# EFFECT OF DIETARY CATION-ANION BALANCE ON GROWTH PERFORMANCE OF BROILER CHICKEN

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

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# DECLARATION

I hereby declare that this thesis entitled **EFFECT OF DIETARY CATION ANION BALANCE ON GROWTH PERFORMANCE OF BROILER CHICKEN** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or other similar title of any other University or Society

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# CERTIFICATE

Certified that the thesis entitled **EFFECT OF DIETARY CATION ANION BALANCE ON GROWTH PERFORMANCE OF BROILER CHICKEN** is a record of research work done independently by **Dr Mary Juliet Francis** under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to her

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***Mary Juliet Francis***

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# *Introduction*

# 1 INTRODUCTION

In the recent past broiler industry has registered a substantial growth India has a total broiler population of 1000 million with annual meat yield of 12 5 lakh tonnes Being a short duration business act vity large number of entrepreneurs have taken up broiler farming Rearing of broiler chicks has now become popular than rearing of layer chicks because of better net ncome in broiler production

A major problem faced by the poultry industry is the high cost of feed ingredients which accounts for 70 per cent of total cost of production So nutritionists are concentrating their research to reduce the feed cost and to increase the feed efficiency Manipulation of acid base balance in the feed is a recent trend in avian nutrition Acid base balance of the diet can affect the performance of broiler birds but is not usually considered when rations are formulated The effect of acid base balance on the performance of broiler birds is currently an issue discussed by researchers worldwide

Dietary cation anion balance (DCAB) is a principal factor in acid base balance regulation which determines blood pH for optimum enzymatic act on and thus influences bird growth and performance Dietary cation anion balance refers to the difference between positive and negative ions present in the diet The most commonly used equation for the same is $Na^+ + K^+$ Cl expressed as milliequivalents per kilogram of dry matter (Mongin 1980) While requirements of the three individual elements have been cle irly defined there is currently an understanding of the need to achieve a balance between cation and anion supply

In most situations birds will attempt to mainta n the balance between cations and anions in the body such that pl ysiological pH is maintained If there is a shift towards acid or base cond tions the ormal physiological defense mechanism is to alter the metabolic processes such that normal conditions prevail In extreme situat ons such modification in regulating mechanisms seems to adversely affect other phys olog cal systems and produce or accentuate potentially debilitating conditions When the balance is altered to an extreme degree due to acidosis or alkalosis metabolic pathways cannot function with maximum efficiency

Electrolyte salts not only alter performance but also tend to alter faecal and l tter mo sture Besides sod um potassium and chloride are low cost nutr ents and the r manipulation has little significance on the diet cost. However because of their mportant metabolic effects on nerve cells acid base balance and amino acid absorption it is necessary to supply them in precise levels for optimum growth bone development and good litter quality Hence this study was conducted to evaluate the effect of altering the cation anion balance on growth feed efficiency and carcass characteristics of broilers and to arrive at the economics in altering DCAB in the diet of bro ler chicken

# *Review of Literature*

# 2 RCVICW OΓ LITCRATURC

## 2 I REQUIREMENTS AND INTER RELATIONSHIPS OF SODIUM POTASSIUM AND CHLORIDE

Increase ın the chlonde content w thout ıncreasıng sodıum or potassıum content depressed growth rate ın chıcks (Neshem *et al* 1964) The balance between dıetary concentratıons of sodıum potassıum and chlonde has sıgnıficant nfluence on the performance of chıcken Hıgh sodıum levels wıthout adequate chlonde caused heavy weıght loss and addıtıon of chlonde reversed thıs effect (Mellıere and Forbes 1966) They also reported that between sodıum and potassıum excess amounts of sodıum was more detrımental A study was conducted by Hurwıtz *et al* (1973) to find out the requırements of sodıum and chlor de and they found that broıler chıcks responded to supplementatıon of sod um (0 06 to 0 24 per cent) at low levels of chlonde (0 16 per cent) whıch was not seen at h gh chlonde levels Peak performance was observed wıth a salt supplementatıon of 0 3 to 0 35 per cent correspondıng to 1 3 per cent sodıum or chlonde Mannıng *et al* (1978) suggested a level of 0 15 per cent sodıum for broıler chıck growth and 0 1 per cent at five weeks of age

Sullıvan and Nıjoku (1979) op ned that for optımum performance layer ratıons should contaın at least 0 11 per cent chlonde and 0 16 per cent sodıum Low levels of sodıum (0 04 per cent) and chlonde (0 05 per cent) were found to depress growth ın layers Damron and Harms (1981) reported that at both four and eıght weeks requırement for sodıum and chlor de was hıgher than 0 15 per cent suggested by NRC for broılers Chrıstmas and Harms (1982) suggested that when sodıum levels were h gh and correspondıng chlonde levels low performance was depressed Low chlor de levels reduced egg weıght at all sodıum levels

Weight gain was increased by adding potassium at 0 8 per cent above basal level of 0 73 per cent in bro lers (dietary potassium levels of 1 5 to 2 1 Smith and Teeter 1987) Austic and Keshavarz (1988) reported that increasing the proportion of sodium relative to chloride decreased food intake but increased eggshell strength and thickness in layers

Dietary chloride did not have a sign f cant effect on body weight gain or fertility of eggs (Harl *et al* 2000) Rondon *et al* (2001) stated that optimum performance was obtained by sodium and chloride levels of 0 28 and 0 25 per cent during 1 to 21 day period where as 0 15 and 0 23 per cent produced maximum performance during 21 to 42 day period in broilers (Murkami *et al* 2001)

2 2 WEIGHT GAIN AND GROWTH

Mell ere and Forbes (1966) fed chicks purified d ets with a wide range of cat on anion ratios They found that growth was depressed by both narrow and wide ratios and that feed consumption and weight ga n were maximized when the ratios ranged from 1 2 1 to 1 8 1 They also reported that when both sod um and potassium were added to the basal diet at a ratio of 2 4 1 weight gain was not depressed Nelson *et al* (1981) found that altering the dietary cation anion ratio by adding either magnes um or phosphorus also had a significant influence on the performance of chicks Growth rates improved when chicks were given diets with narrow (1 7 1) ratios than wide (2 2 1) ratios Halley *et al* (1987) obtained cation anion rat os of 0 85 1 1 06 1 and 1 35 1 using calcium magnesium pl osphorus chlor de and sulphate and they observed that the heaviest chicks were seen at intermediate cation an on ratio of 1 06 1

Mongin (1981) op ned that only sodium potassium and chloride play the major role n ac d base balance and when (Na+K Cl) is higher or lower than 250 meq per kg growth rate was depressed Johnson and Karunajeewa (1985) reported that dietary electrolyte balance between 250 and 300 meq per kg is opt mum for maximum growth of the bro lers

Adekunm si and Robbins (1987) studied the interrelationships between levels of crude protein and electrolyte balance in broiler chicken and concluded that dietary electrolyte balance varies with crude protein content of the diet Increasing the dietary electrolyte balance in low protein diets decreased growth rate whereas in high protein diets ncreased growth rate When anions such as chloride sulphate and mono di tr basic phosphate were added at graded levels none of the anions added to the diet at 160 meq per kg or less affected body weight and a higher level of chlor de decreased weight gain by 16 to 22 per cent (Ruiz Lopez *et al* 1993)

A study was conducted to determine the sodium and chloride requirements for chicks by Murakami *et al* (2001) and the body weight gain was found to be maximum at 249 to 264 meq per kg Borges *et al* (2003a) suggested a dietary electrolyte balance of 240 meq per kg for best weight gain in broiler chicken In another study with dietary electrolyte balance of 40 140 240 and 340 meq per kg 240 meq per kg had the best weight gain during 0 to 21 day period and 0 to 42 day period in broiler chicken (Borges *et al* 2003b) When electrolyte ratio was increased only by the supplementation of sodium 264 meq per kg had the best weight gain and when sodium and potassium levels were increased it was 213 meq per kg Borgatti *et al* (2004) observed best weight gain with diets 290 and 330 meq per kg in broilers Best weight gain was observed at 163 meq per kg by Majorka *et al* (2004) and a quadratic effect was observed between cation anion balance and weight gain in broiler birds Cation anion balance of 166 meq per kg produced a higher weight gain when CP content was 20 per cent and 177 meq per kg for 23 per cent CP in a study conducted by Vieites *et al* (2004) in broiler chicks

Electrolyte balance had no significant effects on growth rate (Karunajeewa *et al* 1986) It was also seen that growth depression caused by higher concentration of inorganic phosphorus in the finisher d ets was partially alleviated by increasing the electrolyte balance to either 250 or 300 meq per kg diet

Hulan *et al* (1987) reported that feeding diets with Na+K Cl between 155 and 300 meq per kg had little effect on growth and feed conversion Increasing the chloride content of the diet increased total growth independently of dietary cat on level In another study to determine the influence of dietary electrolyte balance and source of potassium on performance of broilers it was again found that the dietary treatments had no significant effect on growth performance of bro ler chicken at starter phase (Karunajeewa and Barr 1988) Weight gain ranged from 1370 to 1429g from 21 to 42 days of age But potassium sulphate increased we ght ga n than potassium carbonate Gorman and Balnave (1994) also reported no apparent relationships between broiler performance and dietary electrolyte balance in broiler chicken

## 2 3 FEED CONSUMPTION AND FEED CONVERSION EFFICIENCY

Melliere and Forbes (1966) altered the cation anion ratio in young chicks using L glutamic acid hydrochloride and sodium and potassium carbonate Food consumption was dependent upon the dietary cation anion ratio defined as meq cation per unit weight of diet Increasing the chloride content depressed food consumption when cation content was not increased concurrently Feed consumption and feed efficiency were found to be better at 1 2 1 to 1 8 1 Nelson *et al* (1981) altered the cation anion content with magnesium and phosphorus and narrow ratios showed better feed efficiency when compared to wider ratios in broiler cockerels

Johnson and Karunajeewa (1985) determ ned that the best dietary electrolyte balance in young chicks was between 200 and 250 meq per kg

Adekunm se and Robbıns (1987) after stı dyıng the dıetary electrolyte balances at two dıfferent crude proteın concentratıons came to the conclusıon that there was a reductıon ın feed ıntake when electrolyte balance was ıncreased ın low proteın dıets but ın hıgh proteın d ets feed ıntake ımproved They concluded that dıetary electrolyte balance varıes wıth crude proteın concentratıon Best feed conversıon ratıos were obtaıned when broılers were fed dıets contaınıng 249 and 261 meq per kg Borges *et al* (2002) reported that maxımum feed ıntake was observed at 202 meq per kg when sodıum and potassıum levels are concurrently ıncreased When sodıum alone was ıncreased ın the dıet a lınear ıncrease ın feed ıntake was obtaıned ındıcatıng that sodıum stımulates feed ıntake but when sodıum and potassıum were ıncreased together potassıum depressed feed ıntake above a certa n lımıt Maxımum feed gaın was observed at 264 meq per kg ın broıler chıcken

Borges *et al* (2003a) reported that dıetary electrolyte balance of 240 meq per kg gave hıgher feed ıntake but feed conversıon ratıo was hıgher for 360 meq per kg dur ng 0 to 21 day perıod Dıetary electrolyte balance was altered usıng sodıum b carbonate ammonıum chlorıde and potassıum bıcarbonate ın broılers In another experıment wıth dıetary electrolyte balance of 0 140 240 and 340 meq per kg at two temperature treatments feed ıntake was hıgher for the bırds fed 240 meq per kg (Borges *et al* 2003b) n thermo neutral chamber whereas no treatment dıfference was recorded ın those bırds maıntaıned ın heat stress chamber But no sıgnıficant effect was seen for feed conversıon ratıo

