of fed and fast male broilers age 49-52 d exposed to temperature 37^{O} C for three days.

Treatment			DW(ML)	WC (L)
Main effects	1	Control	293	42
	2	EL	259	37
	3	BL	265	38
	4	EL X BL	245	35
	5	EL X BH	312	45
	FED LEVEL	FAST	304[a]	29[a]
		FED	346[b]	49[b]
Interactions	TRT X FED LEVEL	FAS	267	38
		FED	318	45
		EL X FAS	157	22
		EL X FED	362	52
		BL X FAS	252	36
		BL X FED	278	48
		EL X BL XFAS	127	18
		EL X BL X FED	363	52
		EL X BH X FAS	215	31
		EL X BH X FED	409	58
ANOVA				
		DF	n.s	n.s
TRT		4	n.s	n.s
FED LEVEL		2	**	**
TRTX FED LEVEL		5	n.s	n.s

n.s=not significant,*=p<.005,[a,b] Means within a column with no common superscript, differ significantly(P<0.05). Treatment 1=control; Treatment 2= Electrolyte (EL); Treatment 3= Betaine 0.05%(BL); Treatment 4= ELX BL; Treatment 5= EL x BH(betaine 0.1%).

Table.3. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation and pre fed virginiamycin (VM) on weight difference (WD) daily weight difference (DWD), percentage of weight difference (PWD) of fed and fast male broilers age 49-52 d exposed to temperature 37° C for three days.

Treatment	Treatment		WD	PWD	DWD
Main effects	1	Control	-163	-6.56	-9.1
	2	EL	-139	-5.84	-7.78
	3	BL	-119	-5.02	-6.6
	4	EL X BL	-145	-5.9	-8.13
	5	EL X BH	-137	-5.45	-7.72
	VM	Control	-154[a]	-6.3[a]	-8.63[a]
		VM	-127[b]	-5.2[b]	-7.10[b]
	FED LEVEL	FAST	-265[b]	-6	-14.8[a]
		FED	-16[a]	-0.72	-0.9[b]
Interactions	Treat X VM	Control	-162	-6.0	-9.0
		VM	-163	-9.52	-9.42
		EL	-123	-7.02	-9.71
		EL X VM	-104	-4.37	-5.84
		BL	-132	-5.46	-7.3
		BL X VM	-105	-4.48	-5.8
		EL X BL	-157	-6.38	-8.56
		EL X BL X VM	-137	-5.56	-7.71
		EL X BH	-150	-5.20	-8.40
		EL X BH X VM	-125	-5.16	-7.03
	TRT X FED LEVEL	FAS	-269	-10.9	-14.94
		FED	-57	-2.2	-3.22
		EL X FAS	-252	-10.23	-14.05
		EL X FED	-26	-1.16	-1.51
		BL X FAS	-267	-10.91	-14.8
		BL X FED	+29	+1.00	+1.56
		EL X BL XFAS	-264	-10.7	-14.75
		EL X BL X FED	-26	-1.24	-1.58
		EL X BH X FAS	-273	-11.34	-15.38
		EL X BH X FED	+5	.03	0.06

Table.3. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation and pre fed virginiamycin (VM) on weight difference (WD) daily weight difference (DWD), percentage of weight difference (PWD) of fed and fast male broilers age 49-52 d exposed to temperature 37^{O} C for three days. (continue)

Treatment			WD	PWD	DWD
Interactions	TRT X FED LEVEL X VM	FAS	-288	-11.74	-16.12
		FED	-36	-1.41	-2.05
		VM X FAS	-299	-4.9	-13.85
		VM X FED	-78	-5.0	-4.39
		EL X FAS	-266	-10.86	*14.82
		EL X FED	-81	-3.19	-4.60
		EL XVM XFAS	-238	-9.60	-13.22
		EL X VM X FED	+28	+0.85	-1.58
		BL X FAS	-222	-11.05	-15.16
		BL X FED	+6	+0.12	+0.37
		BL X VM X FAS	-261	-10.9	-14.4
		BL X VM X FED	+50	+1.77	+2.80
		EL X BL X FAS	-262	-10.69	-14.62
		EL X BL X FED	-43	-2.07	-1.96
		EL X BL X VM X FAS	-266	-10.71	-14.87
		EL X BL X VM X FED	-0.9	-0.42	-0.55
		EL X BH X FAS	-299	-12.5	-16.71
		EL X BH X FED	+0.9	+0.28	+0.10
		EL X BH X VM X FAS	-250	-10.19	-14.05
		EL X BH X VM X FED	-0.2	-0.14	-0.02
ANOVA		df			
Treat		4	n.s	n.s	n.s
VM		1	*	*	*
FED		1	**	**	**
TRT X VM		4	n.s	n.s	n.s
TRTX FED LEVEL		4	n.s	n.s	n.s
TRT X VM X FED LEVEL		5	n.s	n.s	n.s

n.s=not significant, **=p<0.05,***=p<.0001, $^{a-b}$ Means within a column with no common superscript, differ significantly(P<0.05).

Treatment 1=control; Treatment 2= Electrolyte (EL); Treatment 3= Betaine 0.05%(BL); Treatment 4= ELX BL; Treatment 5= EL x BH (betaine 0.1%).

Table.4. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation pre fed virginiamycin (VM) on final weight (FW), body temperature (BT) on fed and fast male broilers age 49-52 d exposed to temperature 37^{O} C for three days.

Treatment			FW	BT^{O}C
Main effects	1	Control	2572	42.44
	2	EL	2596	42.59
	3	BL	2616	42.63
	4	EL X BL	2589	42.33
	5	EL X BH	2597	42.44
	VM	Control	2580^{a}	42.49
		VM	2607^{b}	42.48
	FED LEVEL	FAST	2469^{a}	41.91^{b}
		FED	2718^{b}	43.05^{a}
Interactions	Treat X VM	Control	2572	42.41
		VM	2571	42.43
		EL	2561	42.67
		EL X VM	2630	42.52
		BL	2602	42.58
		BL X VM	2629	42.68
		EL X BL	2582	42.28
		EL X BL X VM	2592	42.38
		EL X BH	2585	42.49
		EL X BH X VM	2609	42.39
	TRT X FED LEVEL	FAS	2466	41.89
		FED	2677	42.94
		EL X FAS	2483	42.10
		EL X FED	2708	43.06
		BL X FAS	2468	41.89
		BL X FED	2763	43.41
		EL X BL XFAS	2471	41.89
		EL X BL X FED	2708	42.77
		EL X BH X FAS	2460	41.77
		EL X BH X FED	2734	43.08

Table.4.Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation on pre fed virginiamycin (VM) on final weight (FW), body temperature (BT) on fed and fast male broilers age 49-52 d exposed to temperature 37^{O}C for three days (continue).

Treatments			FW	BT^{O}C
Interactions	TRT X FED LEVEL X VM	FAS	2446	41.96
		FED	2698	42.90
		VM X FAS	2486	41.83
		VM X FED	2650	42.98
		EL X FAS	2469	42.29
		EL X FED	2653	43.02
		EL XVM XFAS	2497	41.94
		EL X VM X FED	2764	43.10
		BL X FAS	2463	41.81
		BL X FED	2742	43.42
		BL X VM X FAS	2473	41.97
		BL X VM X FED	2788	43.40
		EL X BL X FAS	2473	41.78
		EL X BL X FED	2691	42.78
		EL X BL X VM X FAS	2469	42.00
		EL X BL X VM X FED	2725	42.77
		EL X BH X FAS	2436	41.77
		EL X BH X FED	2784	43.14
		EL X BH X VM X FAS	2735	41.77
		EL X BH X VM X FED	2785	43.02
ANOVA		DF	Significant	
Treat		4	n.s	n.s
VM		1	*	n.s
FED LEVEL		1	**	**
TRT X VM		4	n.s	n.s
TRTX FED LEVEL		4	n.s	n.s
TRT X VM X FED LEVEL		5	n.s	n.s

n.s=not significant, p<0.05,*=p<.005,$^{a-b}$ Means within a column with no common superscript, differ significantly(P<0.05).
Treatment 1=control; Treatment 2= Electrolyte (EL); Treatment 3= Betaine 0.05%(BL); Treatment 4= ELX BL; Treatment 5= EL x BH (betaine 0.1%).

Table.5. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation pre fed virginiamycin (VM) on S24 (survivability of 1st 24 h), S48 (survivability of 2nd 24 h), S72 (survivability of 3rd24 h), S1(surv24+surv48), S (surv24+surv48+surv72) on fed and fast male broilers age 49-52 d exposed to temperature 37^{O}C for three days.

Treatment			S24	S48	S72	S1	S
Main effects	1	Control	94	99	97	93	91
	2	EL	96	95	99	92	92
	3	BL	94	97	96	92	88
	4	EL X BL	96	98	93	95	87
	5	EL X BH	93	94	96	88	84
	VM	Control	92^{b}	97	97	90^{b}	87
		VM	98^{a}	96	95	94^{a}	90
	FED LEVEL	FAST	95	98	98^{a}	94^{a}	93^{a}
		FED	94	96	94^{b}	90^{b}	84^{b}
Interactions	Treat X VM	Control	91	100	100	91	91
		VM	97	98	94	95	90
		EL	95	95	100	91	91
		EL X VM	97	95	98	93	91
		BL	91	97	96	88	85
		BL X VM	97	98	96	95	92
		EL X BL	94	98	93	93	86
		EL X BL X VM	98	98	93	97	90
		EL X BH	87	97	100	84	84
		EL X BH X VM	100	91	93	91	84
	TRT X FED LEVEL	FAS	95	100	100	95	95
		FED	93	98	94	91	86
		EL X FAS	95	100	100	95	95
		EL X FED	97	91	98	88	87
		BL X FAS	98	98	100	97	97
		BL X FED	90	97	93	87	80
		EL X BL XFAS	97	98	95	95	91
		EL X BL X FED	95	98	90	94	84
		EL X BH X FAS	91	94	98	86	84
		EL X BH X FED	95	94	94	90	84

Table.5. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation pre fed virginiamycin (VM) on s24 (survivability of 1st 24 h), s48 (survivability of 2nd 24 h), s72 (survivability of 3rd24 h), s1(surv24+surv48), s(surv24+surv48+surv72) on fed and fast male broilers age 49-52 d exposed to temperature 37^{O}C for three days (continue).

Treatments			S24	S48	S72	S1	S
Interactions	TRT X FED LEVEL X VM	FAS	91	100	100	91	91
		FED	91	100	100	91	91
		VM X FAS	100	100	100	100	100
		VM X FED	94	97	88	91	80
		EL X FAS	97	100	100	97	97
		EL X FED	94	91	100	86	86
		EL X VM XFAS	94	100	100	94	94
		EL X VM X FED	100	91	97	91	88
		BL X FAS	97	97	100	94	94
		BL X FED	86	97	93	83	76
		BL X VM X FAS	100	100	100	100	100
		BL X VM X FED	94	97	93	91	84
		EL X BL X FAS	94	97	100	91	91
		EL X BL X FED	94	100	86	94	80
		EL X BL X VM X FAS	100	100	91	100	91
		EL X BL X VM X FED	97	97	94	94	88
		EL X BH X FAS	83	100	100	83	83
		EL X BH X FED	91	94	100	83	86
		EL X BH X VM X FAS	100	88	97	88	83
		EL X BH X VM X FED	100	94	88	94	83
ANOVA		DF	Sig				
Treat		4	n.s	n.s	n.s	n.s	n.s
VM		1	*	n.s	n.s	n.s	n.s
FED LEVEL		1	n.s	n.s	*	**	**
TRT X VM		4	n.s	n.s	n.s	n.s	n.s
TRTX FED LEVEL		4	n.s	n.s	n.s	n.s	n.s
TRT X VM X FED LEVEL		5	n.s	n.s	n.s	n.s	n.s

n.s=not significant, p<0.05,*=p<.005,$^{a-b}$ Means within a column with no common superscript, differ significantly(P<0.05).
Treatment 1=control; Treatment 2= Electrolyte (EL); Treatment 3= Betaine 0.05%(BL); Treatment 4= ELX BL; Treatment 5= EL x BH (betaine 0.1%).

Table.6. Effect of electrolyte (EL) or betaine 0.05% (BL) betaine 0.1% (BH) supplementation pre fed virginiamycin (VM) on dead weight 1st 24 h (DW 1), 2nd 24 h(DW2), 3rd 24 (DW) on fed and fast male broilers age 49-52 d exposed to temperature 37°C for three days.

Treatment			DW1	DW2	DW3
Main effects	1	Control	2565	2457	2529
	2	EL	2645	2722	2270
	3	BL	2535	2269	2531
	4	EL X BL	2533	2295	2479
	5	EL X BH	2623	2567	2496
	VM	Control	2583	2486	2559
		VM	2550	2555	2467
	FED LEVEL	FAST	2555	2300	2381
		FED	2588	2631	2515
	ANOVA				
	Treat	4	n.s	n.s	n.s
	VM	1	n.s	n.s	n.s
	FED LEVEL	1	n.s	n.s	n.s

n.s=not significant, Treatment 1=control; Treatment 2= Electrolyte (EL); Treatment 3= Betaine 0.05%(BL); Treatment 4= ELX BL; Treatment 5= EL x BH (betaine 0.1%).

Table. 7. Correlation between WD, PWD, DWD, FW, DW1, DW2, DW3 and FC,MF, DW, BT,SURV24, SURV48, SURV72, SURV1, SURV of male broilers age 49-52 d exposed temperature 37^{O} C for three days

	WD	PWD	DWD	FW	DW1	DW2	DW3
FC	0.81***	0.80***	0.81***	0.51***	0.15	0.67*	0.46
MF	0.48***	0.48***	0.48***	0.20	0.06	N.E	N.E
DW	0.73***	0.72***	0.73***	0.32	N.E	N.E	N.E
BT	0.52***	0.52***	0.52***	0.42***	021	0.69**	0.22
S24	0.01	0.01	0.01	-0.01	-0.05	0.07	0.12
S48	0.00	-0.00	0.00	0.15*	0.00	-0.51	N.E
S72	-0.08	-0.07	-0.08	-0.11	-0.09	N.E	-0.07
S1	0.01	0.01	0.01	0.00	-0.05	-0.32	0.12
S	-0.01	-0.03	-0.04	-0.07	-0.09	-0.34	0.00

*=p<0.05, **=p<0.001,**=p<0.0001 ,.N.E=not estimated weight difference (WD), percentage of weight difference (PWD), daily weight difference (DWD), final weight (FW), dead weight of 1st day (DW1), dead weight of 2nd day (DW2),dead weight of 3rd day (DW3), feed consumption (FC), mean feed consumption (MF),daily water (DW), body temperature (BT), surv24 (survivability of 1st 24 h), surv48 (survivability of 2nd 24 h), surv72 (survivability of 3rd24 h),, surv1(surv24+surv48), surv (surv24+surv48+surv72)

Table. 8. Correlation between S24, S48, S72, S1, S and FC, MF, WC, DW, BT of male broilers age 49-52 d exposed to temperature 37^{O} C for three days

	S24	S48	S72	S1	S
FC	-0.05	-0.04	-0.10	-0.07	-0.12
MF	0.16	0.12	0.06	0.20	0.21
WC	N.E	-0.09	N.E	-0.09	-0.09
DW	N.E	-0.09	N.E	-0.09	-0.09
BT	-0.11	-0.11	-0.28**	-0.16*	-0.31**

*=p<0.05, **=p<0.0001,N.E=not estimated, feed consumption (FC), mean feed consumption (MF),daily water (DW), body temperature (BT), surv24 (survivability of 1st 24 h), surv48 (survivability of 2nd 24 h), surv72 (survivability of 3rd24 h),, surv1(surv24+surv48), surv (surv24+surv48+surv72)

Table. 9. Correlation between, FC, MF, DW, WC, and BT of male broilers age 49-52 d exposed to temperature 37^{O} C for three days

	FC	MF	DW	WC
BT	0.6**	0.20	0.54*	0.54*

*=p<0.05, **p<0.0001.feed consumption (FC), mean feed consumption (MF),daily water (DW), water consumption, body temperature (BT),

Table 10. Electrolyte

No	Ingredients	Quantity(g)
1	Potassium Bicarbonate	43.12
2	Potassium Chloride	9.24
3	Potassium Sulfate	5.54
4	Sodium Bicarbonate	24.02
5	Magnésium	23.76
6	Manganese	1.58
7	Zinc	0.92
8	Copper	0.21
9	Selenium	0.00024
10	Total	108.4114

Table 11. Feed Composition

INGREDIENT	FINISHER Lbs	STARTER Lbs
Corn Yellow GR	1416.044	1206.116
Soybean Meal	426.094	615.996
Fat , (veg)	72.039	45.139
Calcium Carbonate	34.844	23.582
Dicalcium Phos	23.062	24.000
Pro-Pak	13.079	71.683
Salt	4.6000	6.000
DL-Methionine	3.9642	2.853
L-Lysine	1.8436	
Vit. Premix	1.000	1.000
Mineral Mix	1.000	1.000
Lasolosid	1.000	1.000
Choline Chloride	0.8000	1.000
Copper Sulfate	0.6000	0.6000
Selenium Premix	0.0307	0.0290
Crud Protein %	17	22
M.E. Kcal/Lb	1466	1397

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CHAPTER V

COMPARATIVE EFFECTS OF VIRGINIAMYCIN, BETAINE, AND ELECTROLYTE ON COMPENSATORY GAIN AND THE GENERAL PERFORMANCE OF MALE BROILERS, EXPOSED TO HIGH AMBIENT TEMPERATURE STRESS

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ABSTRACT.

The effects of virginiamycin (VM), betaine (BE), and electrolyte (EL), on body weight gain (WG), Feed consumption (FC), feed efficiency (FE), body weight (BW), water consumption (WC), Body temperature at the age of 36 d (BT36) d 46 (BT46), survivability (SU), specific gravity(SG), breast sample dry matter ratio ((DM), fat pad (FP) fat pad ratio of final body weight(FR), breast ratio of final body weight (BR), liver ratio of final body weight(LP), chloride (CL), magnesium (MG),phosphorus(Phos), sodium(Na), potassium(K), triglyceride (TR), uric acid(UR), total protein (TP), calcium(Ca) , and albumin(AB) were studied in male

broilers exposed to chronic HS (37 C) at 18 to 33 day of age. The flocks were moved in thermoneutral house (TN) at constant temperature 24 C to compare the compensatory (CG) with TN birds. The average compensatory gain at age of 40 and 48 was observed ($p=0.0001$) in CG birds (107 g) compared with TN birds (74 g). Body weight age 40 (BW 40), weight gain age 40 (G 40) and daily gain (DG40) were influenced with VM Survivability, whole body dry matter (SD) and fat was more ($p<0.03$) in CG birds compared with TN birds. Betaine increased ($p<0.02$) the BR, SD and bone mass concentration (BMC) of CG birds compared with TN birds. Electrolyte increased ($p<0.01$) the compensatory gain and decreased ($p<0.007$) the BT36 compared with control of CG and TN birds. Plasma CL, MG, Na, AB, SD, BMC and lean was increased ($p<0.05$) in CG birds compared with the supplementation of VM. On the basis of data presented above it could be concluded that pre-exposed to HS birds have the capability of accelerated growth when moved to TN environment and supplementation of BE, EL and VM further increased the body composition.

(Key words; body weight, feed consumption, body temperature, survivability, heat stress, compensatory gain)

INTRODUCTION

It is well documented that both ambient temperature and relative humidity vary with ecological zone and season. Elevated ambient temperature and relative humidity results in reduce poultry productivity creating substantial economic lose. Age of bird, size, genetic makeup and history of heat exposure are the main factors, which influence the bird's response to HS, Teeter and

Belay (1996). Teeter et al. (1996) have illustrated that the comfort zones for poultry declines from 35 ^{O}C at hatching to approximately 24 ^{O}C at 4 weeks of age.

During chronic HS bird's respiration rate enhanced, very critical for birds to maintain body temperature. Fuquay. J.W. (1981) concluded on the bases of studies and review over last 20 years that high environment temperature reduces productive and reproductive efficiency of livestock seems well justified. He further concluded that in controlled-environment chambers, upper critical temperatures have been established for a number of production traits; these temperatures fall between 24 and 27 ^{O}C for most traits and most species. Upper critical temperatures will vary depending on several factors, including degree of acclimatization, rate of production, pregnancy status, and air movement around the animals and relative humidity Fuquay (1981).

Chronic HS exposure results not only in heavy mortality but also declines growth egg production fertility, and hatchability. Exceeding temperature of 38 ^{O}C, thermo tolerance is over come, leading to marked mortality, with ecological zones and season (Squibb and Wogan, 1960). Yahav et al. (1996) observed growth retardation after short-term exposure to HS during 1st wk of age, where as marked mortality was observed at the age of 42 days when exposed to 35^{O}C. An increase in mortality has been shown in broilers exposed to prolonged periods of high temperature, especially after 4 wk of age (McDouglad and McQuistion, 1980; Thaxton and Pardue, 1984; Bottje and Harisson ,1985). Pardue et al. (1985) observed that cyclic high temperature leads to increase

mortality and reduced growth rate in broilers. Donkoh (1989) explained that body temperature of the adult birds in normally in the range of 41 to 42 ^{O}C and significantly increased body temperature observed when ambient temperature increased. Individual variation in body temperature was found greater at higher temperature (Wilson, 1948). Heat stress response is to elevate the body temperature, inability to regulate body temperature (Brody,1945; Keshavarz and McDougald,1981).

Blood is not only medium for transporting nutrients, metabolic waste products and gases around the body but also plays an important role in the diffusion of body heat. Chickens exposed to acute HS developed hypertension and an increase in cardiac output, hypothermia likewise depress blood pressure in the chicken. Donko (1989) stated that blood values of red cell counts, packed cell volume, hemoglobin concentration and plasma protein concentration were reduced of birds raised at 30 ^{O}C and 35 ^{O}C compare with 20 ^{O}C. Exposure to heat resulted in an irreversible decrease in blood hematocrit, Yahave et al. (1996). Zhou et al. (1997b) observed whole blood viscosity (WBV) of broilers decrease significantly when they were exposed to a high ambient temperature. The decrease in WBV may be advantageous in reducing peripheral resistance and the load on heat, and increasing tissue perfusion and circulatory distribution, including the blood supply to heat exchange surface. Thermal conductivity of Skin increases linearly with rate of blood flow in skin (Ohara ,1981).

Therapeutic application to lessen the consequences of HS through electrolyte supplementation has been partially successfully observed. These therapeutic applications have multiple actions by improving acid base water and mineral balance simultaneously. Some ion effects of electrolytes are frequently confound with such responses making cause and affect evaluation a difficult task.

Studies shows that sodium bicarbonate, potassium bicarbonate, calcium chloride, and ammonium chloride helps to correct the acid-base imbalance of the blood, by counteracting the pH rises of respiratory alkalosis, Macari et al. (1994). Teeter et al. (1985), observed that birds may show positive responses to the use of dietary supplements of NaHCO3 during HS. Heat exposed birds may exhibit a reduction in the levels of plasma carbon dioxide and bicarbonate during panting and when not panting, Balnave and Gorman (1993). Teeter et al. (1985) noted the loss of bicarbonate ions during heat exposure may be affected the blood pH and induce in the bird nutritional requirement for bicarbonate. Increasing dietary bicarbonate, however may accentuate any respiratory alkalosis. Bonsembianate et al. (1990), reported that supplementing feed of 7-d-old turkeys with 5 g NaHCO3/kg in the diet resulted in an improvement in growth , when temperatures ranged from 26 to 30 ^{O}C and relative humidity ranges from 75 to 90%, 6.3 g, sodium bicarbonate increases the water intake and decreases the mortality of HS birds, finishing broilers, whereas 3.2 g NaHCO3/l had no beneficial effect. Belnave and Oliva (1991) working with finishing broilers at high temperatures (30 ^{O}C), found that diets supplemented

with 16.8 g NaHCO3 kg of drinking water supplemented with 5.6 g, NAHCO3/l produced a significant improvement in bird production response. Maria et al. (1998) observed the differences in body weight gain between sexes were increased in birds fed the diets with 1.2 and 1.8% NAHCO3 with females being 37.17 and 18.44% heavier than males.

Virginiamycin (VM) is an effective antibiotic against gram positive microorganisms D.E. Somers and Van Dijck (1955) have observed that VM improved broiler growth rate and feed efficiency, Woodward et al. (1988); Harns et al. (1986); Mile, et al. (1978) as well as carcass yield (Woodward et al., 1988; Lesson, 1984). The performance of broilers was improve which fed diets containing VM which is associated with an increase in feed consumption (Buresh et al., 1985 a; Leeson, 1984) and nutrient absorption efficiency (Nelson et al., 1963 ; March et al.,1984a; Miles and Harms,1983). Enhanced utilization of phosphorus (Buresh et al.,1985 b) and manganese (Henry et al., 1986), reported for birds consuming Virginiamycin.

Betaine is a metabolite of choline that donates methyl groups to homocystein to form methionine, and also to the folate pool. Betaine is formed from choline and that growth responses obtained from betaine are due to its ability to provide methyl group. (Kidd et al., 997). Birds maintain the intracellular concentration of water that is crucial for homeostasis by osmoregulation. Osmoregulation is the ability of a cell to maintain its structure and function by regulation movement of water in and out of the cell (Kidd et al., 1997). The osmoprotective properties of betaine are well conserved in many forms of life,

including bacteria (Chambers and Kunin, 1987), and animals (Law and Burg, 1991).

Bacterial cells to prevent dehydration when growing in concentrated solutions of glucose, sodium chloride or other salt use Osmoprotective substances. Betaine is the most important osmoprotective compound in bacteria (Imhoff and Rodriguz- Valera, 1984) Betaine is known as to serve as an osmoprotectant in bacteria by replacing intracellular K and restoring the osmotic turgor without accumulation of K when the environmental salinity increased (Sutherland et al., 1986). Beneficial osmoprotective properties may be due to the dipolar zwitterin characteristics of betaine and its high solubility in water (Chambers and Kunin, 1985). The unique chemical properties of betaine play a key role in providing osmoprotective properties in microorganisms and these attributes have a parallel in more complex organism (Bagnasco et al., 1986). Saundreson and MacKinlay (1990) evaluated growth and hepatic enzymes in male broiler chicks as influenced by dietary supplementation with combinations of methionine, betaine and choline. Betaine inclusion improved the growth of chicks fed a semi- purified diet (McGinnis et al., 1942). Finkelstein et al. (1983), evaluated that supplemental betaine and choline at dietary levels of 0.2 % on hepatic betaine-homocystine methyltransferase activity increased as dietary levels of betaine and choline increased.

