The Productivity of broiler chicken fed organic zinc supplemented diet (Ozinc)

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Roll No: 0120/03

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Department of Dairy and Poultry Science

Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Chattogram-4225, Bangladesh

December, 2022

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This is to certify that we have examined the above Master's thesis and have found that the thesis is complete and satisfactory in all respects and that all revisions required by the thesis examination committee have been made

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The Author

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LIST OF ABBREVIATIONS

Abbreviations	Elaborations
ANOVA	Analysis of Variance
Ca	Calcium
P	Phosphorus
CF	Crude Fiber
CP	Crude Protein
CRD	Completely Randomized Design
DDPS	Department of Dairy and Poultry Science
CVASU	Chattogram Veterinary and Animal Sciences University
DOC	Day Old Chick
g/b	Gram per bird
mg/dL	Milligram Per Deciliter
g/L	Gram Per Litter
DM	Dry Matter
EE	Ether Extract
FCR	Feed Conversion Ratio
LWG	Live weight gain
MS	Master of Science
PRTC	Poultry Research and Training Center
e.g.	Example Given
et al.	And his associates
etc.	Et cetera
ft.	Feet
i.e.	That is
ml	Mililitre
BW	Bone Weight
BL	Bone Length
Sq. ft.	Square Feet
ME	Metabolizable Energy
%	Percentage
<	Less Than
>	Greater Than

ABSTRACT

The study was conducted to investigate the effect of different levels of organic zinc extract on the productivity, carcass yield traits, relative weight of visceral organs, water consumption, viability, leg health, bone quality and profitability of broiler chicken. Day-old broiler chicks (Lohman Broiler, n=112) of either sex were distributed randomly into four treatments including T_1 (Control), T_2 (Ozinc0.05%), T_3 (Ozinc0.1%), and T_4 (Ozinc 0.15%) in a completely randomized design (CRD). Each treatment was replicated four times with 7 birds per replicate. Chicks were reared in the battery cages of equal size entire the trial period from dl-d28. Ready-made starter diet (crumble-pellet) was given to the chicks up to d14, after that grower diet was fed to the birds for the rest of the trial period. Chicks had a free access to water treated with organic zinc (Ozinc) at the rate of T_1 (0ml/L), T_2 (0.5ml/L), T_3 (1ml/L) and T_4 (1.5ml/L), and this treated water supplied to the birds *ad-libitum* throughout the trial period. Bird was reared under uniform feeding, rearing, lighting and standard management condition throughout the trial period. Data on feed intake (FI), live weight (LW), live weight gain (LWG), feed conversion ratio (FCR) and livability were recorded. Besides, carcass yield traits, relative weights of gastro-intestinal organs, water intake (WI) and cost benefit analyses were also measured on d28.The data revealed that FI and viability % of broiler were unaffected *($P>0.05$)*between treatments. Significantly *($P<0.05$)* higher LW was found in the T_3 group during 21 days. Only except for others the LW and LWG of broiler fed organic zinc (T_3) tend to be significant *($P<0.08$)* on day 28. The highest LW (1841.70g/b) was observed in T_3diet and the lowest LW (1741.0 g/b) found in T_1 diet during d1-28 days. The visceral organ weights (proventriculus, gizzard, liver, heart) were unaffected *($P>0.05$)* between treatments. The results of meat yield traits revealed that dressing %, thigh weight, breast weight, wing weight, back weight, shank weight, head weight, drumstick weight and neck weight percentages etc., were found similar *($P>0.05$)* between treatments. The WI of broiler differed significantly *($P<0.05$)* between treatments on d28. The highest WI was found in T_1 and T_4 group and the lowest WI was seen in the T_2 and T_3treatment group, respectively, during 28 days. Data on latency to sit (LTS), foot pad dermatitis (FPD), gait scoring (GS) tests, bone characters (length, weight, diameter, head width) and bone minerals (Ca, P) etc, were found identical *($P>0.05$)* between treatment, and these were measured to assess leg the bone quality of broiler on day 25. Higher profit margin *($P<0.05$)* and lower production cost were observed in the birds fed T_3 diet group than that of other diet groups. It can be concluded that Ozinc @ 1ml/L of water was found to be more potential for the growth performance and economic for the broiler chickens production under farming condition.

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Keywords: Organic zinc, growth, carcass characters, foot pad dermatitis, latency-to-sit test, gait score, bone quality.

CHAPTER-I

INTRODUCTION

Chapter-I
Introduction

Poultry production (specially broiler) is a profitable business across the globe. The main goal of poultry integrators is to achieve optimum production with low investment. This trend is intensifying and putting force over the poultry geneticists and nutritionists to explore alternative policies, for profitable poultry production. However, poultry nutritionists and researchers are looking for alternative feed supplements to enhance poultry performance, due to ban of animal by-products and indiscriminate uses of antibiotics in animal nutrition by EU (CEC, 2000; Adil *et al*., 2010).Zinc (Zn) is an essential trace element for poultry, and contributes for the maintenance of growth performance (Liu et al., 2011), skeletal development (Ao et al., 2007; Tomaszewska et al., 2017), and immune function (Kidd et al., 1996) of broiler chickens. The feeding standards of chickens in China (Ministry of Agriculture of P. R. China, 2004) indicate that Zn levels of 100 and 80 mg/kg are suitable for broiler chickens from 1 to 21 and 22 to 42 d of age, respectively.

The National Research Council (NRC, 1994) suggested requirements of most of the known nutrients for broilers. However, many of the requirements are based upon research conducted more than 40 years ago with animals of markedly different productive potential than those that exist today. The current NRC zinc requirement for broilers is 40 mg/kg, but this requirement is based on only a few research reports, most of which were carried out using purified or semi-purified diets with growth as the only requirement criterion (Morrison and Sarett, 1958; Roberson and Schaible, 1958; Zeigler et al., 1961). However, the estimates determined in purified or semi-purified diets may not be applicable to conventional diets because of the absence of phytate and fiber (Wedekind et al., 1992). The requirement of nutrients including Zn for animals is usually defined as the minimum dietary concentration required for maximum performance (Sterling et al., 2005). An animal’s maximum performance is difficult to assess because there are often several response criteria for each nutrient. There may be different maximum responses for the various criteria such as growth, feed efficiency, carcass composition, and bone ash, etc. The choice of responsive parameters to use in defining requirements is important. When a corn-soybean meal diet is used, the Zn in the basal diet (usually more than 40 mg/kg) often meets the requirement for chick growth, and there is no significant change in weight gain by Zn supplement (Wedekind et al., 1992). On the other hand, weight gain can be influenced by many factors and is not a sensitive criterion for Zn requirement estimation (Luo et al., 1991). So, weight gain can no longer be used as an index of Zn requirement when a corn-soybean meal diet is used, and criteria other than growth must be chosen to evaluate the Zn requirement. Tissue Zn accumulation and Zn-containing enzyme activities have been considered to be sensitive criteria, and some requirement values of Zn have been determined based on Zn accumulation in bone (Wedekind et al., 1992).

Functions of Zn can be categorized as catalytic (metalloenzymes), structural (e.g., Zn finger domains of proteins), and regulatory (e.g., metal response elements of gene promoters; Cousins, 1996). Cousins et al. (2003) proposed that the catalytic and structural roles of Zn cannot serve as functional indicators; however, the regulatory role of Zn may provide a responsive indicator. Through an interaction with a metal-responsive transcription factor (MTF-1), Zn has been shown to regulate a number of genes in which MT and ZnT-2 are included (Lichtlen et al., 2001). The current dietary Zn allowance for broilers was based on growth. Although effects of dietary Zn on the tissue Zn concentrations were assessed in previous Zn requirement studies, optimal dietary Zn levels for the activity of Zn-containing enzyme, tissue MT concentration, and expression of MT, ZnT-2 have not been studied. However, the NRC (1994) recommends 40 mg/kg Zn for broilers from 1 to 42 d of age. Recent research has shown that the optimal levels of supplemental Zn for the performance of broiler chickens' range between 12 and 60 mg/ kg for (Ao et al., 2007; Huang et al., 2007; Liu et al., 2011). These data suggest that the Zn supplementation recommended by the Feeding Standards of Chickens in China (Ministry of Agriculture of P. R. China, 2004) may be higher than the Zn requirement for broiler chickens and should be revised. Excessive Zn supplementation in chicken diets may cause environmental pollution due to Zn excretion in the feces, as fecal Zn content linearly increases with Zn dietary levels in broiler chickens and laying hens (Burrell et al, 2004; Kim & Patterson, 2004, 2005). Moreover, when Zn load in the soil increases, the Zn content in plant tissues also increases, hindering plant growth (Schmidt, 1997).

However, a clear appreciation of the role of this element in broiler production is still limited.The indispensability of zinc in the diet of animals has been recognized for many years, but the symptoms of a deficiency in avian species have not been described at large at all. Mehring et al. (1956) studied the effect of graded levels of zinc added to a practical broiler ration containing 40 mg/kg of zinc, and observed no effect on growth or feed efficiency. Dannenburg et al. (1955) and Morrison et al. (1955) reported the existence of an unidentified mineral required by the chick fed a simplified diet containing a purified soy bean protein. Subsequently, Camp et al. (1956), and Menge et al. (1956) observed growth stimulation in chicks from the addition of the ash of natural products to practical type corn-soya diets. Morrison et al. (1956) extended their observations on the unidentified mineral required by the chick and reported that it was involved in bone formation. O'Dell and Savage (1957) found that, for optimum growth of chicks, the basal diet provided by Dannenburg et al. (1955) was deficient in both potassium and zinc, and they suggested that zinc is an important constituent of the ash of distillers' dried solubles. In another study, O'Dell et al. (1958) showed that zinc deficiency was responsible for the poor growth and abnormal bone development in chicks received purified diets. The zinc requirement of chicks was first defined to be 30 mg/kg (Roberson and Schaible, 1958).

In recent years, zinc nutrition has become an active research field with several species of animals, particularly in broiler nutrition. Moreover, the role of zinc in broiler nutrition has been an area of strong interest for consumers, producers, feed manufacturers, and others integrators related with broiler industry. Adequate zinc intake and absorption is required for a variety of metabolic functions including immune response to pathogenic challenge, reproduction, growth, and quality of meat products. The potential use of organic zinc as a promising feed additives in poultry nutrition has been started now-a-days very popularly, because organic zinc might work more actively than that of other zinc or mineral contents or feed additives. It is reported that the feed additive extracts (ozinc) could affect the multiple functions including growth performance, metabolic function, building skeletal system or hard structure and defensive mechanism of the animal body positively (Karskova et al., 2015). The additives can be used in the form of extracts or liquid form, basically as essential product in water solution or drinking water.