Among 0 120 240 360 meq per kg dıetary electrolyte balance of 240 meq per kg fed group gave the most favourable result durıng 0 to 42 day perıod wıth mproved feed conversıon ratıos (Borges *et al* 2004a) When all the three electrolytes varıed feed ıntake was max mum at 213 meq per kg and at constant potass um levels feed ntake was maxımum at 254 meq per kg (Borges *et al* 2004b) In a sımılar study ın fınıshers Rondon *et al* (2001) observed maxımum feed ıntake and feed convers on ratıo when electrolyte balance was between 298 meq per kg to 315 meq per kg at fixed chloride levels and between 246 to 264 meq per kg at fixed sodium levels Majorka *et al* 2004 observed that Na+K Cl had a quadratic effect on feed intake and maximum feed intake was at 174 meq per kg during pre starter stage in broilers

In contrast to the above observations Karunajeewa *et al* (1986) observed that dietary electrolyte balance had no effect on feed conversion ratio Hulan *et al* (1987) reported that the feed efficiency was similar in broiler chicken fed diets with 155 meq per kg to 300 meq per kg at a calcium level of 0 95 per cent Karunajeewa and Barr (1988) studied the influence of electrolyte balance on the performance of male broilers and reported that the electrolyte balance of 125 165 and 205 meq per kg had no significant effect on feed intake or feed conversion ratio Gorman and Balnave (1994) reported that there was no apparent relationship between broiler performance and electrolyte balance Jianlin *et al* (2004) reported that there was no significant benefit of maintaining the dietary electrolyte balance at 250 meq per kg for feed consumption or feed conversion ratio

2 4 CARCASS CHARACTERISTICS

Borges *et al* (2003a) evaluated dietary electrolyte balance for broiler chicken under moderately high ambient temperatures at d etary electrolyte balances of 0 120 240 and 360 meq per kg and concluded that no significant effect was found on carcass yield breast thigh plus leg back wing or abdominal fat content

Karunajeewa *et al* (1986) studied the effect of dietary phosphorus concentration and electrolyte balance on the growth performance of broiler chicken He observed that electrolyte balance had no effect on abdominal fat pad weight and tibial ash content But dressing percentage was low in males fed inorganic phosphorus at a rate of 4 7 g per kg with electrolyte balance of 300 meq per kg and females at a rate of 9 8 g per kg w th electrolyte balance of 150 to 200 meq per kg Souza *et al* (2002) reported that potassium chlor de s gnificantly reduced abdominal fat when supplemented at 1 2 per cent and also noted that when energy level of the ration was increased abdom nal fat also increased Whit ng *et al* (1991) observed that there was no s gnificant effect on carcass characterist cs when sodium bicarbonate was supplemented at 0 5 per cent level in drinking water but 0 5 per cent potass um chloride supplemented birds had a h gher abdom nal fat pad when compared to those g ven both potassium chloride and sod um b carbonate or sodium carbonate alone

A quadratic effect was observed on wing yield and dietary electrolyte balance and l near effect on breast yield at dietary electrolyte balance of 210 250 290 and 330 meq per kg (Borgatt *et al* 2004) But no significant effect was seen on carcass yield abdominal fat heart liver gizzard feet blood and i o ied ble parts

## 2 5 MORTALITY

Electrolyte balance had no significant effect on mortality when an experiment was conducted by Karunajeewa *et al* (1986) at dietary electrolyte balance of 150 200 250 and 300 meq per kg during 0 to 49 days A similar result was obtained at 125 165 205 meq per kg during 0 to 21 days (Karunajeewa and Barr 1988) The ma n causes of mortality observed were bacterial omphalitis or yolk sac infect ons dur ng starter phase and sudden death syndrome during finisher phase

There was no signif cant effect of dietary electrolyte balance on mortality but high sodium high calcium and low potassium diets had a trend for higher mortality (Hulan *et al* 1987 Adekunm si and Robbins 1987 Borges *et al* 2003a Borges *et al* 2003b Borges *et al* 2004a Borgatti *et al* 2004)

## 2 6 WATER INTAKE AND LITTER MOISTURE

The moisture of the droppings is dependent on level of d etary sodium (Hurwitz *et al* 1973) They also ind cated that in diets with high sodium calcium ratios supplement ng d etary calcium suppressed the faecal moisture content Mongin (1981) op ned that an increase in salt intake would cause an increase in water intake He also noted that chloride ion was not related to the humidity of droppings Sodium and potassium were the main causes of wet droppings and any increase in (Na+K) will increase water consumption and faecal moisture This finding is supported by Hulan *et al* (1987) who reported an increase in litter wetness at high levels of sodium and potassium whereas effect of chloride depended on the level of calcium n the diet They also noted that wet l tter caused by high calcium levels were moderated by feed ng high chloride

Rondon *et al* (2001) observed a l near increase in litter moisture due to increased dietary sodium levels but there was no effect of dietary chloride on litter moisture in 1 to 21 day old broiler chicken Similar result was obtained in 21 to 42 day old broiler chicks (Murakami *et al* 2001)

Pesti *et al* (1985) after studying the water consumption of broilers under commercial conditions reported that the thumb rule that chicken consume water twice the weight of feed over estimates water consumption of broilers In their trial broilers consumed 1 77 g water for each gram feed consumed Water consumption was a linear function of broiler age They also concluded that water consumption depends upon dietary sodium level in an experiment conducted to review the utilization of sodium from sodium b carbonate by broiler chicks

Damron *et al* (1986) observed that as levels of sodium in the diet increased water intake was higher for sodium bicarbonate treatments but litter moisture d d not differ significantly between treatments given sodium bicarbonate and sodium chloride Whiting *et al* (1991) after supplementing drinking water with potassium chloride and sod um bicarbonate at 0 5 per cent level alone and together concluded that water consumption was higher in those birds given both salts together at 0 5 per cent level than those supplemented a single salt

After comparing the effects of dietary electrolyte balance of 0 120 240 and 360 meq per kg Borges *et al* (2003a) observed that water intake was highest at 360 meq per kg Increasing the dietary electrolyte balance caused a linear increase in water intake wh ch was reflected n increased litter moisture Birds fed 350 meq per kg had higher litter moisture even at one week of age Water consumption showed a linear trend as the electrolyte balance was increased resulting in greater litter moisture Diets with 340 meq per kg resulted in litter mo sture above acceptable limits (Borges *et al* 2004a Majorka *et al* 2004)

## 2 7 MINERAL RETENTION AND EXCRETION

Teeter and Smith (1986) observed a 27 3 per cent increase in K excretion in broiler chicken maintained at 36$^0$C and 60 per cent relative humidity than those at 24$^0$C and 50 per cent relative humidity Belay *et al* (1992) reported a reduct on in the retention of K P S Na Zn and Cl and an increase in the urinary excretion for Mg K P and S They also reported an increased excretion of urinary Na But urinary Cl excret on expressed as mg per kg body we ght per 12h decreased from 18 9 $\pm$ 1 4 to 11 3 $\pm$ 0 7 during heat stress

After studying the m neral supplementation at high temperatures in broilers Gorman and Balnave (1994) concluded that absolute retention of all cat ons was increased by self supplementation with the exception of calcium wh ch showed no effect Percentage retent on of chloride and sulphur were s gnificantly reduced by self supplementation while phosphorus was unaffected Heat stress ncreased ur nary excret on of Ca P K Na Mg S and Mn while reduced urinary chloride excretion by 74 per cent n broiler chicken (Belay and Teeter 1996)

Husseiny and Cregar (1981) after conducting balance studies in broiler chicks concluded that retention efficiency of Ca Cu Fe Mg Mn Na P and Zn declined sharply with increasing temperature up to 32$^0$C Faecal dry matter and nitrogen decreased with increasing cation anion difference

2 8 PLASMA MINERAL CONCENTRATION

Heat stress in birds cause changes in mineral balance and is associated with decreased plasma Na, Ca, Mg and inorganic P concentration in turkeys (Kohne and Jones 1975b) and increased K concentration (Kohne and Jones 1975a) It was also reported that plasma chloride levels did not vary significantly at varying temperatures Plasma Ca and P levels were significantly depressed in hen fed diets containing low phosphorus (Junqueira *et al* 1984a)

Johnson and Karunajeewa (1985) concluded that plasma ion levels of Ca Mg Na, K and Cl were not affected by dietary treatments with cation anion balances of 29 to 553 meq per kg Plasma Na concentration increased linearly with increasing dietary electrolyte balance in swine (Haydon *et al* 1990)

Borges *et al* (2003b) confirmed the finding that blood potassium levels increased significantly under heat stress Borges *et al* (2004a) reported that concentration of Na and K decreased during acute heat stress Serum chloride decreased in dietary electrolyte balance of 0 and increased in 120 240 and 360 meq per kg treatments

2 9 SERUM BIOCHEMICAL PARAMETERS

Kaneko *et al* (1997) reported normal serum cholesterol values of 183 3 mg per dl in chicken Adekunmisi and Robbins (1987) reported significant increase in the plasma uric acid concentration when fed a diet with cation anion balance of 513 meq per kg (1 90 to 2 24 mg per dl) than birds fed 210 meq per kg Plasma uric acid concentration increased in chicks fed high protein diets and decl ned ın bırds fed low proteın d ets (Machın *et al* 2004) He also reported that plasma glucose concentratıon was lower n ch cks fed low proteın dıets Borges *et al* (2003b) observed no sıgnıficant effects of dıetary electrolyte balance on blood glucose levels

# Materials and Methods

# 3 MATERIALS AND METHODS

An experiment was conducted in the Department of Animal Nutr t on College of Veterinary and An mal Sciences Mannuthy for a period of six weeks to study the effect of dietary cation anion balance on growth performance of broiler chicken

## 3 1 EXPERIMENTAL MATERIALS

### 3 1 1 Experimental Birds

One hundred and sixty day old straight run commercial broiler chicks (Ven cobb) procured from Venkateshwara Hatcheries Ltd Palakkad Kerala formed the experimental subjects

### 3 1 2 Experimental Rations

Four experimental rations were formulated viz

(i) T1 Standard broiler ration (as per 1992 BIS spec fications) with DCAB 260 meq per kg feed (control)

(ii) T2 Standard broiler ration with DCAB 210 meq per kg

(iii) T3 Standard broiler ration with DCAB 310 meq per kg

(iv) T4 Standard broiler ration with DCAB 360 meq per kg

Sodium potassium and chlor de content of all ingred ents were estimated The DCAB of the standard ration was calculated based on the estimated values Dietary cation anion balance was altered using sodium bicarbonate and ammonium chloride in all the treatments All other ngredients were similar in all the rations Feed ingred ents used in the formulations of the experimental rations were only yellow maize and soyabean meal in order to avo d much variation in cation anion content

Broiler starter ration was fed upto four weeks of age and then switched over to bro ler finisher ration t ll the end of the experiment The ingredient composit on and the chemical composit on of the four different starter and finisher rations are presented in Tables1 and 2 respectively

3 2 EXPERIMENTAL METHODS

**3 2 1 Disinfection**

The experimental pens feeders waterers and other equ pments were properly cleaned and disinfected one week before the chicks were housed The disinfection was done by using Kohrsolin TH solution (manufactured by Hamburg Germany Marketed in India by Glaxo Smithkline Pharmaceuticals Ltd Agrivet Farm Care Div Dr Annie Besant road Mumbai 400025) the active content being gluteraldehyde 7g per 100 ml The dilution was done at the rate of five ml of the product per 20 litres of water