Thermal conditioning at an early age has bee reposted to result in reduced weight gain during the 1st week of life, followed by an accelerated growth which leads to a higher body weight than that of non-conditioned chickens at

marketing age (Yahav and Hurwitz, 1996: Yahav et al., 1997a). Accelerated growth in broiler chickens has also been observed after food restriction at an early age (Plavink and Hurwitz, 1685, 1988,1989; Deaton, 1995; Zhong et al., 1995). During feed restriction requirement of maintenance energy declined, may be because of reduction in heat production as observed in mammals (Forsum et al., 1981) but it returned to normal upon resumption of normal feeding (Plavink and Hurwitz, 1985) Feed restriction has been found to result in changes in hormones (McMutry et al., 1988), metabolic status (Rosebrough et al., 1986; Zhong et al., 1995) and digestive enzymes activities (Palo et al., 1995). The long time interval (35 d) between conditioning and the challenge at high temperature, precludes explanation of the induced thermo tolerance in terms of reactive physiology, Because the technique of temperature, conditioning takes advantages of the immaturity in the young chick(Dunnington and Siegel, 1984; Arad and Itsaki-Glucklich, 1991; Whittow and Tazawa, 1991; Modrey and Nichelmann, 1992), most probably by changing the threshold core temperature for heat production and or heat loss, the potential thermo tolerance can thus be incorporated into the developing mechanism of thermoregulation. The mechanisms associated with the induction of thermo tolerance by early-age temperature conditioning involve: 1) modulation of heat production through reduction in plasma triiodothyronine (T3) concentration; 2) haemodynamic changes (decrease in heart weight and hematocrit); 3) increase in sensible heat loss; and 4) pronounced ability to control body water economy during thermal challenge (Yahav and Hurwitz, 1996; Yahav et al., 1997a).

The objective of experiment described here was to quantify HS acclimation and effect of therapeutic application on the general performance and carcass composition to decrease the economic loss.

MATERIALS AND METHODS

Experiment 1. Experiment was conducted to evaluate the effect of ambient temperature on basal metabolic rate, general performance, carcass composition and blood chemistry of heat exposed male broiler.

Experiment 2. Experiment was conducted to evaluate effects of electrolyte, virginiamycin, and betaine on basal metabolic rate, general performance, carcass composition and blood chemistry of heat exposed male broiler.

Experiment 3. Experiment was conducted to evaluate compensatory growth effects of electrolyte, virginiamycin, and betaine on basal metabolic rate, general performance, carcass composition and blood chemistry of male broiler.

Phase 1

Flocks of seventy six (Experiment 1), four hundred and eighty (Experiment 2) five hundred and sixty (Experiment 3) Cobb x Cobb male commercial strain broilers was reared from day of hatching in an experimental farm in the winter months of November. Experimental flock was raised in to four pens in controlled environment brooding house. Chicks were pooled randomly and were placed on concrete floor covered with wooden shavings as litter. Heating and ventilation system was strictly followed by stander broiler techniques.

Starter mash feed was provide in open tray feeders for fist four days and then after silver hanging feeder were used simultaneously for feeding. Corn soy

starter (Table 71), mash (1460 Kcal ME / LB and CP 23%) was offered ad libitum till 17 days of age. Automatic nipple drinkers were placed prior to arrival of chicks and water was available ad libitum till the brooding period. At fourteen days of age all birds were wing banded.

Feed consumption and daily mortality was recorded on prescribed data capture farm. At the age of 17 days all birds were over night fasted. On the 18th day of age all birds were weighted and (not less than 490 gram) randomly collected from all pens were shifted to battery house.

Phase II

All birds were individually weighted and 6 chicks per compartment in HS chambers side B and seven birds in side A and TN chambers were placed in battery house, thermostatically and humid statically arranged prior to arrival. Cages, used for experiment were of Wire-Floored grower battery containing 61x 92 CM. Compartment. Each battery was of four level compartments. Each compartment was designed with two cups drinkers and two silver tube feeders, easily accessible to chicks. Drinkers of each compartment were attached with water barrel, pumping motor were fixed for continuous water flow to drinkers. Feed and water were provided randomly and intake records were kept on prescribed Performa. Under continuous tungsent filament lighting, these chicks were provided different treatments, through drinking water and feed. .

Feed efficiency and growth responses under near optimal condition were obtained with environment chamber, set at 24 ^{O}C and 30 % relative humidity and were increased by 2 ^{O}C /day from 24 ^{O}C to 37 ^{O}C at 70 % relative humidity.

Ambient temperature and relative humidity during the investigation were recorded with thermograph placed at the height of upper cages. Birds were exposed to HS period 24 ^{O}C, 25 ^{O}C,37 ^{O}C and relative humidity 50 to 70 %, during which the maximum day time temperature was 37 ^{O}C, and minimum night time temperature was 24 ^{O}C.

Birds were fed corn soy based finisher mash diet (Table 72), containing 1397 Kcal ME/ LB, and 22% CP). Body weight of individual bird were recorded at the age of 48 days, where as feed intake was recorded when offered.

At the age of 33 days two hundred and eighty birds moved from HS to TN chambers. All birds were allotted same treatment as in heat stress birds. Moved birds were used to measure compensatory gain compared with TN birds. Body weight of compensatory birds was recorded at the age of 40 and 48 days. At the age of 36 and 46 days two birds from each compartments were used as for body temperature. Body temperatures were recorded at the peak of ambient temperature. An electronic thermometer (GLA Agriculture Electronic, Model M216) was used. On each data acquisition form person concern recorded body temperature. Thermometers used, were calibrated properly before taking temperature. Birds randomly selected for body temperature, painted for identification and were used for blood collection too, for blood analysis, at the age of 48 days. Hematocrit procedure was performed immediately after collection of blood. Blood was drawn from each bird through the brachial vein and drained into a hematocrit tubes. The hematocrit tubes were immediately moved to the

laboratory for hematocrit reading. To avoid variation only one person has recorded the hematocrit.

Blood for serum chemistry was collected simultaneously while hematocrit samples were collected. Blood samples for chemistry analysis were collected in air tight sealed blood tube and were moved to laboratory for further process. The blood was allowed to clot at room temperature for about 20 minutes. The clot was then slightly and gently rimmed before centrifugation (IEC Model CI Centrifuge, International Equipment CO., 300, 2nd avenue, Ndddham Heights, MA 02149) was carried out within an hour after drawing of blood, Lewandowski et al. (1986). Following centrifugation the serum was immediately frozen at (-20 ^{O}C) till assay time for serum chemistry. Two birds from each replicate already used for body temperature and blood collection, were collected for carcass composition at the age of 49 days followed by over night fasting.
Using sharpest blade to avoid squeezing of samples, for dry matter prior to putting the bird in chill water, collected breast samples (approximate 5 gram). Body weight, liver samples, hot weight, chill weight, breast weight and fat pad weight were collected respectively. Birds were weighed, hung on a rail, electrically stunned, bled for 15 minutes following severing of jugular and carotid veins, passed through a scalding vat, plucking machine, hand eviscerated, and carcass were weighed. In all three experiments, dressing percentage was calculated as dressed carcass weight without the neck and giblets divided by live weight. Fat pad was hand removed from the fat surrounding the bursa of fibricious, cloaca, and adjacent abdominal muscles. Fat pad weight was

calculated as a percentage of body weight. Carcasses were weighed in air and water for computation of specific gravity (Teeter and Smith, 1985). Liver was hand removed and calculated as a percentage of body weight.

At the age of 31 d (VM 0) and 35 d (VM) 6 birds per treatment from HS (30 birds) and TN (30) at the age of 39 (VM 0) and 44 d (VM) 4 birds per treatment of HS (20 birds) TN (20 birds) and compensatory birds (CG=20 birds) were randomly pooled out for basal metabolic rate in respiratory chambers. These birds were weighted and fasted on floor in battery house for 36 hours. Plane water was provided in manual plastic drinkers. After 36 hours these birds were again weighted and shifted to respiratory chambers. Birds were placed in as one bird per chamber and distributed evenly in all there respiratory rooms. Birds were fasted and were kept in room temperature for 6 hours. During 6 hours stay in respiratory chambers, room temperature, oxygen consumption and carbon dioxide production were recorded through automatic computerized data acquisition system. At the end of 6 hours birds were weighted again and body temperature of those fasted birds were recorded. After weight and body temperature birds were killed through gas killing system and were kept in deep freezer for further investigation.

Two level of electrolytes low (L=16 %) high (H=32%) table 70 were mixed and weighted on the whenever required bases. Electrolytes were mixed sufficient for 66- liter water. Every morning treated water were measured and treatment was added if birds consumed at least 66 liter of water (left over water 40 liter) .Two level of betaine were also mixed on the when ever required bases and were

Stamford, CT 06907). The air was then mixed using a 3 cm fan as explained under respiratory chambers above.

DATA ACQUISITION SYSTEM: Chamber and data measurement were controlled and monitored by computer automatic system. Gas concentration (O2 and CO2), and RH quantification, flow rate and ambient temperature were recorded once for each chamber every 12 minutes.

OXYGEN (O2) AND CARBON DIOXIDE (CO2): Oxygen and Carbon dioxide concentration were determined five times per hour per chamber using oxygen and carbon dioxide analyzer (Ametek, Pittsburge, PA 15238) with a .2 % and .03 % accuracy respectively. Relative humidity was monitored by a relative humidity probe, (Omnidata International, Logan, UT 84321), with 1 % accuracy. Oxygen and carbon dioxide consumption were estimated by multiplying chamber airflow rate (litters/minute) by differential gas concentration between reference and test chambers.

Birds were sacrificed at the end of heat production were scanned in Choplogic densitometer for analyzing bone mineral concentration, bone mineral density, fat, and lean composition. Every day 20 birds were brought from freezer and were thawed for 24 hours inside the densitometer chamber. Each bird's weight and dead body temperature were recorded prior to scanning. Body weight was calibrated for the body weight recorded by scanner. Every day after the scanning of birds were moved to electric oven in the nutrition and physiology laboratory of OSU. Each aluminum box with and with out birds were weighted and placed in to the electric oven at the temperature of 60 C for dry matter. After

two weeks period dry matter samples were weighted and observed the decreasing of weight. Dry matter values were finally recorded after decreasing of dry matter samples were not observed.

Upon completion of above three experiments, effects of ambient temperature and appropriate effects of treatments were evaluated using general linear model procedure of the statistical analysis system. When a significant statistic was conducted means were separated using least square means.

RESULTS

Experiment 1.

Live performance.

Live performance displayed in Table 1. No significant effect of final body weight (BW), weight gain (WG) daily gain (DG) weight gain percentage of final body weight (PG) mean feed consumption (MF) feed consumption ratio of final body weight (PFC) and survivability were observed between heat distress (HS) and TN (TN) birds. Numerically difference shows more BW (p=0.4), WG (p=0.4), DG (p=0.7), PG (p=0.7), PFC (p=0.2), and SU (p=0.3) in TN birds compared than that of HS birds. Feed efficiency (FE) was better (p=0.01) in TN birds compared with heat HS birds.

Carcass composition.

Table 2 comprised of carcass composition. Fasted (12h) body weight (BWT), breast weight (BR) breast weight ration of final body weight (BP) hot weight (HW) chill weight (CW) dressing wastage (VS) dressing wastage of final body weight (VP) water absorb CW-HW (WA) water absorb percentage of final body weight (WP) were not significant. Dry matter percentage of breast weight (DM) chill weight percentage of final body weight (CP) was numerically higher (p=0.5, 0.6) in HS. The level of specific gravity (SG) fat pad weight (FP) fat pad percentage of final body weight (FR) were higher (p=0.04, 0.04, 0.02 respectively) in HS birds where as liver weight percentage of final body weight (LP) was significantly lower (p=0.04) in the HS birds compared with TN birds.

Body temperatures

Body temperatures (Table3) at age 36 d (BT36) 46 d (BT46) average body temperatures (ABT) were higher (p=0.0001,0.003, 0.0001) respectively in HS birds where as body temperature differences (BTD) was numerically higher (p>0.05) in HS birds compared with TN birds. Ambient temperature significantly (p=0.01) decreased the fasted (36 h) body temperatures (FTEMP) HS birds compared with TN (Table 5).

Serum chemistry.

Serum chemistry data analyzed showed in table 4. Average hematocrit (AH) was numerically lower (p=0.17) in HS birds. Plasma level of chloride (Cl) and magnesium (Mg) were higher (p=0.7, 0.1) in HS birds whereas uric acid (UR) total protein (TP) sodium (Na) albumin (AB) and potassium (K) were low (p=0.9,

0.1, 0.8, 0.8, 0.6) in HS birds compared with TN birds. Ambient temperatures significantly influenced on the concentration of calcium Ca (p=0.04) and phosphorus PHO (p=0.03) were lower in HS birds.

Body composition. Body composition through scanning comprised in Table 5. At the age 33 and 41 d dry matter ratio of final body weight (SD) was numerically (p=0.09) more in HS birds and mean of both ages were also more (P=0.1) in HS birds. Bone mineral concentration (BMC) at age 33 was significantly (p=0.007) less in HS birds compared with age 41 of TN birds. BMC at age 41 was more (p=0.001) in HS birds compared with age 33 of TN birds. No significant (p=0.33) effect was observed with mean of both ages. Ambient temperature on BMC percentage of final body weight (BMCP) did not influence significantly (p=0.8) at any age. Fat weight (FA) was significantly (p=0.01) higher in HS birds at age 41 compared with age 33 of HS birds and age 33 (p=0.001), 41(p=0.04) of TN birds. Mean FA of both ages of HS birds significantly (p=0.01) more compared with TN birds.

There was no significant effect of age x ambient temperature on FA percentage of final body weight (FP) but mean FP of HS birds was significantly (p=0.01) higher than that of TN birds. Lean (LN) at age 41 of TN birds was higher (p=0.0006) compared with age 33 d of HS and TN (p=0.0006) birds whereas LN of age 41 d of HS birds was elevated (p=0.001) compared with age 33 d of HS and TN (p=0.001) birds. Bone mineral concentration + FA +LN (BFL) of TN and HS birds were significantly (p<0.05) more at the age of 41 d compared with age 33 of both ambient temperatures. Numerically increased (p=0.13) of bone mass

density was observed of TN birds at the age of 41 day compared with 41 of HS birds and age 33 d of both ambient temperatures. Lean + BMC of TN and HS birds age 41 was significantly (p=0.03) of high level compared with 33 age of both groups.

Experiment 2.

Body Weight.

Although final body weight (BW) weight gain (WG) daily gain (DG) and percentage of gain (PG) showed in Table 6 was not influenced by treatments but there were numerical increased in BW with VM (2288 vs. 2283, p=0.8). Electrolyte high level increased BW (4%, p=0.07), WG (4.5%, p=0.05), DG (4.5%, p=0.05) and PG (1.2%, p=0.07). Betaine also increased BW (4%, p=0.05), WG(4.7%, p=0.05), DG (4.7%, p=0.1) and PG (15, p=0.05).

Feed consumption.

Feed consumption (FC) mean feed consumption (MF) feed efficiency (FE) and feed consumption percentage of body weight (PFC) comprised in Table 7. Supplementation of electrolyte low level (EL) significantly ($p<0.05$) increased the FC of HS birds compared with control and electrolyte high level (EH). Betaine low level (BL) responded by significantly ($p<0.05$) increased FC compared with control group birds. Supplementation of EH significantly ($p<0.05$) decreased and supplementation of BH significantly ($p<0.05$) increased the PFC compared with control groups of betaine and electrolytes. Feed efficiency was improved with EL (2.08%, p=0.5), BH (4. 2%, p=0.2) and was reduced with VM (4.2%, p=0.2).

Water Consumption.

No significant effects of treatment were observed for water consumption data showed in Table 8. Numerical increased in water consumption recorded with VM (2.2%, p=0.9) EL (10%, p=0.6) and BL (7.5%, p=0.7).

Carcass composition.

Fasted (12 h) weight (FW) specific gravity (SG) dry matter of breast (DM) fat pad weight (FP) and fat pad percentage of body weight (FR) displayed in table 9. Breast weight (BR) breast weight percentage of body weight (BP) hot weight (HW) chill weight (CW) chill weight percentage of body weight (CP) liver weight (LW) and liver weight percentage of body weight (LP) showed in table 10. Supplementation of VM increased DM by 5.2% (p=0.2) FP by15.9% (p=0.09) FR by 17% (p=0.13). Supplementation of EH and BL elevated the BR by 7% (p=0.05), 5.1% (p=0.1) respectively compared with control group of electrolytes and betaine. Hot weight (HW) was observed more with VM by 0.7% (p=0.1) EH by 2.9% (p=0.2) and with BH by 2.4% (p=0.3) compared with control of each treatment. Liver weight (LW) and LW percentage of body weight (LP) were increased (p=0.02) with the supplementation of BL and BH (p=0.02) compared with control group birds. Dressing wastage (VS) dressing wastage percentage of body weight (VP) dressing percentage (DP) water absorb CW – HW (WA) water absorb percentage of body weight (WP) total yield (TY) and survivability ratio BW / FW (SR) showed in table 11.

Dressing wastage percentage of final body weight was lower with VM by 2.3% (p=0.4) EH by 2% (p=0.4) and with BH by 1.4% (p=0.6) whereas dressing percentage was increased with VM, EH and BH by 1.2 % (p= 0.5, 0.2, 0.6)

respectively compared with control group of treatments. Water absorbed by hot carcass as a percentage of final body weight (WP) was lower with the supplementation of VM by 5.5% ($p=0.5$) EL by 6.6% ($p=0.3$) and BH by 2% ($p=0.9$). Supplementation of electrolytes low level significantly increased the TY compared with control and EH birds. Addition of BH significantly ($p<0.05$) increased the TY compared with control birds of betaine.

Serum Chemistry.

Average hematocrit (AH) comprised in table 12 was elevated ($p>0.05$) with VM, EH, EH, BL, BH, VM X EL and EH, VM X BL and BH compared with control birds of each treatment. Chloride (CL) magnesium (MG) triglyceride (TR) uric acid (UR) total protein (TP) calcium (Ca) phosphorus (PHO) sodium (Na) albumin (AB) and potassium (K) showed in table 13. Supplementation of EL resulted significantly ($p<0.05$) increased serum concentration of CL compared with control and EH. Betaine high level increased ($p<0.05$) the serum level of CL compared with control and BL.

Virginiamycin with and with out electrolyte and betaine did not show any significant effect on CL concentration in serum. Betaine of low level increased ($p=0.007$) the concentration of Mg compared with control group. Electrolyte low and high level significantly increased the level of TR and UR compared with control birds. Sodium concentration was significantly ($p<0.05$) influenced by VM by increasing Na level in serum. Supplementation of EL and BL significantly ($p>0.05$) increased the Na level in serum compared with control birds. Total protein was increased with VM ($p=0.6$) EL ($p=0.2$), EH ($p=0.1$), BL ($p=0.2$) and

BH (0.1). Phosphorus was depressed with VM (p=0.6) and was increase with EL (p=0.3), EH (p=0.6) BL (p=0.1) and BH (p=0.1) compared to their controlled birds. Albumin and K was also increased with VM (p=0.3,0.2) EL (p=0.1, 0.6) EH (p= 0.1, 0.3) BL (p=0.05, 0.8) and BH (p=0.1, 0.6) compared with control group of birds.

Body temperatures.

Body temperature at age 36 (BT36) 46 (BT46) and average body temperature (ABT) showed table 12. Fasted (36 h) body temperature (FBT) displayed in table 13. Supplementation of VM influenced by increased (p=0.05) BT36, ABT (0.4) and decreased BT46 (p=0.9) compared with control birds. Body temperature at age 36 and ABT was increased with EL (p=0.3) and EH (0.1) compared with control birds. Addition of BL and BH increased BT46 (p=0.7) and decreased BT36 (p=0.3) and ABT (p= 0.8, 0.6) compared with control birds. Supplementation of BL and BH significantly ($p<0.05$) increased the FBT compared with control birds.

Survivability.

Electrolyte low level significantly increased the survivability (Table 14) compared with control and EH birds. Supplementation of BH responded significantly ($p<0.05$) high SU compared with BL and control group. Virginiamycin increased the SU by 1% (p=0.7) compared with VM control birds.

Body composition.

Body composition through scanning displayed in table 15. Whole body dry matter percentage of final body weight (DM) at age 41 d showed higher

(p=0.001) compared with age 33 and 46 d higher (p=0.0001) than that of age 37 d. Virginiamycin increased the DM by 9% (p=0.09) compared with control group. Addition of EL, EH, BL and BH reduced the DM (p=0.3,0.8, 0.5, 0.4) respectively compared with control group. Supplementation of EH significantly ($p<0.05$) reduced the bone mineral concentration (BMC) compared with control group. Betaine low level also significantly ($p<0.05$) reduced the BMC compared with control group. Virginiamycin responded with the reduction of BMC (p=0.5). Age 46 responded significantly ($p<0.05$) higher BMC compared with age 33 and 37 d whereas age 37 showed significantly ($p<0.05$) higher BMC compared with age 33 birds.

Fat (FA) was significantly ($p<0.05$) reduced with the supplementation of electrolyte high level compared with control group. Betaine of low and high level also significantly ($p<0.05$) reduced the FA compared with control group whereas VM increase the FA by 25.8% (p=0.1) compared with control of VM birds. Age 41 d and 46 d showed significantly ($p<0.05$) more FA compared with age 33 and 37 d. Fat percentage (FAP) was significantly ($p<0.05$) reduced with the supplementation of BL compared with control group. Virginiamycin elevated the FP by 27% (p=0.1) compared with control of VM birds. Age 41 showed significantly more FAP compared with age 46 d. Lean + BMC (LBM) was significantly ($p<0.05$) reduced with the supplementation of VM compared with control group and age 46 showed significantly ($p<0.05$) higher level compared with age 33, 37, and 41 d. Electrolyte low level, EH, BL and BH showed reduction if LBM (p=0.8, 0.4, 0.3, 0.2) respectively compared with control group

of betaine and electrolyte. Lean (LN) was significantly ($p<0.05$) reduced with the supplementation of VM compared with control group of VM birds. Electrolyte low, high, betaine high and low level also decreased the LN ($p=0.8, 0.5, 0.3, 0.2$ respectively). Age 46 significantly gained more LN compared with 33, 37 and 41 d of age.

Lean percentage (LNP) was significantly ($p<0.05$) increased with the supplementation of VM compared with control group. Betaine high level also responded with significantly ($p<0.05$) higher LNP compared with control of betaine birds. Lean percentage was significantly ($p<0.05$) reduced as bird's age increased. Bone mineral concentration + FA + LN (BFL) showed significantly ($p<0.05$) higher at the age of 46 d compared with age 33, 37 and 41 d. Virginiamycin, EL, EH, BL and BH reduced the BFL ($p=0.1, 0.4, 0.1, 0.08, 0.07$) respectively compared with their control groups. Bone mass density (BMD) was significantly ($p=0.03$) reduced with the supplementation of electrolyte low level and age 41 d showed more BMD compared with age 33 and 37 d. Virginiamycin, BL and BH suppressed the BMD ($p=0.1$) than that of control birds. Lean + BMC percentage of body weight (LBMP) was significantly ($p<0.05$) reduced with VM and was significantly ($p<0.05$) increased with the supplementation of BL compared with their control groups. Supplementation of EH significantly ($p<0.05$) increased the LBMP compared with control group. Age 46 responded with significantly ($p<0.05$) highest level of LBMP compared with age 33, 37 and 41 d.

Correlations.

Body temperature and serum chemistry correlation showed in table 17. Body temperature age 36 (BT36) BT46 and ABT was negative correlated with serum phosphorus and average hematocrit whereas BT46 was negative correlated with serum level of calcium.

Correlation between live performance serum chemistry and body temperature showed in table 18. Potassium was negatively correlated with dead weight. Chloride was negatively correlated with BW, WG and DG. Calcium was positive correlated with PFC. Phosphorus was positively correlated with PF, FE and Survivability and was negatively correlated with mean feed consumption. There was no correlation between Mg, TP, TR, and UR. Albumin was positively correlated with PF. Average hematocrit was positively correlated with PF and survivability. There was negative correlation between BT36 and PF and survivability. Body temperature age 46 was negatively correlated with BW, WG and DG whereas ABT was positive correlation with PF.

Correlation between serum chemistry body temperatures and carcass composition displayed in table 19 and 20. Serum level of sodium was negatively correlated with DM, WA and WP. Calcium was negatively correlated with DM. Potassium was positively correlated with water absorb percentage. Phosphorus level was positive correlated with BR and BP. Magnesium was positive correlated with LW, LP, BR, and BP. Relation ship between TP and LW, LP, HW, CW and FP was positive. Albumin was positively correlated with HW and CW where as UR was positive with LW and LP. Average hematocrit was positively correlated with LW, TY and LP. There was positive correlation ship between BT36 and SG.

Body temperature age 46 was negatively correlated with LW, SG and water weight whereas was positively correlated with WA and WP. ABT was negatively correlated with water weight, SG and positive correlated with WA and WP.

Correlation between serum chemistry body temperature and body composition comprised in table 21. Sodium, K, CL, TP, and TR, AB was negatively correlated with whole body dry matter. Negative correlation was found between K and BFL and LBM. Positive correlation was occurred between CL with LN and CA with BMC, FA, LN, BFL and LBM. Phosphorus was positively correlated with BMC, FA, LN, BFL, and LBM. Body temperature age 36 d was positively correlated with FAP and negatively correlated with LP and LBMP.

Correlation of carcass composition and body composition (scanning) showed in table 23. Fat percentage was negatively correlated with fast body temperature and DM was positively correlated with FA and BFL.

Experiment 3.

Body weight.

Body weight gains are comprised in Table 24, 25 and 26. Compensatory gain (Table 24) was achieved in pre-exposed to HS birds when compared with TN birds. Body weight gain was 30 % more ($p=0.02$) in compensatory birds compared with TN birds. Supplementation with electrolyte low level increased ($p=0.02$) compensatory gain when compared with TN birds. Increased ($p>0.05$) body weight gain was resulted with supplementation of VM by 28%, with BL by 10%, and with BH 35.6% when compared with TN birds of same treatment. Treatments effects among CG birds were high ($p=0.01$) weight gain by 47% with

the supplementation of EH compared with control group of electrolyte birds in CG group. Supplementation with VM increased ($p>0.05$) by 5 %, with BH ($p>0.05$) by 15 % compared with control of VM and BH in CG birds respectively. Body weight (Table 25) at the age of 40 (BW40) was higher ($p=0.03$) with the supplementation of VM in TN birds compared with control birds of VM in TN groups where as BW 40 was higher ($p>0.05$) with the supplementation of VM in CG birds compared with control of TN birds.