Objectives of the Study

Broiler diets supplemented with the organic zinc extract (Ozinc) or feed additives could be very cost-effective or might have potential to enhance the productivity by lowering the cost of raising broiler chickens under farming condition. Considering the above, the present study was undertaken to meet the following objectives:

1. To investigate the productivity (feed intake, weight gain, feed efficiency, viability) of broiler chicken fed on Ozinc treated extract.
2. To assess the carcass yield traitsand gastro-intestinal development of broiler chicken fed on organic zinc treated extract (Ozinc)
3. To measure the water consumption and leg bone health or quality of broiler chicken fed on organic zinc treated extract (Ozinc)
4. To appraise the cost benefit analysis of raising broiler chickens fed on supplemental extract.

CHAPTER-II

REVIEW OF LITERATURE

Chapter-II

Review of literature

2.1 Introduction

Zinc is an essential trace mineral for birds, functioning elaborately in enzyme systems and being involved in protein synthesis, carbohydrate metabolism, and many other biochemical reactions. Zinc is required for normal growth, reproduction, and glandular development of birds. A severe zinc deficiency causes numerous physical and pathological changes including skin lesions, decreased growth, general disability of bones and joints, very poor feathering, reproductive failure, and reduced immunity to infection of several diseases. In skin, it is five to six times more concentrated in the epidermis than the dermis. In addition, zinc is associated with wound healing because of its role in collagen and keratin syntheses. All proliferating cells, including inflammatory cells, epithelial cells, and fibroblast, require zinc. Furthermore, zinc is an essential element of more than 200 metallo enzymes and affects their conformity, stability, and activity (Cousins et al. 2003). The superoxide dismutase, one of the zinc-containing antioxidant enzyme, has a critical role in keeping broiler skin healthy and increasing the shelf-life of broiler meat. However, a clear appreciation of the role of this element in broiler production is still limited. This article provides an overview on the role of zinc in broiler feeding and nutrition, immunity, reproduction, and meat quality in particular.Two inorganic (zinc sulfate and zinc oxide) and three organic (zinc acetate, zinc-methionine, and zinc-lysine) zinc sources were evaluated for their effects on the performance and carcass characteristics of broiler chicks. The birds were randomly assigned to one control (non-supplemented) and 15 treatment (supplemented) groups consisting of four replicates of 10 chicks each in a 5×3 factorial arrangement of treatments (five zinc sources and three supplemental zinc levels). Birds were kept in floor pens in a temperature-controlled room from 1 to 42 d of age and fed a non-supplemented basal diet (control) or the basal diet supplemented with 40, 80 or 120 mg/kg of Zn as mentioned sources(Lichtlen et al., 2001).. Dietary zinc source had considerable effect on feed intake in all experimental periods. Increasing Zn level from 80 to 120 mg/kg decreased the average feed intake in the growth stage and also in the entire experimental period. Similarly, the average daily gain during the entire trial period was affected by the type of Zn source and supplemental level. One degree of freedom contrast comparisons showed that the inclusion of organic zinc sources into the diets caused significant increases in feed intake and body gain when compared with inorganic counterparts. Except in wk 1, dietary supplementation with organic sources improved feed conversion ratio; FCR values were not affected by dietary Zn source or supplementation level. Breast meat yield increased with supplemental levels of organic Zn sources; however, other carcass parameters were not affected by dietary Zn source. On the other hand, organic versus inorganic zinc supplementation caused a significant increase in liver, breast and carcass weight percentages. The present findings suggest that supplemental levels of organic Zn compounds had beneficial effects on broiler performance, and Zn requirements can be reduced using these feed supplements in poultry rations.

2.2Organic zinc

Organic zinc compounds contain carbon-zinc chemical bonds in organic chemistry. Organic zinc compounds are among the first organometallic compounds. Most organic zinc compounds are easily oxidized and decomposed when dissolved in protic solvents. All reactions using organozinc reagents need to be reacted in the absence of inert gas, such as nitrogen or argon.

Organic zinc compounds can be classified according to the substituents bound to the metal. One is diorganozinc, a class of organic zinc compounds with two alkyl ligands. The second type is heteroleptic, which the electronegative or monoanionic ligands such as halides are attached to the zinc center with another alkyl or aryl substituent. The third type is ionic organic zinc compounds, and this class is divided into organozincates and organozinc cations.

2.3 Effect of zinc on growth performance of broilers

2.3.1 Feed intake and feed efficiency

The earliest observed effect of zinc deficiency was reduced feed intake by animals (Mills et al., 1967; Quarterman, 1968; Quarterman et al., 1969), which may be related to the role of zinc in inducing appetite (Hambidge et al., 1986; Berger, 2002). The first recovery response was an increased feed intake that occurs within 1 – 2 hours (Chester and Quarterman, 1970), and 2 – 4 hours (Quarterman et al., 1969) after feeding supplemental zinc to zinc-deficient birds. Ao et al. (2006) showed that feed intake was increased quadratically with increasing levels of dietary zinc up to 10 mg/kg, and increased linearly when zinc was supplied as organic zinc at 40 mg/kg in broiler chicks, after which no further increase occurred. Batal et al. (2001) also reported that weight gain, feed intake, and feed efficiency (feed/gain) responded quadratically to graded levels of supplemental zinc up to 20 mg/kg.

Huang et al. (2007) reported that weight gain and feed intake of broiler chicks were significantly increased with dietary zinc level, and the maximum weight gain and feed intake were observed in the diet supplemented with 20 mg/kg of zinc (equates to 48.37 mg/kg , total dietary zinc). Since zinc functions mostly in enzyme systems, it was generally agreed that deficiency in some enzyme activity was involved in this loss of appetite and taste. Recovery of appetite in zinc-deficient birds occurred when the extra zinc eaten was less than 1% of the total body zinc (Quarterman et al., 1969). O'Dell and Reeves (1989) showed that changes in appetite were associated with changes in the concentrations of amino acid-derived neurotransmitters in the brain. Zinc-deficient rats changed their dietary preferences by avoiding carbohydrates and seeking protein and fat (Kennedy et al., 1998). Key enzymes required for carbohydrates metabolism may be lacking because the expression of zinc dependent-messenger RNA needed to synthesize these enzymes is reduced (Kennedy et al., 1998). Progressive addition of zinc in an organic form (Rossi et al., 2007) or an inorganic form (Sandoval et al., 1998; Kim and Patterson, 2004), and in combination of both as a complex form (Burrell et al., 2004) to the basal diet did not affect the feed efficiency of broilers.

On the other hand, diets supplemented with zinc from zinc-amino acid complexes (ZnAA) improved feed efficiency in broilers. Hess et al. (2001) supplemented practical broiler diets (55 mg/kg organic zinc) with 40 mg/kg zinc from three different ZnAA. Feed efficiency was improved from 0 to 35 days and from 0 to 42 days of age when supplemental ZnAA were provided to female broilers. Sanford and Kawchumnong (1972) reported an improved feed efficiency of broilers when dietary zinc was supplemented as zinc-methionine rather than zinc oxide (ZnO). Similarly, Nollet et al. (2007) indicated that feeding organic minerals replacing inorganic sources may have benefits in feed efficiency in young broilers. These combined data suggest that both zinc concentration and zinc source influence the feed efficiency in broilers.

2.3.2 Growth rate

Growth retardation is universally observed in zinc deficiency, perhaps because of impairment of nucleic acid biosynthesis and amino acid utilisation or protein synthesis (O'Dell, 1981). Much research has been conducted regarding the effect of zinc on broiler growth performance. Batal et al. (2001) found the positive effect of zinc on the growth of broiler in optimum management system but other reports show no significant effect of zinc in broiler growth. Rossi et al. (2007) showed that body weight gain and carcass yield was not influenced by the addition of increasing levels of dietary organic zinc in broiler diets. Earlier studies with inorganic zinc (Mehring et al., 1956; Wang et al., 2002), and with organic zinc (Hudson et al., 2004a), indicated that growth performance, leg abnormalities, and meat yields were unaffected when dietary zinc were provided in excess of the NRC (1994) recommendations of 40 mg/kg.

By contrast, many investigators have added zinc in inorganic form (Mehring et al., 1956; Edwards and Baker, 2000), or in organic form (Johnson and Fakler, 1998; Burrell et al., 2004; Yu et al., 2005), to diets of broilers and observed an improvement in growth performance. Hess et al. (2001) found overall growth rate of broilers was 56.7 g/d (the average growth rate of male broiler in USA is 54.6 g/d) and showed significant improvement in body weight of male broilers at 21 days of age, but not at 42 and 49 days when birds fed zinc-methionine and zinc-lysine as complexed zinc products. Similarly, Mohanna and Nys (1999) showed that chick's body weight significantly increased with the dietary zinc content until supplementation with 25 mg/kg zinc (45 mg/kg total dietary zinc). They also indicated that no additional response was observed at higher zinc concentration in the diet of broiler chicks. The lack of consistent effects of dietary zinc on performance of birds may be due to the amount and sources of zinc present in the basal diet (Leeson and Summers, 2005). Furthermore, the presence of other dietary ligands, such as phytate, and high dietary calcium, which forms insoluble complexes with zinc, may prevent its absorption (Oberleas et al., 1966).

2.4 Zinc and meat quality of broilers

2.4.1 Carcass characteristics

Information about the effect of zinc on carcass characteristics, such as dressing percentage, carcass yield and carcass composition of broilers, is scarce. Rossi et al. (2007) stated that carcass and cut-up (drumstick, thigh, and breast) yield were not influenced by the addition of increasing levels of dietary organic zinc in broilers. Similarly, Hess et al. (2001) showed that no significant difference was detected when birds supplemented with zinc (40 mg/kg) from zinc methionine, zinc lysine or a commercial mixture of zinc methionine and lysine for whole carcass, abdominal fat, or different cut-up yields. Collins and Moran (1999) indicated that supplemental manganese and zinc did not alter processed carcass weights and abdominal fat percentage of diverse broiler strains. They did find significant differences in breast and fillet yields among two broiler strains. Furthermore, the fatty acid composition and crude fat content of raw meat were not affected by zinc or selenium supplementation (Bou et al., 2005). Bou et al. (2005) also reported that zinc supplementation increased selenium content in chicken meat. From these results we can assume that carcass characteristics of broilers depends on breed, strain, plane of nutrition, placement density (Bilgili and Hess, 1995) and environmental conditions (Hess et al., 2001).

2.4.2 Carcass quality

Quantifiable properties of meat, such as water holding capacity, shear force, drip loss, cook loss, pH, shelf life, collagen content, protein solubility, cohesiveness, and fat binding capacity, are indispensable for processors involved in the manufacture of value added meat products (Allen et al., 1998). Raw meat used in further processed products is required to have excellent functional properties that will ensure a final product of exceptional quality and profitability. However, despite their importance, the poultry grading system used worldwide continues to be based on aesthetic attributes, such as conformation, presence or absence of carcass defects, bruises, and skin tears, without taking into account the functional properties of meat (Barbut, 1996). Consequently, this grading system has not been beneficial for the further processing industry. In a modern broiler production system skin quality is a crucial issue to produce healthier broiler meat for consumers. Maximum growth rate nor feed efficiency are not necessarily correlated with skin strength (Leeson and Summers, 2005).