**3 2 2 Feeding Management**

The birds were provided with feed and water *ad libitum* throughout the experimental period and were maintained under deep litter system of management

**3 2 3 Vaccination**

Day old chicks were wing banded weighed individually and vaccinated against Ranikhet disease using lasota vaccine before housing The birds were vaccinated against Infectious Bursal Disease on $14^{th}$ day

**3 2 4 Experimental Design**

Chicks were randomly divided into 16 groups of 10 ch cks each The groups were allotted randomly to four dietary treatments viz T1 T2 T3 and T4 with four replicates in each treatment

**3 2 5 Meteorological Parameters**

The wet and dry bulb thermometer readings were taken at 9 am and 4 pm daily The maximum and minimum temperatures were recorded at 9 am on all days throughout the experimental period From these data weekly mean maximum and minimum temperature and percent relative humidity were arrived at

**3 2 6 Body Weight**

The body weight of each bird was recorded at weekly intervals

**3 2 7 Feed Consumption**

The feed intake of the birds was recorded replication wise at weekly intervals From this data the average feed intake per bird per day was calculated for various treatment groups

**3 2 8 Feed Conversion Ratio**

The feed conversion ratio (kg feed per kg gain) was calculated based on the data on body weight gain and feed intake

**3 2 9 Metabolism Trial**

At the end of the experiment a three day metabolism trial was conducted using one bird from each replicate selected randomly and housed individually in metabolism cages with facilities for feeding watering and excreta collection Excreta samples were collected over 24 hour period for three consecutive days using total collection method as described by Summers *et al* (1976) The droppings were weighed and samples were taken and stored in deep freezer for analysis The total amount of feed and water consumed and excreta voided were also recorded

### 3.2.10 Chemical Analysis

The chemical composition of experimental rations was determined as per the standard procedures (AOAC, 1990). The nitrogen in the excreta sample was determined in fresh material as per the procedure described in AOAC, 1990. For mineral analyses, the diet and excreta samples were subjected to wet digestion using nitric acid and perchloric acid (2:10).

The content of sodium and potassium in the digested sample was determined using Atomic Absorption Spectro photometer (Perkin–Elmer model-3110) and phosphorus by Vanado molybdate method (AOAC, 1990). The content of chloride was determined by Volhard's method (Korthoff and Sandell, 1973). From the data obtained on the total intake and out go of nutrients during the metabolism trial, nitrogen retention and availability of sodium, potassium and chloride were calculated.

### 3.2.11 Dietary Cation-Anion Balance (DCAB) of Ration

Dietary cation-anion balance of the rations were calculated based on Na, K and Cl content of the diet and expressed as meq per kg.

### 3.2.12 Processing Yields

At the end of the sixth week, one bird from each replicate was randomly selected and sacrificed to study the processing yields as per the procedure described by BIS (1973). Percentages of dressed yield, giblet yield and abdominal fat yield were calculated from the slaughter data.

### 3.2.13 Cost Analysis

Cost of production of birds reared on different dietary treatments were calculated based on the cost of feed ingredients used for the study.

**3 2 14 Statistical Analysis**

Data collected on various parameters were statistically analysed by Completely Randomized Design (CRD) as described by Snedecor and Cochran (1985)

Table 1 Ingredient compos tion of experimental diets %

| Ingredients | Starter | | | | Finisher | | | |
|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Yellow maize | 52 50 | 52 50 | 52 50 | 52 50 | 61 00 | 61 00 | 61 00 | 61 00 |
| Soyabean meal | 43 00 | 43 00 | 43 00 | 43 00 | 35 00 | 35 00 | 35 00 | 35 00 |
| Mineral mixture | 1 75 | 1 75 | 1 75 | 1 75 | 1 75 | 1 75 | 1 75 | 1 75 |
| Toxin binder[1] | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 |
| Coccidiostat[2] | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 | 0 05 |
| Choline chloride | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 |
| Methionine | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 | 0 15 |
| Common salt | 0 25 | 0 25 | 0 25 | 0 25 | 0 25 | 0 25 | 0 25 | 0 25 |
| Vitamin premix[3] | 0 03 | 0 03 | 0 03 | 0 03 | 0 03 | 0 03 | 0 03 | 0 03 |
| Ammonium chloride | 0 65 | 0 82 | 0 47 | 0 30 | 0 33 | 0 50 | 0 15 | 0 00 |
| Sodium bicarbonate | 1 42 | 1 25 | 1 6 | 1 77 | 1 24 | 1 07 | 1 42 | 1 57 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

Toxin binder (Toxiwin™)

Contains Hydrated sodium calcium alumino silicate

[2]Coccidiostat (Anacox™ 1%)

Each gram contains Maduramycin ammonium 10 mg

[3]Vitamin mixture NICOMIX $AB_2D_3K$ and NICOMIX BE (Nicholas Primal India Ltd India) 1 1 ratio

Composition per gram

NICOMIX $AB_2D_3K$ Vitamin A 82500 IU Vitamin $B_2$ 50 mg Vitamin $D_3$ 12000 IU Vitamin K 10 mg

NICOMIX BE Vitamin B – 4 mg Vitamin $B_6$ 8 mg Vitamin $B_{12}$ 40 µg Niacin 60 mg Vitamin E 40 mg

Ca pantothenate 40 mg

Table 2 Chemical composition of starter and finisher rations fed to the experimental birds*

| Items** | Starter | | | | Finisher | | | |
|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T1 | T2 | T3 | T4 |
| Crude Protein | 23 0 | 23 30 | 22 9 | 23 07 | 20 20 | 20 12 | 20 67 | 20 15 |
| Ether Extract | 1 60 | 1 51 | 2 40 | 1 45 | 1 89 | 1 95 | 2 40 | 1 75 |
| Crude Fiber | 2 2 | 2 61 | 2 49 | 2 24 | 2 69 | 2 55 | 2 59 | 2 42 |
| N F E | 64 14 | 65 77 | 62 98 | 64 29 | 66 39 | 68 55 | 67 23 | 68 15 |
| Total Ash | 9 06 | 6 81 | 9 23 | 8 95 | 8 83 | 6 85 | 7 11 | 7 53 |
| AIA | 2 32 | 0 84 | 1 81 | 1 55 | 2 46 | 0 70 | 1 14 | 1 60 |
| Nitrogen | 3 68 | 3 73 | 3 66 | 3 69 | 3 23 | 3 22 | 3 31 | 3 22 |
| Calcium | 0 71 | 0 65 | 0 81 | 0 84 | 0 97 | 0 91 | 0 85 | 0 92 |
| Total Phosphorus | 0 55 | 0 61 | 0 71 | 0 69 | 0 62 | 0 59 | 0 60 | 0 56 |
| Sodium | 0 52 | 0 46 | 0 79 | 0 88 | 0 41 | 0 37 | 0 45 | 0 49 |
| Potassium | 0 87 | 0 84 | 0 70 | 0 74 | 0 83 | 0 89 | 0 88 | 0 88 |
| Total Chloride | 0 69 | 0 72 | 0 73 | 0 67 | 0 55 | 0 64 | 0 35 | 0 25 |
| ME Kcal/kg*** | 2824 63 | 2824 63 | 2824 63 | 2824 63 | 2909 25 | 2909 25 | 2909 25 | 2909 25 |

* on dry matter basis
** % except ME
*** calculated values

# *Results*

# 4 RESULTS

The results obtained n the present study are presented under d fferent sub headings

## 4 1 METEOROLOGICAL PARAMETERS

The data pertain ng to climatic parameters v z the mean maximum and m n mum temperatures and percent relative humidity at weekly intervals are presented n Table 3 The mean minimum and max mum temperatures recorded were 23 95$^0$C and 34 56$^0$C respectively The mean relative humid ty recorded was 67 82 per cent at 9 AM and 45 60 per cent at 4 PM

## 4 2 BODY WEIGHT

The data on weekly mean body weight of b rds are presented in Table 4 and graphically in Fig 1 The mean body weight of b rds belonging to four d fferent d etary treatments T1 T2 T3 and T4 at the end of the six week experimental period were 2069 2031 2047 and 2020 g respectively

The data on cumulative mean body we gl t gain of birds up to s x weeks of age are given in Table 5 and graphically in Fig 2 The cumulat ve mean body weight gam of birds of dietary treatments T1 T2 T3 and T4 were 2023 1984 2000 and 1973g respectively at the end of six week experimental period

## 4 3 FEED CONSUMPTION

The data pertaining to cumulative mean feed intake s presented in Table 6 and graphically in Fig 3 The cumulative mean feed intake of b rds on dietary treatments of T1 T2 T3 and T4 were 4030 4010 4101 and 4100 g respectively at the end of six weeks

The data on average daily feed intake of birds belonging to d fferent dietary treatments at weekly intervals are presented in Table 7 The average daily feed intake of birds of dietary treatments T1 T2 T3 and T4 during sixth week was 159 39 164 46 166 65 and 169 81 g respect vely

4 4 FEED CONVERSION RATIO

The data on mean cumulative feed convers on ratio (FCR) of experimental birds at weekly ntervals are represented in Table 8 and graphically in F g 3 The mean cumulative FCR of birds belonging to dietary treatments T1 T2 T3 and T4 were respectively 2 04 2 02 2 04 and 2 09 at the end of six weeks

4 5 WATER CONSUMPTION

The data pertaining to mean daily water consumption are presented in Table 9 and graphically in Fig 4 The mean da ly water consumption of birds was 602 617 629 and 654 ml for dietary treatments T1 T2 T3 and T4 respectively during sixth week

4 6 NITROGEN BALANCE

The data on N balance (g per day) and retention (per cent) of b rds during the metabolism trial are given in Table 10 and graph cally represented in F g 5 The mean N retention percentage for the experimental b rds in T1 T2 T3 and T4 were 32 61 23 62 29 56 and 32 29 respectively

4 7 BALANCES OF Ca P Na K and Cl

The data pertaining to Ca P Na K and Cl balance are set out in Tables 10 and 11 and graphically represented in Fig 6 and 7 The percent retention of minerals in experimental birds belonging to d etary treat nents of T1 T2 T3 and T4 were respectively 49 91 27 24 47 86 and 53 72 for Ca 29 83 19 96 27 89 and 24 23 for P 22 99 26 40 32 75 and 37 86 for Na 31 44 32 17 21 88 and 31 59 for K and 41 51 36 40 51 03 and 53 17 for Cl

4 8 PROCESSING YIELDS

The data on processing yields of the birds slaughtered at the end of experimental period is given in Table 12 The processing yields obtained for the different dietary treatments of T1 T2 T3 and T4 were respectively 89 21 88 51 88 42 and 88 05 for dressing percentage 0 76 0 97 0 82 and 0 92 for abdominal fat percentage and 4 31 4 13 4 30 and 4 26 for giblet y eld

4 9 SERUM CHOLESTEROL URIC ACID AND GLUCOSE

Serum biochemical parameters of birds belonging to different dietary treatments are presented in Table 13 The mean values obta ned for serum biochemical parameters of birds belonging to T1 T2 T3 and T4 were respectively 149 150 163 150 mg per dl for cholesterol 6 00 6 87 6 75 and 6 62 mg per dl for uric acid and 170 152 188 and 150 mg per dl for glucose

4 10 SERUM MINERALS

The serum mineral concentrations are presented in Table 14 The mean values obtained for serum minerals were respectively 115 44 112 39 111 69 and 112 39 mmol per l for sodium 2 40 2 72 2 18 and 2 34 mmol per l for potassium 99 09 95 95 96 32 and 101 19 mmol per l for chloride and 6 49 5 65 5 76 and 4 94 mg per dl for calcium