Daily gain of age 40 d birds (DG 40) and percentage of gain (PG 40) was higher in CG birds ($p<0.01$) with the supplementation of VM compared with the control of TN birds. Numerical increased final body weight (BW 48) final body weight gain (G 48) daily gain (DG 48) and percentage of body weight gain (PG 48) was higher ($p>0.05$) with the supplementation of El and BH in CG birds compared with TN birds (Table 26).

Feed Consumptions.

Feed consumption and efficiency are shown in table 27and 28. Although mean feed consumption (MF 40) at age 40 was lower ($p>0.05$) in CG birds with all treatments but all treatments resulted in better ($p>0.05$) feed-efficiency (FE 40) of CG birds when compared with TN birds. Supplementation of VM significantly ($p=0.03$) increased mean feed consumption at the age of 48 d (MF 48) compared with control of CG and TN birds. Feed efficiency at the age of 48 d (FE 48) did not influence significantly ($p>0.05$) with any treatment but was improved ($p>0.05$) with supplementation of EH and BH and also was better ($P>0.05$) in CG birds compared with TN birds. Feed consumption percentage of

body weight at the age of 48 d (PFC 48) was more (p=0.03) in CG birds compared with TN birds.

Survivability.

Survivability (Table 29) of CG birds was elevated (p=0.03) by 15.6 % compared with TN birds. Numerically increased (P>0.05) survivability was observed with and without treatments in CG birds. Supplementation with VM improved survivability by 8%, with EL by 9%, with EH by 5% with BL 12% and with BH by 3 % compared with control VM, EL, EH, BL and BH of TN birds.

Carcass Composition.

Analysis of carcass composition is displayed in Table 30, 31, 32, 33, and 34. Dry matter percentage of breast sample (DM) was decreased (p>0.05), fat pap (FP) and fat pad ratio of body weight (FR) was increased (p>0.05) in CG birds compared with control birds of TN. Supplementation of electrolytes decreased (p>0.05) the DM and EL increased the FP and FR of CG birds when compared with TN control birds of electrolytes. Virginiamycin supplementation decreased (p>0.05), FP and increased the FR of CG birds compared with control of VM in TN birds whereas increased (p=0.05) FP was observed in TN birds with the supplementation of VM compared with control birds. Supplementation of betaine both level decreased the DM, FP and FR in CG birds compared with control birds of betaine in TN birds. Breast weight (BR) of CG birds (Table 31) was decreased (p<0.03) compared with control birds of TN. Supplementation of BH increased (p=0.009) the BR of CG birds compared with the BH

supplementation of TN birds and control of TN and CG birds. Supplementation of BL also increased the BR of TN birds compared to control birds.

Fasted (12 h) weight (FW) table 32 was low ($p>0.05$) in CG birds and were numerically increased ($p>0.05$) with the supplementation of EL and BH compared with control birds of TN. Supplementation of BL resulted in high ($p=0.05$) hot weight (HW) table 32, in TN birds compared with control of CG and TN birds whereas BH supplementation increased ($p>0.05$) the HW of CG birds compared with BH of TN birds. Chill weight (CW) and chill weight percentage of body weight (CP) was observed more ($p>0.05$) with the supplementation of EL and BH in CG birds compared with EL and BH of TN birds. Liver weight (Table 33) a percentage of body weight (LP) was numerically increased ($p>0.0$) in CG birds with the supplementation of EH and BL compared with EH and BL of TN birds. Dressing percentage in CG birds was high ($p>0.05$) with the supplementation of EL compared with birds of TN group and CG with and without electrolytes supplementation. Water absorbed (Table 34) by hot weight (WA) was more ($p>0.05$) in CG and was influenced by all treatment supplementation by increased ($p>0.05$) WA compared with all groups in TN. Total yield (TY) in table 34 was more ($p>0.05$) in CG birds with and without supplementation of EL, VM and BH compared with TN birds.

Body Temperatures.

Body temperatures are displayed in table 35. Body temperature at the age of 36 d (BT 36) was low ($p=0.007$) in CG birds with the supplementation of EL compared with control, EH supplemented in CG birds and control of TN birds.

Supplementation of VM also decreased (p=0.003) BT 36 compared with control of both CG and TN birds. Supplementation of BH decreased (p=0.05) the BT 36 compared with control of TN and CG birds in betaine supplementation group. Supplementation of EL, VM, and BH decreased (p>0.05) the body temperature at the age of 46 d (BT 46) in CG birds compared with control birds of thermoneutral birds. Generally both BT 36 and BT 46 were observed low (p>0.05) in CG birds compared with TN birds. Fasted body temperature (FBT) of all groups (Table 44) in CG with and without treatment supplementation was lower (p>0.05) compared with TN birds.

Serum Chemistry.

Average hematocrit (Table 36) was not influenced significantly (p>0.05) with any treatment but EL, VM and BH decreased the average hematocrit values (AHC) in CG birds and CG birds AHC was also observed lower (p>0.05) compared with TN birds. Supplementation of VM increased (p=0.01) the plasma CL (Table 37) level in CG birds compared with control of TN birds. All treatments also resulted in increasing (p>0.05) CL in CG birds compared with TN birds. Plasma level of Mg (Table 36) was lower (p=0.03) in CG birds with the supplementation of VM when compared with control of CG birds. Sodium level in plasma was higher (p=0.01) when compared with control of CG and TN birds however was observed more (p>0.05) in CG birds compared with TN birds. There was not significant (p>0.05) influence of any treatment supplementation in CG of TN birds on TR, UR, and TP (Table 36) levels in plasma but were on decreasing (p>0.05) pattern in CG birds compared with TN group of birds.

Plasma level of Albumin (AB) was higher (p=0.03) with the supplementation of VM in CG birds compared with control of TN birds where as supplementation of EH, BL and BH increased the level of AB in CG birds compared with control, EH and BH of TN birds. Phosphorus level (PHO) was decreased (p=0.03) whereas calcium level was decreased (p=0.03) with the supplementation of VM in TN birds compared with CG and TN control birds. Plasma level of potassium was increased (p>0.05) with the supplementation of EH, and BL compared with EH and BL of TN birds.

Data analyzed of scanned birds were shown in table 40. Average of age day 31, 37, 41 and 46 was statistically analyzed and showed that whole body dry matter (SD) was higher (p=0.0001) in CG birds compared with control of TN birds. Supplementation with VM increased (p=0.002) the SD of CG birds compared with control of CG, TN and of VM supplemented in TN birds. Supplementation of EL, EH, BL and BH also increased (p>0.05) the SD when compared with EL, EH and BL of TN birds. Bone mineral concentration (BMC) was higher (p=0.01) in TN birds compared with CG birds and was higher (p=0.002) in CG birds with the supplementation of VM compared with VM supplemented of TN birds.

Supplementation of BL also resulted by increased BMC in CG birds compared with BL, BH, of control birds of TN and BH and control of CG birds as well. Lean was resulted increased (p=.0001) when compared with control of CG, control of TN and VM supplemented of TN birds. Lean of CG birds were found more (p>0.05) compared with control of TN birds. Supplementation of EL, EH, BL

and BH also increased (p>0.05) LN compared with control and EL, EH, BL and BH supplemented birds of TN. Lean percentage of body weight was decreased (p=0.001) of CG birds when compared with TN birds. Fat weight (FA) and fat weight as a percentage of body weight (FP) was increased (p<0.001) in CG birds compared with TN birds.

Supplementation of EH also responded with increased (p=0.05) FA compared with control of TN, control of CG and supplemented with EL and EH of TN birds. Supplementation of VM, BL and BH also increased (p>0.05) the FA and FP of CG birds compared with TN birds. Lean bone mineral concentration + LN was reported low (p=0.0001) in CG birds compared with control of TN birds. Supplementation of VM increased (p=0.0001) the BMC + FA + LN (BMCFL) of CG birds compared with the control of TN birds whereas supplementation of EL, EH, BL and BH also reported higher (p>0.05) BMCFL of CG birds compared with EL, EH, BL and BH of TN birds. Effects of age on scanning date are comprised in table 45. Age 46 d in CG and TN showed more (p=0.001) SD and BMC compared with age 37 and 41 d of CG and TN birds where as SD and BMC of age 46 in CG was higher (p>0.05) in CG birds compared with TN birds. Fat weight FP at the age of 46 d was more (p=0.001) in CG birds compared with age 46 of TN birds. Lean and LP were more (p.) in at the age 46 d in CG compared with control birds of same age. Age 46 d showed that BMD of CG birds were lower (p=0.001) compared with same age of TN birds.

Correlation of thermoneutral birds

Correlation between serum chemistries and feed consumption of TN birds showed in table 46, demonstrated negative relationship of Ca with MF and CL showed positive relationship with PFC. Triglyceride and AB and K positively correlated with MF however K and AHC was negatively correlated with FE. Body temperature at the age 46 was positively with FE. Correlation between BT 36, BT46 and ABT was negatively correlated with PFC and TN birds. Serum chemistries and growth relationship showed in table 47.

Calcium was negatively correlated with BW, WG, DG and PG where as relationship of TR and AHC was positive with these variables. Correlation between serum chemistries and body temperatures showed table 48. Body temperature at the age 36, BT46 and ABT was positive correlated with plasma concentration of Ca, Phos and Mg whereas TP and TR are relationship observed with BT46 and ABT. Chloride, K and AB were positively correlated with AHC.

Correlation between serum chemistries and carcass composition showed in table 49 and 50. Plasma concentration of Ca showed positive relationship with FW, HW, CW and LP. Phosphorus level was positively correlated with FW, CP, FP, LP, BP and SG. Magnesium and TP was positively correlated with LP and TP was negatively correlated with DM. Potassium has positive relationship with LP, BP and SG whereas negative relationship with FW and DM. Average hematocrit relationship was observed negative with FP, FR and DM and was positive with LP. Body temperature age 36 was negatively correlated with CP. Calcium and phosphorus was negatively correlated with VS, VP, WA and WP. Triglyceride was positively correlated with VS, WA and WP. Uric acid was

positively correlated with SR, and K relationship with TY was negative whereas BT36 was negatively correlated with TY and positively correlated with VP.

Correlation between serum chemistries and whole body composition was shown in table 51. Calcium was negatively correlated with BMC, LN, BMFL, BMD, and LBMCP whereas UR was negatively correlated with BMD and LBMC. Potassium was negatively correlated with FP and AHC was positively correlated with LP, LBMCP and FBT. There was no correlation in between live performance and body temperature with SD, BMC< BMCP, FA, FP, LN, LP, BMFL, BMD, LBMC Relationship between whole body composition and carcass composition (Table 53) showed positive between FP and FR with SD, BMC, FA, LN, BMFL, and LBMC. Specific gravity relationship was negative with SD, FA and FP. Water absorbed was positive correlated with LP (Table 54)

There was not any significant ($p>0.05$) effect of treatment on BW 26, BW 34, BW 40, and BW 48 (Table 64) in thermoneutral birds. Numerically increased BW 26 was observed with supplementation of EH, BH, VM X EH and VM X BH whereas BW 48 was numerically increased with supplementation of VM compared with control birds. Significantly increased ($p<0.05$) G 48 and DG 48 was observed with the supplementation of VM compared with control birds (Table 65 and 66). Supplementation of VM increased ($p<0.05$) the PG 26 and PG 34 and PG 40 when compared with control birds of VM group (Table 67). Electrolyte low level reduced ($p<0.05$) the PG 26 compared with control birds (Table 67). No treatment effect was observed on feed consumption and feed efficiency in thermoneutral birds. Mean feed consumption (MF 26), MF 34, MF 40

, MF 48, and FE 34 were seen on increasing ($p>0.05$) pattern with the supplementation of VM compared with control birds (Table 68 and 69). Supplementation of BH increased ($p<0.05$) the PFC 40 and PFC 48 when compared with control birds.

Correlation of Compensatory birds.

Sodium was positively correlated with PFC (Table 55). Negative relationship between TP and WG, DG, and PG was observed in compensatory birds (Table 56). Potassium was also negatively correlated with WG and DG whereas BT36 was negatively correlated with BW (Table 56). Chloride was positively correlated with AHC and Ca was also positively correlated with BT46 and ABT (Table 57). Calcium, Mg and, UR were positively correlated with LW (Table 58) whereas TR was negatively correlated with FW, HW, CW, CP and BR. Albumin was negatively correlated with FP, FR, and positive with SG (Table 58). Sodium was negatively correlated with CP and AHC was positively correlated with BR and BP (Table 58).

Average body temperature was negatively correlated with FW, HW and CW (Table 58). Chloride was positively correlated with VS (Table 59). Triglyceride was negatively correlated with DP and positively correlated with VP and SR whereas Na was positively correlated with VP, and negatively correlated with DP, and K was positively correlated with SR (Table 59). Chloride has positive relationship with SE, FA, FP and negative relationship with LP and LBMCP (Table 60). Calcium and phosphorus was negatively correlated with SD and Mg has negative relationship with LN, LBMCP and positive relationship with

BMCP (Table 60). Sodium was positively correlated with SD, BMCP, LN, BMFL, BMD and LBMCP (Table 61). Body weight (BW), WG, and DG were negatively correlated with FP, and MF was positive with BMD whereas BT36 was also negative with BMFL (Table 62). Positive relationship of FP and FR was with FA and FRP and was negative with LP and LBMCP (Table 62) whereas LP has negative relationship with FA (Table 62). Negative relationship between BP and FAP and positive relationship between BP and LP and LBMCP was observed (Table 62). Water absorbed was negatively correlated with BMCP and WP has also negative relationship with LN were observed (Table 63)

DISCUSSION

Although there were not significant effects of ambient temperatures 24^{O}C and 37^{O}C on body weight and gain but numerically increasing pattern of gain and feed consumption was observed. May et al. (2000) did not observe any temperature effect of weight gain or feed conversion at the age of 21 d of male broilers but current study showed significant increased feed efficiency of TN birds compared with HS birds as observed by Deyhim et al.(1993). Hacina et al., (1996) observed significant effect of body weight gain, feed consumption and feed efficiency in HS (32 ^{O} C) birds compared with TN birds (22 ^{O} C) control birds whereas feed efficiency was significant better of TN birds in their study too.

Body weight gain was not influenced significantly with the supplementation of electrolyte agreed with Abdella et al.(1995); Hayat et al. (1999) ; Bottje and Harrison (1985b) with the addition of sodium bicarbonate. Our results also with the agreement of (Teeter et al., 1985) of no significant ($p < 0.1$) increased rat of

gain in HS birds with the supplementation of sodium bicarbonate. Addition of $KHCO_{3.}$, significantly reduced the overall WG (Hayat et al.,1999). In our study potassium chloride, potassium sulfate, and sodium bicarbonate were included in the pack of electrolytes. Smith and Teeter (1987b) suggested that the gain response might have been partially due to increased water consumption acting as heat sink.

Effect of VM on body weight and FC was not significant ($p>0.05$) is in agreement with Belay and Teeter (1996) with supplementation of VM of HS birds at age 49 d. Betaine low and high level increased ($p>0.05$) the BW, WG, DG, and PG compared with control birds. Schutte et al. (1997) did not observe significant effect of gain of thermoneutral birds with the supplementation of betaine 0.04%.

Current study indicated compensatory gain in birds pre exposed to heat stress (37 C) for 15 days from age 18 to 33 days and then reared in thermoneutral environment (24 C) for 15 days. Results of compensatory birds were compared with control (thermoneutral) birds. Most of studies conducted on compensatory gain were based on feed restriction or feeding low energy or protein diet. Current study on compensatory gain was conducted by reducing feed intake through exposure in high ambient temperature. Compensatory gain results are in the agreement with observations (Yahav and Hurtwitz, 1996; Yahav et al., 1997a) of accelerated growth with the early age thermal conditioning of birds. Hahn et al. (1975), suggested that exposure of young animals to extreme ambient temperatures above upper critical temperature (36 – 37 C) may effect performance even after animals are returned to thermoneutral conditions.

Accelerated growth was also observed after food restriction (Palvnik and Hurwitz, 1985, 1988, 1989; Arjona et al., 1988). Yahav and Palvink .(1998) exposed the birds to HS at the age of 5 days and observed compensatory growth till the age of 42 d. Current results are similar to their observations regarding the accelerated growth, observed at the age of 40 d and 48 d in CG birds compared with TN birds. Supplementation of VM increased ($p=0.03$) the BW40 and G40 in CG birds compared with control of TN birds and increased ($p<0.05$) compared with control of CG birds (Table 25) indicates the capability of VM of nutrient absorption and increased dietary ME (Nelson et al., 1963).

During the phase of forced feed restriction or by exposing to heat stress bird's energy requirements for maintenance declined may be because of low reduced heat production and it returned to normal upon resumption of normal feeding. Data of mean feed consumption (Table 24) demonstrated that at the age of 40 days (first compensatory gain) was only 9 grams less than the control (TN birds) whereas at the age of 48 day MF was only 1 gram more in CG birds compared with TN birds. Palo et al.(1995) observed that same pattern of feed consumption at the age of 48 d . Feed consumption of the early feed restricted birds after access of ad libitum feed showed no significant difference at the age of 48 d.

There was not any significant difference in liver weight (Table 33) is in the agreement with Palo et al. (1995) and Susbilla et al. (1994) of not observing more liver weight in CG birds.

Fat pad weight and FR was numerically higher in current study (Table 24) where as whole body fat and FP was significantly ($p=0.0001$) in CG birds compared with TN birds is in the agreement with Summers et al.(1990) in which more fat was observed in the feed restricted birds compared with ad libitum feed. Increased fat weight is also in agreement with (Beane et al., 1979; Plavnik and Hurwitz, 1985). Most of researches conducted on compensatory gain were based on feed restriction at early age of life and observed less fat pad or whole body fat after accessing to ad libitum feed. Increased whole body fat and fat pad weight can not be related with fat observations of feed restricted birds since birds in current study were exposed to heat stress. Increased fat pad and whole body fat are the effect of HS exposure. Body lipid composition depends partly on hepatic lipogenesis and partly on dietary fat composition. Indeed, linoleic and linolenic acids are not synthesized by the chicken and come from dietary sources. The effect of high temperature upon fatty acid composition of animal tissues appears to be more controversial. Sonaiya (1988) showed a significant increase in polyunsaturated to saturated fatty acid ratio in the abdominal of heat-exposed chicken. Calorimetric studies conducted with broilers so far have shown no conclusive evidence of the role of metabolic heat production during and after early feed restriction on body composition and growth rat (Jones and Farrell, 1992) Studies with other species showed higher fasting heat production and maintenance energy during feed restriction, which was associated with 50% heavier weight of metabolically active tissues such as small intestine, pancreas and liver (Koong et al, 1982)

Although there was not significant ($p>0.05$) feed efficiency but numerically improved FE by 2.2 % in CG birds in agreement with Arjona et al.(1988) regarding the improved feed efficiency of pre- exposed to HS birds whereas Deaton et al. (1995) did not observe significant FE of early feed restricted birds but Palo et al.(1995) observed the significant improved FE in feed restricted birds. Improved ($p>0.05$) FE through feed restriction has been attributed in part to higher metabolic efficiency associated with maintaining a smaller body and to lower metabolic rate during early growth (Dickerson, 1978). Survivability of CG birds was improved ($p>0.03$) compared with TN birds. Breast weight of CG birds was increased ($p=0.03$) with supplementation of BH compared with control of CG birds. Early feed restriction decreases the cell size and increases the cell size of birds after re-feeding (Zubair and Leeson, (1996). It could be explained that because of increased in cell size water accumulation may increased with betaine as its capability of water absorption. Dry matter of breast samples also indicates that with the supplementation of BL water content of breast muscles were increased($p=0.05$) compared with control of CG birds. The result of this study demonstrate that compensatory growth occurred in following a period of growth retardation cause by less feed consumption through heat stress. This confirms the findings of Plavnik et al.(1985) in which they suggested compensatory growth after feed restriction at early age.

Suk and Washburn (1995) have shown decreased efficiency of feed utilization with increased environment temperatures whereas Stilborn et al.(1988) reported no significant effects of HS on efficiency of feed utilization. Deaton et

al.(1986) reported that feed utilization was improved under hot environmental temperatures. Heat exposure leads to decreased feed intake in most animal species. In our study retardation of feed intake percentage of body weight was greater than the reduction of growth.

Feed intake was significantly increased with EL same as (Hayat et al. 1999) but FE was significantly improved in their experiment may be because of 31 C house temperature compared with our study on 37 O C., but was deteriorated in their study with increasing concentration of sodium bicarbonate above 10 g / Kg. Smith and Teeter (1987b) observations are in the agreement with our FE not significant with supplementation of solution of three type salts (potassium chloride, potassium sulfate, and sodium bicarbonate) in heat stressed broilers. Betaine low level BH increased FC (p=0.005, 0.005) MF (P=0.7, 0.8) FE (p=0.7, 0.2) and PFC (p=0.02, 0.007). Schutte et al. (1997) reported significant improvement in FE with the supplementation of 0.04 % betaine not in heat stress birds.

Serum concentration of electrolyte partially agreed with the study of Teeter et al.,(1993) regarding decreased Na and K whereas as Cl was increased in heat distress birds. Our result also agreed with Belay and Teeter (1992a) regarding the decreased plasma PHO, K, Na and Mg of HS birds compared with TN birds. Serum calcium was significantly ($p<0.05$) decreased in HS birds compared with TN birds agreed with the observation of Edens (1976). Total protein was reduced ($p<0.05$) in serum of HS birds when compared to TN birds agrees with the observation of Vo et al.(1978).

Results obtained in the experiment in general are in the agreement with other studies of higher hematocrit values at lower ambient temperatures. Olson (1937) observed the number of erythrocytes in the domestic fowl increased during the winter. Huston (1960) reported an increase in hematocrit for birds reared at 21.1 C when compared to birds reared at 30.0 C. Deaton et al. (1969a, b) observed significantly higher hematocrit values for birds reared at 7.2 C. than for birds at 32.2 C., but no consistent significant difference in values for the birds reared at 23.9 C compared than that of 32 C. Wideman et al.(2000) reported lower level of hematocrit in heat distress birds compared to TN birds. Their difference was significant may be due to 16^{O} C verses 28 ^{O}C. Kubena et al.(1972) observed the high level of hematocrit values in TN birds compared to HS birds.

Electrolyte low level supplementation (KCL included) slightly increased (p=0.6) plasma K, Ca, Na and Cl similar to Abdellah et al.(1995) with the supplementation of KCL and $KHCO_3$ through drinking water. High level of plasma electrolytes with electrolytes betaine and virginiamycin supplementation may be because of more water intake as a result of treatments effect.

Breast weight as percentage of body weight was decreased (p=0.4) and fat was increased (p=0.04) due to HS compared with control birds (Table 2), which aggress with the finding of (Yahav et al.,1995: Hacina et al., 1996) . Howlier and Rose (1989) and Deyhim et al.(1993) also found reduced breast meat yield during HS as observed in our study. Chronic heat exposure enhanced fat deposition in finishing broilers. The abdominal fat and whole body fat was

increased (p=0.04, 0.02) respectively in HS birds compared with TN bird's. Our result are in agreement with (Hacina et al., 1996) of increasing fat in HS birds compared with TN birds. The effect of heat exposure on fat deposition has long been controversial and could be related to the age of birds. Hacina et al. (1996) and Deyhim et al. (1993) have observed the same as our study on increasing fat pad in table 5. Using chemical body composition, increased fatness has been reported by Swain and Farrell (1975), EL Husseiny and Creger et al. (1980), Howlider and Rose (1987), and Geraert et al. (1996a). Moreover, under cyclic high ambient temperature, the increase in fatness may often not be as great as under constant high temperature. Indeed deposited lipids might be used for thermoregulatory purpose during the coolest part of the day. Our result in agreement with observations of Deyhim et al.(1993) regarding decrease in SG, LW and LP of HS birds compared with TN bird's.

Breast yield was not significant ($p<0.05$) with EL or EH agreed with the observation of Hayat et al. (1999). All dependent variables of broiler carcasses measured in the present study was not significant with electrolytes supplementation is in agreement with Whiting et al (1991) and Smith (1994). Liver weight LP and total yield (TY) showed significant ($p<0.05$) effect of betaine supplementation. Fat pad was increased ($p=0.09$) by 15 % with fortification of VM of HS birds. Whole body fat (FA) was significantly reduced ($p<0.05$) with electrolyte, betaine and VM whereas FA percentage of final body weight (FAP) was increased with VM ($p=0.1$). Virginiamycin improved HW ($p=0.9$) DM ($p=0.3$)

FP (p=0.2) FR (p=0.09) HW (p=0.6) CW (p=0.8) CP (p=0.5) DP (p=0.5) TY (p=0.7) of HS birds.

Current study did not find significant influence of VM on carcass weight and dressing percentage as the findings of Belay and Teeter (1996) may be due to more ambient temperature (37 C) in our study compared with 35 C. Whole body dry matter SD was reduced (p>0.05) with EL, EH, BL, BH and increased with VM (p=0.09) compared with control birds. Lean percentage of body weight was increased with VM (p=0.05) and BH (p=0.04) whereas was reduced non significant (p>0.05) with EL and EH. Betaine supplementation increased (p>0.05) the FW, FP, FR, BR, BP, HW, CW, CP, whereas significantly increased the LW with BL (p=0.01) BH (p=0.02) LP with BL (p= 0.01) and with BH (p=0.02) compared with control birds. Schutte et al. (1997) reported increase in breast meat yield with the supplementation of betaine of TN birds whereas betaine in our study also increased the breast yield.

Improvement (p>0.05) in carcass weight, DM, FP, FR, HW, CW, CP, SD, FAP with the dietary VM indicates beneficial influence during heat stress. It can be suggested that this improvement in carcass variables possibly related with reduced intestinal weight (Woodard et al., 1988) increased FC (Leeson, 1984; Buresh et al., 1985a) and nutrient absorption (Nelson et al., 1963).

Survivability of HS birds was decreased (p>0.05) compared with TN birds agreed by Deyhim et al.(1993) difference between both studies was significant and not significant. This difference may be due comparatively more experimental period in our study. Deaton et al. (1968) and Donkoh (1989) using environmental

temperatures up to 32 C found that environmental temperature did not affect mortality but a significant increase in mortality was observed by Vo et al. (1977) when the environmental temperature was increased to 37.8 C. Cooper et al. (1998) did not observe effect of HS on mortality. Vo, et al.(1978) did not observe any significant effect of ambient temperature on survivability and observed that mortality in their trial was not temperature dependent.

