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## Influence of Dietary Supplementation with Complexed Zinc on Meat Quality and Shelf Life of Broilers

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**Abstract:** Influence of complexed zinc supplementation on growth performance and meat quality of broiler chickens were assessed at 49 d of age. A total of 960 male broilers were assigned to four dietary treatments: negative control (C), positive control (C + IZn; 40 ppm ZnSO<sub>4</sub>), C + 40 ppm complexed Zn (C + OZn) and C + IZn + 40 ppm complexed Zn added to the positive control (C + IZn + OZn). Each treatment feed was provided in a three-stage feeding program. No differences ( $p > 0.05$ ) were observed in the body weight, feed conversion, carcass and component yields due to any of the dietary treatments. However, drip loss was significantly ( $p < 0.05$ ) increased in fillets from birds fed organic trace minerals when measured at 24 h post deboning. Overall, fillet color (L\*, a\* and b\* measurements) did not differ significantly ( $p > 0.05$ ) but after 28 d of storage, fillets from birds with high levels of zinc showed increased ( $p < 0.05$ ) redness (a\* value). Breast fillet quality and microbial profile over a 28 d storage period under refrigeration (4°C) were not different ( $p > 0.05$ ) due to any of the dietary treatments.

**Key words:** Zinc supplementation, dietary treatments, storage period

### INTRODUCTION

In recent years, organic trace mineral sources, such as amino acid chelates and proteinate have been used widely in animal production because of increased mineral bioavailability, lower fecal excretion and reduced environmental waste loading (Wedekind and Baker, 1989; Wedekind *et al.*, 1992; Cao *et al.*, 2000; Pierce *et al.*, 2005). Enhanced bioavailability of a mineral source could reduce the amount of a mineral that is added to a diet to meet the nutritional requirements, which in turn would reduce the amount of mineral excreted by birds (Cheng *et al.*, 1998).

Since many natural feed ingredients are Zn deficient, animal feeds are supplemented with this trace mineral. The most common Zn sources for supplementing poultry diets are from inorganic sources (i.e., ZnO and ZnSO<sub>4</sub>; Batal *et al.*, 2001). Complexing Zn with organic compounds results in better absorption by animals than with inorganic Zn sources (Cao *et al.*, 2000; Kidd *et al.*, 1996; Wedekind *et al.*, 1992). Organic Zn compounds may enhance growth and live performance in poultry (Hess *et al.*, 2001). One of the functions of zinc is related to its role in the antioxidant defense system (Powell, 2000). Zn deficiency provokes oxidative damage through the effects of free radicals (Salgueiro *et al.*, 2000). The mechanism of antioxidant action of Zn is not well defined. However, it has been suggested that zinc increases the synthesis of metallothionein, a cysteine-rich protein, which acts as a free radical scavenger (Prasad *et al.*, 1993; Sahin *et al.*, 2005).

Quality of poultry meat and meat products can be influenced by various production and processing factors. Extending the shelf life of poultry meat and products is a major goal for the poultry industry. Because fresh poultry meat is highly perishable, it is essential to maintain the shelf life of the product as long as possible. The changes that occur in poultry meat during storage are generally chemical and microbiological in nature and are primarily influenced by storage factors such as time, temperature, oxygen availability and light (Huis in't Veld, 1996). Little information is available regarding the effects of dietary micronutrient sources and supplementation levels, on broiler chicken carcass, meat quality and shelf life.

The objectives of this study were to evaluate live performance, carcass and parts yields, meat quality and shelf life determinations of broilers fed Zn from inorganic or organic sources to 49 d of age.

### MATERIALS AND METHODS

**Treatment diets and sample collection:** Male broiler chickens (Ross x Ross 708) were raised to 49 d of age in 32 floor pens (30 birds/pen; 960 birds total). Birds were reared on one of four dietary treatments (8 pens/treatment): (1) Control diet (standard broiler diet with about 65 ppm of inorganic Zn) [C], (2) Inorganic Zn (40 ppm additional Zn from ZnSO<sub>4</sub> to control diet) [C + IZn], (3) Organic Zn (40 ppm additional Zn from complexed Zn) [C + OZn] and (4) Inorganic plus organic Zn (40 ppm Zn additional Zn from ZnSO<sub>4</sub> and 40 ppm

from complexed Zn) [C+ IZn + OZn]. The experimental diets were provided in a three stage feeding program involving starter, grower and withdrawal diets to 49 d of age. Average body weights, feed conversion and percent mortality were calculated at 21 and 42 and 48 days of age.