4 11 FAECAL PROXIMATE COMPOSITION

The proximate composition of droppings of treatments T1 T2 T3 and T4 are presented in Table 15

4 12 COST OF PRODUCTION

Cost of production is presented in Table 16 and graph cally presented in F g 8

Table 3 Weekly meteorological data during the experimental period of six weeks*

| Week | Temperature (°C) | | Relative Humidity (%) | |
|---|---|---|---|---|
| | Maximum | Minimum | 9am | 4pm |
| 1 | 33 00 | 22 14 | 70 60 | 45 66 |
| 2 | 34 25 | 23 85 | 63 00 | 47 17 |
| 3 | 34 50 | 24 71 | 68 50 | 44 00 |
| 4 | 34 60 | 23 80 | 63 50 | 47 68 |
| 5 | 35 20 | 24 20 | 67 00 | 48 50 |
| 6 | 36 00 | 25 00 | 74 33 | 41 00 |
| Mean ± SE | 34 56<br>1 00 | 23 95<br>1 00 | 67 82<br>1 43 | 45 60<br>0 92 |

* 17 12 2004 to 28 01 2005

Table 4 Weekly mean body weight of birds maintained on different dietary treatments g*

| Treatments | Age in weeks | | | | | | | CD |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | |
| T1 | 46 87 ± 0 00 | 161 75 ± 0 00 | 383 34 ± 0 00 | 746 80 ± 0 00 | 1206 60 ± 0 02 | 1611 90 ± 0 03 | 2069 40 ± 0 04 | NS |
| T2 | 47 42 ± 0 00 | 157 07 ± 0 00 | 366 00 ± 0 00 | 727 12 ± 0 01 | 1180 79 ± 0 02 | 1562 33 ± 0 02 | 2031 25 ± 0 03 | NS |
| T3 | 46 72 ± 0 00 | 155 55 ± 0 00 | 353 95 ± 0 00 | 721 57 ± 0 01 | 1185 35 ± 0 01 | 1587 62 ± 0 01 | 2046 77 ± 0 02 | NS |
| T4 | 47 00 ± 0 00 | 158 30 ± 0 00 | 370 80 ± 0 01 | 748 94 ± 0 01 | 1229 80 ± 0 03 | 1568 80 ± 0 02 | 2020 28 ± 0 04 | NS |

* mean with SE
NS – Not Significant

Table 5 Weekly cumulative mean body weight gain of birds maintained on different dietary treatments g*

| Treatments | Age in weeks | | | | | | CD |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| T1 | 115 40 ± 0 00 | 336 52 ± 0 00 | 681 04 ± 0 02 | 1130 00 ± 0 04 | 1526 87 ± 0 06 | 2022 53 ± 0 04 | NS |
| T2 | 109 65 ± 0 00 | 318 57 ± 0 00 | 679 70 ± 0 01 | 1134 40 ± 0 02 | 1514 94 ± 0 02 | 1983 86 ± 0 03 | NS |
| T3 | 108 82 ± 0 00 | 307 22 ± 0 00 | 674 85 ± 0 01 | 1138 62 ± 0 01 | 1540 90 ± 0 01 | 2000 05 ± 0 02 | NS |
| T4 | 111 30 ± 0 00 | 323 8 ± 0 01 | 701 84 ± 0 01 | 1182 70 ± 0 03 | 1521 70 ± 0 01 | 1973 18 ± 0 04 | NS |

* mean with SE
NS Not Significant

Table 6 Cumulative mean feed intake of birds mainta ned on different dietary treatments g*

| Treatments | Age in weeks | | | | | | CD |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| T1 | 156 50 ± 2 29 | 523 97 ± 23 40 | 1180 05 ± 22 33 | 1973 95 ± 42 60 | 2942 22 ± 62 17 | 4030 37 ± 98 10 | NS |
| T2 | 158 75 ± 4 95 | 530 82 ± 13 06 | 1148 07 ± 12 34 | 1922 27 ± 30 55 | 2888 57 ± 63 51 | 4010 22 ± 86 03 | NS |
| T3 | 149 12 ± 3 19 | 517 82 ± 14 90 | 1137 75 ± 41 55 | 1945 92 ± 49 30 | 2934 20 ± 60 42 | 4100 80 ± 65 81 | NS |
| T4 | 158 50 ± 1 77 | 542 20 ± 45 22 | 1171 90 ± 41 30 | 1961 97 ± 51 88 | 2940 77 ± 69 00 | 4099 95 ± 97 50 | NS |

* mean with SE
NS – Not Significant

Table 7 Average daily feed intake of birds maintained on different dietary treatments g*

| Treatments | Age in weeks | | | | | | CD |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| T1 | 22 51 ± 0 31 | 52 31 ± 3 62 | 93 72 ± 3 90 | 116 31± 2 13 | 141 81 ± 0 81 | 159 39 ± 2 67 | NS |
| T2 | 22 67 ± 0 70 | 53 15 ± 1 35 | 88 17 ± 0 76 | 113 41 ± 2 23 | 141 55 ± 3 40 | 164 46 ± 2 44 | NS |
| T3 | 21 57 ± 0 60 | 52 39 ± 1 53 | 88 55 ± 3 80 | 115 44 ± 1 12 | 141 17 ± 2 32 | 166 65 ± 2 55 | NS |
| T4 | 22 31 ± 0 35 | 56 58 ± 6 55 | 92 33 ± 1 54 | 115 67 ± 2 08 | 143 45 ± 3 18 | 169 81 ± 0 70 | NS |

* mean with SE
NS – Not Significant

Table 8 Weekly mean cumulative feed conversion ratio of birds maintained on different dietary treatments * kg feed/kg gain

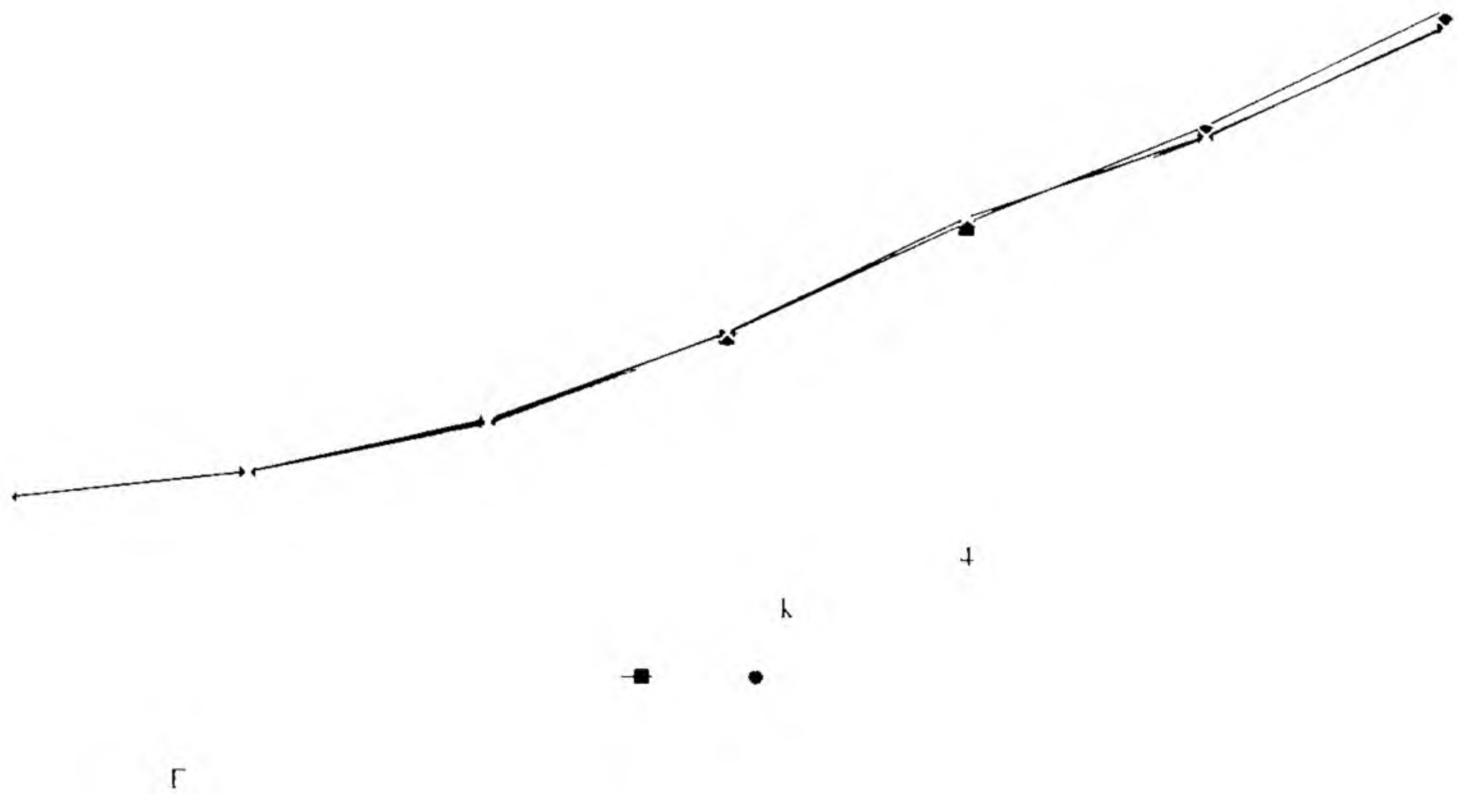
| Treatments | Age in weeks | | | | | | CD |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| T1 | 1 36 ± 0 02 | 1 49 ± 0 09 | 1 68 ± 0 03 | 1 74 ± 0 05 | 1 90 ± 0 03 | 2 04 ± 0 04 | NS |
| T2 | 1 45 ± 0 08 | 1 66 ± 0 07 | 1 69 ± 0 02 | 1 74 ± 0 03 | 1 95 ± 0 01 | 2 02 ± 0 04 | NS |
| T3 | 1 39 ± 0 02 | 1 68 ± 0 05 | 1 68 ± 0 03 | 1 71 ± 0 02 | 1 89 ± 0 03 | 2 04 ± 0 01 | NS |
| T4 | 1 42 ± 0 03 | 1 68 ± 0 16 | 1 72 ± 0 09 | 1 71 ± 0 06 | 1 98 ± 0 03 | 2 09 ± 0 05 | NS |

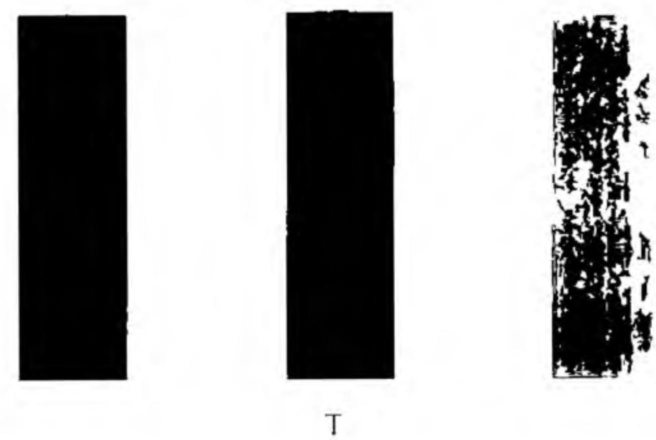
* mean with SE
NS – Not Significant

Table 9 Mean daily water consumption of birds maintained on different dietary treatments ml

| Treatments | Age in weeks | | | | | | CD |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| T1 | 80 53 ± 1 96 | 173 39 ± 1 60 | 249 32 ± 7 18 | 355 42 ± 10 60 | 436 82 ± 08 69 | 602 11 ± 13 31 | NS |
| T2 | 71 16 ± 1 14 | 176 60 ± 4 60 | 252 50 ± 4 71 | 344 00 ± 17 45 | 443 69 ± 14 28 | 617 27 ± 17 88 | NS |
| T3 | 75 35 ± 3 60 | 182 50 ± 5 40 | 260 03 ± 8 71 | 379 28 ± 16 35 | 459 64 ± 09 41 | 628 50 ± 06 11 | NS |
| T4 | 78 30 ± 1 80 | 182 85 ± 3 30 | 261 24 ± 10 85 | 387 04 ± 14 08 | 453 67 ± 07 40 | 653 89 ± 15 08 | NS |