Table1: Effect of zinc supplementation on carcass yields of broilers

Carcass yield (%)			References
Thigh	Breast	Total Carcass	
_	_	Not Affected	Mehring et al. (1956)
Decreased	Increased	Increased	Collins and Moran (1999)
_	Increased	Not Affected	Yihfwu and Ali (2000)
Not Affected	Not Affected	Not Affected	Hess et al. (2001)
_	_	Not Affected	El-Wafa et al. (2003)
_	_	Decreased	Bou et al. (2005)
Increased	Decreased	Decreased	Rossi et al. (2007)
_	_	Increased	Sunder et al. (2008)

2.4.3 Antioxidant activity of zinc

Zinc has an antioxidant capability that plays vital role in avian nutrition. Prasad (2007) reported that zinc may act as an antioxidant and its deficiencies in animals are alleviated by a-tocopherol and other antioxidants (Kraus et al., 1997). Laying hens reared at a low temperature (6.8C) and given supplemental zinc (30 mg/kg) had higher serum a-tocopherol contents than those not receiving supplements (Onderci et al., 2003). Likewise, Japanese quail supplemented with zinc (0, 30 or 60 mg/kg) and reared at a temperature (34C) had higher serum a-tocopherol levels (Sahin and Kucuk, 2003). However, these authors did not find differences in serum a-tocopherol content between birds on distinct levels of zinc supplements reared at 22C. On the other hand, Bou et al. (2005) showed that zinc supplementation at 300 or 600 mg/kg did not affect the sensory quality, or lipid oxidation, and atocopherol content in raw meat. Bou et al. (2004) also reported that zinc supplementation at the level of 200 mg/kg did not affect the a-tocopherol content in mixed raw chicken meat. However, antioxidant role of zinc may provide an important defense system for skin (Elizabeth et al., 2002) and limit production of free radicals, such as superoxide content in broiler meat.

2.4.4 Tissue zinc concentration

Meat products are one of the main sources of dietary zinc in humans (Subar et al., 1998; Ma and Betts, 2000; Terre´s et al., 2001). According to American Zinc Association (Washington DC, VA, USA), the average zinc content in red meat from mammals and white meat from poultry are 5.2 and 1.5 mg/100g, respectively. The dark meat of a chicken has more zinc than the light meat (Health Line, 2007). Furthermore, zinc in meat products has a high bioavailability (Hortin et al., 1993; Lonnerdal, 2000).However, redistribution of zinc among body tissues can occur under stress (Beisel et al., 1976), and also could be affected by the level of zinc supplementation in animal diet. Bou et al. (2004) demonstrated that a zinc supplementation did not affect the content of zinc in mixed dark and white raw meat on a wet weight basis. Zinc content in chicken thigh is known to be higher than in breast (Emmert and Baker, 1995; Leonhardt and Wenk, 1997; Mavromichalis et al., 2000). In case of humans, about 90% of total body zinc content is in skeletal muscle and bone, but in chickens this value is only 55% (Mavromichalis et al., 2000).

Furthermore, Sandoval et al. (1998) observed that an increasing dietary zinc supplementation resulted in higher zinc concentrations in the bone, liver, kidney, and muscle of broilers studied at 1, 2 and 3 weeks of age. They also indicated that the increase of zinc concentration was less marked in muscle than in the other tissues. In relation to these results, Mohanna and Nys (1998) found that body zinc concentration in whole chickens, including feathers, supplemented with zinc (100 mg/kg) changed mainly with age. The higher body zinc concentrations were observed at 4 and 11 days of age and these concentrations decreased and then maintained its level from 21 to 50 days of age. Subsequently, Mohanna and Nys (1999) reported that the whole body zinc concentration of 21 day-old chickens was significantly lower in birds fed 40 mg kg 1 of zinc supplementation than in birds fed 170 mg/kg. These authors also found that when dietary zinc content was greater than the requirements for growth, an increase the zinc concentration in the plasma and tibia was observed up to dietary concentrations of 75 mg/kg of feed. Bartlett and Smith (2003) reported that the zinc concentration in tibia was increased with increasing dietary zinc levels. Emmert and Baker (1995) reported that experimental diets with different zinc content (37 versus 1,037 mg/kg) fed to 1 day-old chicks for 7 days affected zinc concentration in the tibia, liver, small intestine, and skin plus feathers, but not in dark and white chicken meat. They also obtained similar results when 2 day-old chicks were fed the experimental diets with different zinc content (10.6 versus 300 mg/kg) for 8 days (Emmert and Baker, 1995).

2.5 Effect of Zinc deficiency on the immune function or viability of broilers

Zinc affects multiple aspects of the immune system (Shankar and Prasad, 1998), primarily in the production of T lymphocytes in the thymus (Dardenne and Bach, 1993; Kidd et al., 1996). According to Fraker et al. (1986), zinc is an essential cofactor for thymulin, a thymic hormone that regulates T lymphocyte maturation. Helper T lymphocytes are responsible for B cell growth and differentiation, and cytolytic T lymphocytes are involved with lyses of virus-infected cells and tumor cells. Both types of T lymphocytes are involved in macrophage activation (NIH, 1991). Splenic macrophages from zinc deficient mice were less able to facilitate T-cell mitogenesis than from pair fed controls and was directly related to the degree of zinc depletion (James et al., 1987). Many researchers have assumed that the decreased immune response is a secondary response associated with reduced nutrient intake. However, the immune competent defects associated with nutritional deficiencies can contribute to the establishment and severity of several disease states (Chandra and Dayton, 1982; Gershwin et al., 1985). Therefore, the influence of a nutrient on the immune response involves a complex interaction among at least three major mechanisms: antibody-mediated-immunity, cell-mediated-immunity, and phagocytosis.

Supplementing the zinc of diets fed to broiler breeders and turkey hens increased the cellular immune response of progeny as measured by coetaneous basophile hypersensitive tests (Kidd et al., 1993, 1996, 2000; Virden et al., 2002). Similarly, Bartlett and Smith (2003) and Hudson et al. (2004a) reported that the immune response of broilers can be influenced by the level of ZnAA in the diet and by environmental conditions. Hens provided diets with added ZnAA had increased thymus weight (Virden et al., 2002) and improved livability of progeny (Flinchum et al., 1989; Virden et al., 2004). Khajarern et al. (2002) reported that high level of zinc supplementation (75 versus 175 mg/kg) resulted in higher antibody titres to Newcastle disease, infectious bursal disease and infectious bronchitis. Some researchers, however, reported that dietary zinc concentration did not influence antibody titres of broilers in response to sheep red blood cell injections (Stahl et al., 1989; Mohanna and Nys, 1999). In agreement with this data, Pimental et al. (1991a) indicated that dietary zinc concentration (8 – 58 mg/kg) or source (zinc-methionine or ZnO) did not influence antibody titers to human gamma globulin or delayed type hypersensitivity to phytohemagglutinin in broilers. The inconsistent results of the zinc effect indicate that the immune response of broiler chicks can be influenced by the level of zinc in the diet and by environmental condition.

Table2: Effect of zinc supplementation on immunity of broilers

Response		References
Humoral Immunity	Cellular Immunity	
Increased	_	Stahl et al. (1989)
Not affected	_	Pimentel et al. (1991a)
Not affected	Increased	Kidd et al. (1992)
Increased	Increased	Kidd et al. (1993)
Increased	Increased	Bertuzzi et al., (1998)
Not affected	_	Mohanna and Nys (1999)
Increased	Increased	Swain et al. (2000)
_	Increased	Virden et al. (2002)
Increased	_	Khajarern et al. (2002)
Increased	_	El-Wafa et al. (2003)
Increased	Increased	Bartlett and Smith (2003)
Increased	_	Virden et al. (2004)
Increased	_	Cardoso et al. (2004)
Increased	Increased	Hudson et al. (2004b)
Increased	Increased	Sunder et al. (2008)

2.6 Effect of organic Zinc on the water consumption of broiler chickens

Water consumption decreases from a normal level of 9.0 ml. per bird per hour to 7 ml. within 24 hours after the birds were on zinc, and to 6.8 ml. 32 hours later. Room temperatures ranged from 50-65°F. most of the time. Consumption then drop drastically to 0.41 and 0.87 ml. for the following 65 and 24 hours, respectively (Goodman, L. S., and A. Gilman, 1955). Firstly, the amount consumed increased considerably but was still less than one-half normal. It then decreased and followed by an increase.

2.7 Impact of organic Zinc on the leg bone health or bone quality of broiler chickens

The strength of poultry bones is affected by many factors having both a direct and indirect effect, nutrition being one of the most significant ones. Few studies dealing with biochemical changes in bones resulting from Zn deficiency suggest that this element is necessary to ensure the correct course of ossification and mineralisation of the bone tissue (Salim et al., 2008). Incorrect bone development is one of the basic symptoms of Zn deficiency in the birds' diet (El-Husseiny et al., 2012). Zn ions occur in the active centres of many enzymes such as alkaline phosphatase (a significant role in formation of "nuclei" of crystallization in the form of Zn phosphate) or carbonic anhydrase (necessary to ensure the resorptive activity of osteoclasts); thus, Zn is highly important to ensure correct ossification and mineralisation of the bone tissue (Scrimgeour et al., 2007). Depending on the dose, Zn affects bone metabolism and simulates bone-forming processes: it stimulates the synthesis of DNA in osteoblasts and increases bone weight and the concentration of Ca ions (Ma and Yamaguchi, 2000). Both the excess and deficiency of Zn can cause a gradual decrease in the body weight, bone weight, and bone thickness, and can give rise to bone deformation, low mineralisation, and reduced content of calcium ions in bones and blood plasma (Rath et al., 2000). According to Wang et al. (2002), Zn deficiency (10 mg kg^{-1}) in young birds has a negative effect on the formation of the skeleton. On the other hand, introducing 100 mg kg^{-1} into chicken feed significantly increased bone strength and decreased the likelihood of locomotor disorders (Štofanikova et al., 2011).

2.9 Conclusion

Although the importance of zinc as a nutrient for chickens has been known for over a century, we are still learning the role of zinc in the aspects of both nutrition and production performance. Zinc is critical to maintain broiler growth, reproductive efficiency, bone and glandular development, a strong immune system, and a host of other functions as an essential element of more than 200 metalloenzymes. More recently, the antioxidant role of zinc for skin health for humans has been demonstrated. Unfortunately, there has been only limited research related with the effect of zinc in improving broiler skin and meat quality. In addition, as an antioxidant and its role in collagen synthesis, zinc may play a significant role in producing healthy skin. Healthy skin will increase the shelf-life of broiler meat, and satisfy consumer demand at the same time. Therefore, further study is needed to improve broiler meat and skin quality, and to get optimum broiler production using dietary zinc, while maintaining friendly environment and production costs.