At 49 d of age, 10 birds per pen (320 total) were randomly selected and processed at the Auburn University Poultry Science Department Processing Plant simulating commercial processing practices. Whole eviscerated carcasses were chilled for approximately 2 h in static slush-ice prior to deboning. Whole carcass, abdominal fat, parts (wings, drumsticks and thighs) and deboned breast (fillet and tender) weights and yields were determined. Deboned breast fillets (skinless *Pectoralis major* muscle) were individually packed in Ziploc® bags and stored at 4°C until analysis. One-half of the birds (5 birds per pen) were used to determine cook loss, drip loss, Water Holding Capacity (WHC) and color after deboning, while the remaining half of the birds were stored at 4°C over a 28 d period for lipid oxidation analysis (TBARS), microbial profile and color measurements.

#### Meat quality measurements

**Color measurement:** Color measurements (L\*, a\* and b\* values) were taken with a Hunters' MiniScan XE Sensor (Hunter Lab Associates Laboratory, Inc.) on the breast meat fillets after deboning.

**Drip loss analysis:** A total of 80 samples (10 breast meat samples/treatment) were used for drip loss analysis. Breast fillets were individually weighed, placed in Ziploc bags, stored at 4°C for 24 and 48 h and then reweighed. Breast fillets were lightly blotted before reweighing and the drip loss (%) was calculated as the difference between deboned and stored fillet weights divided by deboned weight x 100.

**Cook loss determination:** The breast fillets were weighed, arranged on wire oven racks, cooked in a preheated convection oven (177°C) until the desired internal temperature was reached. Breast fillets were cooked to an internal temperature of 77°C, removed from the oven and allowed to cool to an internal temperature of 24°C and reweighed. Cooking loss (%) was calculated as a difference between the raw and cooked fillet weight divided by raw fillet weight x 100.

**Water Holding Capacity (WHC):** The Water Holding Capacity (WHC) of the breast fillets was determined by the press method. In this method, one gram of the meat was placed between pre-weighted filter papers (Whatman #1; Whatman Inc., Clifton, NJ) and compressed using 50 kg-force for 3 min on a Texture

Analyzer (TA.XTplus Texture Analyzer, Texture Technologies Corporation, Scarsdale, NY). Filter papers were then reweighed and the percent free water was calculated as a difference between wet filter paper and initial filter paper weight divided by raw meat sample x 100 (Trout, 1988).

**Thiobarbituric Acid Reactive Substances (TBARS):** Breast fillet samples (10 g of meat) were homogenized with 30 ml of Distilled Water (DW) for 2 min and 2 ml of the homogenate was added with 4 ml of TCA/TBA (trichloroacetic acid/thiobarbituric acid; Alfa Aesar) stock solution [15% TCA (w/v) and 20 mM TBA] and 100 µl BHA (butylated hydroxyanisole; Sigma Chemicals). The solution was then heated for 15 min in boiling water and cooled for 10 min in cold water. Absorbance of this solution was measured against the blank which contained all reagents minus the meat sample at 531 nm. The absorbance was calculated from a calibration prepared by using 1,1,3,3-tetramethoxypropane (Fluka) as a standard (Pikul *et al.*, 1989). Stored meat samples were analyzed at 0, 7, 14, 21 and 28 d of storage.

**Microbial profile:** Breast fillets were aseptically removed from the Ziploc® bags and 10 g of each fillet was weighed into a sterile stomacher bag. The fillets were then diluted with 90 ml of 0.1% peptone water (PW; Acumedia Manufacturers, Inc., Lansing, MI) and homogenized for 180 s using a stomacher (Stomacher 400 Circulator; Seward Ltd, West Sussex, UK). Following this, serial dilutions were made by adding 1 ml of the diluent into 9 ml of 0.1% PW and spread plating 0.1 ml of the sample onto Plate Count Agar (PCA; Acumedia Manufacturers, Inc., Lansing, MI), Cephaloridine Fucidin Cetrimide Agar (CFC; Oxoid, Basingstoke, UK) and deMan, Rogosa and Sharpe Agar (MRS; Oxoid, Basingstoke, UK) for enumeration of Aerobic Plate Counts (APC), *Pseudomonas* sp. and lactic acid bacteria (LAB; Oxoid, Basingstoke, UK), respectively. The PCA plates were incubated aerobically at 35°C for 18-48 h, CFC plates were incubated aerobically at 25°C for 48 h and the MRS plates were incubated anaerobically at 25°C for 48 h in anaerobic jars with a disposable Anaerobic Gas Pak (Anaerogen; Oxoid, Basingstoke, UK). Microbial profiles of the breast meat fillets were measured on 0, 7, 14, 21 and 28 d of storage at 4°C.