* mean with SE
NS Not Signif cant



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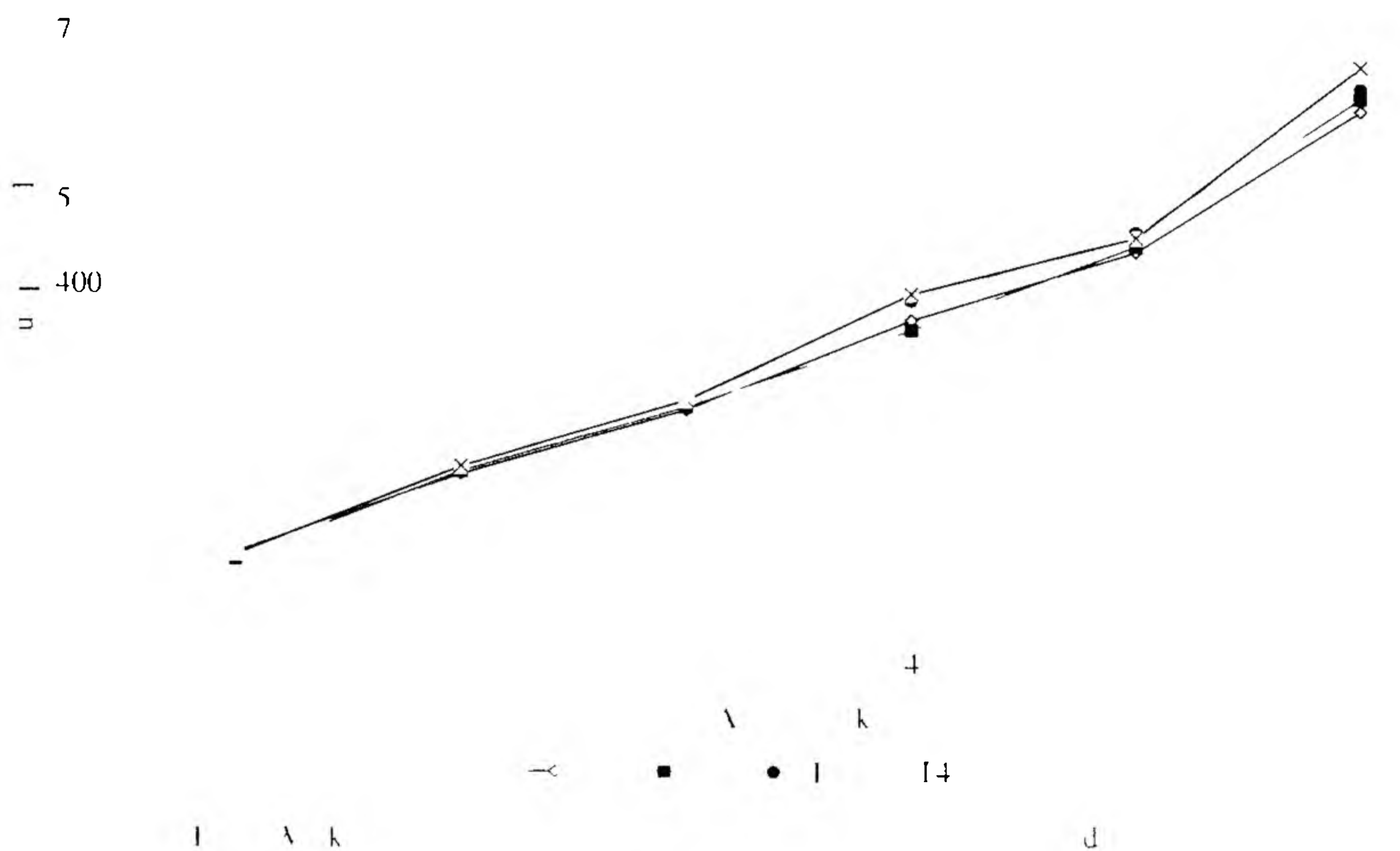

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Table 10 Nitrogen Calcium and Phosphorus balance of birds maintained on d fferent dietary treatments*

| Element | Treatments | Intake (g/day) | Outgo (g/day) | Balance (g/day) | Retention (%) |
|---|---|---|---|---|---|
| Nitrogen | T1 | 4 18 ± 0 59 | 2 85 ± 0 48 | 1 31 ± 0 11 | 32 61 ± 2 76 |
| | T2 | 3 47 ± 0 22 | 2 63 ± 0 12 | 0 83 ± 0 17 | 23 62 ± 3 88 |
| | T3 | 4 63 ± 0 30 | 3 24 ± 0 12 | 1 38 ± 0 18 | 29 56 ± 2 04 |
| | T4 | 3 77 ± 0 17 | 2 61 ± 0 11 | 1 16 ± 0 14 | 32 29 ± 1 92 |
| Calcium** | T1 | 1 15 ± 0 17 | 0 60 ± 0 14 | 0 55$^{a}$ ± 0 07 | 49 91$^{a}$ ± 6 92 |
| | T2 | 1 01 ± 0 07 | 0 72 ± 0 05 | 0 28$^{b}$ ± 0 06 | 27 24$^{b}$ ± 4 43 |
| | T3 | 1 19 ± 0 08 | 0 61 ± 0 04 | 0 58$^{a}$ ± 0 09 | 47 86$^{a}$ ± 4 84 |
| | T4 | 1 07 ± 0 05 | 0 49 ± 0 05 | 0 58$^{a}$ ± 0 06 | 53 72$^{a}$ ± 4 85 |
| Phosphorus | T1 | 0 73 ± 0 11 | 0 51 ± 0 06 | 0 22 ± 0 05 | 29 83 ± 3 24 |
| | T2 | 0 63 ± 0 04 | 0 50 ± 0 04 | 0 13 ± 0 05 | 19 96 ± 6 64 |
| | T3 | 0 83 ± 0 05 | 0 60 ± 0 03 | 0 23 ± 0 04 | 27 89 ± 4 01 |
| | T4 | 0 65 ± 0 03 | 0 49 ± 0 02 | 0 16 ± 0 02 | 24 23 ± 3 54 |

* mean with SE

** a, b Means bear ng different superscr pt within the same column of the same element differed significantly (P<0 05)

Table 11 Sodium Potassium and Chloride balance of birds maintained on different dietary treatments*

| Element | Treatments | Intake (g/day) | Outgo (g/day) | Balance (g/day) | Retention (%) |
|---|---|---|---|---|---|
| Sodium** | T1 | 0 42$^{a}$ ± 0 06 | 0 33 ± 0 05 | 0 09$^{a}$ ± 0 02 | 22 99 ± 3 66 |
| | T2 | 0 40$^{a}$ ± 0 02 | 0 29 ± 0 02 | 0 10$^{a}$ ± 0 02 | 26 40 ± 5 46 |
| | T3 | 0 67$^{b}$ ± 0 04 | 0 45 ± 0 02 | 0 22$^{b}$ ± 0 03 | 32 75 ± 2 47 |
| | T4 | 0 56$^{b}$ ± 0 02 | 0 35 ± 0 04 | 0 21$^{b}$ ± 0 03 | 37 86 ± 5 67 |
| Potassium | T1 | 0 98 ± 0 15 | 0 67 ± 0 11 | 0 30 ± 0 06 | 31 44 ± 4 51 |
| | T2 | 0 95 ± 0 06 | 0 66 ± 0 13 | 0 29 ± 0 09 | 32 17 ± 11 15 |
| | T3 | 1 24 ± 0 08 | 0 96 ± 0 03 | 0 27 ± 0 05 | 21 88 ± 2 54 |
| | T4 | 1 03 ± 0 04 | 0 70 ± 0 03 | 0 33 ± 0 05 | 31 59 ± 4 36 |
| Chloride** | T1 | 0 65$^{ab}$ ± 0 10 | 0 38$^{a}$ ± 0 05 | 0 27 ± 0 05 | 41 51$^{ab}$ ± 3 49 |
| | T2 | 0 68$^{a}$ ± 0 04 | 0 37$^{a}$ ± 0 02 | 0 25 ± 0 04 | 36 40$^{b}$ ± 3 92 |
| | T3 | 0 48$^{b}$ ± 0 03 | 0 23$^{b}$ ± 0 01 | 0 25 ± 0 02 | 51 03 ± 2 62 |
| | T4 | 0 29$^{c}$ ± 0 01 | 0 13$^{c}$ ± 0 01 | 0 15 ± 0 02 | 53 17 ± 5 71 |

* mean with SE

** a b c – Means bearing different superscript within the same column of the same element differed significantly (P<0 05)

Table 12 Processing yields of birds maintained on four different dietary treatments % *

| Treatments | Live weight (kg) | Dress ng percentage (%) | Giblet yield (%) | Abdominal fat (%) | CD |
|---|---|---|---|---|---|
| T1 | 1 90 ± 0 02 | 89 21 ± 0 33 | 4 31 ± 06 | 0 76 ± 0 12 | NS |
| T2 | 1 96 ± 0 04 | 88 51± 0 33 | 4 13 ±0 09 | 0 97 ± 0 13 | NS |
| T3 | 1 93 ± 0 06 | 88 42 ± 0 25 | 4 30 ± 09 | 0 82 ± 0 11 | NS |
| T4 | 1 87 ± 0 09 | 88 05 ± 0 50 | 4 26 ± 07 | 0 92 ± 0 03 | NS |

* mean with SE
NS Not Significant

Table 13 Serum cholesterol uric acid and glucose of birds maintained on four dietary treatments mg/dl

| Treatments | Serum cholesterol | Uric acid | Glucose | CD |
|---|---|---|---|---|
| T1 | 148 55 ± 6 48 | 6 00 ± 1 4 | 169 5 ± 15 12 | NS |
| T2 | 149 71 ± 4 87 | 6 87 ± 0 72 | 152 25 ± 18 06 | NS |
| T3 | 162 73 ± 7 81 | 6 75 ± 1 01 | 188 38 ± 35 89 | NS |
| T4 | 149 90 ± 5 81 | 6 62 ± 0 46 | 149 5 ± 15 04 | NS |

* mean with SE
NS – Not Significant

Table 14 Serum minerals of birds maintained on d fferent dietary treatments *

| Treatments | Na (mmol/l) | K (mmol/l) | Cl (mmol/l) | Ca (mg/dl) | CD |
|---|---|---|---|---|---|
| T1 | 115 44 ± 7 81 | 2 40 ± 0 22 | 99 09 ± 2 45 | 6 49 ± 0 09 | NS |
| T2 | 112 39 ± 4 12 | 2 72 ± 0 23 | 95 95 ± 2 93 | 5 65 ± 0 31 | NS |
| T3 | 111 69 ± 4 04 | 2 18 ± 0 15 | 96 32 ± 2 75 | 5 76 ± 0 54 | NS |
| T4 | 112 39 ± 3 03 | 2 34 ± 0 21 | 101 19 ± 2 13 | 4 94 ± 0 09 | NS |