Survivability was significantly (p=0.03) increased with the supplementation of EL in contrast Hayat et al. (1999) reported significantly high low survivability with the addition of sodium bicarbonate 10g / l but with the low level had not adverse effect on livability in agreement with our sodium bicarbonate level < than 10 g / l of water. Supplementation of VM improved (p=0.7) survivability of HS birds in agreement with observation of Belay and Teeter (1994) with 20 ppm. The effect of VM on survivability of HS birds could be related to either reducing immune challenge or heat production if VM improves chick energetic efficiency (Belay and Teeter., 1994). Since dead birds of HS showed clear sign of severe dehydration therefore increased (p=0.9) water intake with VM by 7%, EH by 3% (p= 0.07) and BH by 4% (p=0.05) may be one more reason to protect birds from dehydration during HS. Since betaine known as osmo-protectants (Kidd et al.,1997) therefore birds can be prevented from dehydration.

One of the factors influenced by ambient temperature and affected feed intake and body weight gain in the hormone triiodothyronine (T_3) is inversely related to environment temperature (May *et al.*, 1986; Iqbal *et al.*, 1990) may be as a result of modulation of peripheral deiodination (Rudas and Pethes, 1984;

Kuhn et al., 1987). It is also well documented that T_3 related to energy metabolism (Williamson *et al.*, 1995) and to feed intake in chickens and turkeys (Klandorf and Harvey, 1985; Yahav *et al.*, 1995, 1996, 1998). The mechanism may include direct effects on the hypothalamo-pituitary axis and the associated polypeptide hormones, or temperature responses of T3 metabolism to pituitary hormones of peripheral deiodination (Kuhn et al., 1993; MCNabb and King, 1993).

Body temperatures at the age of 36, 46 d, average body temperatures were significantly increased whereas 36 hours fasted body temperature was decreased in HS birds compared with TN birds. Increased body temperature agrees with the observation of Donkoh (1989) where he found the significant increasing body temperature during heat exposure. Kohne et al.(1975) observed that body temperature of the turkeys began to rise after the ambient temperature reached 32 C., but did not increase significantly until the ambient temperature was well above the body temperature of the bird. This is consistent with reposts by Wilson and Woodard (1955) and Kenchtges and Boone (1971). Cooper et al.(1998) observed the significantly increased body temperature during HS compared with TN birds.

Body temperatures of BT36, BT46 and ABT did not show any significant effect of electrolyte but was numerically depressed ($p > 0.05$) at the age of 46 d is similar with Abdella et al. (1995) and Smith (1994). All body temperatures were decreased ($p > 0.05$) with supplementation of betaine. Body temperatures were not correlated with any serum variable except phosphorus negatively correlated

with all body temperatures and Ca positive correlated with BT46. Correlation with Ca agrees with the observation of Abdellah et al. (1995).

Addition of EL increased ($p=0.4$) water intake by 10 % compared with (Hayat et al.,1999) by 9% with the supplementation of sodium bicarbonate at temperature 31 C. Betaine increased ($p>0.05$) the water intake, daily water and reduced ($p>0.05$) water feed ratio compared with control birds.

Table 1.Effect of ambient temperatures 37^{O}C (HS) 24^{O}C (TN) on BW, WG, DG, PG, MF, FE and SU of male broilers age 18-48 d.

Variables	HS	TN	Significant
BW (g)	2210	2310	n.s
WG (g)	1645	1742	n.s
DG (g)	56.74	60.07	n.s
PG (g)	74.40	74.98	n.s
MF (g)	130.41	112.88	n.s
PFC	8.13	9.20	n.s
FE	0.44^{b}	0.53^{a}	*
SU %	81	92	n.s

n.s=not significant,*=p<0.005, a-b means within a row with unlike superscripts differ (p<0.05), BW=final body weight, WG=body weight gain, DG=daily weight gain, PG=percentage of gain, MF=mean feed consumption, FE=gain ;feed ratio, PFC= feed consumption ratio of body weight, SU=survivability

Table 2.Effect of ambient temperatures 37^{O}C (HS) 24^{O}C (TN) on BWT, SG, DM, FP, FR, BR, BP, HW, CW, CP, LW, LP, VS, VP, WA, WP and TY of male broilers age 49 d.

Variables	HS	TN	Significant
BWT (g)	2226	2284	n.s
SG	1.04^{b}	1.05^{a}	*
DM %	28.70	25.56	n.s
FP (g)	44.62^{a}	27.85^{b}	*
FR %	2.00^{a}	1.18^{b}	*
BR (g)	369.48	400.78	n.s
BP %	16.60	17.38	n.s
HW (g)	1665.62	1690	n.s
CW (g)	1719.12	1752.25	n.s
CP %	77.19	76.63	n.s
LW (g)	32.11^{b}	37.69	n.s
LP %	1.44^{b}	1.63^{a}	*
VS (g)	560.37	594.75	n.s
VP %	25.22	26.12	n.s
WA (ml)	53.50	62.25	n.s
WP %	2.41	2.76	n.s
TY (g)	67564.14^{b}	90702^{a}	*

n.s=not significant,*=p<0.05,**=p<0.005, a-b means within a row unlike superscripts differ (p<0.05), BWT=Twelve h fasting weight, SG= specific gravity, DM= dry matter percentage of breast sample, FP=fat pad, FR=fat pad percentage of final body weight, BR=breast weight, BP=breast percentage of final body weight, HW=hot weight, CW=chill weight, CP=chill weight percentage of final body weight, LW=liver weight, LP= liver weight percentage of final body weight, VS=dressing wastage, VP= dressing wastage percentage of final body weight, WA= water absorbed (cw-hw), WP=water absorb percentage of final body weight, TY= total yield,

Table 3.Effect of ambient temperatures 37°C (HS) 24°C (TN) on body temperature at the age of 36 d (BT36 °C), 46 d (BT46 °C), average body temperature (ABT °C) and difference of body temperature (BTD °C) of male broilers.

Variables	HS	TN	Significant
BT36	42.71[a]	41.59[b]	*
BT46	42.84[a]	41.57[b]	*
ABT	42.77[a]	41.58[b]	*
BTD	0.13	0.02	n.s

n.s=not significant,*=p<0.0005, a-b means within a row with unlike superscripts differ (p<0.0005)

Table 4.Effect of ambient temperatures 37^{O}C (HS) 24^{O}C (TN) on AH, CL, Mg, TR, UR, TP, Ca, PHO, Na, AB and K of male broilers age 49 d.

Variables	HS	TN	Significant
AH	31.83	36.12	n.s
CL	118.31	116.87	n.s
Mg	1.63	1.84	n.s
TR	38.18	35.25	.s
UR	2.75	2.81	n.s
TP	3.24	4.06	n.s
Ca	7.88^{b}	10.36^{a}	*
PHO	5.83^{b}	7.24^{a}	*
Na	149.18	150.50	n.s
AB	1.14	1.16	n.s
K	5.83	6.40	n.s

n.s=not significant,*=p<0.0005, a-b means within a row with unlike superscripts differ (p<0.0005)
AH=average hematocrit, ,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 5.Effect of ambient temperatures 37^{O}C (HS) 24^{O}C (TN) on sd(%), bmc(g), bmcp(%), fa(g), fap (%), ln(g), bfl(g), bmd, lbm(g), ftemp of male broilers age 33,41 d.

	HS		TN		
Variables	33(d)	41(d)	33 (d)	41(d)	Sig
Sd (%)	32.05	32.40	30.21	30.49	n.s
Mean	32.26		30.35		n.s
Bmc (g)	22.52b	28.55^{a}	21.25^{b}	29.08^{a}	**
Mean	25.53		25.16		n.s
Bmcp(%)	1.65	1.55	1.64	1.57	n.s
Mean	1.602		1.608		n.s
Fa(g)	203.97^{b}	306.56^{a}	139.87^{b}	207.66^{b}	*
Mean	255.27^{a}		173.92^{b}		*
Fap(%)	14.71	16.45	10.71	11.23	n.s
Mean	15.58^{a}		10.97^{b}		*
Ln(g)	1166.20b	1519.06^{a}	1156.40^{b}	1622.95^{a}	***
Mean	1342.63		1389.67		n.s
Bfl(g)	1392.88^{b}	1854.05^{a}	1317.28^{b}	1859.98^{a}	***
Mean	1623.46		1588.63		n.s
Bmd	0.148	0.159	0.148	0.161	n.s
Mean	0.154		0.155		n.s
Lbmp(%)	87.06	84.33	81.37	89.33	n.s
Means	85.70		85.35		n.s
Ftemp	40.30	40.41	41.02	41.15	n.s
Mean	40.35^{b}		41.08^{a}		*

n.s=not significant,*=p<0.05,**=p<0.005,***=P<0.0005, a-b Means with different superscript within a row under a major heading differ(p<0.05), n.s=not significant., sd(%)=dry matter percentage of body weight, bmc(g)=bone mass, bmcp(%)=bone mass percentage of body weight,, fa(g)=fat, fap (%)=fat percentage of body weight, ln(g)=lean, bfl(g)=bone mass fat and lean, bmd=bone density, lbm(g)=lean and bone mass, ,Ftemp=36 h fasted body temperature

Table 6. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on final body weight (BW), body weight gain (WG), daily weight gain (DG), and body weight gain percentage of BW (PG) of male broilers exposed to 37^{O} C age 18-48 d.

Treatments			BW (g)	WG (g)	DG (g)	PG (g)
Main effects#	VM	Control	2283	1729.68	59.64	75.69
		VM	2288	1726.87	59.54	75.37
	E	Control	2258	1695.39	58.46	75.02
		EL	2268	1717.11	59.21	75.61
		EH	2331	1772.33	61.11	75.96
	B	Control	2240	1685.08	58.10	75.16
		BL	2291	1732.26	59.73	75.48
		BH	2325	1767.49	60.94	75.96
Interactions#	VM X E	Control	2225	1693.68	58.40	75.01
		EL	2281	1734.80	59.82	75.96
		EH	2312	1760.54	60.70	76.11
		VM	2260	1697.09	58.52	75.03
		VM X EL	2254	1699.41	58.60	75.27
		VM X EH	2351	1784.12	61.52	75.81
	VM X B	Control	2237	1681.50	57.98	75.09
		BL	2277	1718.19	59.42	75.33
		BH	2334	1789.34	61.70	76.65
		VM	2243	1688.66	58.22	75.22
		VM X BL	2306	1746.32	60.21	75.63
		VM X BH	2316	1745.64	60.19	75.26
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 7. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on feed consumption (FC), mean feed consumption (MF), feed efficiency (FE) and feed consumption ratio of final body weight (PFC) of male broilers exposed to 37^{O} C age 18-48 d.

Treatments			FC (g)	MF (g)	FE (g:g)	PFC
Main effects#	VM	Control	19627	122	0.48	8.60
		VM	20497	128	0.46	8.97
	E	Control	19397^{a}	124	0.47	8.59^{a}
		EL	21298^{b}	123	0.48	8.39^{a}
		EH	19491^{a}	129	0.47	8.38^{b}
	B	Control	18317^{b}	125	0.46	8.19^{b}
		BL	20609^{a}	126	0.47	9.00^{ab}
		BH	21261^{a}	124	0.48	9.17^{a}
Interactions#	VM X E	Control	19203	125	0.46	8.52
		EL	20885	118	0.50	9.16
		EH	18792	124	0.48	8.11
		VM	19590	124	0.47	8.66
		VM X EL	21712	127	0.46	9.62
		VM X EH	20190	133	0.46	8.64
	VM X B	Control	18357	127	0.45	8.21
		BL	19789	119	0.49	8.69
		BH	20735	122	0.50	8.89
		VM	18277	123	0.47	8.16
		VM X BL	21428	134	0.45	9.31
		VM X BH	21786	127	0.47	9.45
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		*	n.s	n.s	*
B	2		**	n.s	n.s	*
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, *=p<0.05,**=p<0.005,a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 8 Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on water consumption (WC), daily water consumption (DW) and water feed ratio (WF) of male broilers exposed to 37^{O} C age 18-48 d

Treatments			WC (l)	DW (ml)	WF
Main effects#	VM	Control	392.88	274.69	2.35
		VM	401.11	294.05	2.28
	E	Control	381.50	293.04	2.51
		EL	424.00	266.64	2.23
		EH	385.50	293.43	2.21
	B	Control	390.50	317.66	2.71
		BL	422.00	283.35	2.25
		BH	378.50	252.10	1.99
Interactions#	VM X B	Control	433.66	328.49	n.e
		BL	379.50	252.82	n.e
		BH	365.50	242.76	n.e
		VM	347.33	306.82	n.e
		VM X BL	464.33	313.88	n.e
		VM X BH	391.50	261.44	n.e
ANOVA	DF	Significant			
VM	1		n.s	n.s	n.s
E	2		n.s	n.s	n.s
B	2		n.s	n.s	n.s
VM X B	2		n.s	n.s	n.e

n.e=not estimated, n.s=not significant, EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 9. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on fasted (12h) body weight (FW), specific gravity (SG), dry matter ratio of breast (DM), fat pad weight (FP) and fat percentage of final body weight (FR) of male broilers exposed to 37^{O} C age 49 d

Treatments			FW(g)	SG	DM	FP(g)	FR (g)
Main effects#	VM	Control	2247	1.049	24.20	37.44	1.63
		VM	2246	1.046	25.53	44.49	1.97
	E	Control	2216	1.048	25.99	42.28	1.89
		EL	2257	1.048	24.32	40.99	1.81
		EH	2266	1.047	24.28	39.09	1.70
	B	Control	2227	1.048	25.78	41.67	1.86^{ab}
		BL	2239	1.047	24.24	36.20	1.59^{b}
		BH	2273	1.048	24.58	44.51	1.95^{a}
Interactions#	VM X E	Control	2230	1.049	26.50	38.33	1.73
		EL	2281	1.047	23.19	40.99	1.79
		EH	2230	1.050	22.91	31.42	1.38
		VM	2202	1.047	25.49	45.73	2.05
		VM X EL	2232	1.048	25.45	40.98	1.84
		VM X EH	2303	1.045	25.66	46.76	2.20
	VM X B	Control	2242	1.048	26.40	42.87	1.90
		BL	2209	1.047	23.16	30.80	1.37
		BH	2290	1.051	23.03	37.57	1.62
		VM	221	1.048	25.15	40.40	1.81
		VM X BL	2269	1.046	25.32	41.61	1.81
		VM X BH	2257	1.045	26.13	51.46	2.29
ANOVA	DF	Significant					
VM	1		n.s	n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s	*
VM X EL	2		n.s	n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s	n.s

n.s=not significant, a-b means with in a major heading with unlike super script differ ($p<0.05$), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 10. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on breast weight (BR), breast weight percentage of final body weight (BP), hot weight (HW), chill weight (CW), chill weight percentage of final body weight (CP), liver weight (LW) and liver weight percentage of final body weight (LP) male broilers exposed to 37° C age 49 d.

Treatments			BR(g)	BP	HW(g)	CW(g)	CP	LW(g)	LP
Main effects#	VM	Control	389.88	17.44	1694	1751	77.91	37.51	1.67
		VM	389.92	17.35	1706	1760	78.31	37.48	1.67
	E	Control	378.29	17.12	1669	1722	77.71	34.84	1.57
		EL	384.70	17.09	1714	1772	78.56	39.00	1.73
		EH	406.72	17.97	1718	1771	78.19	38.64	1.71
	B	Control	376.22	16.87	1678	1732	77.78	34.45[b]	1.55[b]
		BL	397.03	17.75	1703	1757	78.53	39.19[a]	1.75[a]
		BH	396.46	17.54	1720	1776	78.15	38.84[a]	1.70[a b]
Interactions#	VM X E	Control	386.54	17.42	1675	1728	77.47	34.43	1.54
		EL	381.88	16.83	1721	1782	78.16	38.83	1.70
		EH	401.22	18.08	1687	1741	78.11	39.27	1.76
		VM	370.03	16.82	1663	1716	77.95	35.26	1.59
		VM X EL	387.52	17.36	1707	1762	78.96	39.16	1.76
		VM X EH	412.22	17.86	1749	1801	78.27	38.01	1.65
	VM X B	Control	372.82	16.62	1684	1741	77.63	35.19	1.57
		BL	396.26	17.94	1664	1721	77.90	38.26	1.74
		BH	400.56	17.76	1734	1790	78.21	39.08	1.70
		VM	379.62	17.16	1671	1723	77.94	33.70	1.52
		VM X BL	397.79	17.55	1741	1794	79.17	40.38	1.77
		VM X BH	392.35	17.33	1707	1762	78.08	38.6	1.71
ANOVA	DF	Significant							
VM	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s	n.s	*	*
VM X EL	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant,*=p<0.05,a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 11. Effects of electrolyte (E), virginiamycin (VM) and betaine (E) on dressing wastage (VS), dressing wastage percentage of final body weight (VP), dressing percentage (DP), water absorption CW-HW (WA), water absorption percentage of final body weight (WP), total yield (TY) and survivability ratio (SR) of male broilers exposed to 37^{O} C age 49 d.

Treatments			VS(g)	VP	DP	WA(g)	WP	TY(g)	SR
Main effects*	VM	Control	552.87	24.55	0.77	56.33	2.51	76969	0.98
		VM	539.10	23.98	0.78	53.22	2.37	78380	0.98
	E	Control	547.09	24.68	0.77	53.21	2.40	74502^{b}	0.98
		EL	542.78	24.00	0.78	58.09	2.57	83862^{a}	0.99
		EH	548.09	24.17	0.78	53.03	2.36	74569^{b}	0.97
	B	Control	548.89	24.65	0.77	54.06	2.41	70725^{b}	0.99
		BL	536.23	23.90	0.78	54.65	2.44	78997^{ab}	0.97
		BH	552.83	24.30	0.78	55.62	2.46	83302^{a}	0.97
Interactions#	VM X E	Control	555.33	24.95	0.77	53.45	2.39	73849	0.98
		EL	560.70	24.53	0.78	61.70	2.70	84188	1.00
		EH	542.58	24.33	0.78	53.83	2.44	72870	0.96
		VM	538.85	24.44	0.77	52.97	2.40	75154	0.97
		VM X EL	524.85	23.48	0.78	54.47	2.44	83537	0.99
		VM X EH	553.60	24.01	0.78	52.29	2.28	76449	0.98
	VM X B	Control	557.91	24.89	0.77	56.37	2.53	70684	1.00
		BL	544.41	24.64	0.77	56.50	2.54	77574	0.97
		BH	556.29	24.24	0.78	56.12	2.46	82649	0.98
		VM	539.87	24.40	0.77	51.75	2.34	70766	0.98
		VM X BL	528.06	23.16	0.79	52.18	2.33	80420	0.98
		VM X BH	549.37	24.37	0.78	55.12	2.45	83954	0.97
ANOVA	DF	Significan							
VM	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s	n.s	*	n.s
B	2		n.s	n.s	n.s	n.s	n.s	*	n.s
VM X EL	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant, *=p<0.05,a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 12. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on average hematocrit (AH), body temperature age 36 (BT36), age 46 (BT46) and average body temperature (ABT) of male broilers exposed to 37° C.

Treatments			AH	BT36 °C	BT46 °C	ABT °C
Main effects#	VM	Control	31.50	42.67 [b]	42.68	42.67
		VM	31.97	42.89 [a]	42.66	42.78
	E	Control	31.38	42.67[b]	42.72	42.69
		EL	32.16	42.79	42.65	42.72
		EH	31.65	42.86	42.65	42.75
	B	Control	31.56	42.83	42.78	42.80
		BL	31.65	42.78	42.53	42.65
		BH	31.99	42.71	42.70	42.71
Interactions#	VM X E	Control	31.67	42.59	42.70	42.65
		EL	31.83	42.68	42.70	42.69
		EH	31.05	42.69	42.63	42.66
		VM	31.10	42.74	42.73	42.73
		VM X EL	32.50	42.91	42.59	42.75
		VM X EH	32.30	43.03	42.66	42.85
	VM X B	Control	31.68	42.77	42.81	42.79
		BL	31.15	42.66	42.62	42.64
		BH	31.68	42.52	42.61	42.56
		VM	31.45	42.89	42.74	42.81
		VM X BL	32.15	42.89	42.44	42.67
		VM X BH	32.30	42.90	42.80	42.85
ANOVA	DF	Significant				
VM	1		n.s	*	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant,*=p<0.05,a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 13. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on CL, Mg, TR, UR, TP, Ca, PHO, Na, AB and K of male broilers exposed to 37^{O} C age 49 d.

Treatments			CL	Mg	TR	UR	TP	Ca	Phos	Na	AB	K
Main effects#	VM	Control	121.27	1.82	44.50	3.64	3.68	8.59	6.23	153.83^{b}	1.25	5.63
		VM	122.93	1.75	46.39	3.51	3.76	8.35	6.14	156.81^{a}	1.30	5.78
	E	Control	120.93^{b}	1.72	41.23^{b}	3.03^{b}	3.55	8.46	6.08	153.40^{b}	1.23	5.53
		EL	125.03^{a}	1.81	49.53^{a}	3.99^{a}	3.78	8.61	6.30	158.18^{a}	1.31	5.70
		EH	120.34^{b}	1.81	45.58^{ab}	3.71^{a}	3.83	8.35	6.18	154.37^{ab}	1.29	5.88
	B	Control	119.76^{b}	1.71^{b}	43.58^{b}	3.21	3.55	8.13	5.95	152.16^{b}	1.22	5.68
		BL	122.29^{ab}	1.85^{a}	44.40^{ab}	3.93	3.83	8.96	6.30	157.54^{a}	1.33	5.59
		BH	124.26^{a}	1.79^{b}	48.36^{a}	3.59	3.78	8.33	6.31	156.26^{ab}	1.29	5.85
Interactions#	VM X E	Control	121.29	1.74	41.45	2.93	3.50	8.36	6.17	153.06	1.22	5.82
		EL	125.10	1.87	49.98	3.81	3.82	8.75	6.27	155.25	1.25	5.48
		EH	117.41	1.84	42.08	4.17	3.71	8.67	6.26	153.18	1.27	5.60
		VM	120.58	1.71	41.08	3.12	3.60	8.56	5.99	153.75	1.23	5.25
		VM X EL	124.95	1.76	41.02	4.16	3.75	8.46	6.33	161.12	1.36	5.93
		VM X EH	123.27	1.78	49.08	3.25	3.95	8.04	6.10	155.56	1.32	6.16
	VM X B	Control	118.29	1.71	49.08	3.46	3.41	8.12	5.90	149.95	1.17	5.64
		BL	121.66	1.89	41.83	4.15	3.89	9.35	6.32	156.08	1.31	5.44
		BH	123.85	1.85	45.61	3.31	3.72	8.31	6.48	155.45	1.27	5.82
		VM	121.22	1.72	46.67	2.95	3.70	8.15	6.00	154.37	1.26	5.71
		VM X BL	122.91	1.80	45.93	3.72	3.76	8.57	6.29	159.00	1.34	5.75
		VM X BH	124.66	1.72	43.18	3.87	3.84	8.34	6.13	157.06	1.30	5.88
ANOVA	DF	Significant										
VM	1		n.s	n.s	n.s	n.s	n.s	n.s	n.s	*	n.s	n.s
E	2		*	n.s	*	*	n.s	n.s	n.s	*	n.s	n.s
B	2		*	*	n.s	n.s	n.s	n.s	n.s	*	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant,*=p<0.05,a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1),CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphorus (mg dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 14. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on Survivability of male broilers exposed to 37° C age 18-49 d.

Treatments			Survivability (%)
Main effects#	VM	Control	91
		VM	92
	E	Control	90[b]
		EL	99[a]
		EH	87[b]
	B	Control	84[b]
		BL	93[b]
		BH	97[a]
Interactions#	VM X E	Control	88
		EL	99
		EH	86
		VM	91
		VM X EL	98
		VM X EH	88
	VM X B	Control	84
		BL	94
		BH	96
		VM	85
		VM X BL	93
		VM X BH	99
ANOVA	DF	Significant	
VM	1		n.s
E	2		*
B	2		*
VM X EL	2		n.s
VM X B	2		n.s

n.s=not significant, *=p<0.05, a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 15 Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on SD(%), BMC(g), BMCP(%), FA(g), FAP (%), LN(g), LNP(%), BFL(g), BMD, LBM(g), of male broilers exposed to 37^{O} age 33, 37, 41,and 46 d.

Treatments			SD	BMC	BMCP	FA	LN	LNP	BFL	BMD	FAP	LBM
Main effects[a]	VM	Control	30.69	25.68	1.51	181.67	1536.66^{a}	88.12	1742.23	0.15	10.87	1562^{a}
		VM	33.75	24.32	1.61	245.85	1259.25^{b}	90.42	1529.51	0.14	14.99	1283^{b}
	E	Control	32.43	26.04^{a}	1.59	234.69^{a}	1412.08	89.63	1672.18	0.15^{a}	13.98	1438
		EL	31.89	25.21^{ab}	1.57	209.36^{ab}	1400.64	83.72	1634.71	0.15^{ab}	12.57	1426
		EH	32.35	23.75^{b}	1.51	197.22^{b}	1381.15	84.56	1600.72	0.14^{b}	12.24	1404
	B	Control	32.86	26.22^{a}	1.57	242.55^{a}	1431.80	85.61	1700.43	0.15	14.26^{a}	1457
		BL	31.44	24.13^{b}	1.54	193.91^{b}	1389.45	87.86	1605.24	0.14	11.91^{b}	1414
		BH	32.40	24.64^{ab}	1.56	204.82^{b}	1372.62	90.70	1601.94	0.14	12.62^{ab}	1397
	Age (d)	33	31.94^{c}	18.81^{c}	1.64	181.45^{cd}	943.62^{d}	89.64^{ab}	1142.02^{d}	0.13^{c}	14.15^{ab}	961^{d}
		37	29.66^{c}	24.03^{b}	1.51	182.50^{c}	1432.80^{c}	83.79^{ba}	1638.46^{c}	0.15^{bc}	11.86^{a}	1456^{c}
		41	33.82^{a}	26.81^{ab}	1.62	276.11^{a}	1366.48^{bc}	85.62^{b}	1669.61^{bc}	0.14^{ab}	15.56^{a}	1393^{bc}
		46	33.47^{b}	30.35^{a}	1.46	214.97^{ab}	1848.92^{a}	84.48^{a}	2093.39^{a}	0.16^{a}	10.15^{b}	1879a

Table 15.ffects of electrolyte (E), virginiamycin (VM) and betaine (B) on SD(%), BMC(g), BMCP(%), FA(g), FAP (%), LN(g), LNP(%), BFL(g), BMD, LBM(g), LBMP(%) of male broilers exposed to 37^{O} C (continue).