CHAPTER-III

MATERIALS AND METHODS

Chapter—III
Materials and Methods

3.1 Statement of the experiment

The experiment was carried out under the Department of Dairy and Poultry Science, Chattogram Veterinary and Animal Sciences University (CVASU) to ascertain the efficacy of organic zinc on the improvement of broiler chickens fed a diet supplemented with organic zinc. Feeding trial in broiler chicken was conducted at the CVASU Research and Farm based campus at Hathazari, from October to November, 2022. Laboratory analyses were performed in Poultry Science Laboratory, Poultry Research and Training Centre (PRTC), and Biochemistry Laboratory of CVASU, Khulshi, Chattogram.

3.2 Preparation of the experimental shed

Firstly, the experimental poultry shed was prepared by swiping and removing of dust dirt by broom. The battery cage was also washed and cleaned by whisk. Both shed and battery cages was then washed and cleaned properly with tap water containing detergent. The shed and cages were left for air drying for 3 days. After that, ceiling, wall and floor along with battery cages were treated with disinfectant with FAM 30R (5ml/1L water) via sprayer and again left for drying for 1 week. The cage divided into 16 pens of equal size to accommodate broiler chicken. Before allowing the entrance of chick, the individual tube feeder, drinker and each pen were marked properly by sticker (bearing cage no. and treatment). An electric bulb (60 watt) was used to brood the chicks and set at the roof of each pen by hanging condition. The floor space provided for each bird was 0.8 sq. ft in the cage. The floor of each pan was covered with medium thick paper to reduce leg injury and to maintain warm temperature within each pen. All equipment was cleaned and disinfected accordingly outside the shed. Foot bath was also washed and prepared for use. Outside the shed, all of the tools were cleaned and sanitized properly.

3.3 Collection of day-old broiler chicks and experimental design

A total of 112 (Lohman Broiler) day-old broiler chicks of either sex was purchased from a local renowned hatchery (Kazi Farms Ltd.) on a pre-order basis to run the experimental trial from day 1 to day 28. The chicks were weighed just after having them and randomly distributed into four treatments including T_1, T_2, T_3 and T_4, and each treatment had four replicates with seven broiler chicks per replicate cage in a completely randomized design (CRD). The layout of the experimental trial was demonstrated below in Table 2.

Table 3: Experimental design

Treatments	No. of Replicates				No. of chicks per treatment
	R_1	R_2	R_3	R_4	
T_1	7	7	7	7	28
T_2	7	7	7	7	28
T_3	7	7	7	7	28
T_4	7	7	7	7	28
Total	28	28	28	28	Grand Total=112

[T_1 refers to control diet, T_2, T_3 and T_4 refers to test diet / treatment which are supplemented with 0.05 %, 0.1 % and 0.15 %, organic zinc, respectively, R_1, R_2, R_3 and R_4 refer to replicates 1, 2 and 3, 4, respectively]

3.4 Collection of the experimental feed and feedstuffs

Ready-made compound diet (crumble-starter) (Aman Feed) was collected from the market by purchasing and fed the broiler chicks up to 2 weeks After that, the grower feed (Aman Feed) was fed to the birds from 15-28 days. The test feed was analyzed in the lab and shown below in the Tables (3, 4).The test ingredient named organic zinc (Ozinc) was purchased from the local market of Hathazari. The organic zinc (Ozinc) was supplied to the bird by treating with water at the rate of 0.05%, 0.1% and 0.15%, respectively,from d1 to d28. A brief description of *Ozinc was given bellow.

***Ozinc:**

Composition: Organic zinc chelated with Amino acid.

Fig: Ozinc with composition

Properties:

1. It helps to maintain a healthy immune system

2. It is an important nutrient for skin.

3. It heals the gut.

4. It may aid in macular degeneration.

Table 4: Chemical composition of starter diet

Nutrient components	Proximate values	Reporting values
Moisture	10.39%	11%
CP	23.10%	22-22.5%
CF	3.71%	3%
EE	4.74%	5%
Ash	5.05%	5%

Table 5: Chemical composition of grower diet

Nutrient components	Proximate values	Reporting values
Moisture	9.92%	11%
CP	22.35%	21-21.5%
CF	3.94%	3%
EE	7.26%	5-6%
Ash	4.76%	5%

3.5 Management

Throughout the entire experimental period, the following management practices were used in an effort to maintain uniformity (similar feeding, lighting, environmental condition) in the management practices as much as possible. The overall management procedure was supervised properly.

3.5.1 Brooding

Day old chicks (DOC) were placed into the 16 equal sized pen of battery cage, a linear feeder and a drinker were provided for each pen. Electric bulb was used to brood the chicks. A 60watt electric bulb was hanged at a height of 45 cm in the upper middle of each pen roof in order to maintain brooding temperature. For the first two days, the birds were exposed to a temperature of 35 °C. When the chicks arrived at 14 days old, the temperature was lowered. Following that, the poultry shed's temperature was held at 25 °C for the rest of the experiment.

3.5.2 Floor space

Birds were reared in battery cage of 16 equal size pens. Each pen (5.7 sq. ft.) was marked out for 7 birds. Therefore, each bird had 0.8 square feet of floor space.

3.5.3 Feeder and drinker space

One drinker and feeder were kept in each pen. One feeder (4.5 linear inches per bird) and one round drinker with a capacity of 3.0 L were provided for each pen. The tube feeder and drinker were arranged in a pattern to make it easy for the birds to intake food and water. Tube feeder was given up to 14 days. Then linear feeder was given from 15th day to 28th day. Drinkers are cleaned and dried by detergent water 3-5 days interval.

3.5.4 Feeding and watering

Feed and drinking water were supplied *ad-libitum* to the birds throughout the experimental period. Starter feed was supplied to birds up to 14d, once a day in the tube feeder in the early morning as an adjustment diet. Paper along with tube feeder and drinkers were used for feeding and watering the chicks during the early stages soon after coming from the hatchery. The grower diets were given to the experimental birds from d15-28 days two times daily, where once in the morning at 6 AM and another in the afternoon at 6 PM. Fresh, clean and cool drinking water was supplied the birds three times a day i.e., at 6 AM, 12 AM, and 6PM.

3.5.5 Lighting

The birds were exposed to a continuous lighting (23h: 1h) in each 24 hrs. of photo period.

3.5.6 Immunization of birds

Birds were vaccinated against Ranikhet (New Castle Disease), and Gumboro disease, according to the schedule mentioned in Table 5. Ranikhet live vaccine (Cevac New LR) and Gumboro live vaccine (Cevac Gumbo LR) were procured from local veterinary medicine Dispensary. Vaccines were collected in ice contained air tight flask and individual vaccine was collected at the vaccination date. Nearly 25 ml distilled water was added to vaccine vial via syringe to make 300 dose diluted live vaccine. Vaccine was administered to individual birds via eye within 2 hours of collection. Individual vaccines were administered at the evening time of respective vaccination date (Table 6).

Table 6: Vaccination schedule

Age (Days)	Name and type of the Vaccine	Name of diseases	Route of administration
3	Cevac New LR , Live	Newcastle disease	One drop in one eye
10	Cevac Gumbo LR , Live	Gumboro	One drop in one eye
17	Cevac New LR , Live	Newcastle disease	One drop in one eye
21	Cevac Gumbo LR , Live	Gumboro	One drop in one eye

3.5.7 Medication

The chicks were given glucose and vitamin-C as soon as they were removed from the chick boxes to minimize any stress that might have occurred during transportation. Water soluble vitamin and normal saline were also provided for the first 3 days of brooding. During the course of experimental period, electrolytes and vitamin-C were added with the drinking water to combat stress due to high environmental temperature (33 °C to 37 °C).

3.5.8 Sanitation

Adequate and proper hygiene and sanitary measures were adopted and followed throughout the experimental period. Proper cleaning and disinfection of all equipment were done prior to the beginning of the trial. Potassium permanganate ($KMnO_4$) solution (1.5 %) was prepared and kept into a plastic bottle fitted with a sprayer at its opening mouth. It was kept at the entry point of poultry shed and used as disinfectant before entry into poultry shed. Hands and feet were also properly disinfected with 70% alcohol before entry into the shed.

3.5.9 Data and sample collection

Both the starter feed sample and grower feed sample were collected prior to supplying birds for the assessment of the nutritive value of each diet. Body weight, feed intake and remaining feeds were recorded in record sheet in weekly basis to calculate body weight gain and feed conversion ratio (FCR). Besides, two healthy birds from each replicate were also selected randomly and then slaughtered by halal method to collect bone sample, and meat yield traits like dressing percentage, breast weight, thigh weight, drumstick weight, shank weight, wing weight, neck weight, head weight etc. were recorded on d28. Individual weight of gastrointestinal organs (liver, heart, proventriculous, gizzard) was also recorded to ascertain the gastrointestinal organ development of the birds. Water consumption was recorded weekly, and to assess the leg bone health or bone quality data on latency to-sit (LTS) test, foot pad dermatitis (FPD), and gait scoring test were also measured on day 25. Bone samples were processed after collection and measured to find the record on bone characters or traits (e.g. bone weight, bone length, bone width, bone diameter) as well as bone mineralization (Ca and P). Cost benefit analysis was calculated at the end of trial period.

3.5.10 Feed sample processing and analyses

Two feed samples were collected from ready-made diets prior to feeding the birds. The samples were prepared by using a mortar and pestle to grind them, and they were then thoroughly mixed for laboratory analyses. About 250gm of each diet of grower as well as starter diet were taken and sent to the Poultry Research and Training Center (PRTC) Lab for proximate analysis. Each analysis was done two times for each sample to minimize technical errors. The samples were tested for proximate analysis of dry matter (DM %), moisture %, crude protein (CP %), crude fiber (CF %), ether extract (EE %) and ash using standard laboratory procedures (AOAC, 2007). Dry matter estimation was done by oven dry method. Crude protein estimation was accomplished by Kjeldahl Method. 33 Ether Extract estimation was done by Soxhlet apparatus. Ash was measured by igniting the pre-asking sample on a Muffle furnace at a temperature of 600 °C for four to six hours.

3.5.11 Method for the broiler processing

At the end of trial period, two broilers were selected randomly, weighed and killed humanely from each replicate pen to assess carcass yield traits and visceral organ weight. Feed and water were withdrawn from the pens 3 hours prior to killing in order to facilitate proper bleeding and skinning. After slaughter, birds were processed by removing the feather, skin, head, shank, viscera, oil gland, heart, kidneys, liver, lungs and small and large intestine of the carcasses. Heart and liver were removed from the gastro-intestinal tract by cutting and traction gently to let them loose. Gall-bladder was removed from liver. Gizzard and proventriculus was separated from gastro-intestinal tract by cutting it loose in front of the duodenum and behind the last end of esophagus.

3.6 Recordkeeping

Throughout the entire experimental period, the following parameters were noted.

3.6.1 Mortality

Mortality record was kept when it happened. 5 birds died during trial period.

3.6.2 Body weight

Live weight of broiler was taken by weighing balance replication wise for each treatment weekly. Average live weight of the broilers was also recorded at the beginning of the experiment and at the end of each weekend.