**Statistical analysis:** A completely randomized block design was used to assign pens to the various treatments. Pens served as the experimental unit in the analyses. The data was analyzed using the General Linear Model (GLM) procedures of SAS 9.1.2 software (SAS, 2004). All percentage data were transformed to arcsine values prior to analysis and the Tukey's test was used to compare and separate means when main effects were significant (p<0.05).

## RESULTS AND DISCUSSION

Growth performance (body weight, feed conversion and mortality) between the dietary treatments did not differ in this study ( $p>0.05$ ; data not shown). Average body weights of the broilers at 48 d of age were 3677, 3630, 3638 and 3634 g for the control, C + IZn, C + OZn and C + IZn + OZn treatments, respectively. Dozier *et al.* (2003) evaluated the addition of organic Zn to decrease Zn excretion in broilers and reported that birds fed organic Zn excreted more Zn as a percent of Zn intake. In this study, neither body weight nor feed conversion was affected by source or level of Zn in the diet. This lack of effect of additional Zn supplementation on growth performance is consistent with those reported by Bou *et al.* (2005); Collins and Moran (1999); Richards and Dibner (2005). Similar to growth performance, carcass and parts (thighs, fillets, tenders and total breast) weights and yields were not affected ( $p>0.05$ ) by the dietary treatments (data not shown). Effect of complexed Zn on breast meat yield observed in this study are contrary to previous studies where birds fed complexed Zn supplementation had higher breast fillet and total breast (fillet + tender) yields as compared to the inorganic treatment (Saenmahayak *et al.*, 2010).

Overall, the meat quality attributes (cook loss, WHC and color) measured after deboning were not influenced by Zn sources ( $p>0.05$ ) at 49 d of age (Table 1). However, drip loss was significantly ( $p<0.05$ ) increased in fillets from birds fed diets supplemented with Zn at 24 h post-deboning whereas, drip losses were not significant ( $p>0.05$ ) among the dietary treatments at 48 h post-deboning. No differences between treatments were observed in cooking loss and water holding capacity. Overall, fillet color did not differ ( $p>0.05$ ) amongst the four treatments. Results from our study are similar to those reported by Saenmahayak *et al.* (2007), where complexed Zn supplementation has been shown to affect meat quality through reduced cooking loss and darker fillets, which may be correlated with a lower incidence of pale, soft and exudative meat. This effect may be due to the ability of Zn to bind myoglobin and increase its oxygenation. Zn also inhibits mitochondrial respiration and decreases the production of free radicals by acting as an antioxidant, thus facilitating the maintenance of meat color (O'Keeffe and Hood, 1982; Powell, 2000; Prasad, 1993).

Microbial profile of breast meat during refrigerated storage from 1 to 28 d did not differ ( $p>0.05$ ) due to dietary treatments (Fig. 1). However, spoilage bacteria increased as storage time increased and the average initial microbial load of aerobic bacteria (APC) and Lactic Acid Bacteria (LAB) were 2.63 and 2.42  $\log_{10}$  CFU/g, respectively for all four treatments. *Pseudomonas* sp. was not detected during the first week of storage and all meat samples reached 7  $\log_{10}$  CFU/g after the initial 7 d of refrigerated storage. Dainty and Mackey (1992) have

Table 1: Broiler meat quality at 49 d of age resulting from dietary supplementation of complexed zinc

Factors	Drip loss (%)		Cook loss (%)	WHC (%)
	24 h	48 h		
Diet	*	NS	NS	NS
C	0.54 <sup>ab</sup>	2.75	26.3	30.0
C + IZn	0.50 <sup>b</sup>	3.77	28.7	33.7
C + OZn	0.69 <sup>a</sup>	2.48	26.9	31.5
C + IZn + OZn	0.65 <sup>ab</sup>	3.00	26.5	30.3
SEM	0.05	0.46	1.33	2.79

C [Control diet; 65 ppm inorganic Zn], C + IZn [Inorganic Zn; 40 ppm additional Zn from ZnSO<sub>4</sub> to control diet], C + OZn [Organic Zn; 40 ppm additional Zn from complexed Zn], C + IZn + OZn [Inorganic plus organic Zn; 40 ppm Zn additional Zn from ZnSO<sub>4</sub> and 40 ppm from complexed Zn], \* $p<0.05$ , NS = Not-Significant ( $p>0.05$ ), SEM = Pooled Standard Error of the Mean