* mean with SE
NS – Not Significant

Table 15 Chemical composition of faecal matter of birds maintained on different dietary treatments %*

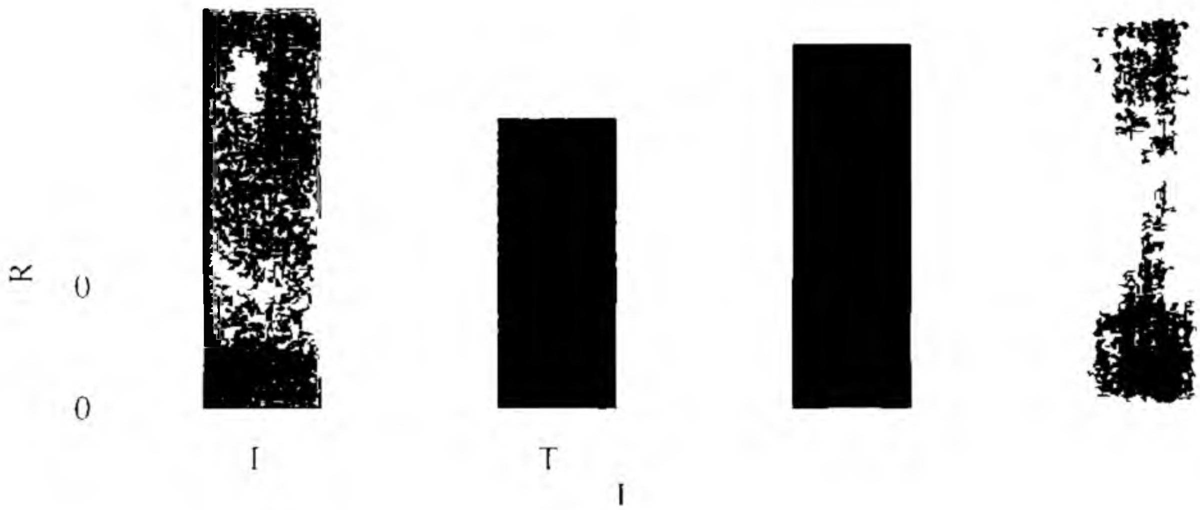
| Treatment | T1 | T2 | T3 | T4 |
|---|---|---|---|---|
| Crude protein | 48 80 | 46 40 | 46 48 | 42 58 |
| Ether extract | 2 35 | 2 98 | 1 95 | 1 64 |
| Crude fibre | 5 44 | 4 22 | 6 74 | 5 86 |
| NFE | 26 13 | 34 12 | 30 32 | 32 74 |
| Total ash | 17 28 | 12 28 | 14 51 | 17 18 |
| Acid ins ash | 3 48 | 2 31 | 2 48 | 3 59 |
| Calcium | 2 94 | 3 72 | 3 19 | 1 57 |
| Phosphorus | 2 77 | 3 07 | 2 89 | 2 10 |
| Sodium | 1 95 | 1 77 | 2 13 | 1 44 |
| Potassium | 5 38 | 5 33 | 4 71 | 3 02 |
| Chloride | 0 90 | 0 98 | 0 46 | 0 40 |

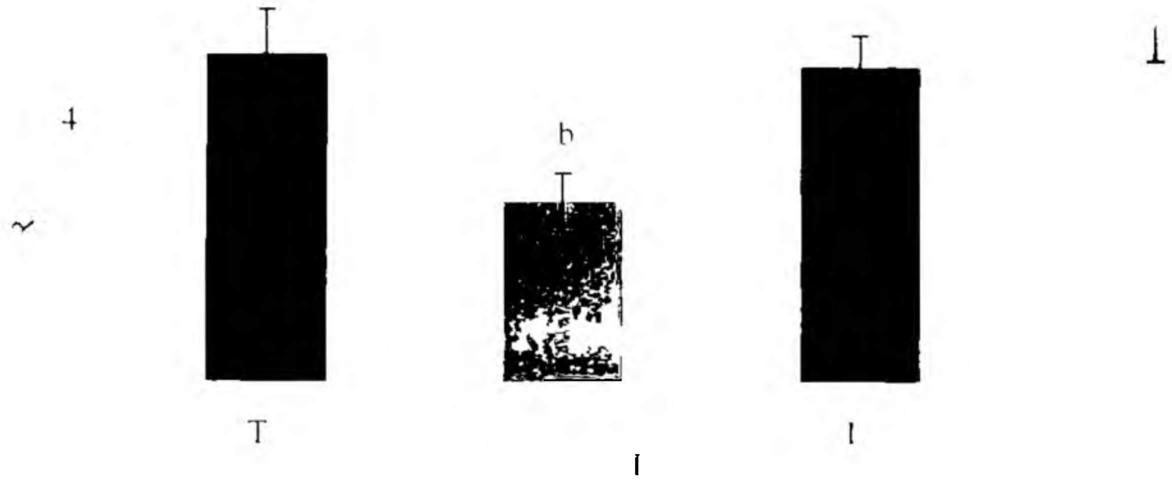
* mean with SE
NS Not Significant

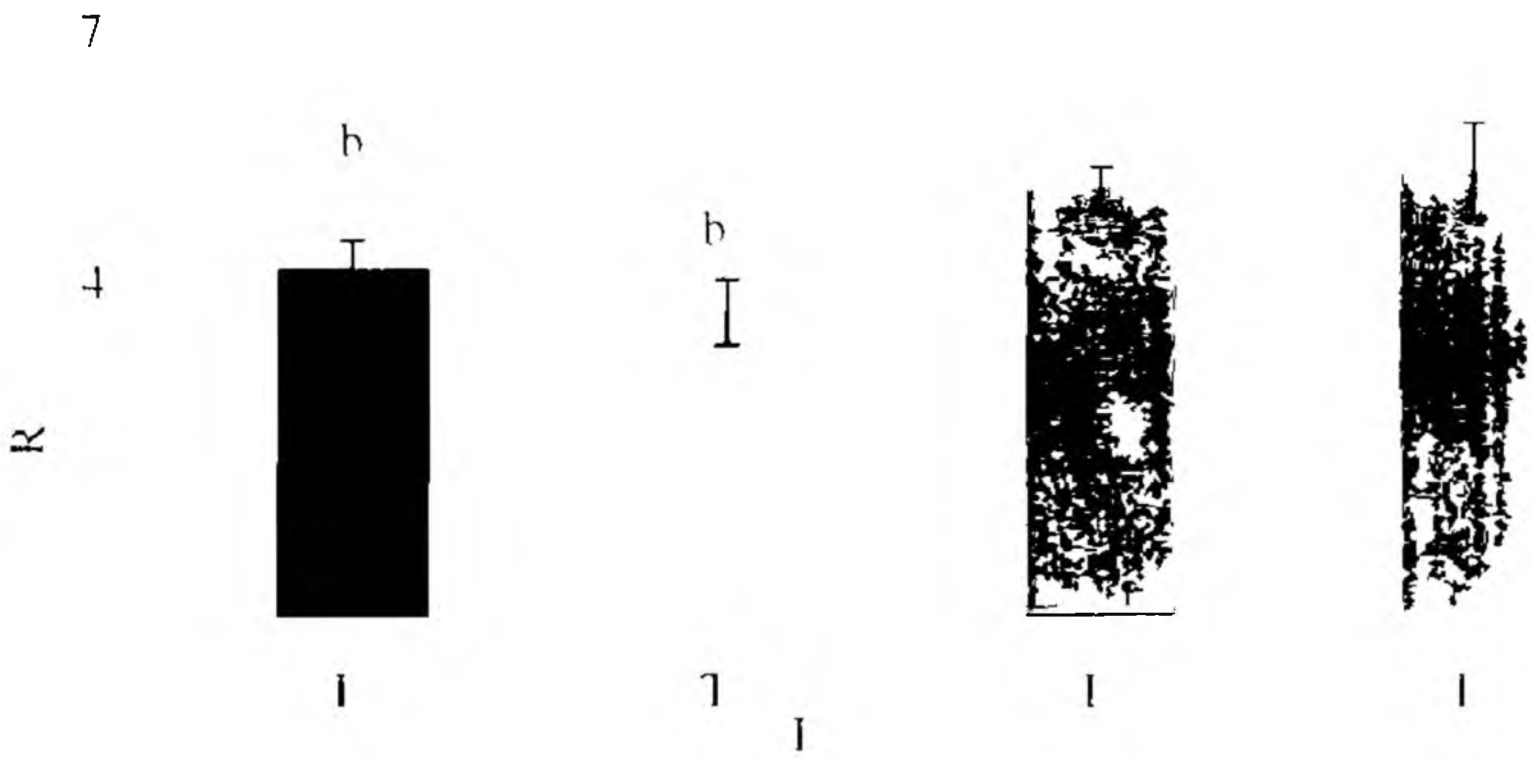
Table 16 Cost of production of birds maintained on different dietary treatments

| Parameters | Treatments | | | |
|---|---|---|---|---|
| | T1 | T2 | T3 | T4 |
| Cost of feed/kg* (Rs ) | | | | |
| Starter | 11 38 | 11 59 | 11 17 | 10 96 |
| Finisher | 10 49 | 10 69 | 10 27 | 10 09 |
| Total feed intake (kg) | | | | |
| Starter | 1 97 | 1 92 | 1 95 | 1 96 |
| Finisher | 2 06 | 2 09 | 2 15 | 2 14 |
| Live weight gain of birds (kg) | | | | |
| 0 4 week | 1 13 | 1 13 | 1 14 | 1 18 |
| 4 6 week | 0 89 | 0 85 | 0 86 | 0 79 |
| 0 6 week | 2 02 | 1 98 | 2 00 | 1 97 |
| Cost of production/kg live weight gain (Rs ) | | | | |
| 0 4 week | 19 84 | 19 69 | 19 11 | 18 20 |
| 4 6 week | 24 35 | 26 28 | 26 67 | 27 33 |
| 0 6 week | 21 79 | 22 52 | 21 93 | 21 86 |

* Cost was calculated using the rate contract values fixed for feed ingredients for the year 2003 2004 by College of Veterinary and Animal Sciences Mannuthy







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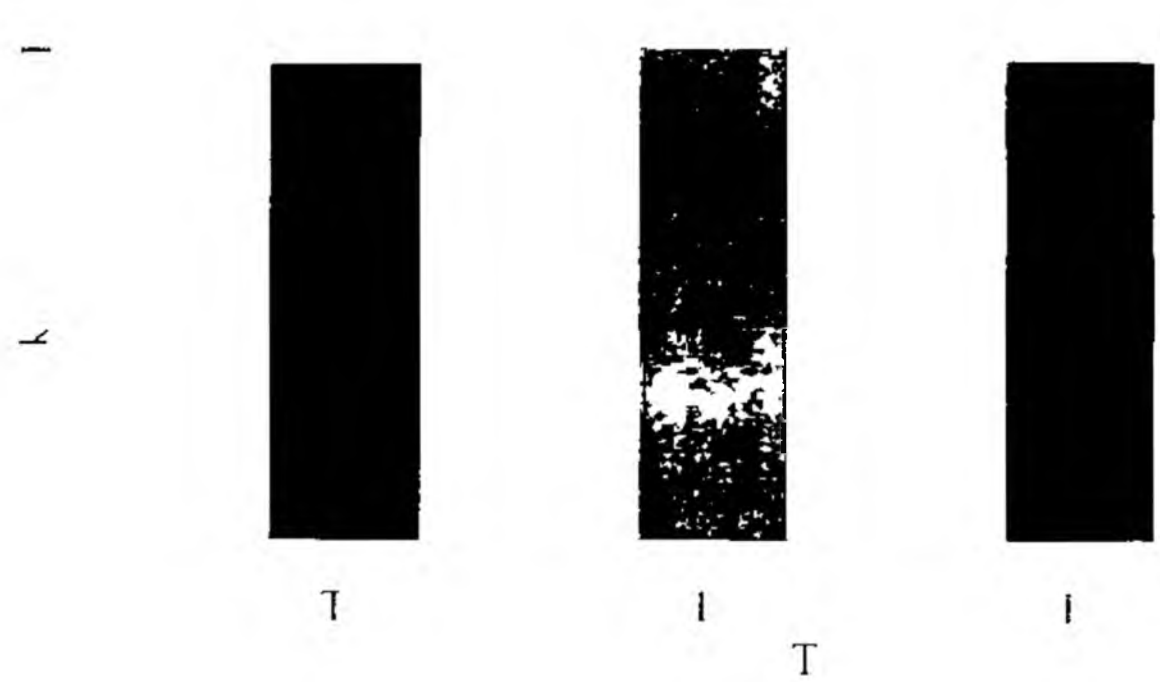