3.6.3 Feed intake

By calculating the left over from the total amount of feed given to birds on each weekend, the quantity of feed consumed was determined at the weekend.

3.6.4 Water intake

By calculating the left over from the total amount of water given to birds on each weekend, the quantity of water intake was determined at the weekend.

3.7 Calculation of data

3.7.1 Weight gain

By subtracting the initial body weight from the final weight, the weight gain was calculated.

3.7.2 Feed conversion ratio (FCR)

The amount of feed needed for per unit of production is called feed conversion ratio. The efficiency of converting feed into meat called feed efficiency. It was calculated by using the following formula:

$$\text{FCR} = \frac{\text{Feed intake}}{\text{Body weight gain}}$$

3.7.3 Mortality and livability

Mortality of birds was calculated on the basis of number of dead birds throughout the experimental period divided by the total number of birds housed at the start of experiment. Livability was calculated from mortality of birds per replicate cage. Using this formula, the mortality percentage was calculated.

$$\text{Mortality (\%)} = \frac{\text{Number of broiler died}}{\text{Toutal number of broiler housed}} \times 100$$

3.7.4 Dressing percentage

Slaughtering data ‘such as body weight, blood loss, feather loss, abdominal fat, shank weight, heart weight, gizzard weight, heart weight, small intestine, pancreas, bursa etc., were expressed in percentage. The dressing percentage of birds was calculated as follows:

$$\text{Dressing (\%)} = \frac{\text{Dressed Weight}}{\text{Body Weight}} \times 100$$

3.8 Latency to sit test, Gait scoring and Foot pad dermatitis test

At the 25th day of rearing the above tests were done. One bird from each replication was taken. A big tub with small amount of water was taken for the latency test. A stopwatch was taken to count the time. Then a close observation was done for gait scoring and foot pad dermatitis. The following methods write/add herein briefly and precisely as stated below:

Latency-to-sit (LTS) and gait-scoring tests

On day 25, leg bone development was assessed through LTS and gait-scoring tests. The LTS tests were performed according to the method of Berg and Sanotra (2003), with some modifications. Birds were tested in pairs in a luke-warm water. The test is based on the fact that bodily contact with water is an aversive experience for broiler chicken. Standing time is therefore positively correlated to the strength of leg bone. One bird per replicate was used to carry out this test. Plastic tub containing warm water (32 ^{o}C) at a depth of 3 cm was used to carry on the test (Fig 1). The water temperature was checked every 10 minutes with a thermometer to ensure the correct temperature was maintained, and it was checked again before another batch of birds was tested. Hot or cold water was added to raise or lower the water temperature if needed. Two birds from each replicate were selected randomly from the cage and put into the water tubs. The tubs were covered with mesh lids to prevent birds from flying out. The birds were observed and left to stand in the tubs of water for up to 3 minutes. The time elapsed before the birds first attempted to sit down in the water was recorded in seconds with the aid of a stopwatch. If any bird was still standing after 10 minutes, the test was terminated. The gait-scoring test conducted followed the 3-point scoring system developed by Kestin*et al*.(1992) and Webster *et.al.* (2008). To conduct the test, two birds were randomly selected from each replicate group and allowed to walk freely on the floor. The birds were then scored by visual observation against a number of criteria as described in Table 7.

Table7: 3-point scoring system

Gait scores	Degree of impairment	Criterion
1	None	Bird can walk at least 1.5 meter with a balanced gait. Bird may appear ungainly but with little effect on function.
2	Obvious impairment	Bird can walk at least 1.5 meter but with a clear limp or decidedly awkward gait.
3	Severe impairment	Bird will not walk 1.5 meter. May shuffle on shanks or hocks with assistance of wings.

Bone processing and characteristics

The collected tibia bones were boiled for 10 minutes in deionized water, to remove all the soft tissue and defatted. After that, bone characteristics such as bone length and head width were measured using digital callipers (Mitutoyo, Japan) and the weight was recorded. After taking the measurements of the bone traits, the samples were ground and put on a muffle furnace at a temperature of 600°C for 4 hours to make ash. The bone ash weight of samples was recorded. After that, the ash was analyzed for bone mineral concentration (Ca and P only), by atomic absorption and spectrophotometry, respectively.

Measuring of Hock burn (HB) and Foot pad dermatitis (FPD)

HB is closely related to FPD, in which the skin of the hock becomes dark brown. In severe cases, scabs are observed. A total of 10 birds were randomly selected from each replication, and observed the HB of each bird visually for any incidence of dermatitis or disorder, wound, lesions and scored against a number of criteria. The hocks were given score 1 (not affected), score 2 (color changes or minor lesions), or score 3 points (severe lesions). Left and right hock were scored separately.

Method of scoring the incidence of FPD of broiler

FPD is a type of contact dermatitis affecting the plantar region of the feet in poultry and other birds. At an early stage, discoloration of the skin is seen. Hyperkeratosis and necrosis of the epidermis can develop, and in severe cases, these changes are followed by ulcerations with inflammatory reactions of the subcutaneous tissue (Ekstrand et al., 1997). The severity and incidence of FPD of broilers are scored by visual ranking system on day 42. The FPD scoring test followed the 3-point scoring system developed by Nagaraj *et al*. (2007). To conduct the test, 10 birds were randomly selected from each replication, and observed the foot-pad of each bird visually for any incidence of dermatitis or disorder, wound, lesions and scored against a number of criteria accordingly (Table 8).

Table 8: 3-point scoring system of foot-pad dermatitis of broiler chickens

Scores	Degree of impairment	Criteria
1	Foot-paw with no lesion	Dermal ridges intact within central plantar footpad surface, with or without discoloration;
2	Footpads with mild lesions	Dermal ridges not intact within a central, round to oval ulcer on the central plantar footpad surface, roughened lesion surface with small tag of crust less than 1.5 cm in diameter;
3	Footpads with severe lesions	A brown crust more than 1.5 cm in diameter, adhered to the central plantar footpad, sometimes extending up to the hock joint

3.9 Processing bone sample and data collection

The both femur bones were collected and boiled for 10 minutes in deionized water to facilitate the removing of the attached soft tissues and fat. 34 After that, bone characteristics such as bone length, width and head width were measured using digital callipers (In size, Japan) and the weight was recorded by digital balance. After taking the measurements of the bone traits, the samples were sent to the Department of Animal Science and Nutrition to analyze the bone mineral concentration. The samples were thoroughly dried before being ground and placed in a muffle furnace for four hours at 600°C to develop ash. The weight of bone ash samples was taken and then used to analyze the bone mineral concentration (Calcium and Phosphorus only) by atomic absorption and spectrophotometry respectively.

3.10 Evaluation of meat yield parameters

Two broilers were humanely dispatched on day 29, and various meat yield parameters including carcass weight, dressed weight, as well as the weights of various cuts of meat (neck, thigh, wings, breast, back, shank, drumstick), and giblets (head, heart, liver, proventriculus, and gizzard) were accurately recorded.

3.11 Production cost

All the costs involved for the production of broiler say costs for labor, feedstuffs, electricity, water, chicks, medication, vaccination, selling price of live broiler including others are taken into account for the cost benefit analyses.

3.12 Statistical analyses

All collected data were subjected to analysis by one way ANOVA procedure using Minitab software (Minitab, Minitab Version, 16, 2000). The significance of differences between means was tested using the Duncan‘s multiple range tests (DMRT). Statistical significance was considered at $P \leq 0.05$.

PICTORIAL PRESENTATION OF ACTIVITIES DURING EXPERIMENT

Fig: Poultry shed

Fig: Chick box

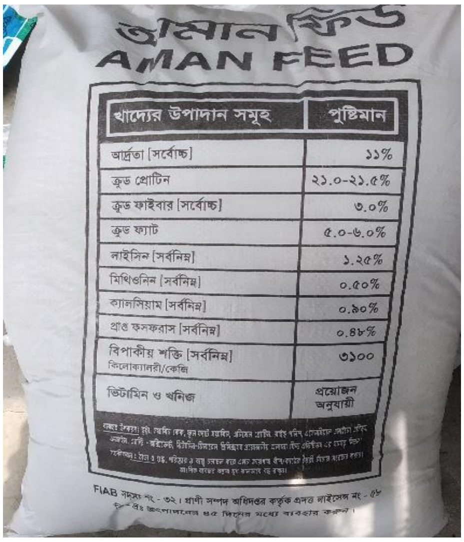

Fig: Poultry feed

Fig: Brooding

Fig: Feeding

Fig: Vaccinating

Fig: Preparing feed sample

Fig: Preparing water sample

Fig: Tray washing

Fig: Foot bath

Fig: Weighing bird

Fig: Latency test

Fig: Adult bird at day 29

Fig: Test for bumble foot

Fig: Gait scoring test

Fig: Taking samples

Fig: Taking bone parameters

CHAPTER-IV

RESULTS

Chapter-IV

Results

4.1 Gross responses of broiler chickens fed organic zinc treated extract (Ozinc).

The results of gross responses of broilers say live weight, body weight gain, feed intake, feed conversion ratio (FCR) and viability are presented below in a tubular form. Apart from this, carcass yield traits, gastro-intestinal organ weights, water intake, and profitability of broiler data also demonstrated herein this section. Besides, leg bone quality assessment in terms of latency to- sit (LTS), food pad dermatitis (FPD), gait scoring (GS), leg bone characters and bone minerals (Ca and P) data of broiler also presented below in this section.

4.2 Live weight of broiler chicken fed organic zinc extract

The live weight (LW) of broiler chicken is shown in Table 9. The results showed that the LW of broiler was not influenced (P>0.05) by the dietary treatment from d1 to d14. Significantly (P<0.05) greater FI was observed in the supplemented diets (T_2 and T_3) compared to control group on day 21. The LW of broiler fed on supplemented diets tend to be significant (P<0.08) during d1-28 days of age.

Table 9: Live weight (LW) of broiler chicken fed organic zinc (Ozinc)

Traits	Days	Treatment				SEM	P-value
		T_1	T_2	T_3	T_4		
LW (g/b)	1	41.29	41.57	42.38	41.86	0.35	0.73
	1-7	203.64	2010.35	211.57	206.00	1.10	0.09
	1-14	537.58	553.15	550.00	534..43	3.57	0.23
	1-21	1064.72^c	1127.50^a	1135.40^a	1077.20^b	8.70	0.05
	1 -28	1741.00	1825.00	1841.00	1749.00	22.68	0.08

[Data refer to mean values of seven birds per replicate from d1-d28; T_1 refers to control diet with no supplemental feed, whereas T_2, T_3 and T_4 diets are supplemented with 0.05, 0.1, and 0.15 % organic zinc (Ozinc) treated with water, respectively; SEM-standard error mean; Means bearing different superscripts in a row differ significantly at * P<0.05]]

4.3 Body weight gain (BWG) of broiler chicken fed organic zinc extract (Ozinc)

The BWG of broiler chicken on 28 days fed supplemental organic zinc extract (Ozinc) is presented through a graph (Fig.1). It is evident from the BWG data that there was insignificant (P>0.05) difference between treatment on day 28. Marginally increased BWG (P=0.08) was found in the treated group (T_2 and T_3) compared to other treatment.