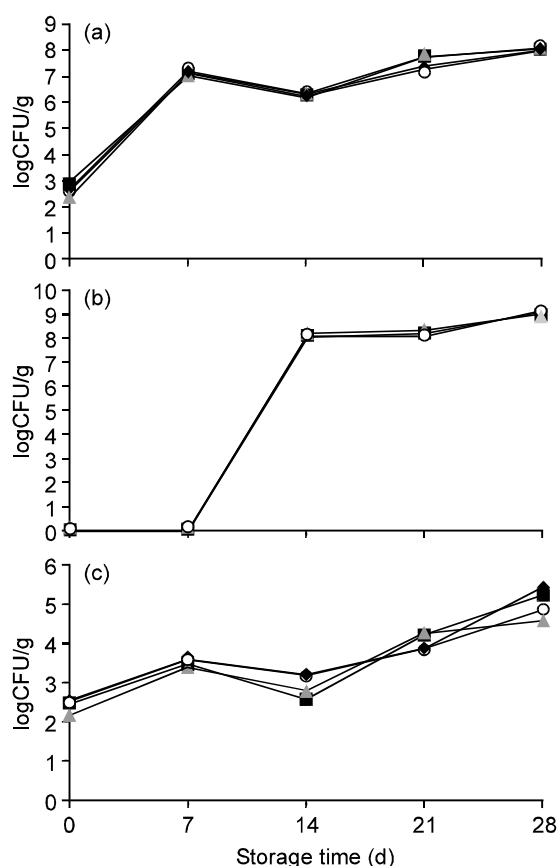


Fig. 1: Microbial profile of breast meat fillets obtained from broilers fed diets supplemented with complexed Zinc during refrigerated storage. (a) Aerobic Plate Count (b) *Pseudomonas* sp. and (c) Lactic Acid Bacteria. (◆) Control (C); (■) C + IZn; (▲) C + OZn and (●) C + IZn + OZn. [Each data point is the average of eight replications and is expressed as mean±SEM (0.1-0.4)]

reported that the initial microbial load present on carcasses after evisceration can reach 2 to 4  $\log_{10}$  CFU/

Table 2: Influence of complexed zinc on the oxidative stability of breast meat fillets during refrigerated storage

Factors	TBARS (mg of malonaldehyde/kg of meat)				
	0 d	7 d	14 d	21 d	28 d
Diet	NS	NS	NS	NS	NS
C	0.37	1.76	3.09	4.92	5.63
C + IZn	0.35	2.16	3.07	3.78	3.66
C + OZn	0.26	1.82	2.58	3.60	4.25
C + IZn + OZn	0.29	1.83	2.72	4.82	4.36
SEM	0.04	0.20	0.17	0.61	0.72

C [Control diet; 65 ppm inorganic Zn], C + IZn [Inorganic Zn; 40 ppm additional Zn from ZnSO<sub>4</sub> to control diet], C + OZn [Organic Zn; 40 ppm additional Zn from complexed Zn], C + IZn + OZn [Inorganic plus organic Zn; 40 ppm Zn additional Zn from ZnSO<sub>4</sub> and 40 ppm from complexed Zn], NS = Not-Significant (p>0.05), SEM = Pooled Standard Error of the Mean

sq. cm and is dominated by mesophilic bacteria that vary with the storage conditions. When meat is refrigerated, a psychrotrophic flora dominates due to the shorter generation time of this group of bacteria as compared to the other microorganisms under aerobic conditions at low temperatures. *Pseudomonas* sp. usually prevails and constitutes from 50-90% of the overall microbial population during refrigerated storage (Saucier *et al.*, 2000).

Oxidative rancidity of stored breast fillets (Table 2) increased over time as expected. However, the TBARS values were not influenced (p>0.05) by dietary Zn treatments. Even though Zn may act as an antioxidant as suggested by Oteiza *et al.* (1995), observations from our study were consistent with other studies where 200 and 600 mg/kg of Zn supplementation had no effect on the oxidative stability of broiler meat (Bou *et al.*, 2004; 2005). Dietary supplementation level and source of Zn had minor influences on meat quality and shelf life in this study.

Response of broiler chickens to complexed Zn supplementation was variable. Furthermore, dietary Zn sources did not influence meat quality parameters; cook loss, WHC, oxidative rancidity and shelf life. However, rate of lipid oxidation and spoilage bacterial levels on stored breast fillets increased over time.

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