Treatments			SD	BMC	BMCP	FA	LN	LNP	BFL	BMD	FAP	LBM
Interactions #	VM X E	Control	30.62	26.81	1.54	207.00	1558.54	89.39	1791.08	0.15	12.08	1586
		EL	30.36	25.60	1.53	169.06	1528.01	84.63	1721.52	0.15	10.21	1554
		EH	31.05	24.63	1.46	168.97	1523.44	85.91	1714.52	0.15	10.33	1546
		VM	34.19	25.27	1.64	262.39	1265.61	87.49	1553.29	0.14	15.88	1290
		VM X EL	33.41	24.82	1.61	249.67	1273.27	87.62	1547.90	0.14	14.92	1298
		VM X EH	33.65	22.86	1.56	225.48	1238.86	85.80	1487.35	0.13	14.15	1261
	VM X B	Control	31.69	26.73	1.50	214.35	1568.66	88.16	1809.42	0.15	12.42	1595
		BL	29.41	25.19	1.50	166.51	1542.08	87.06	1729.15	0.15	9.94	1568
		BH	30.98	25.11	1.52	164.16	1499.25	87.06	1688.13	0.15	10.27	1523
		VM	34.03	25.71	1.63	270.76	1294.94	85.88	1591.44	0.14	16.09	1320
		VM X BL	33.41	23.07	1.58	221.30	1236.81	88.68	1481.34	0.14	13.88	1259
		VM X BH	33.82	24.17	1.60	245.48	1245.99	83.86	1515.76	0.14	14.98	1270
ANOVA	DF	Significant										
VM	1		n.s	n.s	n.s	n.s	*	*	n.s	n.s	n.s	*
E	2		n.s	*	n.s	*	n.s	n.s	n.s	*	n.s	n.s
B	2			*	n.s	**	n.s	*	n.s	n.s	*	n.s
Age	3		***	***	n.s	***	***	*	***	***	**	***
VM X EL	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s=not significant,*=p<0.05,**=p<0.005,***=P<0.0005, a-c Means with different superscript within a major heading differ(p<0.05), n.s=not significant., sd(%)=dry matter percentage of body weight, bmc(g)=bone mass, bmcp(%)=bone mass percentage of body weight,, fa(g)=fat, fap (%)=fat percentage of body weight, ln(g)=lean, lnp(%)=lean percentage of body weight, bfl(g)=bone mass fat and lean, bmd=bone density, lbm(g)=lean and bone mass, lbmp(%)=lean and bone mass percentage of body weight., #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 16 Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on 36 h fasted body temperature (FBT)of male broilers exposed to 37^{O} age 33, 37, 41,and 46 d

Treatments			FBT
Main effects[#]	VM	Control	40.86
		VM	40.96
	E	Control	40.75
		EL	40.95
		EH	41.06
	B	Control	40.61[b]
		BL	41.08[a]
		BH	41.06[a]
	Age (d)	33	40.83
		37	40.82
		41	41.11
		46	40.91
Interactions[#]	VM X E	Control	40.63
		EL	40.95
		EH	41.03
		VM	40.86
		VM X EL	40.95
		VM X EH	41.08
	VM X B	Control	40.55
		BL	40.95
		BH	41.11
		VM	40.67
		VM X BL	41.20
		VM X BH	41.01
ANOVA	DF	Significant	
VM	1		n.s
E	2		n.s
B	2		**
Age	3		n.s
VM X EL	2		n.s
VM X B	2		n.s

*=p<0.05, a-b Means with different superscript with in a major heading differ(p<0.05), n.s=not significant , [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 17. Correlation between Na, K, CL, Ca, Phos, Mg, TP, TR, AB, UR, AVH and BT36, BT46 and ABT of male broilers exposed to 37^{O}C age 49 d.

	Na	K	CL	Ca	Phos	Mg	TP	TR	AB	UR	AVH
BT36	-0.14	-0.09	-0.14	-0.05	-0.20*	-0.14	-0.10	-0.09	-0.08	0.29	-0.23*
BT46	-0.15	0.02	0.04	-0.09*	-0.28**	-0.12	-0.12	-0.13	-0.11	-0.06	-0.24*
ABT	-0.17	-0.02	-0.04	-0.16	-0.29**	-0.15	-0.13	-0.13	-0.12	-0.03	-0.28*

*=P<0.05,**=P<0.005,CL=chloride , Mg=magnesium , TR=Triglyceride, UR=uric acid, TP=total protein, Ca=calcium , PHO=phosphorus, Na= sodium, AB = albumin, K=potassium,

Table 18. Correlation between BW, WG, DG, PG, MF, PF, FE, WC, DW, WF, SU, DWT and Na, K, CL, Ca, Phos, Mg, TP, TR, AB, UR, AVH and BT36, BT46 and ABT of male broilers exposed to 37^{O}C age 49 d.

	BW	WG	DG	PG	MF	PF	FE	WC	DW	WF	SU	DWT
Na	-0.12	-0.12	-0.12	-0.12	0.02	0.12	-0.15	0.40	-0.32	-0.22	0.03	0.11
K	-0.08	-0.07	-0.07	-0.04	-0.08	-0.18	0.02	0.22	0.01	0.01	-0.12	-0.39**
CL	-0.20*	-0.20*	-0.21*	-0.18	-0.05	0.15	-0.09	0.19	-0.44	-0.29	0.08	-0.02
Ca	0.05	0.03	0.03	-0.02	0.01	0.22*	0.00	-0.03	0.00	0.08	0.17	0.29
Phos	0.07	0.10	0.10	0.15	-0.22*	0.25*	0.25*	-0.24	-0.44	-0.39	0.33**	0.08
Mg	0.00	0.02	0.02	0.04	-0.18	0.07	0.17	-0.03	-0.14	-0.22	0.13	-0.10
TP	0.00	-0.12	-0.01	-0.06	-0.05	0.19	0.016	0.09	0.23	0.08	0.13	0.09
TR	-0.07	-0.07	-0.07	-0.08	-0.14	-0.02	0.06	0.29	0.28	0.21	0.01	-0.20
AB	-0.00	-0.01	-0.01	-0.05	-0.05	0.19*	0.02	-0.17	-0.21	-0.34	0.14	0.07
UR	0.07	0.05	0.05	-0.00	0.00	-0.04	0.02	0.25	0.50	0.52	-0.01	0.00
AVH	0.05	0.07	0.07	0.09	-0.08	0.33**	0.10	0.36	0.27	0.32	0.30**	0.16
BT36	0.00	0.03	0.03	0.10	0.07	-0.22*	-0.38	-0.37	0.19	0.30	-0.22*	-0.08
BT46	-0.22*	-0.22*	-0.22*	-0.19	-0.16	-0.16	-0.00	-0.14	-0.05	-0.04	-0.11	-0.22
ABT	-0.14	-0.13	-0.13	-0.07	-0.07	-0.22*	-0.25	-0.28	0.07	0.20	-0.18	-0.19

*=P<0.05,**=P<0.005,CL= chloride , Mg=magnésium , TR=Triglyceride, UR=uric acid, TP=total protein, Ca=calcium , PHO=phosphorus, Na= sodium, AB=albumine, K=potassium,Bw=body weight , WG= weight gain, DG= daily gain, MF= mean feed consumption, FE= feed efficiency, WC= water consumption, DW=daily water, WF=water feed ratio, SU= survivability, DWT=dead weight, .

Table 19. Correlation between FW, LW, LP, HW, CW, CP, WW, BR, BP, FP, FR, DM and Na, K, CL, Ca, Phos, Mg, TP, TR, AB, UR, AVH and BT36, BT46 and ABT of male broilers exposed to 37^{O}C age 49 d.

	FW	LW	LP	HW	CW	CP	WW	BR	BP	FP	FR	DM
Na	-0.04	0.09	0.12	-0.00	-0.02	0.03	0.01	-0.23	0.02	-0.01	-0.00	-0.28**
K	-0.08	0.02	0.05	-0.09	-0.06	0.03	-0.10	-0.01	0.07	-0.07	-0.05	0.04
CL	-0.04	0.03	0.05	-0.00	0.00	0.13	-0.08	0.02	0.10	0.00	0.01	-0.28*
Ca	0.15	0.12	0.08	0.16	0.14	-0.0	0.08	018	0.07	0.04	0.00	-0.10
Phos	0.10	0.18	0.13	0.14	0.15	0.11	0.11	0.29**	0.26*	-0.06	-0.09	-0.04
Mg	0.05	0.26*	0.26*	0.06	0.06	0.02	0.06	0.24*	0.27*	-0.02	-0.03	-0.13
TP	0.18	0.30**	0.23*	0.20*	0.20*	0.07	-0.04	0.15	0.05	0.20*	0.18	-0.03
TR	-0.00	0.14	0.14	0.01	0.02	0.07	0.00	0.05	0.07	-0.04	-0.03	0.11
AB	0.15	0.15	0.09	0.20*	0.20*	0.14	-0.00	0.10	0.02	0.15	0.13	-0.01
UR	0.09	0.28*	0.27*	0.05	0.05	-0.12	0.00	0.02	-0.07	0.02	0.00	-0.05
AHC	0.04	0.21*	0.20*	0.02	0.00	-0.1	0.07	0.01	-0.01	-0.02	-0.02	0.04
BT36	0.10	-0.04	-0.09	014	0.15	0.16	-0.11	0.02	-0.08	0.17	0.16	0.05
BT46	-0.13	-0.20*	-0.15	-0.10	-0.06	0.15	-0.31**	-0.17	-0.09	0.07	0.10	0.04
ABT	-0.04	-0.16	-0.15	-0.00	0.03	0.18	-0.27*	-0.10	-0.10	0.13	0.15	0.05

*=P<0.05,**=P<0.005,CL=chloride , Mg=magnesium , TR=Triglyceride, UR=uric acid, TP=total protein, Ca=calcium , PHO=phosphorus, Na= sodium, AB=albumin, BT36=body temperature age 36d, BT46= body temperature age 41 d, ABT= average body temperature.

Table 20. Correlation between SG, DP, TY, VS, VP, WA, WP, SR and Na, K, CL, Ca, Phos, Mg, TP, TR, AB, UR, AVH and BT36, BT46 and ABT of male broilers exposed to 37^{O}C age 49 d.

	SG	DP	TY	VS	VP	WA	WP	SR
Na	0.04	0.03	0.01	-0.10	-0.10	-0.21*	-0.20*	0.05
K	-0.07	0.03	-0.14	-0.03	0.02	0.19	0.21*	-0.02
CL	-0.08	0.13	0.07	-0.11	-0.11	0.08	0.07	0.11
Ca	0.00	-0.00	0.20	0.05	-0.04	-0.15	-0.19	0.12
Phos	0.03	0.11	0.34	-0.03	-0.12	0.03	-0.00	0.04
Mg	0.04	0.02	0.12	-0.00	-0.04	-0.04	-0.06	0.05
TP	-0.17	0.07	0.18	0.04	-0.10	-0.01	-0.07	0.20
TR	-0.00	0.07	0.02	-0.06	-0.07	0.01	0.01	0.06
AB	-0.13	0.14	0.19	-0.02	-0.16	0.01	-0.02	0.17
UR	-0.02	-0.12	0.01	0.13	0.10	-0.05	-0.07	0.04
AVH	0.06	-0.10	0.26*	0.08	0.06	-0.12	-0.12	-0.00
BT36	-0.23*	0.16	-0.14	-0.03	-0.13	0.13	0.11	0.10
BT46	-0.30**	0.15	-0.12	-0.13	-0.05	0.31**	0.35**	0.03
ABT	-0.32**	0.18	-0.15	-0.11	-0.10	0.28*	0.29**	0.07

*=P<0.05,**=P<0.005,CL=chloride , Mg=magnesium , TR=Triglyceride, UR=uric acid, TP=total protein, Ca=calcium , PHO=phosphorus, Na= sodium, AB=albumin, K=potassium, specific gravity (SG), BT36=body temperature age 36d, BT46= body temperature age 41 d, ABT= average body temperature, DP=dressing percentage, TY=total yield, VS= dressing wastage, VP= vs percentage of body weight, WA=water absorb, WP=water absorb percentage of body weight.

Table 21. Correlation between SD, BMC, FA, FAP, LN, LNP, BFL, BMD, LBM, LBMP, FBT and Na, K, CL, Ca, Phos, Mg, TP, TR, AB, UR, AVH and BT36, BT46 and ABT of male broilers exposed to 37^{O}C age 49 d.

	SD	BMC	FA	FAP	LN	LNP	BFL	BMD	LBM	LBMP	FBT
Na	-0.31**	-0.03	0.01	0.04	-0.03	-0.07	-0.02	-0.10	-0.03	-0.06	0.10
K	-0.39***	-0.17	-0.12	0.03	-0.21	-0.05	-0.21*	0.17	-0.21*	-0.03	0.16
CL	-0.24*	-0.08	0.02	0.13	*0.12	-0.13	-0.10	-0.17	-0.12	-0.12	0.17
Ca	0.21	0.26*	0.23*	0.01	0.32**	0.07	0.32**	0.17	0.32**	0.06	0.05
Phos	0.16	0.26*	0.22*	0.03	0.25*	0.05	0.26*	0.08	0.25*	0.05	0.10
Mg	-0.11	0.14	0.10	0.03	0.13	0.03	0.13	0.12	0.13	0.05	0.10
TP	-0.26*	0.08	0.05	0.00	0.10	0.03	0.09	-0.02	0.10	0.04	0.17
TR	-0.37**	-0.09	-0.03	0.08	-0.14	-0.08	-0.13	-0.11	-0.14	-0.06	0.13
AB	-0.33**	-0.03	0.00	0.05	-0.05	-0.06	-0.04	-0.14	-0.04	-0.05	012
UR	-0.03	-0.05	0.09	0.18	-0.04	-0.12	-0.02	-0.08	-0.04	-0.12	-0.13
AVH	-0.04	0.10	0.01	-0.00	0.07	0.00	0.06	0.04	0.07	0.01	-0.12
BT36	0.07	-0.04	0.17	0.30**	-0.10	-0.02*	-0.05	-0.06	-0.09	-0.23*	0.03
BT46	0.04	-0.01	0.02	0.01	0.03	0.07	0.03	-0.06	0.03	0.08	0.05
ABT	0.06	-0.02	0.09	0.15	-0.02	-0.07	-0.00	-0.07	-0.02	-0.06	0.04

*=P<0.05,**=P<0.005,CL=chloride , Mg=magnesium , TR=Triglyceride, UR=uric acid, TP=total protein, Ca=calcium , PHO=phosphorus, Na= sodium,AB=albumin, K=potassium , sd(%)=dry matter percentage of body weight, bmc(g)=bone mass, bmcp(%)=bone mass percentage of body weight,, fa(g)=fat, fap (%)=fat percentage of body weight, ln(g)=lean, lnp(%)=lean percentage of body weight, bfl(g)=bone mass fat and lean, bmd=bone density, lbm(g)=lean and bone mass, lbmp(%)=lean and bone mass percentage of body weight., Fbt=36 hr fasted body,

Table 22. Correlation between SD, BMC, FA, FAP, LN, LNP, BFL, BMD, LBM, LBMP, FBT and BW, WG, DG, PG, FC, WC, SU, FBT of male broilers exposed to 37^{O}C age 49 d.

	SD	BMC	FA	FAP	LN	LNP	BFL	BMD	LBM	LBMP	FBT
BW	0.004	-0.05	-0.13	-0.17	-0.03	0.15	-0.05	-0.13	-0.03	0.15	-0.05
WG	0.01	-0.04	-0.12	-0.16	-0.02	0.14	-0.04	-0.11	-0.02	0.14	-0.07
DG	0.01	-0.04	-0.12	-0.16	-0.02	0.14	-0.04	-0.11	-0.02	0.14	-0.07
PG	0.07	.003	-0.07	-0.12	-0.00	0.10	-0.01	-0.02	-0.00	0.11	-0.11
FC	0.08	0.19	0.19	0.07	0.17	-0.08	0.18	0.19	0.17	-0.08	-0.07
WC	0.06	-0.02	-0.00	0.03	-0.05	0.08	-0.04	-0.07	-0.05	0.08	-0.50
SU	0.06	-0.00	0.09	0.16	-0.04	-0.19	-0.02	0.13	-0.04	-0.19	-0.02
FBT	0.11	0.03	0.00	-0.11	0.11	0.13	0.09	-0.03	0.11	0.13	0.09

*=P<0.05,**=P<0.005 , sd(%)=dry matter percentage of body weight, bmc(g)=bone mass, bmcp(%)=bone mass percentage of body weight,, fa(g)=fat, fap (%)=fat percentage of body weight, ln(g)=lean, lnp(%)=lean percentage of body weight, bfl(g)=bone mass fat and lean, bmd=bone density, lbm(g)=lean and bone mass, lbmp(%)=lean and bone mass percentage of body weight., Fbt=36 hr fasted body, Bw=body weight , WG= weight gain, DG= daily gain, MF= mean feed consumption, WC= water consumption, SU= survivability,.

Table 23. Correlation between SD, BMC, FA, FAP, LN, LNP, BFL, BMD, LBM, LBMP, FBT and HW, CW, CP, WW, FP, FR, DM, SG, DP, WA, WP, SR of male broilers exposed to 37^{O}C age 49 d.

	SD	BMC	FA	FAP	LN	LNP	BFL	BMD	LBM	LBMP	FBT
HW	-0.02	-0.06	-0.04	0.00	-0.05	0.00	-0.05	-0.19	-0.05	0.01	0.10
CW	-0.02	-0.07	-0.06	-0.01	-0.06	0.02	-0.06	-0.19	-0.06	0.03	0.10
CP	-0.06	-0.13	-0.14	-0.03	-0.12	0.01	-0.13	-0.11	-0.12	0.02	-0.01
WW	-0.10	-0.11	-0.08	-0.00	-0.08	0.00	-0.08	-0.26	-0.08	0.00	0.07
FP	0.10	-0.05	0.06	0.15	-0.06	-0.11	-0.03	-0.06	-0.06	-0.11	-0.20*
FR	0.11	-0.04	0.07	0.15	-0.06	-0.12	-0.04	-0.00	-0.06	-0.12	-0.26
DM	0.15	0.20	0.26*	0.15	0.18	-0.14	0.21*	0.13	0.18	-0.15	-0.17
SG	-0.11	-0.00	-0.06	0.00	-0.07	-0.02	-0.07	-0.20	-0.07	-0.02	0.03
DP	-0.06	-0.13	-0.14	-0.03	-0.12	0.01	-0.13	-0.11	-0.12	0.02	-0.01
WA	-0.02	-0.13	-0.17	-0.16	-0.03	0.16	-0.05	-0.05	-0.03	0166	0.02
WP	-0.02	-0.12	-0.16	-0.15	-0.02	0.15	-0.05	-0.01	-0.02	0.15	-0.01
SR	-0.03	0.03	0.14	0.19	0.02	-0.14	0.04	-0.05	0.02	-0.13	0.19

*=P<0.05,**=P<0.005, hot weight (HW), chill weight (CW), chill weight percentage of body weight (CWP), fat pad weight (FP), fat pad weight percentage of body weight (FR), liver weight (LW), liver weight percentage of body weight (LP), dry matter percentage of breast sample (DM), breast weight (BR), breast weight percentage of body weight (BP), and specific gravity (SG), dressing percentage (DP), water absorb (WA), percentage of water absorb (WAP), survivability ratio (SR),

Table 24. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL), high level (0.1 BH), and virginiamycin (VM) on compensatory gain of male broilers .

TRT		CG	TN
Main effects[#]	Control	104	70
	VM	110	79
	Control	100	56
	BL	101	90
	BH	118	76
	Control	89[b]	72[b]
	EL	168[a]	79[b]
	EH	62[b]	72[b]
HIS	Mean	107[a]	74[b]
ANOVA	DF	Sig	
VM X HIST	2	0.84	
B X HIST	4	0.78	
E X HIST	4	0.03	
HIST	1	0.02	
HIST	1	0.01	

[a-b], means with in a column and row with unlike superscripts differs ($p < 0.05$), His=history (37^0 C, 24^0 C).CG= compensatory birds pre-exposed to HS (37^0 C), TN= thermoneutral (24^0 C).
[#]=main effects values represent least square means averaged over treatment not listed with category.

Table 25. Effects of electrolyte (E) low-level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on body weight (BW40), body weight gain (WG 40), daily weight gain (DG40), percentage of weight gain (PG40) of compensatory (CG) and TN (TN) male broilers age 40 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
interacttios#		BW40	BW40	G40	G40	DG40	DG40	PG40	PG40
Class		2053	2027	1490	1453	67.73	66.07	72.70	71.47
E X Class	Control	2028	2063	1461	1496	66.45	68.03	71.87	72.32
	EL	2091	1993	1526	1418	69.33	64.45	73.25	70.93
	EH	2040	2025	1482	1445	67.40	65.71	72.96	71.15
VM X Class	Control	2017[ab]	1980[b]	1453[ab]	1396[b]	66.04[ab]	63.47[b]	72.04[ab]	70.28[b]
	VM	2088[a]	2075[a]	1527[a]	1510[a]	69.41[a]	68.67[a]	73.36[a]	72.65[a]
B X Class	Control	2044	2047	1470	1473	66.83	66.97	71.74	71.80
	BL	2015	2034	1460	1460	66.40	66.39	72.76	71.38
	BH	2100	2001	1538	1426	69.95	64.85	73.58	71.22
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		*		*		*		*
B X Class	4		n.s		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), means with in a column with unlike superscripts differs ($p < 0.05$), *=$p<0.05$, [a-c], means with in a row and under major heading with unlike superscripts differs ($p < 0.05$), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 26. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on body weight (BW48), body weight gain (WG 48), daily weight gain (DG48), percentage of weight gain (PG48) of compensatory (CG) and TN (TN) male broilers age 48 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
Interactions#		BW48	BW48	G48	G48	DG48	DG48	PG48	PG48
Class		2351	2341	1776	1769	61.25	61.02	75.45	75.49
E X Class	Control	2337	2408	1776	1844	61.27	63.06	75.98	76.38
	EL	2422	2261	1834	1687	63.26	58.17	75.68	74.57
	EH	2295	2353	1717	1777	59.22	61.29	74.48	75.52
VM X Class	Control	2317	2299	1746	1719	60.21	59.27	75.24	74.73
	VM	2386	2383	1806	1820	62.29	62.76	75.66	76.42
B X Class	Control	2366	2375	1798	1803	62.02	62.17	75.94	75.63
	BL	2324	2373	1749	1797	60.31	61.98	75.18	75.74
	BH	2364	2273	1781	1708	61.42	58.91	75.22	75.09
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 27. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on mean feed consumption (MF40), weight gain to feed ratio (FE40), and feed consumption ratio of body weight (PC40) compensatory (CG) and TN (TN) male broilers age 18-40 d

Treatments		CG	TN	CG	TN	CG	TN
Interactions#		MF40	MF40	FE40	FE40	PFC40	PFC40
Class		120.53	129.53	0.56	0.52	8.63	9.67
E X Class	Control	129.30	134.23	0.52	0.52	9.33	8.84
	EL	118.87	124.64	0.58	0.53	8.38	8.27
	EH	113.43	128.95	0.59	0.52	8.18	8.90
VM X Class	Control	117.19	126.54	0.56	0.52	8.58	8.802
	VM	123.87	132.00	0.57	0.53	8.68	8.55
B X Class	Control	123.13	124.51	0.55	0.54	9.03	8.63
	BL	119.48	135.33	0.56	0.52	8.62	8.29
	BH	118.99	127.97	0.59	0.51	8.23	9.10
ANOVA	DF	Sig					
Class	1		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN),
#=main effects values and /or interactions represent least square means averaged over treatment not listed with category

Table 28. . Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on mean feed consumption (MF48),
weight gain to feed ratio,(FE48), and feed consumption ratio of body weight (PC48) compensatory (CG) and TN (TN) male broilers age 18-48 d..

Treatments		CG	TN	CG	TN	CG	TN
Interactions#		MF48	MF48	FE48	FE48	PFC48	PFC48
Class		118.31	117.16	0.53	0.52	9.82[a]	9.17[b]
E X Class	Control	127.15	122.36	0.48	0.52	10.49	9.32
	EL	120.98	111.28	0.53	0.53	9.82	8.80
	EH	106.81	117.84	0.59	0.52	9.16	9.39
VM X Class	Control	113.19[b]	112.51[b]	0.55	0.53	9.57	9.17
	VM	123.44[a]	121.91[ab]	0.52	0.52	10.08	9.16
B X Class	Control	120.65	116.37	0.53	0.53	10.08	9.18
	BL	116.87	117.05	0.53	0.54	9.71	8.56
	BH	117.43	118.07	0.54	0.50	9.68	9.77
ANOVA	DF	Sig					
Class	1		n.s		n.s		*
E X Class	4		n.s		n.s		n.s
VM X Class	2		*		n.s		n.s
B X Class	4		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), *=p<0.05, [a-c], means with in a row and under major heading with unlike superscripts differs (p <0.05), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 29. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on survivability (SUR) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN
Interactions[#]		SUR	SUR
Class		96[a]	81[b]
E X Class	Control	95	89
	EL	97	88
	EH	96	91
VM X Class	Control	96	90
	VM	96	88
B X Class	Control	97	92
	BL	95	83
	BH	95	92
ANOVA	DF	Sig	
Class	1		*
E X Class	4		n.s
VM X Class	2		n.s
B X Class	4		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), *=p<0.05, [a-b], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 30. . Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on specific gravity (SG), dry matter (DM), fat pad weight (FP) and fad pad weight percentage of body weight (FR) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
Interactions[#]		SG	SG	DM	DM	FP	FP	FR	FR
Class		1.04	1.04	25.20	26.20	43.33	42.24	1.77	1.69
E X Class	Control	1.04	1.05	25.95	26.16	42.28	44.56	1.81	1.78
	EL	1.04	1.04	24.90	26.08	45.75	36.93	1.81	1.49
	EH	1.04	1.05	24.76	26.35	41.37	45.21	1.69	1.80
VM X Class	Control	1.04	1.04	25.51	26.48	41.29[ab]	37.63[b]	1.68	1.53
	VM	1.04	1.05	24.89	25.92	45.36 [ab]	46.85[a]	1.86	1.85
B X Class	Control	1.04	1.05	24.71	25.55	45.97	37.47	1.92	1.52
	BL	1.04	1.04	24.70	25.47	46.46	50.51	1.92	1.92
	BH	1.05	1.05	26.20	27.30	37.55	38.73	1.47	1.63
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		n.s		n.s		*		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), *=p<0.05, [a-b], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 31 Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on 12 h fasted body weight breast weight (BR),breast weight percentage of body weight (BP) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN
Interactions[#]		FW	FW	BR	BR	BP	BP
Class		2431	2460	432.21[b]	452.55[a]	17.79	18.21
E X Class	Control	2362	2468	406.38	438.09	17.16	17.72
	EL	2509	2398	447.47	459.17	17.89	18.61
	EH	2421	2514	442.79	460.38	18.33	18.32
VM X Class	Control	2428	2427	431.32	451.82	17.75	18.52
	VM	2433	2493	433.10	453.28	17.84	17.91
B X Class	Control	2387	2418	411.53[b]	433.00[b]	17.21	17.71
	BL	2396	2617	426.14[b]	500.47[a]	17.83	19.03
	BH	2508	2345	458.98[a]	424.18[b]	18.37	17.91
ANOVA	DF	Sig					
Class	1		n.s		*		n.s
E X Class	4		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s
B X Class	4		n.s		**		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), **=p<0.05, **=P<0.005, [a-b], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 32 Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on),on hot weight (HW), chill weight (CW) and chill weight (CP), liver weight (LW), of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
Interactions[#]		HW	HW	CW	CW	CP	CP	LW	LW
Class		1833	1856	1889	1905	77.71	77.57	42.25	43.96
E X Class	Control	1761	1856	1808	1912	76.50	77.55	40.96	43.60
	EL	1916	1806	1979	1855	79.02	77.47	41.09	44.42
	EH	1821	1904	1878	1949	77.61	77.70	45.07	43.86
VM X Class	Control	1834	1839	1889	1887	77.79	77.94	42.08	44.20
	VM	1832	1874	1888	1924	77.64	77.21	42.42	43.72
B X Class	Control	1775[b]	1796[b]	1830	1851	76.61	76.53	40.84	41.03
	BL	1817[ab]	1980[a]	1876	2026	78.35	77.44	44.04	46.85
	BH	1907[ab]	1793[b]	1959	1839	78.18	78.75	41.87	44.00
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s		n.s
B X Class	4		*		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), *=p<0.05, [a-c], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions
represent least square means averaged over treatment not listed with category.