Body weight gain (BWG)

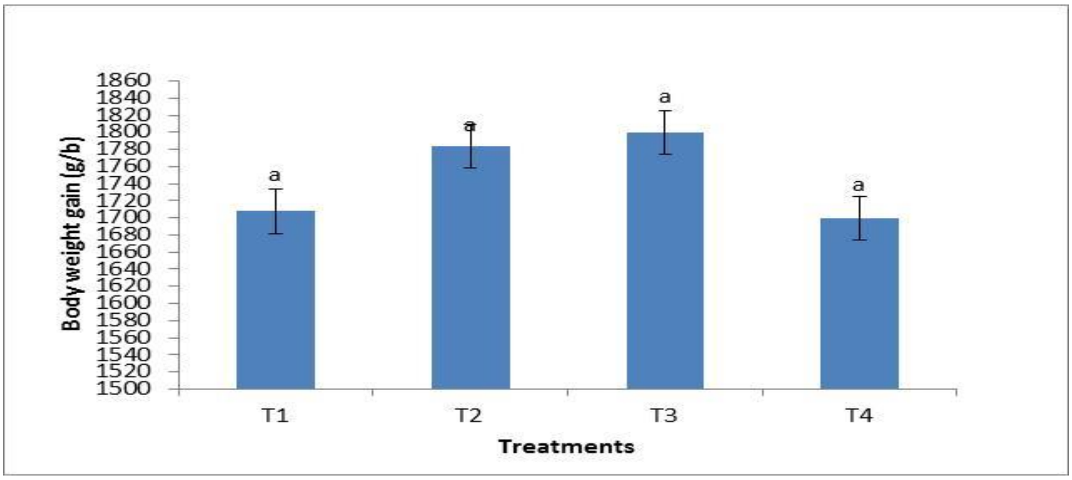

Fig 1: Body weight gain (mean± SE) of broilers from d1 to 28 days fed organic zinc treated diets; Bar bearing same superscripts has no significant (P>0.05) difference between treatments

4.4 Feed intake of broiler chicken fed organic zinc extract (Ozinc)

The feed intake (FI) result of broiler chicken up to 28 days of age was shown in Table 7. The data showed that the FI of broiler was not influenced (P>0.05) by the dietary treatment. Numerically greater FI was observed in the supplemented diets compared to control group.

Table 10: Feed intake (FI) of broiler chicken fed organic zinc (Ozinc)

Traits	Day	Treatments				SEM	P-value
		T_1	T_2	T_3	T_4		
FI (g/b)	1-7	178.50	180.50	172.85	172.00	2.23	0.45
	1-14	578.36	591.41	583.50	580.40	3.57	0.60
	1-21	1257.00	1324.00	1284.30	1275.40	11.03	0.23
	1-28	2336.40	2386.00	2360.00	2338.00	17.85	0.74

[Data refer to mean values of seven birds per replicate from d1-28 days; T_1 refers to control diet with no supplemental feed, whereas T_2, T_3 and T_4 diets are supplemented with 0.05, 0.1, and 0.15 % organic zinc (Ozinc) treated with water, respectively]

4.5 The feed conversion ratio (FCR) of broiler chicken fed organic zinc (Ozinc)

The result show that FCR was not influenced significantly ($P>0.05$) among the treatment except for 21 days (Table 8). The data show that superior FCR ($P<0.05$) was found in the T_3 group compared to others on day 21.Though no variation ($P>0.05$) was observed in the FCR values between treatment, but an improved FCR value (1.31) was observed in the T_3 supplemented diets compared to other dietary group on day 28.

Table 11: Feed conversion ratio (FCR) of broiler chicken fed organic zinc (Ozinc)

Traits	Days	Treatments				SEM	P-value
		T_1	T_2	T_3	T_4		
FCR	1-7	1.10	1.07	1.02	1.05	0.02	0.38
	1-14	1.17	1.16	1.15	1.18	0.09	0.77
	1-21	1.22^b	1.21^b	1.18^c	1.25^a	0.01	0.05
	1-28	1.37	1.34	1.31	1.38	0.02	0.09

[Data refer to mean values of seven birds per replicate from d1-28 days; T_1refers to control diet with no supplemental feed, whereas T_2, T_3 and T_4 diets are supplemented with 0.05, 0.1, and 0.15 % organic zinc (Ozinc) treated with water, respectively; Means bearing different superscripts has a significant ($P<0.05$) difference between treatments]

4.6 Survivability of broiler chicken fed with organic zinc treated extract

The response of broiler in terms of viability fed with organic zinc treated water on d28 was not influenced ($P>0.05$) by treatments (Figure 2). The results show that the numerically ($P>0.05$) the highest survivability (96.43%) was found in the bird of T_3, T_2 and T_4 treated groups and the lowest viability (%) being in T_1 (93%) untreated group.

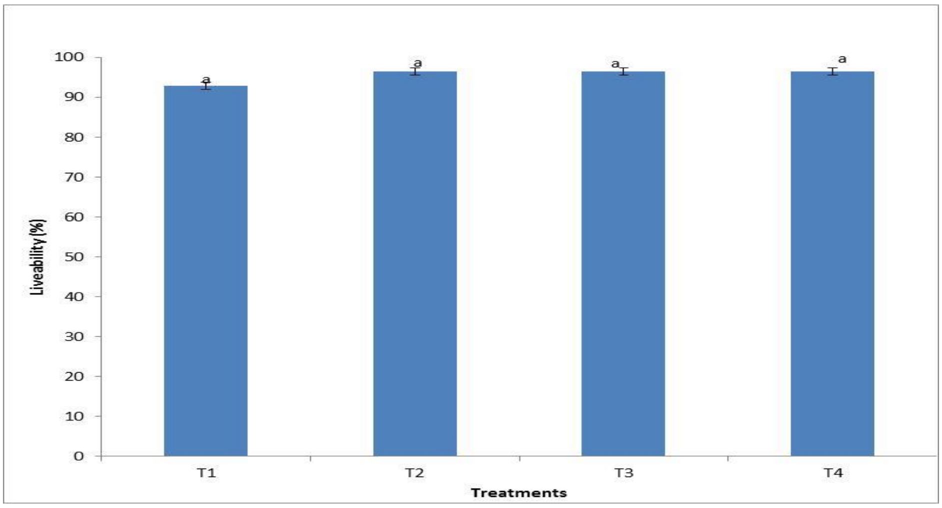

Fig 2: Viability (%) of broilers from d1 to 28 days fed organic zinc treated extracts; Bar bearing same superscripts has no significant ($P>0.05$) difference between treatment

4.7 Meat yield parameters of broiler chicken

Results of meat yield parameters shown in Table 9 demonstrated that the dietary treatment had no impact (P>0.05) on the weights of dressing percent, breast weight, drumstick weight, thigh weight, wing weight, head weight and neck weight percent, among other weights. The data show that numerically (P>0.05) greater carcass yield was found in the T_3 group than that of others.

Table 12: Carcass yield traits (g/100g) of broiler chicken organic zinc treated extract (Ozinc)

Traits (%)	Treatment				SEM	P-value
	T_1	T_2	T_3	T_4		
Dressing %	61.92	63.23	63.60	62.56	0.29	0.33
Breast weight	25.68	26.56	27.10	26.44	0.40	0.69
Drumstick weight	8.95	9.01	9.50	8.41	0.11	0.20
Thigh weight	8.63	9.14	9.08	9.83	0.25	0.47
Shank weight	4.48	4.50	4.20	3.75	0.09	0.11
Wing weight	5.28	5.40	5.41	5.64	0.09	0.59
Back weight	11.00	11.60	12.40	11.24	0.19	0.10
Neck weight	5.28	5.40	5.41	5.64	0.88	059

[Data refer to mean values of two birds per replicate on 28 days; T_1 refers to control diet with no supplemental feed, whereas T_2, T_3 and T_4 diets are supplemented with 0.05, 0.1, and 0.15 % organic zinc extract (Ozinc) treated with water, respectively]

4.8 Gastro-intestinal development of broiler

The relative weight of visceral organs of broiler chicken fed on the organic zinc diet is shown in Table 10. The result demonstrated that the proventriculus, gizzard, liver and heart weights of the birds were identical between treatments (P>0.05).

Table 13: Gastro-intestinal organ weight (g/b) of broilers fed organic zinc (Ozinc)

Traits	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Gizzard & proventriculus	69.00	75.00	69.50	58.00	2.15	0.18
Heart weight	13.00	14.00	16.00	15.00	0.79	0.62
Liver weight	66.00	65.00	62.00	49.56	4.25	0.53

[Data refer to mean values of two birds per replicate on 28 days; T_1 refers to control diet with no supplemental feed, whereas T_2, T_3 and T_4 diets are supplemented with 0.05, 0.1, and 0.15 % organic zinc extract (Ozinc) treated with water, respectively]

4.9 Water consumption of broiler fed with the organic zinc treated extract

The water intake (WI) results of broiler were shown in the following graph during d1 to 28 days of rearing period (Fig-3). The result of WI differed significantly ($P<0.05$) between treatment group. The data denote that the highest WI observed in the broilers of T_1(5930.31 ml/b) group, followed by T_4(5892.11 ml/b), T_3(5884.85.0 ml/b) and T_2 (5881.01ml/b) group, respectively (Figure-3).

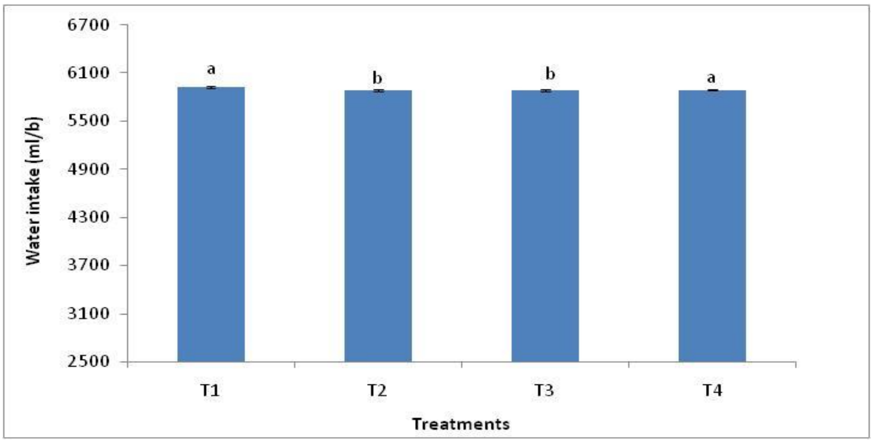

Fig 3: Water intake (ml/b) of broilers from d1 to 28 days fed organic zinc treated diets; Bar bearing different superscripts has a significant ($P<0.05$) difference between treatments

4.10 Latency to sit test (LTS) of broilers on day25 fed organic zinc treated extract

The LTS score was shown graphically. The results of LTS test denote that there had no significant ($P>0.05$) effect on the LTS score of broiler chicken on day 25, as shown in Figure 4.