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# *Discussion*

# 5 DISCUSSION

The results obtained during the course of present study on the effect of d etary cation anion balance on growth performance of broiler chicken are discussed below

## 5 1 BODY WEIGHT

The weekly mean body weight of birds belong ng to four dietary treatments T1 T2 T3 and T4 at the end of the s x week experimental period were 2069 2031 2047 and 2020 g respectively The data presented in Table 4 and Fig 1 showed no significant difference between the four dietary treatments

The results are in agreement with Karunajeeva *et al* (1986) who also observed that electrolyte balance had no significant effects on growth rate Hulan *et al* (1987) also reported that there was no significant interaction between cation anion balance and growth rate within a range of 155 to 300 meq per kg The cation anion balance in the present study ranged from 210 to 360 meq per kg But the results strongly disagree with Mongin (1981) who opined that when Na+K Cl were higher or lower than 250 meq per kg growth rate was depressed Johnson and Karunajeeva (1985) reported that an electrolyte balance lower than 180 meq per kg or higher than 300 meq per kg depressed live weight at 42 days of age

The cumulative mean body weight gain of birds up to six weeks of age of T1 T2 T3 and T4 were 2023 1984 2000 and 1973 g respectively Cumulative mean body weight gain of birds is given in Table 5 and Fig 2 There is no significant difference between dietary treatments The results agree with Karunajeeva and Barr (1988) who observed no significant interaction between dietary electrolyte balance and weight gain Body weight gam ranged from 1971 to 2050 g in two different groups with electrolyte balance ranging from 125 to 205 meq per kg In the present study electrolyte balance ranged from 210 to 360 meq per kg and weight gain from 1972 to 2000 g Similar results were observed by Gorman and Balnave (1994) who opined that d etary effects if any were due to e ther specific salt supplements or supple nentat on with individual ions

The results are in contrast to the f ndings of Murakami *et al* (2001) who observed best weight ga n at 249 to 264 meq per kg when birds were fed rations with increasing levels of Na and Cl Best we ght gain was observed w th 290 and 330 meq per kg by Borgatti *et al* (2004) They observed that we ght ga n during the starter phase ncreased l nearly with electrolyte balance Body weight gain was 32 83 g per b rd per day at 210 meq per kg and 35 32 g per b rd per day at 330 meq per kg in case of female birds

5 2 FEED CONSUMPTION

Cumulative mean feed intake of birds belong ng to four different dietary treatments T1 T2 T3 and T4 were 4030 4010 4101 and 4100 g respectively Average daily feed intake of birds of T1 T2 T3 and T4 were 159 39 164 46 166 65 and 169 81 g respect vely during s xth week Cumulative mean feed intake is presented in Table 6 The weekly average of da ly feed ntake s presented in Table 7 No s gn f cant difference was observed between the four dietary treatments But Melliere and Forbes (1966) stated that food consumption was dependent on d etary cat on anion rat o and ncrease in the chloride content w thout concurrently increas ng the cation content depressed food consumption In this study the highest chloride level was added in T2 and lowest in T4 But no depression in feed intake was seen Borges *et al* (2002) reported that maximum feed intake was at 202 meq per kg Maximum feed intake of 4214 g per bird during 42 day period was observed for 240 meq per kg and a feed intake of 3969 g per bird for 0 meq per kg (Borges *et al* 2003a)

In contrast Karunajeeva *et al* (1986) reported that there was no significant effect of dietary electrolyte balance on feed ntake in the case of finishers But in starter phase reduced feed intake was observed w th ncrease in electrolyte balance with low inorgan c phosphorus Karunajeeva and Barr (1988) also reported that there was no significant effect on food consumption with dietary electrolyte balances of 125 165 and 205 meq per kg Feed intake varied from 3805 g per bird to 4019 g per bird dur ng 1 to 42 days of age whereas in our study it varied from 4010 to 4100 g per bird

5 3 FEED CONVERSION RATIO (FCR)

The mean cumulative FCR of birds maintained on different dietary treatments were 2 04 2 02 2 04 and 2 09 for T1 T2 T3 and T4 respectively (Table 8 Fig 3) Feed conversion ratio values had no significant difference between treatment groups T1 T2 T3 and T4 The findings agree with Karunajeeva *et al* (1986) who observed that dietary electrolyte balance had no significant effect on FCR Hulan *et al* (1987) also observed that feed efficiency was similar for birds fed diets with 155 to 300 meq per kg Similar results were also observed by Gorman and Balnave (1994) The findings disagree with Adekumisi and Robbins (1987) who obtained best FCR at 249 to 261 meq per kg Rondon *et al* (2001) observed best FCR between 298 to 315 meq per kg when chloride levels were fixed at 0 1 per cent and 246 to 264 meq per kg when sodium levels were fixed at 0 1 per cent Borges *et al* (2002) reported best feed gain at 264 meq per kg

5 4 WATER CONSUMPTION

Weekly average of daily water consumption of birds was 602 617 629 and 654 ml for T1 T2 T3 and T4 respectively (Table 9 and Fig 4) No significant difference was observed between different treatments Birds under T3 and T4 had a trend for higher water consumption than T1 throughout the experiment except during the first week This agrees with the findings of Mongin (1981) that any increase in sodium and potassium will cause an increase in water consumption Among the four treatments T4 group received more $NaHCO_3$ (1 77 per cent in starter ration and 1 57 per cent in finisher ration) In this study the water consumption was low for T1 and T2 the treatments which received more ammonium chloride (0 65 and 0 33 per cent for T1 and 0 82 and 0 5 per cent for T2)

Pesti *et al* (1985) reported that broilers averaged 1 77 ml water per g feed consumed In the present study however water consumption is higher than the above value Damron *et al* (1986) reported a daily water intake of 69 3 ml and 60 9 ml for 0 2 per cent sodium chloride supplemented group and 0 144 per cent sodium bicarbonate supplemented group respect vely These were the average of 21 days and the values are comparable with the values obtained in the present study which ranged from 71 16 to 80 53 ml per b rd per day during the first week But as the salt supplementation in this study was several t mes higher than those of Damron *et al* (1986) such h gher values were expected Borges *et al* (2003a) reported a water intake of 146 ml per b rd per day for 360 meq per kg group during the 0 to 21 day per od and 398 ml during 21 to 42 day period In the present study values were 174 13 and 498 2 ml for 360 meq per kg group (T4)

5 5 BALANCE OF NITROGEN CALCIUM AND PHOSPHORUS

The data on balance of n trogen calc um and phosphorus are presented in Table 10 and Fig 5 and 6

**5 5 1 Nitrogen**

The nitrogen retention ranged from 23 62 to 32 61 per cent in the present study There was no significant difference between treatments Values are comparable to those obtained by Mohan *et al* (1996) The r values ranged from 46 3 to 48 5 per cent

The result is in contrast to Dersjant *et al* (2001) who reported a decrease in nitrogen excretion when dietary cation anion balance increased Digestibility of nitrogen was higher for 500 meq per kg than 100 or 200 meq per kg in case of pigs Golz and Crenshaw (1991) stated that an ncrease n K+ resulted in an increase in N retention

**5 5 2 Calcıum**

The retentıon percentage of Ca for dıetary treatments T1 T2 T3 and T4 were 49 91 27 24 47 86 and 53 72 per cent respect vely Treatment T2 had a sıgnıficantly lower (P<0 05) calcıu n balance and retentıon than T1 T3 and T4 But no sıgnıficant dıfference was observed between d fferent dıetary treatments ın case of ıntake and outgo Treatment T2 was supplemented wıth the hıghest level of ammon um chlor de (0 5 per cent) and lowest level of sodıum bıcarbonate (1 07 per cent)

**5 5 3 Phosphorus**

Phosphorus retentıon ın the present study ranged from 19 96 to 29 83 per cent No sıgnıficant dıfference was observed between d fferent dıetary treatments Gorman and Balnave (1994) concluded that self supplementatıon dıd not affect phosphorus retent on Values are comparable wıth Hemme *et al* (2005) who obtaıned 35 5 to 48 6 per cent retentıon ın broılers w th d fferent sources of phosphorus

5 6 BALANCE OF SODIUM POTASSIUM AND CHLORIDE

Balance of sodıum potassıum and chlor de are presented ın Table 11 and F g 7

**5 6 1 Sodıum**

A sıgnıficant dıfference (P<0 05) was observed ın the ıntake and balance of sodıum whereas outgo and retentıon dıd not show any sıgnıfcant dıfference Intake of sodıum was 0 42 0 40 0 67 and 0 56 g per day for dıetary treatments T1 T2 T3 and T4 respectıvely Treatments T1 and T2 showed sıgnıficantly lower ıntake than T3 and T4 Treatments T3 and T4 showed hıgher ıntake whıch corresponds to the amount of $NaHCO_3$ added to the d et Treatments T1 and T2 receıved less Na when compared to T3 and T4 wh ch ıs reflected ın the ıntake and balance Hıgher ıntake leads to hıgher balance But retentıon of sodıum when expressed ın percentage was sımılar ın all the groups

The findıng agrees wıth Gorman and Balnave (1994) who showed that there was no apparent relatıonshıp between eıther mıneral ıntake or retentıon and catıon anıon balances Belay and Teeter (1996) observed a reduced retent on of sodıum at 32°C than at 24 C ın bırds

**5 6 2 Potassıum**

There was no s gn f cant dıfference ın the balances of potassıum as the dıetary levels of K was not varıed n thıs exper ment Thıs agrees wıth Golz and Crenshaw (1991) and Gorman and Balnave (1994)

**5 6 3 Chlorıde**

There was sıgnıficant dıfference ($P<0\ 05$) ın the ıntake outgo and retentıon of chlorıde whereas no sıgnıficant dıfference was there ın the balance Intake of chlorıde for dıetary treatments T1 T2 T3 and T4 were 0 65 0 68 0 48 and 0 29 g per day respectıvely The h ghest ıntake was seen for T1 and T2 and lowest for T4 Thıs ıs accordıng to the ınclusıon of ammonıum chlor de ın the dıet Treatment T2 receıved hıghest level (0 5 per cent) than T1 (0 33 per cent) and T4 receıved none at all Though outgo was hıgher for the hıgh ntake groups retentıon was hıghest for low ıntake groups Th s agrees w th the f ndıngs of Gorman and Balnave (1994) that self supplementatıon reduced percentage retentıon of chlorıde The result dısagrees wıth Golz and Crenshaw (1991) that retentıon of chlor de dıd not vary wıth dıetary levels