Table 33. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on liver weight percentage of body weight (LP), dressing wastage (VS), dressing wastage percentage of body weight (VP) and dressing percentage of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
Interactions#		LP	LP	VS	VS	VP	VP	DP	DP
Class		1.74	1.80	597	603	24.57	24.23	77.71	77.57
E X Class	Control	1.72	1.77	600	609	25.47	24.59	76.50	77.55
	EL	1.64	1.87	592	591	23.48	24.62	79.02	77.47
	EH	1.87	1.76	600	609	24.77	24.08	77.61	77.70
VM X Class	Control	1.74	1.83	594	588	24.49	24.06	77.79	77.94
	VM	1.75	1.77	601	618	24.65	24.80	77.64	77.21
B X Class	Control	1.71	1.70	612	621	25.70	25.78	76.61	76.53
	BL	1.85	1.81	579	636	24.15	24.30	78.35	77.44
	BH	1.67	1.89	601	552	23.86	23.21	78.18	78.75
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), #=main effects values and/or interactions represent least square means averaged over treatment not listed with category.

Table 33. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on liver weight percentage of body weight (LP), dressing wastage (VS), dressing wastage percentage of body weight (VP) and dressing percentage of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
Interactions#		LP	LP	VS	VS	VP	VP	DP	DP
Class		1.74	1.80	597	603	24.57	24.23	77.71	77.57
E X Class	Control	1.72	1.77	600	609	25.47	24.59	76.50	77.55
	EL	1.64	1.87	592	591	23.48	24.62	79.02	77.47
	EH	1.87	1.76	600	609	24.77	24.08	77.61	77.70
VM X Class	Control	1.74	1.83	594	588	24.49	24.06	77.79	77.94
	VM	1.75	1.77	601	618	24.65	24.80	77.64	77.21
B X Class	Control	1.71	1.70	612	621	25.70	25.78	76.61	76.53
	BL	1.85	1.81	579	636	24.15	24.30	78.35	77.44
	BH	1.67	1.89	601	552	23.86	23.21	78.18	78.75
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), #=main effects values and/or interactions represent least square means averaged over treatment not listed with category.

Table 34. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on water absorb (WA), water absorb percentage of body weight (WP), total yield (TY) survivability ratio (SR) and dressing percentage (DP) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN
Interactions#		WA	WA	WP	WP	TY	TY
Class		55.70	49.18	2.29	2.01	101519	97614
E X Class	Control	46.75	52.68	1.98	2.14	96351	97459
	EL	62.75	49.43	2.50	2.09	107283	93484
	EH	57.62	45.43	2.38	1.78	100923	101898
VM X Class	Control	55.78	48.39	2.29	2.00	101428	98794
	VM	55.63	49.97	2.29	2.01	101610	96433
B X Class	Control	55.83	55.37	2.32	2.31	99906	96307
	BL	59.70	46.24	2.50	1.75	100129	100294
	BH	51.58	45.93	2.04	1.97	104523	96240
ANOVA	DF	Sig					
Class	1		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN),
#=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 35. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on body temperature age 36 (BT36) age 46 (BT46) and average body temperature (ABT) of compensatory (CG) and TN (TN) male broilers.

Treatments		CG	TN	CG	TN	CG	TN
Interactions#		BT36	BT36	BT46	BT46	ABT	ABT
Class		41.26	41.37	41.48	41.50	41.69	41.64
E X Class	Control	41.53^{b}	41.40^{c}	41.65	41.51	41.77	41.62
	EL	41.14^{a}	41.43^{b}	41.38	41.59	41.67	41.76
	EH	41.13^{a}	41.27^{bc}	41.40	41.41	41.68	41.55
VM X Class	Control	41.40^{a}	41.41^{a}	41.54	41.55	41.69	41.69
	VM	41.13^{b}	41.32^{ab}	41.41	41.46	41.69	41.59
B X Class	Control	41.44^{a}	41.42^{a}	41.61	41.55	41.78	41.68
	BL	41.27^{a} ^{b}	41.31^{ab}	41.53	41.51	41.80	41.70
	BH	41.09^{b}	41.37^{ab}	41.29	41.46	41.49	41.55
ANOVA	DF	Sig					
Class	1		n.s		n.s		n.s
E X Class	4		**		n.s		n.s
VM X Class	2		**		n.s		n.s
B X Class	4		*		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN),
=p<0.05,=P<0.005, $^{a-b}$, means with in a row and under major heading with unlike superscripts differs (p <0.05)
#=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 36. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on average hematocrit (AHC) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN
Interactions #		AHC	AHC
Class		35.57	36.19
E X Class	Control	34.66	35.61
	EL	35.80	36.85
	EH	36.24	36.11
VM X Class	Control	35.63	35.85
	VM	35.50	36.53
B X Class	Control	34.52	36.02
	BL	36.84	35.19
	BH	35.34	37.36
ANOVA	DF	Sig	
Class	1		n.s
E X Class	4		n.s
VM X Class	2		n.s
B X Class	4		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 36. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on average hematocrit (AHC) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN
Interactions #		AHC	AHC
Class		35.57	36.19
E X Class	Control	34.66	35.61
	EL	35.80	36.85
	EH	36.24	36.11
VM X Class	Control	35.63	35.85
	VM	35.50	36.53
B X Class	Control	34.52	36.02
	BL	36.84	35.19
	BH	35.34	37.36
ANOVA	DF	Sig	
Class	1		n.s
E X Class	4		n.s
VM X Class	2		n.s
B X Class	4		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 37. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on chloride (CL), magnesium (Mg), sodium (Na) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN
Interactions[#]		CL	CL	MG	MG	NA	NA
Class		120.27	118.12	1.83	1.84	153.08	151.28
E X Class	Control	120.68	118.89	1.84	1.84	155.20	152.42
	EL	119.50	117.76	1.79	1.85	150.27	151.11
	EH	120.68	117.70	1.86	1.82	153.77	150.30
VM X Class	Control	118.98^{ab}	116.07^{b}	1.89^{a}	1.88^{ab}	150.83^{bc}	149.10^{b}
	VM	121.56^{a}	120.17^{a}	1.77^{b}	1.80^{ab}	155.28^{a}	153.46^{ac}
B X Class	Control	120.33	119.54	1.83	1.88	154.75	154.29
	BL	120.40	117.22	1.85	1.80	152.81	149.82
	BH	120.08	117.60	1.82	1.83	151.68	149.72
ANOVA	DF	Sig					
Class	1		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s
VM X Class	2		*		*		*
B X Class	4		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), CL=chloride (mmol/l), Mg=magnesium (meq/l), Na= sodium (mmol/l), ***=p<0.05,***=P<0.0005, $^{a-b}$, means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 38. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on triglyceride (TR), uric acid (UR), total protein (TP), of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN
Interactions#		TR	TR	UR	UR	TP	TP
Class		39.44	40.61	2.55	2.65	4.07	3.94
E X Class	Control	42.75	39.75	2.29	2.53	3.89	4.13
	EL	33.94	44.52	2.31	2.65	3.86	3.99
	EH	41.62	37.75	3.05	2.78	4.46	3.69
VM X Class	Control	39.60	37.33	2.63	2.73	4.24	3.91
	VM	39.28	43.92	2.47	2.58	3.90	3.96
B X Class	Control	43.00	41.92	2.64	2.56	4.03	4.05
	BL	40.45	42.07	2.70	2.92	4.31	3.88
	BH	34.85	37.86	2.32	2.48	3.86	3.88
ANOVA	DF	Sig					
Class	1		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s
VM X Class	2		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 39. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on albumen (AB), phosphorus (PHO) and calcium (Ca) and potassium (k) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
Interactions[#]		AB	AB	PHO	PHO	Ca	Ca	K	K
Class		1.34	1.32	7.29	7.23	9.80	9.89	6.92	6.66
E X Class	Control	1.31	1.29	7.24	7.15	9.71	9.87	6.83	6.51
	EL	1.33	1.37	7.19	7.37	9.61	10.15	6.53	7.06
	EH	1.40	1.30	7.45	7.17	10.09	9.65	7.41	6.42
VM X Class	Control	1.33^{ab}	1.26^{b}	7.63^{a}	7.66^{a}	10.40^{a}	10.88^{a}	6.99	6.30
	VM	1.36^{a}	1.38^{b}	6.96^{b}	6.79^{b}	9.21^{a}	8.90^{b}	6.83	7.03
B X Class	Control	1.32	1.35	6.88	7.23	9.10	9.80	6.73	6.90
	BL	1.35	1.31	7.58	7.23	10.77	9.84	6.97	6.39
	BH	1.36	1.31	7.42	7.23	9.54	10.03	7.07	6.70
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		*		**		***		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), Ca=calcium (mg/dl), PHO= phosphate (mg/dl), AB=albumin (g/dl), K=potassium (mmol/l), *=p<0.05, **=p<0.005,***=P<0.0005[a-c], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 39. Effects of electrolyte (E) low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) on albumen (AB), phosphorus (PHO) and calcium (Ca) and potassium (k) of compensatory (CG) and TN (TN) male broilers age 49 d.

Treatments		CG	TN	CG	TN	CG	TN	CG	TN
Interactions[#]		AB	AB	PHO	PHO	Ca	Ca	K	K
Class		1.34	1.32	7.29	7.23	9.80	9.89	6.92	6.66
E X Class	Control	1.31	1.29	7.24	7.15	9.71	9.87	6.83	6.51
	EL	1.33	1.37	7.19	7.37	9.61	10.15	6.53	7.06
	EH	1.40	1.30	7.45	7.17	10.09	9.65	7.41	6.42
VM X Class	Control	1.33^{ab}	1.26^{b}	7.63^{a}	7.66^{a}	10.40^{a}	10.88^{a}	6.99	6.30
	VM	1.36^{a}	1.38^{b}	6.96^{b}	6.79^{b}	9.21^{a}	8.90^{b}	6.83	7.03
B X Class	Control	1.32	1.35	6.88	7.23	9.10	9.80	6.73	6.90
	BL	1.35	1.31	7.58	7.23	10.77	9.84	6.97	6.39
	BH	1.36	1.31	7.42	7.23	9.54	10.03	7.07	6.70
ANOVA	DF	Sig							
Class	1		n.s		n.s		n.s		n.s
E X Class	4		n.s		n.s		n.s		n.s
VM X Class	2		*		**		***		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), AB=albumin (g/dl), K=potassium (mmol/l), *=p<0.05, **=p<0.005,***=P<0.0005[a-c], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 40. Effects of electrolyte (E), low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) and class (TN=thermoneutral birds, CG=compensatory growth birds) on dry matter percentage (SD), bone mineral concentration (BMC), BMC percentage (BMCP) male broilers average age 33, 37, 41, and 46 d.

Treatment Interactions#		CG SD	TN SD	CG BMC	TN BMC	CG BMCP	TN BMCP
Class		34.97[a]	31.77[b]	32.45[a]	38.17[b]	1.57	1.59
E X Class	Control	34.14	32.14	30.78	29.22	1.58	1.58
	EL	35.82	31.82	32.17	27.54	1.56	1.62
	EH	34.94	31.35	34.40	27.74	1.58	1.58
VM X Class	Control	33.45[b]	31.30[b]	30.17[b]	28.33[b]	1.62[a]	1.60[ab]
	VM	36.48[a]	32.24[b]	34.73[a]	28.01[b]	1.52[b]	1.59[ab]
B X Class	Control	34.57	31.77	30.67[b]	29.61[b]	1.56	1.60
	BL	35.10	32.14	35.58[a]	27.34[b]	1.62	1.57
	BH	35.23	31.40	31.10[b]	27.55[b]	1.54	1.61
ANOVA	DF	Sig					
Class	1		***		*		n.s
E X Class	4		n.s		n.s		n.s
VM X Class	2		**		**		*
B X Class	4		n.s		*		n.s

n.s= not significant, DF=degree of freedom, Class=compensatory group(CG), TN birds(TN), *=p<0.05, **=p<0.005,***=P<0.0005[a-c], means with in a row and under major heading with unlike superscripts differs (p <0.05), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category

Table 41. Effects of electrolyte (E), low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) and class (TN=thermoneutral birds, CG=compensatory growth birds) on lean (LN), lean percentage (LNP) fat (FA), fat as a percentage of body weight (FR) of male broilers average of age 33, 37, 41, and 46 d.

Treatment		CG	TN	CG	TN	CG	TN	CG	TN
Interactions[#]		LN	LN	LP	LNP	FA	FA	FR	FR
Class		1749.88	1567.02	84.57[b]	88.32[a]	317.10[a]	210.23[b]	15.25[a]	11.27[b]
E X Class	Control	1672.06	1617.39	85.77	87.43	279.45[b]	237.74[c]	14.14	12.5
	EL	1753.61	1511.93	84.3	88.28	313.74[ab]	201.23[c]	15.18	11.77
	EH	1823.98	1571.74	83.60	89.25	358.75[a]	191.73[c]	16.4	10.87
VM X Class	Control	1558.78[b]	1563.61[b]	83.59	88.10	298.03	207.25	15.83	11.63
	VM	1940.99[a]	1570.43[b]	85.19	88.54	336.16	213.22	14.67	11.77
B X Class	Control	1683.53	1631.19	85.26	88.01	286.00	218.91	14.46	11.72
	BL	1830.78	1547.44	82.70	88.31	369.79	206.65	16.89	11.72
	BH	1735.34	1522.44	85.75	88.64	295.50	205.14	14.39	11.67
ANOVA	DF	Sig							
Class	1		n.s		***		***		***
E X Class	4		n.s		n.s		*		n.s
VM X Class	2		***		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s= not significant, DF=degree of freedom, Class=compensatory group(CG), TN birds(TN),*=p<0.05,***=P<0.0005[a-b], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 41. Effects of electrolyte (E), low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) and class (TN=thermoneutral birds, CG=compensatory growth birds) on lean (LN), lean percentage (LNP) fat (FA), fat as a percentage of body weight (FR) of male broilers average of age 33, 37, 41, and 46 d.

Treatment		CG	TN	CG	TN	CG	TN	CG	TN
Interactions[#]		LN	LN	LP	LNP	FA	FA	FR	FR
Class		1749.88	1567.02	84.57[b]	88.32[a]	317.10[a]	210.23[b]	15.25[a]	11.27[b]
E X Class	Control	1672.06	1617.39	85.77	87.43	279.45[b]	237.74[c]	14.14	12.5
	EL	1753.61	1511.93	84.3	88.28	313.74[ab]	201.23[c]	15.18	11.77
	EH	1823.98	1571.74	83.60	89.25	358.75[a]	191.73[c]	16.4	10.87
VM X Class	Control	1558.78[b]	1563.61[b]	83.59	88.10	298.03	207.25	15.83	11.63
	VM	1940.99[a]	1570.43[b]	85.19	88.54	336.16	213.22	14.67	11.77
B X Class	Control	1683.53	1631.19	85.26	88.01	286.00	218.91	14.46	11.72
	BL	1830.78	1547.44	82.70	88.31	369.79	206.65	16.89	11.72
	BH	1735.34	1522.44	85.75	88.64	295.50	205.14	14.39	11.67
ANOVA	DF	Sig							
Class	1		n.s		***		***		***
E X Class	4		n.s		n.s		*		n.s
VM X Class	2		***		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s		n.s

n.s= not significant, DF=degree of freedom, Class=compensatory group(CG), TN birds(TN),*=p<0.05,***=P<0.0005[a b], means with in a row and under major heading with unlike superscripts differs (p <0.05), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 42. Effects of electrolyte (E), low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) and class (TN=thermoneutral birds, CG=compensatory growth birds) on fat percentage (FP), bone density (BMD), LN+BMC (LBM), LBMC percentage (LBMP), BMC+ FA+LN (BMCFL) of male broilers average of age 33, 37, 41, and 46 d.

Treatment		CG	TN	CG	TN	CG	TN
Interactions#		FP	FP	BMD	BMD	LBM	LBM
Class		15.25[a]	11.70[b]	0.162	0.158	1782.34[a]	1592.16[b]
E X Class	Control	14.11	12.52	0.162	0.160	1702.85	1646.86
	EL	15.18	11.73	0.162	0.156	1785.79	1534.76
	EH	16.43	10.82	0.162	0.158	1858.37	1594.86
VM X Class	Control	15.83	11.63	0.159	0.157	1588.95[b]	1589.12[b]
	VM	14.67	11.77	0.165	0.159	1975.72[a]	1595.20[b]
B X Class	Control	14.46	11.72	0.162	0.162	1714.21	1662.55
	BL	16.89	11.72	0.166	0.156	1866.36	1571.73
	BH	14.39	11.67	0.158	0.156	1766.43	1542.21
ANOVA	DF	Sig					
Class	1		***		n.s		*
E X Class	4		n.s		n.s		***
VM X Class	2		n.s		n.s		n.s
B X Class	4		n.s		n.s		n.s

n.s= not significant, DF=degree of freedom, Class=compensatory group(CG), TN birds(TN),*p<0.05,***=P<0.0005 [a,b], means with in a row and under major heading with unlike superscripts differs (p <0.05), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 43. Effects of electrolyte (E), low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) and class (TN=thermoneutral birds, CG=compensatory growth birds) on LN+BMC (LBM), LBMC percentage (LBMP), BMC+ FA+LN (BMCFL) of male broilers average of age 37, 41, and 46 d

Treatment		CG	TN	CG	TN
Interactions#		LBMP	LBMP	BMCFL	BMCFL
Class		86.15[b]	89.73[a]	2099.33[a]	1805.13[a]
E X Class	Control	87.36	89.02	1982.20	1884.24
	EL	85.90	89.61	2098.73	1740.54
	EH	85.19	90.54	2217.06	1790.61
VM X Class	Control	85.58	89.53	1886.85[b]	1798.67[b]
	VM	86.72	89.92	2311.81[a]	1811.58[b]
B X Class	Control	86.83	89.72	2000.20	1879.41
	BL	84.32	89.71	2235.92	1781.18
	BH	87.30	89.75	2061.87	1754.80
ANOVA	DF	Sig			
Class	1		***		**
E X Class	4		n.s		n.s
VM X Class	2		n.s		***
B X Class	4		n.s		n.s

n.s= not significant, DF=degree of freedom, Class=compensatory group(CG), TN birds(TN),*=p<0.05,**=p<0.005,***=P<0.0005 [a-c], means with in a row and under major heading with unlike superscripts differs (p <0.05), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 44. Effects of electrolyte (E), low level (EL) high level (EH), betaine (B) low level (0.05, BL) high level (0.1 BH), and virginiamycin (VM) and class (TN=TN birds, CG=compensatory growth birds) on 36 h fasted body temperature of male broilers average of age 37, 41, and 46 d.

Treatment		CG	TN
Interactions#		FBT	FBT
Class		40.81	41.09
E X Class	Control	40.92	41.04
	EL	40.75	41.24
	EH	40.77	40.98
VM X Class	Control	40.77	41.08
	VM	40.85	41.10
B X Class	Control	40.87	40.98
	BL	40.77	41.16
	BH	40.79	41.12
ANOVA	DF	Sig	
Class	1	n.s	
E X Class	4	n.s	
VM X Class	2	n.s	
B X Class	4	n.s	

n.s= not significant, DF=degree of freedom, Class=compensatory group(CG), TN birds(TN), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 45. Compensatory gain of sd(%), bmc(g), bmcp(%), fa(g), fap (%), ln(g), lnp(%), bfl(g), bmd, lbm(g), lbmp(%) and ftem of male broilers age 37,41 and 46 d.

Treatments	CG	TN	CG	TN	CG	TN	Sig
	37	37	41	41	46	46	
Sd (%)	31.81^{e}	29.91^{d}	33.00^{b}	31.43^{b}	36.17^{a}	35.1^{ac}	***
Bmc (g)	22.6^{c}	25.09^{c}	28.82^{b}	29.22^{b}	33.79^{a}	33.52^{a}	***
Bmcp(%)	1.68^{abce}	1.62^{a}	1.62^{abf}	1.60^{acg}	1.51^{ce}	1.54^{de}	**
Fa(g)	190.80^{cd}	187.48^{c}	270.71^{bc}	221.15^{c}	312.50^{a}	271.93^{b}	***
Fap(%)	14.00^{acfgh}	11.87^{bh}	15.07^{ac}	11.98^{bg}	13.85^{acdg}	12.29^{befd}	**
Ln(g)	1149^{d}	1366^{d}	1502^{c}	1603^{b}	1915^{a}	1901^{a}	***
Lnp(%)	85.92^{cde}	88.55^{ac}	84.70^{bd}	87.63^{ac}	86.01^{bc}	87.55^{ac}	**
Bmd	0.159^{acde}	0.154^{be}	0.159^{be}	0.159^{bd}	0.166^{c}	0.171^{a}	***
Lbm(g)	1172.20^{c}	1392.00^{c}	1531.11^{b}	1632.29^{b}	1949.47^{a}	1934.97^{a}	***
Lbmp(%)	87.60^{ad}	90.17^{a}	86.33^{bd}	89.23^{ac}	87.53^{bcde}	89.10^{ae}	**
Bfl(g)	1363.10^{c}	1579.22^{c}	1801.71^{b}	1853.01^{b}	2261.93^{a}	2206.90^{a}	***
Ftem	42.26^{a}	41.01^{b}	40.84^{b}	41.03^{b}	40.86^{b}	41.05^{b}	***

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), **=p<0.005, ***=p<.0005, a-h Means with different superscript within a row under a major heading differ($p<0.05$), sd(%)=dry matter percentage of body weight, bmc(g)=bone mass, bmcp(%)=bone mass percentage of body weight,, fa(g)=fat, fap (%)=fat percentage of body weight, ln(g)=lean, lnp(%)=lean percentage of body weight, bfl(g)=bone mass fat and lean, bmd=bone density, lbm(g)=lean and bone mass, lbmp(%)=lean and bone mass percentage of body weight., Ftem=36 hr fasted body temperature

Table 45. Compensatory gain of sd(%), bmc(g), bmcp(%), fa(g), fap (%), ln(g), lnp(%), bfl(g), bmd, lbm(g), lbmp(%) and ftem of male broilers age 37,41 and 46 d.

Treatments	CG	TN	CG	TN	CG	TN	Sig
	37	37	41	41	46	46	
Sd (%)	31.81^{e}	29.91^{d}	33.00^{b}	31.43^{b}	36.17^{a}	35.1^{ac}	***
Bmc (g)	22.6^{c}	25.09^{c}	28.82^{b}	29.22^{b}	33.79^{a}	33.52^{a}	***
Bmcp(%)	1.68^{abce}	1.62^{a}	1.62^{abf}	1.60^{acg}	1.51^{ce}	1.54^{de}	**
Fa(g)	190.80^{cd}	187.48^{c}	270.71^{bc}	221.15^{c}	312.50^{a}	271.93^{b}	***
Fap(%)	14.00^{actgh}	11.87^{bh}	15.07^{ac}	11.98^{bg}	13.85^{acdg}	12.29^{befd}	**
Ln(g)	1149^{d}	1366^{d}	1502^{c}	1603^{b}	1915^{a}	1901^{a}	***
Lnp(%)	85.92^{cde}	88.55^{ac}	84.70^{bd}	87.63^{ac}	86.01^{bc}	87.55^{ac}	**
Bmd	0.159^{acde}	0.154^{be}	0.159^{be}	0.159^{bd}	0.166^{c}	0.171^{a}	***
Lbm(g)	1172.20^{c}	1392.00^{c}	1531.11^{b}	1632.29^{b}	1949.47^{a}	1934.97^{a}	***
Lbmp(%)	87.60^{ad}	90.17^{a}	86.33^{bd}	89.23^{ac}	87.53^{bcde}	89.10^{ae}	**
Bfl(g)	1363.10^{c}	1579.22^{c}	1801.71^{b}	1853.01^{b}	2261.93^{a}	2206.90^{a}	***
Ftem	42.26^{a}	41.01^{b}	40.84^{b}	41.03^{b}	40.86^{b}	41.05^{b}	***

n.s=not significant, DF=degree of freedom, Sig=significant, Class=compensatory group(CG), TN birds(TN), **=p<0.005, ***=p<.0005, a-h Means with different superscript within a row under a major heading differ($p<0.05$), sd(%)=dry matter percentage of body weight, bmc(g)=bone mass, bmcp(%)=bone mass percentage of body weight,, fa(g)=fat, fap (%)=fat percentage of body weight, ln(g)=lean, lnp(%)=lean percentage of body weight, bfl(g)=bone mass fat and lean, bmd=bone density, lbm(g)=lean and bone mass, lbmp(%)=lean and bone mass percentage of body weight., Ftem=36 hr fasted body temperature

Table 46. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and Mean feed consumption (MF), weight gain to feed ratio (FE),
and feed consumption per body unit (PFC) of TN birds age 49 d.

Variables	MF	FE	PFC
CL	0.00	-0.15	0.29*
Ca	-0.31**	0.03	0.05
Phos	-0.04	-0.09	-0.05
Mg	-0.13	-0.07	0.16
TP	0.05	-0.15	0.10
TR	0.23*	0.04	-0.13
AB	0.29*	90.12	-0.00
UR	-0.14	-0.06	0.05
Na	0.06	-0.10	0.16
K	0.25*	-0.45***	0.12
AHC	0.13	-0.37**	0.23*
BT36	-0.01	-0.06	-0.28*
BT46	-0.09	0.24*	-0.25*
ABT	0.07	0.17	-0.32**

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 47. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and final body weight (BW), weight gain (WG), daily weight gain (DG), percentage of weight gain (PG), survivability (SURV) of thermoneutral birds age 49 d.