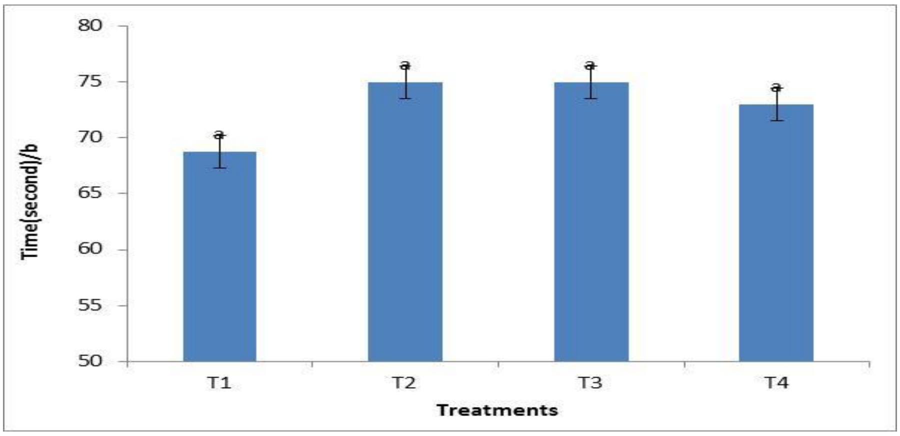

Fig 4: Latency to-sit test (LTS) of broilers on day25 fed organic zinc treated diets; Bar bearing same superscripts has no significant ($P>0.05$) difference between treatments

4.11 Foot pad dermatitis (FPD) and Gait scoring (GS) test

The data showed that the FPD and GS test of broilers were not influenced (P>0.05) by the dietary treatment (Table 11). Numerically (P>0.05) lower scores of FPD and GS were observed in the T_2 and T_3 treatment groups.

Table 14: Incidences of foot pad dermatitis (FPD) and gait scoring (GS) of broiler chicken fed organic zinc treated extract (Ozinc)

Traits	Day	Treatment				SEM	P-value
		T_1	T_2	T_3	T_4		
FPD	28	1.25	0.50	0.75	1.00	0.11	0.17
GS	28	2.00	1.50	1.70	2.00	0.10	0.25

[Data refer to mean values of four birds per replicate on day 25; T_1 refers to control diet with no supplemental feed, whereas T_2, T_3 and T_4 diets are supplemented with 0.05, 0.1, and 0.15 % organic zinc (Ozinc) treated with water, respectively]

4.12 Bone quality and bone mineralization of broiler chicken

The relative traits of bone of broiler chicken fed on the organic zinc treated extract were shown in Table 12. The result demonstrated that the bone weight (BW), bone length (BL), bone diameter, bone head width (BHW), calcium (Ca) and phosphorus (P) contents of the birds were not affected (P>0.05) by the treatments. The BW, BL and BHW were tended to be significant (P<0.08) between treatment. Comparatively greater BW, BL and BHW were observed in the $T_2$and T_4 treatment groups than that of others in this study.

Table 15: Bone quality and bone mineral contents of broiler fed organic zinc treated extract (Ozinc)

Traits	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Bone weight(g/b)	6.35	6.80	6.62	5.96	0.08	0.08
Bone length (mm/b)	60.00	64.0	63.92	62.00	0.48	0.09
Bone width(mm/b)	8.48	8.68	8.65	8.13	0.01	0.38
Bone head width (mm/b)	16.70	17.72	17.70	16.30	0.14	0.09
Ca (mg/g)	180.00	183.00	184.11	181.11	0.44	0.17
P (mg/g)	80.81	84.44	85.00	82..14	0.66	0.26

[Data refer to mean values of two birds per replicate on 28 days; T_1 refers to control diet with no supplemental feed, whereas T_2, T_3 and T_4 diets are supplemented with 0.05, 0.1, and 0.15 % organic zinc extract (Ozinc) treated with water, respectively]

4.13 Analysis of cost-benefit

Cost benefit analyses data of broiler was shown in the Table 12. The cost of production was found to be lower in the birds fed supplemented diets of T_2 and T_3 than that of control or basal diets (T_1). The birds fed diets supplemented with organic zinc at 1% (T_3) had the lowest total cost of production (Tk/Kg live broiler). Significantly ($P<0.05$) the highest profit (12.08 Tk/kg) was found for the broiler of T_3 treatment group compared to other treatments in this study.

Table 16: Cost of production and profit of broiler chicken

Traits	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Live weight (g/b)	1749.00	1825.00	1842.00	1741.00	22.68	0.09
Viability (%)	93.00	96.43	96.43	96.43	1.86	0.87
Total production cost (Tk/ kg live weight)	135.70	129.79	127.92	133.25	-	-
Selling price (Tk/kg live bird)	140.00	140.00	140.00	140.00	-	-
Profit (Tk/kg live bird)	4.30^{d}	10.21^{b}	12.08^{a}	6.75^{c}	0.28	0.05
Cost-benefit ratio	31.55	12.71	10.59	19.74	-	-

[**Data refer to mean values on the last of the trial period (28 days);** Values bearing different superscripts in a row differ significantly between treatment at *P<0.05; Detailed cost of production shown in the Appendix Table]

CHAPTER-V

DISCUSSION

Chapter-V
Discussion

5.1 Growth performances of broiler chicken fed organic zinc supplemented extract

Generally, the growth rate, FCR, and carcass composition have been the most significant factors for measuring broiler performance (Rezaei et al, 2004). The present study aimed to determine the effects of organic zinc and their relationships with growth performance, carcass yield traits, gastro-intestinal development, bone quality, water consumption and profitability of broiler chickens. The supplementation of organic zincin poultry has been known to influence the productivity. Addition of organic zinc in diet has been the subject of studies on improvement of weight gain and feed efficiency (Johnson and Fakler, 1998; Burrell et al., 2004; Yu et al., 2005).However, it is evinced from our current study that the live weight (LW) of broiler was significantly influenced by the organic zinc supplemented extract during d1-21, but poorly improved LWG was noticed during d1-d28of age, which was agreed with the findings of previous investigators ((Quarterman et al., 1969, Hess et al., 2001). Broiler fed on 1% organic zinc supplemented extract (T_3) gained higher body weight than that of other dietary groups in this study. The organic zinc can act as growth promoter, anti-oxidant and these properties might stimulate the broiler to grow better than that of untreated groups. Besides, the improved feed efficiency and the numerically higher feed intake of broiler chicken of this diet group might be a result of increased body weight of broiler chicken fed organic zinc extract treated with water, as is observed in this current study. Our result is agreed with the reports of previous studies (Hudson et al., 2004a). The poor growth development in chicks might be occurred due to zinc deficiency in diet reported by O'Dell et al. (1958).

5.2 Effect of organic zinc supplemented extract on the feed consumption of broiler chicken

The feed intake of broiler was not influenced by the dietary treatment, as is observed in this study. The uniform feed intake of broiler might be due to offering similar diet to the birds during the whole experimental periods. The feed procured from the same company has no doubt in that, it must possess similar characters such as feed composition, nutritional value, color, texture, form, taste, odor, palatability and feedstuffs, which might stimulate the birds to consume identical or same feed amount without influencing their feed intake. In this study, we see that numerically slightly greater feed intake in T_2(0.05%) and T_3(0.1%) of supplemented group than that of control diet. The increased feed intake might be an outcome of improved growth rate of the broilers, as feed requirement might vary due to attaining heavy body weight of the individual birds. The similar result was also reported by the previous researchers (Ao et al., 2006, Batal et al., 2001).

5.3 Effect of organic zinc supplemented extract on the feed conversion ratio of broiler chicken

The FCR values in different dietary treatments during the 21 and 28 days, respectively, were found to be improved in this study. At the end of the trial period, marginally improved FCR (1.31) value was seen in the T_3 diet group. It indicates that the broiler of this treatment group is assumed to be very efficient in converting feed to meat. The efficient FCR might stimulate the bird to grow heavier body weight gain, as is found in this study. Organic zinc is thought to have better antioxidant properties which can hasten growth rate by promoting better gut health, which leads to better nutrient utilization and feed conversion. Similar result was also found by other researches (Johnson and Fakler, 1998; Burrell et al., 2004; Yu et al., 2005) who reported that broilers that received diet less than 1% organic zinc utilized their diets more efficiently.

5.4 Effect of organic zinc on the survivability of broiler chicken

The data on viability of broiler showed that adding organic zinc extract to the water had no significant effect on the livability or death of birds amongst the treatments. It implies that organic zinc treated with water had no detrimental effect on the birds, even though numerically lower viability (%) of broiler was seen in the control or untreated group. The immune-booster properties of organic zinc might improve the survivability of broiler chicken (Flinchum et al., 1989; Virden et al., 2004; Guo et al. 2002).

Further it can be assumed that organic zinc in the broiler diets can be used undoubtedly, as it had no harmful impact on the growth and survivability of the broiler chicken. It can be assumed that organic zinc can act as a defensive mechanism of the body, as it is reported that it could work positively on broiler chickens (James et al., 1987).

5.5 Effect of organic zinc on carcass yield traits of broiler chicken

From the data it is obvious that there was no significant variation found in the different meat cuts say dressing %, breast weight, thigh weight, neck, wing, drumstick weight % of broiler chicken in this study (Rossi et al. 2007). The identical growth pattern of different organs of broiler carcass might be a result of uniform growth and development of the broiler chicken. With the report of previous researcher, our result is agreed who found similar results when broiler fed organic zinc supplemented diet (Collins and Moran 1999; Rossi et al., 2007). Body weight gain and carcass yield was unaffected by the addition of increasing levels of dietary organic zinc in broiler diets stated by previous researchers. The difference in the experimental results might be due to number of factors say, age, rearing length, sex, feed composition, feed quality, strain, environment, temperature and so on (Bilgili and Hess, 1995; Hess et al., 2001).

5.6 Effect of organic zinc on the relative weight of gastro-intestinal organs of broiler chicken

It is clear from the data that the relative weights of the proventriculus, gizzard, liver and heart of birds were also found identical between treatments. It is generally known that visceral organs associated with digestive function develop most rapidly in the first 7 to 10 days of life (Nitsan et al.1991). The liver, heart, proventriculus and gizzard are the main gastro-intestinal organs of the chicken. The uniform growth of visceral organ development might be due to similarity in body growth (Collins and Moran, 1999).