5 7 PROCESSING YIELD

The dressıng percentage of bırds belong ng to dıetary treatments T1 T2 T3 and T4 were 89 21 88 51 88 42 and 88 05 per cent respectıvely Abdomınal fat percentage ranged from 0 76 per cent to 0 97 per cent Gıblet yıeld ranged from 4 13 to 4 31 per cent The process ng yıelds of b rds slaughtered at the end of experımental per od are gıven ın Table 12 There was no sıgnıficant dıfference between T1 T2 T3 and T4

Borges *et al* (2003a) obtained s milar results Borgatti *et al* (2004) observed a significant effect on w ng yield but carcass yield abdominal fat pad and giblet yield were not significantly different Karunajeeva *et al* (1986) noted that dressing percentage was low n males fed inorganic phosphorus at a rate of 4 7 g per kg with electrolyte balance of 300 meq per kg and females fed at a rate of 9 8 g per kg and electrolyte balance 150 to 200 meq per kg Whit ng *et al* (1991) observed that abdominal fat content was h gher in birds when supplemented with potassium at 0 5 per cent

5 8 SERUM MINERALS

Data on serum minerals is presented in Table 14 There was no sign ficant difference among four dietary treatments

**5 8 1 Sodium**

Serum sodium levels ranged fro n 111 69 to 115 44 mmol per litre Results are in agreement with Borges *et al* (2003b) Dersjant *et al* (2001) noted that plasma sodium levels did not change significantly by altering d etary cation an on balance from –100 neq per kg to 500 meq per kg n pigs Johnson and Karunajeewa (1985) reported that plasma sod um levels were not affected by dietary treatments from –29 to +553 meq per kg But our results disagree with the findings of Dersjant *et al* (2002) who observed an increased sod um ion concentration in the blood by increasing dietary electrolyte balance from 100 to +200 meq per kg Haydon *et al* (1990) reported a linear increase in the sodium concentration with increase in dietary electrolyte balance

**5 8 2 Potassium**

Serum potassium ranged from 2 18 to 2 40 mmol per litre in the present study The results agree with Borges *et al* (2003b) who also reported that there was no sign ficant difference among dietary treatments ranging from 40 to 340 meq per kg Dersjant *et al* (2001) also reported that a cation anion difference of 100 to 500 meq per kg did not affect plasma potassium levels Johnson and

Karunajeeva (1985) showed that plasma ion levels of potassium were not affected by dietary treatments when electrolyte balance ranged from 29 to 553 meq per kg Values are comparable to those obta ned by Gregorian *et al* (1983) who reported values ranging from 2 9 to 3 9 mmol per l But our results disagree with Dersjant *et al* (2002) who studied the plasma electrolytes in pigs at two dietary electrolyte balance levels of –100 meq per kg and 200 meq per kg and stated that potassium concentration decreased as electrolyte balance increased Roche *et al* (2005) also observed a reduct on in plasma potassium concentration when dietary cation anion balance increased in case of cows

**5 8 3 Chloride**

The serum chloride concentration ranged from 95 95 mmol per litre to 101 19 mmol per litre in the present study and they did not differ between treatments Result is in agreement with Johnson and Karunajeeva (1985) who also reported that plasma chloride levels were unaffected by dietary electrolyte balance Borges *et al* (2003b) obtained plasma chloride values rang ng from 109 to 111 mmol per l tre when cation anion balances ranged from 40 to 140 meq per kg But Dersjant *et al* (2001) reported a s gn f cant h gher plasma chloride concentration at –100 meq per kg group when compared to 200 or 500 meq per kg group Dersjant *et al* (2002) also reported that as electrolyte balance increased the chloride concentrat on decreased in p gs Hamilton and Thompson (1980) reported that dietary (Na+K)/Cl ratios had significant effects on plasma chlor de levels

**5 8 4 Calcium**

Serum calcium ranged from 4 94 to 6 49mg per dl No significant difference was observed between different dietary treatments Results agree with Johnson and Karunajeewa (1985) who stated that plasma ion levels of calc um was not affected by d etary electrolyte balance in broilers Borucki *et al* (2004) and Roche *et al* (2005) reported an increase in serum calc um with ncrease in cat on an on balance

5 9 SERUM BIOCHEMICAL PARAMETERS

The data on serum biochemical parameters are presented in Table 13

**5 9 1 Uric Acid**

Ur c acid concentrat on in bro lers ranged from 6 00 to 6 87 mg per dl in the present study and there was no significant difference among treatments The result disagrees with Adekunm si and Robbins (1987) who observed a significant increase in plasma uric acid concentration when fed a diet with 513 meq per kg than those fed 210 meq per kg Serum uric acid content was reported to be 5 22 mg per dl in case of broilers fed soyabean meal as protein supplement (Saoud and Daghir 1980)

**5 9 2 Glucose**

The glucose levels varied from 149 5 to 188 38 mg per dl There was no significant d fference among d fferent dietary treatments Daly and Peterson (1990) reported sim lar values for serum glucose (188 to 193 mg per dl) Peebles *et al* (1997) reported serum glucose concentrat on of 240 4 mg per dl n bro lers fed corn soya diet Similar result was obtained by Borges *et al* (2003b) The glucose levels varied from 257 8 mg per dl to 271 0 mg per dl in a study by Borges *et al* (2004a) No significant effects of DEB levels were found in association with heat stress

**5 9 3 Cholesterol**

The serum cholesterol values obtained in the present study ranged from 148 55 to 162 73 mg per dl There was no significant difference between four dietary treatments Meluzzi *et al* (1992) reported plasma total cholesterol as 134 to 146 mg per dl Mohan *et al* (1996) in another study obtained values ranging from 93 3 to 132 2 mg per dl The values are comparable to serum cholesterol levels of 183 3 mg per dl as reported normal by Kaneko *et al* (1997)

# *Summary*

# 6 SUMMARY

A study was conducted to evaluate the effect of dietary cation anion balance on the growth performance of bro ler ch cken One hundred and sixty day old commercial broiler chicks (Ven cobb) were randomly divided into 16 groups of 10 birds each The groups were randomly allotted to four dietary treatments viz T1 T2 T3 and T4 with four replicates in each treatment The experimental diets were standard broiler ration (as per BIS specification) with varying dietary cation an on balance (DCAB) of 260 meq per kg (T1 control) 210 meq per kg (T2) 310 meq per kg (T3) and 360 meq per kg (T4) The DCAB of the ration was varied by sodium bicarbonate and ammonium chloride added at various levels Ch cks in each replicate were housed randomly and reared under deep litter system of management Feed and water were provided *ad libitum* Birds were fed broiler starter rat on up to four weeks of age and then switched over to broiler finisher rat on till the end of the experi nental period The body weight of each indiv dual bird was recorded at weekly intervals Feed consumption was recorded replicate wise at weekly intervals Water consumption was recorded repl cate wise daily At the end of sixth week two b rds from each replicate were randomly selected and slaughtered to study the processing yields such as dressing percentage giblet yield and abdominal fat percentage Serum m nerals and biochemical parameters were also studied A three day metabolism trial was conducted us ng one bird from each replicate selected randomly

Body weight of birds belonging to dietary treatments T1 T2 T3 and T4 were 2069 2031 2047 and 2020 g respectively The cumulative mean body weight ga n observed were 2023 1984 2000 and 1973 g for T1 T2 T3 and T4 respectively There was no sign ficant difference among four d etary treatments for body we ght or weight gain

Cumulative mean feed intake recorded at the end of sixth week were 4030 4010 4101 and 4100 g and average daily feed intake were 159 39 164 46 166 65 and 169 81 g respectively for T1 T2 T3 and T4 No significant difference was observed among the treatments

The mean cumulative FCR of birds were 2 04 2 02 2 04 and 2 09 for birds belonging to T1 T2 T3 and T4 respectively and the values did not differ Water consumption ranged from 602 to 654 ml in birds fed experimental diets and there was no significant difference among the treatments

The per cent retention values of N ranged from 23 62 to 32 29 and that of P ranged from 19 96 to 29 83 There was no significant difference in the balances of N and P Balance and retention of Ca were low (P<0 05) for T2 (27 24 per cent) when compared to T1 (49 91 per cent) T3 (47 86 per cent) and T4 (53 72 per cent) Sodium intake and balance showed significant difference (P<0 05) among dietary treatments while outgo and retention showed no significant difference Sodium intake was significantly higher (P<0 05) for birds in T3 (0 67g per day) and T4 (0 56g per day) compared to those in T1 (0 42 g per day) Sodium balance was significantly higher (P<0 05) for birds in T3 (0 22g per day) and T4 (0 21 g per day) compared to those fed control diet (T1 0 09g per day)

Potassium balance showed no significant difference among dietary treatments Chloride intake outgo and retention showed significant difference among treatments Chloride intake was lower (P<0 05) for T4 (0 29 g per day) and T3 (0 48 g per day) than those in T1 (0 65 g per day) and T2 (and 0 68 g per day) Retention was higher (P<0 05) for T3 and T4 (51 03 and 53 17 per cent) than T1 and T2 (41 51 and 36 40 per cent) respectively

No significant difference was observed for dressing percentage giblet yield and abdominal fat yield among dietary treatments T1 T2 T3 and T4 The values ranged from 88 05 to 89 21 4 13 to 4 31 and 0 76 to 0 97 respectively

No significant difference was observed among four dietary treatments for serum cholesterol serum uric acid and serum glucose The values ranged from 148 55 to 162 73 mg per dl 6 00 to 6 87 mg per dl and 149 5 to 188 38 mg per dl respectively

Serum minerals of the birds under different dietary treatments showed no significant difference Serum sodium ranged from 111 69 to 115 44 mmol per litre serum potassium from 2 18 to 2 72 mmol per litre serum chloride from 95 95 to 101 19 mmol per litre and serum calcium from 4 94 to 6 49 mg per dl

Upon scrutiny of the results of the present study it is concluded that dietary cation anion balance had no significant influence on growth performance in broiler chicks

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# EFFECT OF DIETARY CATION - ANION BALANCE ON GROWTH PERFORMANCE OF BROILER CHICKEN

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# ABSTRACT

An investigation over a period of six weeks was carried out to study the effect of dietary cation anion balance on growth performance of broiler chicken One hundred and sixty commercial day old broiler chicks were randomly allotted to four dietary treatments viz T1 T2 T3 and T4 having four replicates each The experimental diets were standard broiler ration with varying DCAB of 260 meq/kg (T1 control) 210 meq/kg (T2) 310 meq/kg (T3) and 360 meq/kg (T4) Cation anion balance was varied using sodium bicarbonate and ammonium chloride Results indicated that the dietary treatments did not differ significantly in body weight weight gain feed conversion ratio feed intake water consumption and processing yields Body weight at the end of six weeks was 2069 2031 2047 and 2020 g and the cumulative mean body weight gain was 2023 1984 2000 and 1973 g for T1 T2 T3 and T4 respectively Average daily feed intake was 159 39 164 46 166 65 and 169 81 g and mean cumulative FCR were 2 04 2 02 2 04 and 2 09 respectively for T1 T2 T3 and T4 No significant difference was observed in serum minerals or biochemical parameters such as serum uric acid cholesterol and glucose Birds in T3 and T4 showed significantly higher (P<0 05) intake and balance of sodium than T1 and T2 Retention of chloride was significantly higher (P<0 05) for T3 and T4 whereas chloride intake was significantly lower (P<0 05) for T3 and T4 Overall evaluation of the results of the present study reveals that dietary cation anion balance does not have a significant influence on growth performance of broiler chicken