Variables	BW	WG	DG	PG	SURV
CL	-0.14	-0.14	-0.14	-0.18	0.13
Ca	-0.29*	-0.30*	-0.30*	-0.32**	0.17
Phos	-0.10	-0.10	-0.10	-0.10	-0.06
Mg	-0.21	-0.22	-0.22	-0.24*	0.16
TP	-0.08	-0.09	-0.09	-0.12	0.00
TR	0.28*	0.28*	0.28*	0.29*	-0.14
AB	0.20	0.18	0.18	0.09	-0.10
UR	-0.22	-0.22	-0.22	-0.17	0.01
Na	-0.01	-0.02	-0.02	-0.06	0.08
K	-0.16	-0.17	-0.17	-0.23*	-0.26*
AHC	-0.22	-0.24*	-0.24*	-0.28*	-0.10
BT36	-0.14	-0.14	-0.14	-0.13	-0.04
BT46	0.15	0.15	0.15	0.14	0.20
ABT	0.06	0.05	0.05	0.04	0.13

.*=p<0.05,**=p<0.005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 48. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, AHC, BT36, BT46 and ABT and body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and average hematocrit of TN birds age 49 d.

Variables	BT36	BT46	ABT	AHC
CL	-0.10	-0.14	-0.05	0.28*
Ca	0.31**	0.37**	0.42***	-0.10
Phos	0.23*	0.36**	0.38**	0.01
Mg	0.33**	0.46***	0.50***	0.06
TP	0.15	0.45***	0.41***	0.31*
TR	0.04	0.23*	0.20	0.14
AB	-0.08	0.35***	0.23*	0.23*
UR	0.01	0.01	0.01	0.07
Na	-0.07	0.19	0.11	0.18
K	0.08	0.00	0.04	0.51***

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 49. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and twelve hour fasted weight (FW), hot weight (HW), chill weight (CW), chill weight percentage of body weight (CWP), fat pad weight (FP), fat pad weight percentage of body weight (FR), liver weight (LW), liver weight percentage of body weight (LP), dry matter percentage of breast sample (DM), breast weight (BR), breast weight percentage of body weight (BP), and specific gravity (SG) of thermoneutral birds age 49 d.

Variables	FW	HW	CW	CP	FP	FR	LW	LP	DM	BR	BP	SG
CL	-0.03	-0.10	-0.09	-0.15	0.00	-0.00	0.00	0.04	-0.14	-0.05	-0.16	-0.00
Ca	-0.37**	-0.27*	-0.30*	0.15	-0.22	-0.14	0.04	0.27*	0.08	-0.14	0.20	0.18
Phos	-0.28*	-0.13	-0.17	0.25*	-0.26*	-0.19	0.07	0.26*	-0.09	0.06	0.44***	0.38**
Mg	-0.22	-0.17	-0.11	0.07	-0.22	-0.16	0.07	0.22*	-0.09	-0.09	0.09	0.15
TP	-0.15	-0.09	-0.09	0.12	-0.09	-0.06	0.16	0.29*	-0.27*	-0.12	-0.03	0.21
TR	0.35**	0.25*	0.30*	-0.10	0.18	0.10	0.22	0.01	-0.22	0.20	-0.07	-0.22
AB	0.16	0.15	0.16	0.02	-0.06	-0.10	0.06	0.00	-0.22	0.05	-0.07	0.19
UR	0.09	0.03	0.01	-0.16	-0.10	-0.13	0.08	0.00	-0.07	0.11	0.07	0.01
Na	0.03	001	0.02	-0.03	-0.06	-0.09	0.03	0.03	-0.17	-0.20	-0.11	0.13
K	-0.24*	-0.21	-0.19	0.07	-0.21	-021	0.03	0.23*	-0.32**	0.13	0.26*	0.50***
AHC	-0.18	-0.14	-0.15	0.07	-0.33**	-0.36**	0.19	0.33**	-0.30*	0.09	0.16	0.20
BT36	-0.11	-0.21	-0.22	-0.26*	-0.11	-0.11	-0.24	0.04	0.11	-0.08	-0.06	-0.10
BT46	-0.03	0.03	0.03	0.14	0.17	0.21	0.03	0.07	0.01	-0.03	0.06	-0.15
ABT	-0.07	-0.06	-0.06	-0.00	0.08	0.11	0.01	0.07	0.06	-0.06	0.02	-0.16

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 49. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and twelve hour fasted weight (FW), hot weight (HW), chill weight (CW), chill weight percentage of body weight (CWP), fat pad weight (FP), fat pad weight percentage of body weight (FR), liver weight (LW), liver weight percentage of body weight (LP), dry matter percentage of breast sample (DM), breast weight (BR), breast weight percentage of body weight (BP), and specific gravity (SG) of thermoneutral birds age 49 d.

Variables	FW	HW	CW	CP	FP	FR	LW	LP	DM	BR	BP	SG
CL	-0.03	-0.10	-0.09	-0.15	0.00	-0.00	0.00	0.04	-0.14	-0.05	-0.16	-0.00
Ca	-0.37**	-0.27*	-0.30*	0.15	-0.22	-0.14	0.04	0.27*	0.08	-0.14	0.20	0.18
Phos	-0.28*	-0.13	-0.17	0.25*	-0.26*	-0.19	0.07	0.26*	-0.09	0.06	0.44***	0.38**
Mg	-0.22	-0.17	-0.11	0.07	-0.22	-0.16	0.07	0.22*	-0.09	-0.09	0.09	0.15
TP	-0.15	-0.09	-0.09	0.12	-0.09	-0.06	0.16	0.29*	-0.27*	-0.12	-0.03	0.21
TR	0.35**	0.25*	0.30*	-0.10	0.18	0.10	0.22	0.01	-0.22	0.20	-0.07	-0.22
AB	0.16	0.15	0.16	0.02	-0.06	-0.10	0.06	0.00	-0.22	0.05	-0.07	0.19
UR	0.09	0.03	0.01	-0.16	-0.10	-0.13	0.08	0.00	-0.07	0.11	0.07	0.01
Na	0.03	001	0.02	-0.03	-0.06	-0.09	0.03	0.03	-0.17	-0.20	-0.11	0.13
K	-0.24*	-0.21	-0.19	0.07	-0.21	-021	0.03	0.23*	-0.32**	0.13	0.26*	0.50***
AHC	-0.18	-0.14	-0.15	0.07	-0.33**	-0.36**	0.19	0.33**	-0.30*	0.09	0.16	0.20
BT36	-0.11	-0.21	-0.22	-0.26*	-0.11	-0.11	-0.24	0.04	0.11	-0.08	-0.06	-0.10
BT46	-0.03	0.03	0.03	0.14	0.17	0.21	0.03	0.07	0.01	-0.03	0.06	-0.15
ABT	-0.07	-0.06	-0.06	-0.00	0.08	0.11	0.01	0.07	0.06	-0.06	0.02	-0.16

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 50. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and dressing percentage (DP), total yield (TY), dressing wastage (VS), dressing wastage percentage of body weight (VP), water absorb (WA), water absorb percentage of body weight (WP), and survivability ratio (SR) of thermoneutral birds age 49 d.

Variables	DP	TY	VS	VP	WA	WP	SR
CL	-0.12	0.04	0.10	0.17	0.08	0.11	0.10
Ca	0.15	-0.01	-0.35**	0.20	-0.36**	-0.28*	-0.03
Phos	0.25	-0.14	-0.38**	-0.31*	-0.34**	-0.29*	-0.10
Mg	0.07	0.04	-0.19	-0.10	-0.19	-0.16	0.03
TP	0.12	-0.05	-0.17	-0.12	-0.15	0.02	-0.04
TR	-0.16	0.05	0.32**	0.18	0.47***	0.39**	0.02
AB	0.02	0.00	0.08	-0.00	0.12	0.07	-0.02
UR	-0.16	0.05	0.15	0.13	-0.11	-0.13	0.31*
Na	-0.03	0.07	0.05	0.05	0.09	0.09	0.54
K	0.07	-0.32**	-0.16	-0.2	0.11	0.21	-0.05
AHC	0.07	-0.17	-0.15	-0.06	-0.02	0.06	0.03
BT36	-0.26*	-0.33**	0.11	0.25*	-0.07	-0.02	0.00
BT46	0.144	0.06	-0.12	-0.13	0.04	0.01	-0.17
ABT	-0.00	-0.09	-0.04	0.00	-0.00	0.00	-0.13

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 50. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and dressing percentage (DP), total yield (TY), dressing wastage (VS), dressing wastage percentage of body weight (VP), water absorb (WA), water absorb percentage of body weight (WP), and survivability ratio (SR) of thermoneutral birds age 49 d.

Variables	DP	TY	VS	VP	WA	WP	SR
CL	-0.12	0.04	0.10	0.17	0.08	0.11	0.10
Ca	0.15	-0.01	-0.35**	0.20	-0.36**	-0.28*	-0.03
Phos	0.25	-0.14	-0.38**	-0.31*	-0.34**	-0.29*	-0.10
Mg	0.07	0.04	-0.19	-0.10	-0.19	-0.16	0.03
TP	0.12	-0.05	-0.17	-0.12	-0.15	0.02	-0.04
TR	-0.16	0.05	0.32**	0.18	0.47***	0.39**	0.02
AB	0.02	0.00	0.08	-0.00	0.12	0.07	-0.02
UR	-0.16	0.05	0.15	0.13	-0.11	-0.13	0.31*
Na	-0.03	0.07	0.05	0.05	0.09	0.09	0.54
K	0.07	-0.32**	-0.16	-0.2	0.11	0.21	-0.05
AHC	0.07	-0.17	-0.15	-0.06	-0.02	0.06	0.03
BT36	-0.26*	-0.33**	0.11	0.25*	-0.07	-0.02	0.00
BT46	0.144	0.06	-0.12	-0.13	0.04	0.01	-0.17
ABT	-0.00	-0.09	-0.04	0.00	-0.00	0.00	-0.13

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 51. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of thermoneutral birds age 49 d.

Variables	SD	BMC	BMCP	FA	FP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
CL	0.11	0.18	-0.10	0.12	-0.02	0.22	0.04	0.21	0.04	0.22	0.07	-0.12
Ca	-0.22	-0.25*	0.25*	-0.15	0.11	-0.32**	-0.12	-0.30*	-0.2*	-0.30*	0.01	-0.24*
Phos	-0.18	-0.14	0.09	-0.18	-0.14	-0.14	0.08	-0.16	-0.05	-0.15	-0.03	-0.26*
Mg	-0.13	-0.08	0.09	-0.06	0.01	-0.11	-0.01	-0.11	-0.15	-0.07	0.16	-0.40***
TP	-0.16	0.00	0.10	-0.08	-0.06	-0.01	0.05	-0.03	-0.02	0.00	0.16	-0.23*
TR	0.13	0.13	-0.12	0.04	-0.08	0.16	-0.00	0.14	0.11	0.16	0.04	0.00
AB	-0.00	0.16	0.14	-0.03	-0.19	0.13	0.09	0.10	0.13	0.15	0.19	-0.02
UR	0.07	-0.17	0.03	-0.03	0.11	-0.17	0.04	-0.16	-0.23*	-0.21*	-0.17	-0.05
Na	0.08	0.09	-0.00	0.03	-0.03	0.10	0.05	0.09	0.07	0.11	0.08	-0.13
K	-0.08	0.10	-0.199	-0.15	-0.41***	0.19	0.20	0.14	0.14	0.19	0.18	-0.11
AHC	-0.10	0.07	-0.04	-0.13	-0.28	0.13	0.24*	0.09	0.03	0.14	0.23*	0.27*

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 52. Correlation between final body weight (BW), weight gain (WG), daily weight gain (DG) percentage of gain (PG),survivability (SURV) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of thermoneutral birds age 49 d.

Variables	SD	BMC	BMCP	FA	FP	LN	LNP	BMFL	BMD	LBMC	LBMCP
BW	0.01	0.02	0.00	0.00	-0.01	0.02	0.03	0.02	0.09	-0.00	-0.13
WG	0.04	0.04	0.00	0.03	0.00	0.03	0.00	0.04	0.11	0.00	-0.16
DG	0.04	0.04	0.00	0.03	0.00	0.03	0.00	0.04	0.11	0.00	-0.16
PG	0.12	0.09	0.00	0.11	0.08	0.08	-0.06	0.09	0.14	0.04	-0.21
FE	0.10	0.07	0.04	0.14	0.20	0.03	-0.20	0.05	0.11	0.02	-0.15
MF	-0.05	-0.05	-0.06	-0.11	-0.17	-0.01	0.19	-0.03	-0.05	-0.03	0.02
PFC	-0.03	0.14	0.01	0.09	-0.01	0.14	0.10	0.13	0.05	0.15	0.13
SURV	0.06	0.16	0.04	0.15	0.03	0.12	-0.03	0.14	0.14	0.13	0.06
BT36	-0.06	-0.01	0.07	-0.08	-0.00	-0.11	0.05	-0.11	-0.08	-0.08	0.16
BT46	0.88	0.88	.07	0.71	0.99	0.44	0.02	-0.08	-0.04	-0.07	0.05
FBT	0.04	0.11	-0.05	0.07	-0.03	0.09	-0.06	0.09	0.00	0.08	-0.07
ABT	-0.04	-0.06	0.19	-0.06	-0.00	-0.11	0.03	-0.11	-0.06	-0.09	0.11

Table 53. Correlation between FW, HW,CW, CWP,FP, FR, LW, LP, DM,BR, BP, and SG, SD, BMC, BMCP, FP, LN, LNP, BMFL, BMD, LBMC, LBMCP of thermoneutral birds age 49 d.

Variables	SD	BMC	BMCP	FA	FP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
FW	0.10	0.03	-0.02	0.04	-0.03	0.04	0.07	0.04	-0.03	0.05	0.08	0.24
HW	0.06	0.04	-0.01	0.03	-0.04	0.03	0.04	0.03	0.00	0.04	0.07	0.26*
CW	0.04	0.04	-0.01	0.02	-0.05	0.04	0.06	0.04	0.00	0.04	0.06	0.26*
CP	-0.12	0.01	0.03	-0.03	-0.06	-0.00	-0.01	-0.01	0.10	-0.00	-0.02	0.16
FP	0.58*	0.27*	-0.10	0.28*	0.17	0.27*	-0.10	0.29*	0.21	0.27*	-0.00	-0.16
FR	0.28*	0.27*	-0.08	0.29*	0.20	0.27*	-0.13	0.28*	0.22	0.26*	-0.02	-0.24*
LW	0.05	0.08	0.06	0.02	-0.06	0.08	0.15	0.07	0.04	0.10	0.20	-0.09
LP	-0.03	0.06	0.07	-0.00	-0.06	0.06	0.10	0.05	0.07	0.07	0.14	-0.20
DM	0.00	-0.02	0.02	0.01	0.07	-0.03	-0.04	-0.02	-0.01	-0.03	-0.02	0.02
BR	0.02	-0.05	-0.17	-0.11	-0.21	0.02	0.12	-0.00	-0.04	0.02	0.06	0.18
BP	-0.06	-0.14	-0.14	-0.20	-0.21	-0.07	0.04	-0.10	-0.05	-0.08	-0.02	0.06
SG	-0.22*	-0.14	-0.02	-0.27*	-0.28*	-0.11	0.18	-0.15	-0.04	-0.10	0.11	0.04

,*=p<0.05,**=p<0.005,***=P<0.0005,Twelve hour fasted weight (FW), hot weight (HW), chill weight (CW), chill weight percentage of body weight (CWP), fat pad weight (FP), fat pad weight percentage of body weight (FR), liver weight (LW), liver weight percentage of body weight (LP), dry matter percentage, of breast sample (DM), breast weight (BR), breast weight percentage of body weight (BP), and specific gravity (SG) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FP), lean (LN), lean percentage (LP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP and 36 hour fasted body temperature (FBT)

Table 54. Correlation between and dressing percentage (DP), total yield (TY), dressing wastage (VS), dressing wastage percentage of body weight (VP), water absorb (WA), water absorb percentage of body weight (WP), and survivability ratio (SR) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of thermoneutral birds age 49 d.

Variables	SD	BMC	BMCP	FA	FP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
DP	-0.12	0.01	0.03	-0.03	-0.06	-0.00	-0.01	-0.01	0.10	-0.00	-0.00	0.16
TY	0.04	0.16	0.03	0.16	0.07	0.13	-0.02	0.14	0.11	0.14	0.06	0.03
VS	0.12	0.00	-0.03	0.03	0.00	0.02	0.08	0.03	-0.08	0.03	0.05	-0.02
VP	0.09	-0.01	-0.03	0.01	0.02	0.01	0.06	0.01	-0.08	0.00	0.01	-0.18
WA	-0.10	0.02	-0.00	-0.09	-0.18	0.04	0.22*	0.02	0.05	0.01	-0.02	-0.03
WP	-0.12	0.01	-0.00	-0.10	-0.17	0.03	0.20	0.01	0.07	0.00	-0.04	-0.08
SR	0.07	0.01	-0.01	0.02	-0.02	0.01-	0.03	0.01	-0.13	0.04	0.17	0.11

.*=p<0.05

Table 54. Correlation between and dressing percentage (DP), total yield (TY), dressing wastage (VS), dressing wastage percentage of body weight (VP), water absorb (WA), water absorb percentage of body weight (WP), and survivability ratio (SR) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of thermoneutral birds age 49 d.

Variables	SD	BMC	BMCP	FA	FP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
DP	-0.12	0.01	0.03	-0.03	-0.06	-0.00	-0.01	-0.01	0.10	-0.00	-0.00	0.16
TY	0.04	0.16	0.03	0.16	0.07	0.13	-0.02	0.14	0.11	0.14	0.06	0.03
VS	0.12	0.00	-0.03	0.03	0.00	0.02	0.08	0.03	-0.08	0.03	0.05	-0.02
VP	0.09	-0.01	-0.03	0.01	0.02	0.01	0.06	0.01	-0.08	0.00	0.01	-0.18
WA	-0.10	0.02	-0.00	-0.09	-0.18	0.04	0.22*	0.02	0.05	0.01	-0.02	-0.03
WP	-0.12	0.01	-0.00	-0.10	-0.17	0.03	0.20	0.01	0.07	0.00	-0.04	-0.08
SR	0.07	0.01	-0.01	0.02	-0.02	0.01-	0.03	0.01	-0.13	0.04	0.17	0.11

,*=p<0.05

Table 55. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and Mean feed consumption (MF), weight gain to feed ratio (FE), and feed consumption per body unit (PFC) of compensatory birds age 49 d.

Variables	MF	FE	PFC
CL	0.17	-0.15	0.20
Ca	-0.10	0.06	-0.11
Phos0	-0.22	0.12	-0.20
Mg	-0.07	-0.00	-0.12
TP	0.09	-0.19	0.18
TR	-0.07	-0.04	0.10
AB	0.18	-0.21	0.17
UR	0.05	-0.05	0.11
Na	0.18	-0.27	0.38*
K	0.07	-0.22	0.21
AHC	0.01	-0.03	0.05
BT36	-0.10	-0.05	0.05
BT46	-0.10	0.07	-0.09
ABT	-0.13	0.00	-0.021

.*=p<0.05,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 56. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and final body weight (BW), weight gain (WG), daily weight gain (DG), percentage of weight gain (PG), survivability (SURV) of compensatory birds age 49 d.

Variables	BW	WG	DG	PG	SURV
CL	0.02	-0.01	-0.01	-0.09	0.13
Ca	-0.14	-0.14	-0.14	-0.08	-0.10
Phos	-0.15	-0.13	-0.13	-0.03	-0.10
Mg	-0.11	-0.11	-0.11	-0.06	-0.20
TP	-0.30	-0.39*	-0.39*	-0.44**	-0.06
TR	-0.27	-0.16	-0.16	0.14	0.11
AB	0.03	-0.11	-0.11	-0.39*	-0.00
UR	-0.03	-0.04	-0.04	-0.05	0.07
Na	-0.21	-0.27	-0.27	-0.29*	0.24
K	-0.29*	-0.32*	-0.32*	-0.27	0.00
AHC	-0.1	-0.19	-0.19	-0.20	-0.05
BT36	-0.35*	-0.26	-0.26	0.03	-0.00
BT46	-0.01	-0.01	-0.01	-0.01	0.05
ABT	-0.24	-0.19	-0.19	0.01	0.02

,*=p<0.05,**=p<0.005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 56. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and final body weight (BW), weight gain (WG), daily weight gain (DG), percentage of weight gain (PG), survivability (SURV) of compensatory birds age 49 d.

Variables	BW	WG	DG	PG	SURV
CL	0.02	-0.01	-0.01	-0.09	0.13
Ca	-0.14	-0.14	-0.14	-0.08	-0.10
Phos	-0.15	-0.13	-0.13	-0.03	-0.10
Mg	-0.11	-0.11	-0.11	-0.06	-0.20
TP	-0.30	-0.39*	-0.39*	-0.44**	-0.06
TR	-0.27	-0.16	-0.16	0.14	0.11
AB	0.03	-0.11	-0.11	-0.39*	-0.00
UR	-0.03	-0.04	-0.04	-0.05	0.07
Na	-0.21	-0.27	-0.27	-0.29*	0.24
K	-0.29*	-0.32*	-0.32*	-0.27	0.00
AHC	-0.1	-0.19	-0.19	-0.20	-0.05
BT36	-0.35*	-0.26	-0.26	0.03	-0.00
BT46	-0.01	-0.01	-0.01	-0.01	0.05
ABT	-0.24	-0.19	-0.19	0.01	0.02

.*=p<0.05,**=p<0.005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 57. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, AHC, BT36, BT46 and ABT and body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and average hematocrit of compensatory birds age 49 d.

Variables	BT36	BT46	ABT	AHC
CL	-0.29	0.00	-0.19	-0.36*
Ca	0.17	0.37*	0.34*	-0.03
Phos	0.26	0.18	0.28	0.20
Mg	0.22	0.22	0.28	0.00
TP	0.06	0.20	0.16	0.28
TR	0.25	0.05	0.20	0.13
AB	-0.18	-0.09	-0.18	0.25
UR	-0.04	0.14	0.06	0.03
Na	-0.07	0.03	-0.02	-0.01
K	0100	-0.11	-0.00	0.27

,*=p<0.05,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 57. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, AHC, BT36, BT46 and ABT and body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and average hematocrit of compensatory birds age 49 d.

Variables	BT36	BT46	ABT	AHC
CL	-0.29	0.00	-0.19	-0.36*
Ca	0.17	0.37*	0.34*	-0.03
Phos	0.26	0.18	0.28	0.20
Mg	0.22	0.22	0.28	0.00
TP	0.06	0.20	0.16	0.28
TR	0.25	0.05	0.20	0.13
AB	-0.18	-0.09	-0.18	0.25
UR	-0.04	0.14	0.06	0.03
Na	-0.07	0.03	-0.02	-0.01
K	0100	-0.11	-0.00	0.27

,*=p<0.05,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 58. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and twelve hour fasted weight (FW), hot weight (HW), chill weight (CW), chill weight percentage of body weight (CWP), fat pad weight (FP), fat pad weight percentage of body weight (FR), liver weight (LW), liver weight percentage of body weight (LNP), dry matter percentage of breast sample (DM), breast weight (BR), breast weight percentage of body weight (BP), and specific gravity (SG) of compensatory birds age 49 d.

Variables	FW	HW	CW	CP	FP	FR	LW	LNP	DM	BR	BP	SG
CL	0.211	0.15	0.14	-0.13	0.100	0.05	0.13	0.01	0.06	0.11	-0.01	0.02
Ca	0.09	0.12	0.11	0.12	0.03	-0.01	0.34*	0.26	0.25	0.05	-0.01	0.11
Phos	0.11	0.15	0.14	0.15	0.04	-0.00	0.12	0.04	0.20	0.18	0.14	0.14
Mg	0.10	0.05	0.04	-0.22	-0.02	-0.05	0.27	0.20	0.31*	0.08	-0.00	0.31*
TP	0.01	-0.03	-0.03	-0.20	-0.16	-0.18	0.41**	0.39*	0.15	0.06	0.08	0.32*
TR	-0.35*	-0.40**	-0.42**	-045**	0.00	0.10	-0.06	0.13	0.06	-0.34*	-0.18	-0.13
AB	0.05	0.00	0.01	-0.14	-0.33*	-0.33*	0.155	0.13	0.29*	0.13	0.16	0.38*
UR	0.06	0.00	0.02	-0.14	0.04	0.01	0.38*	0.34*	-0.06	0.06	0.05	-0.10
Na	-0.11	-0.20	-0.20	-0.42**	-0.06	-0.02	0.00	0.06	0.10	-0.18	-0.14	0.03
K	0.07	0.01	0.00	-0.24	-0.11	-0.13	0.23	0.19	0.11	0.18	0.19	0.22
AHC	-0.45	-0.00	0.011	0.19	0.04	0.05	0.14	0.17	0.00	0.30*	0.48**	0.20
BT36	-0.24	-0.27	-0.27	-0.26	-0.08	-0.03	-0.03	0.09	-0.01	-0.18	-0.06	-0.14
BT46	-0.24	-0.22	-0.21	-0.01	0.13	0.19	0.01	0.11	-0.06	-0.21	-0.06	-0.08
ABT	-0.31*	-0.32*	-0.31*	-0.18	0.02	0.09	-0.12	0.13	-0.05	-0.25	-0.08	-0.14

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 59. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and dressing percentage (DP), total yield (TY),dressing wastage (VS), dressing wastage percentage of body weight (VP), water absorb (WA), water absorb percentage of body weight (WP), and survivability ratio (SR) of compensatory birds age 49 d.

Variables	DP	TY	VS	VP	WA	WP	SR
CL	-0.13	0.20	0.31*	0.13	-0.00	-0.02	0.16
Ca	0.12	0.01	-0.02	-0.17	-0.06	-0.08	0.18
Phos	0.15	0.04	-0.05	-0.22	-0.09	-0.12	0.23
Mg	-0.22	-0.09	0.24	0.21	-0.02	-0.05	0.19
TP	-0.20	-0.07	0.18	0.23	0.03	0.03	0.25
TR	-0.45**	-0.22	-0.08	0.38*	-0.23	-0.18	*0.11
AB	-0.14	0.00	0.19	0.19	0.07	0.08	0.04
UR	-0.14	0.05	0.24	0.24	0.16	0.16	0.09
Na	-0.42**	0.00	0.21	0.44**	-0.06	-0.03	0.04
K	-0.24	-0.00	0.23	0.24	-0.03	-0.04	0.29*
AHC	0.19	-0.04	-0.16	-0.14	0.10	0.11	0.05
BT36	-0.22	-0.22	-0.08	0.24	-0.11	-0.08	0.02
BT46	-0.01	-0.13	-0.19	0.05	0.01	0.06	-0.20
ABT	-0.18	-0.23	-0.18	0.19	-0.06	-0.01	-0.10

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 60. Correlation between Cl, Ca, Phos, Mg, TP, TR, AB, UR, Na, K, average hematocrit (AHC), body temperature age 36 d (BT36), 46 d (BT46), average body temperature (ABT) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FAP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of compensatory birds age 49 d.