5.7 Effect of organic zinc extract on the water Intake of broiler chicken

Water intake (WI) of broilers in different dietary treatments during 28 days of the experimental periods was significantly affected by the treatment. In this study, we can see that more decreased WI was found in the zinc treated groups than that of control group. It is reported that multiple factors including season, temperature, cold, humidity, heat stress, diseases incidences, taste, bad dour, flavor, thirstiness, palatability, water condition, water holding capacity, feed composition, health condition, age, rearing length, sex, feed quality, strain, environment etc., might affect the water consumption level of the individual birds (Bilgili and Hess, 1995; Hess et al., 2001, Lee et al., 2003; Sang-Oh et al., 2013, Chowdhury, 2022). It can be predicted that the, sensory flavours, higher water holding capacity and lower thirstiness of broiler chicken fed organic extract might induce lower water consumption by supplemental treatment groups of birds.

5.8 Effect of organic zinc treated extract on the leg health or bone quality of broiler chicken

In view of above, data on latency to sit (LTS), foot pad dermatitis (FPD) and gait scoring (GS) tests were undertaken to assess the broiler leg health or leg bone quality in this study. In addition, leg bone traits and bone minerals, particularly Ca and P were also measured to find out the overall bone quality of broiler fed organic zinc extracts. The results of LTS, FPD and GS tests demonstrated that it had no significant effect on the different treatment groups of broilers fed organic zinc treated extract. Apart from this, bone traits namely bone length, bone weight and bone head width were slightly increased in the broiler fed T_2organic zinc treated group. The concentration of bone calcium (Ca %) and phosphorus (P %) was also numerically increased in T_2group. The higher bone length, weight, and head width might be a resultant of better growth performance of broiler chicken fed organic zinc extract, as is observed in this study as previous researches showed (Sandoval et al.1998). The poor growth and abnormal bone development in chicks might be occurred due to zinc decency reported by O'Dell et al. (1958).

5.9 Profitability of broiler chicken fed organic zinc extract

The cost-benefit analysis showed that broilers fed on a supplemental organic zinc extract in this study gained heavier body weight at the expense of low-cost involvement. Higher body weight gain and lower production costs might give rise to the higher profit margin. Additionally, net cost also varied between the experimental groups. However, number of factors could affect the profitability of broiler production say variations in feed intake, variation in feed cost (per kg), livability, weight gain and variations in mortality across experimental groups were considered to be the main causes of variations in return or profit margin.

The increased body weight gain and lower production cost counted in organic zinc treated group (T_2 and T_3) could be responsible for the higher profit margin. However, the birds' fed diets without organic zinc diets and 1.5% of organic zinc diets (T4) were seen for lower profit (Tk/Kg live broiler). Today's broiler industries are flourishing rapidly with a goal of selling their finished products in the market in diversified forms such as live bird, dressed carcass, different meat cut, deboned or fillet meat etc. to increase farm 's profitability by reducing production cost (Akter et al., 2020). This sudden change in the market forms for poultry industry recently, from a whole live bird commodity to modern highly diversified processed products, has been an emerging issue to look ahead for quality poultry production along with low investment and cost.

CHAPTER-VI

CONCLUSION AND RECOMMENDATIONS

Chapter VI

Conclusion and Recommendations

Conclusion

From an overview of the results obtained in this study revealed that adding organic zinc to broiler diets increased body weight, profitability, better FCR without affecting feed intake or livability. Besides, bone quality in terms of bone length, bone weight, and bone width were also slightly improved by adding organic zinc in the water of the birds. Water consumption capacity of broiler was found to be significantly decreased in the treated group compared to untreated group. No significant improvement of carcass yield was observed in the broiler fed diet regardless of supplemented or non-supplemented feed in this study. Further, it could facilitate the digestion with gastro-intestinal development. From the result, considerable further research study is required regarding the limitations to the use of organic zinc diets and how these diets could be used prudently for profitable livestock and poultry production. It was determined that the product is safe to use as a growth promoter or feed additives in broiler feed.In summary, it could be said that organic zinc extract (Ozinc @ 1ml/L of water)may work more effectively for broilers, enhancing growth performance, nutrient utilization, carcass characteristics and economic broiler production without having any negative impact on broiler health.

Limitations

1. Small number of birds.

2. Cage rearing.

Recommendations

1. Zinc from organic sources can be used as a growth promoter in diet supplements.

2. Further research should be conducted to point out the optimum level of organic zinc in the diet within a larger population of broiler chickens.

3. Floor rearing of birds in an open-sided house is recommended.

4. Blood profile test and biochemical meat analysis of the broilers should be done.

CHAPTER-VII

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Chapter VII

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CHAPTER-VIII

APPENDIX

Chapter-VIII

Appendix

Table 1: Cost-Benefit analysis of broiler chicken fed organic zinc diet

Parameters	Dietary treatments			
	T_1	T_2	T_3	T_4
Live weight (kg/b) on the last day of trial (29th day)	1.75	1.82	1.84	1.74
Livability (%) at the end of trial	93	96.5	96.5	96.5
No. of birds' survivability / treat.	26	27	27	27
Feed intake (kg/b) on 29th day	2.34	2.39	2.36	2.34
Feed cost (Tk/kg)	64	64	64	64
Total Feed intake (kg)	57.08 kg (26 birds @ 2.2 kg)	59.53 kg (27 birds @ 2.2 kg)	59.16 kg (27 birds @ 2.19kg)	57.68 kg (27 bird @ 2.13 kg)
Total Feed cost (Tk)	57.08×64 = 3653tk	59.53 × 64 =3809tk	59.16 ×64 = 3786tk	57.68 ×64=3691tk
Total live weight (kg) of birds per treatment	26 ×1.75 = 45.5 kg	27 ×1.82 = 49.14kg	27 × 1.84 =49.68kg	27×1.74 =46.98kg
A). Feed cost (Tk/kg live weight)	33653/45.5 =80.28	3809/49.14=77.51	3786/49.68=76.21	3691/46.98=78.57
Day-old chick cost (Tk/bird)	47	47	47	47
B). Day-old chick cost (Tk/kg live bird)	47/1.75=26.85	47/1.82=25.82	47/1.84=25.54	47/1.74=27.01
Other costs include:				
i) Vaccination cost	300 Tk	300 Tk	300 Tk	300
ii) Medication cost	200	200	200	200
iii) Disinfectant cost (iosan & phenyl)	80	80	80	80
iv) Bulb & wire cost	150	150	150	150
v) Water & Electricity cost	70	70	70	70
v) Labour cost	100	100	100	100
vi) Transport cost	400	400	400	400
Total other cost (Tk) [i…..vi]	1300	1300	1300	1300
Other cost (Tk/kg live wt)	1300/45.5= 28.57	1300/49.14=26.46	1300/49.68=26.17	1300/46.98=27.67
C). Other cost (Tk/kg live weight)	28.57	26.46	26.17	27.67
D). Total production cost (Tk / kg live wt.) [A+B+C]	135.70	129.79	127.92	133.25
E). Selling live bird market price (Tk /kg live bird)	140.00	140.00	140.00	140.00
Profit (Tk/kg live bird) [E-D]	4.30	10.21	12.08	6.75

Table 2: Feed conversion ratio of broilers

Treatment	FCRd8	FCRd15	FCRd22	FCRd29
T1	1.2413163	1.24985689	1.21875373	1.39240112
T1	1.0248288	1.15577601	1.20963722	1.25860794
T1	1.0322034	1.1279921	1.22117256	1.29728483
T1	1.1096014	1.13160632	1.20237628	1.29471637
T2	1.0121917	1.17620448	1.27619804	1.33657878
T2	1.1767764	1.14981707	1.17727533	1.26304449
T2	1.0732538	1.16188589	1.23790404	1.33932001
T2	1.0196399	1.13715577	1.18539207	1.19486879
T3	1.0654664	1.16841463	1.16483463	1.26174971
T3	0.994863	1.11113145	1.15301719	1.22426245
T3	0.979062	1.1230294	1.17782725	1.25791053
T3	1.0311958	1.20336142	1.205625	1.28198494
T4	1.0792683	1.15113126	1.2827813	1.29607945
T4	1.0121951	1.19756373	1.2547696	1.44513989
T4	1.0679012	1.16354556	1.25452233	1.30338012
T4	1.0343643	1.201043	1.19834751	1.23997853

Table 3: Survivability% of broilers

Treatment	1st wk	2nd wk	3rd wk	4th wk
T1	100	100	85.71	85.71
T1	100	100	100	100
T1	100	100	85.71	85.71
T1	100	100	100	100
T2	85.71	85.71	85.71	85.71
T2	100	100	100	100
T2	100	85.71	100	100
T2	100	100	100	100
T3	100	100	100	100
T3	100	85.71	85.71	85.71
T3	100	100	100	100
T3	100	100	100	100
T4	100	100	100	100
T4	100	100	85.71	85.71
T4	100	100	100	100
T4	100	100	100	100

Table 4: Water intake of broilers

Treatment	WI(ml/b) d1-7	WI(ml/b) d8-14	WI(ml/b) d15-21	WI(ml/b) d22-28
T1	614.2857143	1107.214286	1859.259259	2351.153846
T2	578.5714286	1116.296296	1868.148148	2320.740741
T3	576.4285714	1098.714286	1892.148148	2315.185185
T4	548.5714286	1075.142857	1829.214286	2342.592593

Table 5: Meat yield traits of broilers

Treat.	dressing%	Breast%	drumstick%	Thigh%	shank%	wing%	Back%	heart%	Neck%
T1	61.734	24.387	9.285	7.755	4.693	5.204	12.653	0.714	5.204
T1	65.906	26.970	9.211	9.971	4.273	5.603	12.155	0.664	5.603
T2	63.098	26.707	8.053	8.970	4.383	5.300	11.722	0.713	5.300
T2	63.368	26.421	8.947	7.894	4.105	5.263	11.473	0.631	5.263
T3	62.697	27.813	8.651	8.930	4.093	5.209	9.953	0.744	5.209
T3	64.476	26.380	9.238	9.238	4.285	5.619	11.238	0.761	5.619
T4	62.930	27.081	8.546	9.433	3.995	5.438	10.987	0.665	5.438
T4	64.654	25.803	8.276	10.22	3.505	5.842	11.489	0.876	5.842

Brief Bio-data of the Author

Md. Zahid Hossain, the author of this manuscript, was born on 10 December 1996 in the Satkhira district of Bangladesh. He is the son of Md. Akram Ali and Aleya Begum. He passed Secondary School Certificate (SSC) Examination in 2011 from Balli M. M. R. High School, Satkhira and Higher Secondary School Certificate (HSC) Examination in 2013 from Jhaudanga College, Satkhira. He obtained his Doctor of Veterinary Medicine (DVM) degree in 2019 from Chattogram Veterinary and Animal Sciences University (CVASU). He did his clinical training in Veterinary Clinical Medicine from Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), India in the year of 2019. Now, he is a candidate for the Master Degree in Poultry Science under the Department of Dairy and Poultry Science, Faculty of Veterinary Medicine, CVASU. The author got NST Fellowship for his MS research. He has a great interest to work in the field of Poultry Science.