Variables	SD	BMC	BMCP	FA	FAP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
CL	0.49**	0.19	0.03	0.39*	0.34*	0.06	-0.32*	0.15	0.15	0.07	-0.32*	0.01
Ca	-0.37*	0.02	0.27	0.07	0.13	-0.16	-0.14	-0.13	-0.00	-0.16	-0.13	-0.10
Phos	-0.49**	-0.10	0.16	-0.12	-0.03	-0.18	0.03	-0.20	-0.06	-0.18	0.04	-0.15
Mg	-0.26	-0.10	0.32*	0.05	0.20	-0.33*	-0.22	-0.29	0.06	-0.32*	-0.21	-0.01
TP	-0.09	0.14	0.35*	0.13	0.18	-0.10	-0.20	-0.06	0.19	-0.10	-0.19	0.06
TR	0.06	0.21	0.15	0.14	0.10	0.07	-0.12	0.10	0.16	0.07	-0.11	0.02
AB	-0.00	0.18	0.09	-0.01	-0.12	0.13	0.10	0.12	0.26	0.13	0.11	0.20
UR	-0.05	0.17	0.13	0.23	0.22	0.00	-0.30*	0.06	-0.02	0.11	-0.30*	-01.5
Na	0.30*	0.33*	-0.15	0.26	0.00	0.37*	0.00	0.40**	0.35*	0.37*	-0.00	0.14
K	0.11	0.02	0.13	0.08	0.09	-0.06	-0.08	-0.04	0.14	-0.06	-0.07	-0.01
AHC	-0.21	0.09	-0.06	-0.10	-0.18	0.14	0.13	0.10	0.07	0.14	0.13	-0.05

,*=p<0.05,**=p<0.005,***=P<0.0005,CL=chloride (mmol/l), Mg=magnesium (meq/l), TR=Triglyceride (mg/dl), UR=uric acid (mg/dl), TP=total protein (g/dl), Ca=calcium (mg/dl), PHO= phosphate (mg.dl), Na= sodium (mmol/l), AB=albumin (g/dl), K=potassium (mmol/l)

Table 61. Correlation between final body weight (BW), weight gain (WG), daily weight gain (DG) percentage of gain (PG),survivability (SURV) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FAP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of compensatory birds 49 d.

Variables	SD	BMC	BMCP	FA	FAP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
BW	-0.02	0.10	-0.29*	-0.17	-0.3*	0.28	0.29*	0.21	-0.00	0.28	0.28	0.03
WG	-0.01	0.17	-0.18	-0.14	-0.34*	0.27	0.26	0.22	0.03	0.27	0.26	-0.00
DG	-0.14	0.17	-0.18	-0.14	-0.34*	0.27	0.26	0.22	0.03	0.27	0.26	-0.00
PG	0.02	0.26	0.13	-0.01	-0.12	0.14	0.08	0.13	0.10	0.14	0.09	-0.10
FE	-0.11	-0.11	-0.12	-0.04	-0.02	-0.06	-0.00	-0.07	-0.28	-0.06	-0.00	-0.05
MF	0.12	0.18	-0.00	-0.03	-0.015	0.20	0.14	0.18	0.33*	0.20	0.14	0.12
PFC	0.15	0.09	0.15	0.09	0.10	0.01	-0.06	0.03	0.26	0.01	-0.06	0.05
SURV	0.05	-0.07	0.04	0.17	0.25	-0.13	-0.22	-0.08	-0.16	-0.13	-0.22	-0.09
BT36	-0.26	-0.26	0.06	-0.25	-0.08	-0.26	0.01	-0.30*	-0.20	-0.27	0.02	-0.05
BT46	0.18	0.20	0.04	0.23	0.17	0.10	-0.16	0.15	-0.09	0.10	-0.16	-0.26
ABT	-0.07	-0.05	0.07	-0.03	0.04	-0.12	-0.08	-0.11	-0.19	-0.12	-0.08	-0.19
FTEM	-0.20	-0.11	0.12	-0.23	-0.23	-0.15	0.13	-0.14	0.23	-0.10	0.13	n.e

,*=p<0.05,

Table 61. Correlation between final body weight (BW), weight gain (WG), daily weight gain (DG) percentage of gain (PG),survivability (SURV) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FAP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of compensatory birds 49 d.

Variables	SD	BMC	BMCP	FA	FAP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
BW	-0.02	0.10	-0.29*	-0.17	-0.3*	0.28	0.29*	0.21	-0.00	0.28	0.28	0.03
WG	-0.01	0.17	-0.18	-0.14	-0.34*	0.27	0.26	0.22	0.03	0.27	0.26	-0.00
DG	-0.14	0.17	-0.18	-0.14	-0.34*	0.27	0.26	0.22	0.03	0.27	0.26	-0.00
PG	0.02	0.26	0.13	-0.01	-0.12	0.14	0.08	0.13	0.10	0.14	0.09	-0.10
FE	-0.11	-0.11	-0.12	-0.04	-0.02	-0.06	-0.00	-0.07	-0.28	-0.06	-0.00	-0.05
MF	0.12	0.18	-0.00	-0.03	-0.015	0.20	0.14	0.18	0.33*	0.20	0.14	0.12
PFC	0.15	0.09	0.15	0.09	0.10	0.01	-0.06	0.03	0.26	0.01	-0.06	0.05
SURV	0.05	-0.07	0.04	0.17	0.25	-0.13	-0.22	-0.08	-0.16	-0.13	-0.22	-0.09
BT36	-0.26	-0.26	0.06	-0.25	-0.08	-0.26	0.01	-0.30*	-0.20	-0.27	0.02	-0.05
BT46	0.18	0.20	0.04	0.23	0.17	0.10	-0.16	0.15	-0.09	0.10	-0.16	-0.26
ABT	-0.07	-0.05	0.07	-0.03	0.04	-0.12	-0.08	-0.11	-0.19	-0.12	-0.08	-0.19
FTEM	-0.20	-0.11	0.12	-0.23	-0.23	-0.15	0.13	-0.14	0.23	-0.10	0.13	n.e

,*=p<0.05,

Table 62. Correlation between and twelve hour fasted weight (FW), hot weight (HW), chill weight (CW), chill weight percentage of body weight (CWP), fat pad weight (FP), fat pad weight percentage of body weight (FR), liver weight (LW), liver weight percentage of body weight (LP), dry matter percentage of breast sample (DM), breast weight (BR), breast weight percentage of body weight (BP), and specific gravity (SG) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FAP), lean (LN), lean percentage (LNP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of compensatory birds 49 d.

Variables	SD	BMC	BMCP	FA	FAP	LN	LNP	BMFL	BMD	LBMC	LBMCP	FBT
FW	0.04	-0.11	0.04	-0.10	-0.03	-0.10	0.00	-0.12	0.02	-0.16	0.00	-0.01
HW	0.03	-0.11	0.04	-0.13	-0.05	-0.10	0.02	-0.12	-0.00	-0.10	0.03	-0.07
CW	0.02	-0.11	0.00	-0.13	-0.07	-0.07	0.03	-0.10	-0.03	-0.07	0.03	-0.08
CP	-0.02	-0.01	-0.13	-0.15	-0.17	0.08	0.15	0.04	-0.23	0.08	0.14	-0.26
FP	0.16	-0.01	-0.23	0.32*	0.31*	0.03	-0.33*	0.10	-0.24	0.03	-0.34*	-0.27
FR	0.16	0.01	-0.25	0.36*	0.33*	0.05	-0.26*	0.13	-0.26	0.05	-0.35*	-0.27
LW	0.07	0.03	-0.02	0.31*	0.26	-0.03	-0.26	0.04	0.00	-0.03	-0.26	-0.09
LP	0.04	0.09	-0.02	0.33*	0.26	0.00	-0.24	0.08	-0.00	0.01	-0.24	-0.08
DM	-0.20	-0.02	0.23	-0.19	-0.13	-0.12	0.13	-0.16	-0.05	-0.12	0.14	-0.01
BR	0.00	-0.01	-0.06	-0.21	-0.24	0.05	0.20	0.00	0.01	0.05	0.20	-0.09
BP	-0.02	0.10	-0.13	-0.19	-0.32*	0.19	0.30*	0.13	-0.00	0.19	0.30*	-0.12
SG	0.01	0.04	-0.01	-0.26	-0.35	0.12	0.36*	0.05.	0.30*	0.12	0.36*	0.28

,*=p<0.05,

Table 63. Correlation between dressing percentage (DP), total yield (TY),dressing wastage (VS), dressing wastage percentage of body weight (VP), water absorb (WA), water absorb percentage of body weight (WP), and survivability ratio (SR) and dry matter percentage of body (SD), bone mineral concentration (BMC), BMC percentage (BMCP), fat (FA) fat percentage (FP), lean (LN), lean percentage (LP), BMC+FA+LN (BMFL), bone density (BMD), LN+BMC (LBMC), LBMC percentage (LBMCP) and 36 hour fasted body temperature (FBT) of compensatory birds age 49 d.

Variables	SD	BMC	BMCP	FA	FP	LN	LP	BMFL	BMD	LBMC	LBMCP	FBT
DP	-0.02	-0.01	-0.13	-0.15	-0.17	0.08	0.15	0.04	-0.23	0.08	0.14	-0.26
TY	0.06	-0.15	0.02	-0.00	0.10	-0.15	-0.10	-0.14	-0.13	-0.15	-0.10	-0.12
VS	0.04	-0.08	-0.00	0.02	0.04	-0.07	-0.08	-0.06	0.13	-0.07	-0.08	0.14
VP	-0.00	0.02	-0.04	0.17	0.11	0.01	-0.12	0.05	0.14	0.01	-0.12	0.22
WA	-0.06	-0.02	-0.36*	-0.03	-0.15	0.18	0.07	0.16	-0.22	0.18	0.06	-0.12
WP	-0.07	-0.16	-0.38	-0.0	-0.14	-0.22*	0.07	0.20	-0.22	0.22	0.06	-0.12
SR	0.05	-0.18	0.25	0.02	0.23	-0.30*	-0.21	-0.27	0.02	-0.30*	-0.20	-0.04

,*=p<0.05,

Table 64. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on body weight age 26 d (BW26), 34 d (BW 34), 40 d (BW40) and 48 d (BW48) of male broilers reared at 24^{O} C.

Treatments			BW26	BW34	BW40	BW48
Main effects#	VM	Control	1077	1613	2021	2355
		VM	1063	1608	2033	2322
	E	Control	1073	1626	2063	2406
		EL	1054	1585	1993	2259
		EH	1085	1620	2025	2351
	B	Control	1067	1649	2047	2375
		BL	1069	1597	2034	2367
		BH	1074	1584	2001	2273
Interactions#	VM X E	Control	1075	1623	2020	2351
		EL	1073	1607	2009	2321
		EH	1084	1608	2034	2387
		VM	1068	1628	2106	2455
		VM X EL	1035	1563	1976	2197
		VM X EH	1085	1631	2016	2315
	VM X B	Control	1055	1618	1974	2308
		BL	1092	1630	1991	2345
		BH	1085	1591	2099	2411
		VM	1079	1681	2119	2442
		VM X BL	1046	1565	2077	2389
		VM X BH	1063	1577	1903	2136
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 64. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on body weight age 26 d (BW26), 34 d (BW 34), 40 d (BW40) and 48 d (BW48) of male broilers reared at 24^{O} C.

Treatments			BW26	BW34	BW40	BW48
Main effects#	VM	Control	1077	1613	2021	2355
		VM	1063	1608	2033	2322
	E	Control	1073	1626	2063	2406
		EL	1054	1585	1993	2259
		EH	1085	1620	2025	2351
	B	Control	1067	1649	2047	2375
		BL	1069	1597	2034	2367
		BH	1074	1584	2001	2273
Interactions#	VM X E	Control	1075	1623	2020	2351
		EL	1073	1607	2009	2321
		EH	1084	1608	2034	2387
		VM	1068	1628	2106	2455
		VM X EL	1035	1563	1976	2197
		VM X EH	1085	1631	2016	2315
	VM X B	Control	1055	1618	1974	2308
		BL	1092	1630	1991	2345
		BH	1085	1591	2099	2411
		VM	1079	1681	2119	2442
		VM X BL	1046	1565	2077	2389
		VM X BH	1063	1577	1903	2136
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 65. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on body weight gain age 26 d (G26), 34 d (G34), 40 d (G40) and 48 d (G8) of male broilers reared at 24° C.

Treatments			G26	G34	G40	G48
Main effects#	VM	Control	491	1030	1434[a]	1770
		VM	497	1046	1472[b]	1763
	E	Control	508	1063	1496	1842
		EL	470	1009	1418	1684
		EH	504	1042	1445	1775
	B	Control	494	1078	1474	1803
		BL	493	1027	1460	1790
		BH	495	1009	1426	1708
Interactions#	VM X E	Control	504	1052	1441	1782
		EL	473	1015	1419	1732
		EH	495	1023	1443	1796
		VM	512	1074	1551	1901
		VM X EL	467	1002	1416	1636
		VM X EH	512	1061	1448	1753
	VM X B	Control	477	1041	1394	1730
		BL	502	1043	1400	1752
		BH	494	1005	1509	1830
		VM	511	1114	1552	1876
		VM X BL	484	1011	1520	1828
		VM X BH	497	1012	1343	1586
ANOVA	DF	Significant				
VM	1		n.s	n.s	*	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, ,*=p<0.05,a-b means with in a major heading with unlike super script differ (p<0.05),
EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1),
#=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 66. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on daily body weight gain age 26 d (DG26), 34 d (DG34), 40 d (DG40) and 48 d (DG48) of male broilers reared at 24° C.

Treatments			DG26	DG34	DG40	DG48
Main effects#	VM	Control	61.42	64.39	65.22[a]	61.06
		VM	62.20	65.39	66.92[b]	60.81
	E	Control	63.57	66.46	68.03	63.15
		EL	58.83	63.06	64.45	58.09
		EH	63.02	65.14	65.71	61.21
	B	Control	61.79	67.39	66.97	62.17
		BL	61.66	64.21	66.39	61.73
		BH	61.99	63.07	64.85	58.91
Interactions#	VM X E	Control	63.09	65.75	65.54	61.48
		EL	59.19	63.48	64.53	59.75
		EH	61.98	63.95	65.59	61.96
		VM	64.06	67.18	70.53	65.55
		VM X EL	58.47	62.65	64.38	56.43
		VM X EH	64.07	66.33	65.84	60.45
	VM X B	Control	59.66	65.12	63.39	59.66
		BL	62.79	65.21	63.64	60.41
		BH	61.81	62.85	68.62	63.12
		VM	63.92	69.67	70.54	64.69
		VM X BL	60.53	63.20	69.13	63.04
		VM X BH	62.14	63.29	61.08	54.07
ANOVA	DF	Significant				
VM	1		n.s	n.s	*	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, ,*=p<0.05,a-b means with in a major heading with unlike super script differ (p<0.05),
EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1),
#=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 67 Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on body weight percentage of final body weight age 26 d (PG26), 34 d (PG34), 40 d (PG40) and 48 d (PG48) of male broilers reared at 24^{O} C.

Treatments			PG26	PG34	PG40	PG48
Main effects[#]	VM	Control	45.51[b]	63.78[b]	70.61[b]	75.02
		VM	46.73[a]	65.02[a]	72.32[a]	75.72
	E	Control	47.41[a]	65.32	72.32	76.35
		EL	44.57[b]	63.65	70.93	74.54
		EH	46.39[ab]	64.23	71.15	75.49
	B	Control	46.24	65.26	71.08	74.63
		BL	46.07	64.29	71.38	75.65
		BH	46.08	63.65	71.22	75.09
Interactions[#]	VM X E	Control	46.81	64.71	71.10	75.47
		EL	44.05	63.20	70.28	74.70
		EH	45.61	63.44	70.46	75.43
		VM	47.94	65.94	73.54	77.23
		VM X EL	45.09	64.10	71.58	74.39
		VM X EH	47.18	65.02	71.83	75.54
	VM X B	Control	45.19	64.30	70.48	74.41
		BL	45.90	63.93	69.58	74.89
		BH	45.45	63.12	71.77	76.00
		VM	47.29	66.22	73.12	76.55
		VM X BL	46.24	64.66	73.18	76.42
		VM X BH	46.68	64.19	70.66	74.18
ANOVA	DF	Significant				
VM	1		*	*	*	n.s
E	2		*	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, ,*=p<0.05, a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), [#]=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 68. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on mean feed consumption (MF) age 26 d (MF26), 34 d (MF34), 40 d (MF40) and 48 d (MF48) of male broilers reared at 24° C.

Treatments			MF26	MF34	MF40	MF48
Main effects#	VM	Control	120	135	128	115
		VM	125	136	129	119
	E	Control	124	139	134	122
		EL	119	132	124	111
		EH	123	135	128	117
	B	Control	117	129	124	116
		BL	131	143	135	117
		BH	119	134	127	118
Interactions#	VM X E	Control	124	137	132	117
		EL	110	127	117	105
		EH	125	140	136	122
		VM	125	140	136	127
		VM X EL	128	138	131	117
		VM X EH	122	130	121	113
	VM X B	Control	113	125	119	110
		BL	123	140	134	113
		BH	123	138	132	121
		VM	120	133	129	122
		VM X BL	139	146	136	120
		VM X BH	117	130	123	114
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 68. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on mean feed consumption (MF) age 26 d (MF26), 34 d (MF34), 40 d (MF40) and 48 d (MF48) of male broilers reared at 24° C.

Treatments			MF26	MF34	MF40	MF48
Main effects#	VM	Control	120	135	128	115
		VM	125	136	129	119
	E	Control	124	139	134	122
		EL	119	132	124	111
		EH	123	135	128	117
	B	Control	117	129	124	116
		BL	131	143	135	117
		BH	119	134	127	118
Interactions#	VM X E	Control	124	137	132	117
		EL	110	127	117	105
		EH	125	140	136	122
		VM	125	140	136	127
		VM X EL	128	138	131	117
		VM X EH	122	130	121	113
	VM X B	Control	113	125	119	110
		BL	123	140	134	113
		BH	123	138	132	121
		VM	120	133	129	122
		VM X BL	139	146	136	120
		VM X BH	117	130	123	114
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 69. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on feed efficiency (EF) age 26 d (EF26), 34 d (EF34), 40 d (EF40) and 48 d (EF48) of male broilers reared at 24° C.

Treatments			EF26	EF34	FE40	FE48
Main effects#	VM	Control	0.52	0.48	0.52	0.53
		VM	0.50	0.49	0.52	0.52
	E	Control	0.52	0.48	0.52	0.52
		EL	0.50	0.49	0.53	0.53
		EH	0.51	0.49	0.52	0.52
	B	Control	0.53	0.52	0.54	0.53
		BL	0.48	0.46	0.52	0.54
		BH	0.52	0.47	0.51	0.50
Interactions#	VM X E	Control	0.51	0.49	0.51	0.52
		EL	0.54	0.51	0.57	0.57
		EH	0.50	0.46	0.49	0.51
		VM	0.52	0.48	0.53	0.52
		VM X EL	0.46	0.46	0.50	0.49
		VM X EH	0.53	0.51	0.55	0.54
	VM X B	Control	0.52	0.52	0.53	0.54
		BL	0.52	0.48	0.50	0.54
		BH	0.51	0.46	0.53	0.53
		VM	0.53	0.53	0.54	0.53
		VM X BL	0.44	0.45	0.53	0.54
		VM X BH	0.53	0.49	0.50	0.48
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	n.s	n.s	n.s
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	n.s	n.s

n.s=not significant, EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 70. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on feed consumption percentage of final body weight age 26 d (PFC26), 34 d (PFC34), 40 d (PFC40) and 48 d (PFC48) of male broilers reared at 24° C.

Treatments			PFC26	PFC34	PFC40	PFC48
Main effects#	VM	Control	5.56	8.39	8.85	9.37
		VM	5.67	8.17	8.54	9.08
	E	Control	5.71	8.41	8.84	9.37
		EL	5.39	7.99	8.27	8.85
		EH	5.74	8.45	8.90	9.44
	B	Control	5.64	8.05^{b}	8.63	9.18^{a}
		BL	5.50	8.06^{b}	8.29	8.72^{b}
		BH	5.70	8.72^{a}	9.10	9.77^{a}
Interactions#	VM X E	Control	5.72	8.35	8.95	9.47
		EL	5.47	8.45	8.63	9.26
		EH	5.50	8.40	8.95	9.38
		VM	5.70	8.47	8.73	9.28
		VM X EL	5.31	7.54	7.92	8.45
		VM X EH	5.98	8.49	8.85	9.51
	VM X B	Control	5.63	8.12	8.75^{ab}	9.10^{a}
		BL	5.45	8.39	9.15^{ab}	9.91^{a}
		BH	5.60	8.67	8.64^{ab}	9.09^{ab}
		VM	5.65	7.98	8.51^{ab}	9.25^{a}
		VM X BL	5.54	7.74	7.43^{b}	7.53^{b}
		VM X BH	5.80	8.78	9.56^{a}	10.45^{a}
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	*	n.s	*
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	**	**

n.s=not significant, ,*=p<0.05,*=p<0.0005,a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 70. Effects of electrolyte (E), virginiamycin (VM) and betaine (B) on feed consumption percentage of final body weight age 26 d (PFC26), 34 d (PFC34), 40 d (PFC40) and 48 d (PFC48) of male broilers reared at 24° C.

Treatments			PFC26	PFC34	PFC40	PFC48
Main effects#	VM	Control	5.56	8.39	8.85	9.37
		VM	5.67	8.17	8.54	9.08
	E	Control	5.71	8.41	8.84	9.37
		EL	5.39	7.99	8.27	8.85
		EH	5.74	8.45	8.90	9.44
	B	Control	5.64	8.05[b]	8.63	9.18[a]
		BL	5.50	8.06[b]	8.29	8.72[b]
		BH	5.70	8.72[a]	9.10	9.77[a]
Interactions#	VM X E	Control	5.72	8.35	8.95	9.47
		EL	5.47	8.45	8.63	9.26
		EH	5.50	8.40	8.95	9.38
		VM	5.70	8.47	8.73	9.28
		VM X EL	5.31	7.54	7.92	8.45
		VM X EH	5.98	8.49	8.85	9.51
	VM X B	Control	5.63	8.12	8.75[ab]	9.10[a]
		BL	5.45	8.39	9.15[ab]	9.91[a]
		BH	5.60	8.67	8.64[ab]	9.09[ab]
		VM	5.65	7.98	8.51[ab]	9.25[a]
		VM X BL	5.54	7.74	7.43[b]	7.53[b]
		VM X BH	5.80	8.78	9.56[a]	10.45[a]
ANOVA	DF	Significant				
VM	1		n.s	n.s	n.s	n.s
E	2		n.s	n.s	n.s	n.s
B	2		n.s	*	n.s	*
VM X EL	2		n.s	n.s	n.s	n.s
VM X B	2		n.s	n.s	**	**

n.s=not significant, ,*=p<0.05,*=p<0.0005,a-b means with in a major heading with unlike super script differ (p<0.05), EL=electrolyte low level, EH= electrolyte=high level, b=betaine, BL=betaine low level (0.05), BH=betaine high level (0.1), #=main effects values and /or interactions represent least square means averaged over treatment not listed with category.

Table 71. Electrolytes

No	Ingredient	EL (L) G
1	Potassium Bicarbonate	43.12
2	Potassium Chloride	9.24
3	Potassium Sulfate	5.54
4	Sodium Bicarbonate	24.02
5	Magnésium	23.76
6	Manganese	1.58
7	Zinc	0.92
8	Copper	0.21
9	Selenium	0.00024
10	Total	108.4114

Table 71 (a). Electrolytes

No	Ingredient	EL (H) G
1	Potassium Bicarbonate	86.248
2	Potassium Chloride	18.48
3	Potassium Sulfate	11.088
4	Sodium Bicarbonate	48.048
5	Magnésium	47.52
6	Manganese	3.166
7	Zinc	1.848
8	Copper	0.4224
9	Selenium	0.00048
10	Total	216.822

TABLE 72. NUTRIENT COMPOSITION

NUTRIENT	UNIT	STARTER	FINISHER
PROTEIN, CRUD (%)	PCT	23.500	22.67
FAT, CRUD	PCT	7.8188	4.9524
CALCIUM	PCT	1.2500	1.00
FIBBER CRUDE	PCT	4.952	4.592
PHO.TOTAL	PCT	0.8033	0.689
M.E.	KCAL/ LB	1460	1397
METHIONINE	PCT	0.5350	0.540
CYSTINE	PCT	0.3678	0.3554
LYSINE	PCT	1.3144	1.2570
TRYPTOPHAN	PCT	0.2649	0.2581
THERONINE	PCT	0.9428	0.9160
ISOLEUCINE	PCT	1.1204	1.0942
HISTIDINE	PCT	0.5222	0.5150
VALINE	PCT	0.12558	1.2168
LEUCINE	PCT	2.0015	1.9670
ARGININE	PCT	1.6743	1.6245
PHENYLALANINE	PCT	1.1095	1.0969
VITAMIN A	KIU/LB	0.5954	0.6593
VITAMIN E	MG/LB	7.3972	7.8742
THIAMINE	MG/LB	1.1808	1.2794
RIBOFLAVIN	MCG/LB	0.6884	0.7075
PANTOTHENIC ACID	MG/LB	0.34024	3.5005
BIOTIN	MCG/LB	67.1696	67.8629
FOLIC ACID	MCG/LB	200.416	207.754
CHOLINE	MG/LB	752.126	750.474
VITAMIN B 12	MCG/LB	0.0750	0.0850
NIACIN	M/LB	8.68388	9.2055
SODIUM	PCT	0.2000	0.2000
POTASSIUM	PCT	0.7940	0.7938
MAGNESIUM	PCT	0.1761	0.1821
SULPHUR	PCT	0.2042	0.2070
MANGANESE	PPM	257.866	256.960
IRON	PPM	375.755	430.213
COPPER	PPM	109.354	109.442
ZINC	PPM	226.406	227.800
SELENIUM	PPM	3.6653	0.1500
FLOURINE	PCT	---	0.0044

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