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The effective role of trace elements on broiler meat characteristics and its impact on the quality of processed chicken burger

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Abstract

The objective of this study was to investigate the effect of trace elements supplementation on broiler chicken meat and the quality characteristics of chicken burger. A total of ninety one-day-old chicks of cob 500 were used for this study, the chicks were randomly assigned to three treatment groups. The experimental treatments were (T1) control (basal diet – without additives), (T2) 0.8 mg sodium selenite / liter of drinking water and (T3) 1 gm zinc oxide/ liter of water. Results showed that significant differences were found in pH values chicken meat. No significant differences were found in shear force values of chicken meat fed on diet supplemented with selenium and zinc. Meat from (T2) treatment had the higher a* value than the other dietary groups. Chicken meat of T2 and T3 groups had the lowest cooking loss. No significant differences were found in sensory attributes and overall acceptability of chicken burger samples.

Keywords: Trace elements, Broiler feed, Chicken burger, Quality characteristics

1. Introduction

Most studies on poultry nutrition have been focused on the influence of dietary supplementation on the poultry production, performance and carcass traits, but not on poultry meat quality improvement. Poultry meat and meat products quality can be influenced by various production and processing factors. The major goal for the poultry industry is extending the shelf life of poultry meat and products, because fresh poultry meat is highly perishable, it is essential to maintain the shelf life of the product as long as possible [1].

Selenium is one of essential trace element required for humans and animals [2]. It supports multiple functions related to poultry production, fertility, and immunity. Supplementation of selenium in broiler diets could improve growth performance parameters and immune function, without any negative effects on internal organs, carcass traits and gastrointestinal parts [3].

Dietary selenium supplementation in poultry diets serves as an antioxidant enzyme and helps to control levels of hydrogen peroxide in broiler meat and can prevent the oxidation of products during storage [4]. Zinc (Zn) is the second most abundant trace element in the animal body is required for growth, bone development, feathering, and enzyme structure and plays important roles in various biological activities, with particular importance for fast-growing poultry [5,6]. In addition, zinc plays a significant role as an antioxidant for skin and collagen synthesis.

A healthy skin will increase the shelf-life of broiler meat, and satisfy the consumer demand at the same time [7]. It can't be stored in the body and requires regular dietary intake to meet the physiological needs. Zinc is commonly added as a supplement to all formulated poultry diets. The most common Zn sources for supplementing poultry diets are from inorganic sources [8].

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Therefore, this research aims to study the effective role of trace elements in diets of broiler chicken on meat characteristics and its impact on the quality of processed chicken burger.

2.Material and method

2.1. Experimental Design

The experimental procedures were approved by the Animal Physiology Department and as followed by the Animal Breeding Department, Animal and Poultry Production Division, Desert Research Center. The current study was conducted at South Sinai Experimental Research Station (Ras-Suder City) which belongs to the Desert Research Center, Egypt. A total of ninety one-day-old chicks of cob 500 were used for this study, the chicks were randomly assigned to three treatment groups. Each group included five replicates and each replicate was made up of six chicks. The basal diet was formulated to meet the nutrient requirements of broiler chicken following the National Research Council (NRC,1994) [9]. Diets were offered in three feeding phases, starter from one-day-old to 10 days, grower from 11 to 21 days and finisher from 22 to 35 days as shown in Table (1).

The experimental treatments were (T1) control (basal diet – without additives), (T2) 0.8 mg sodium selenite / liter of drinking water (80 mg sodium selenite (Na_2-SeO_3) and 5.486 gm vitamin E (Alpha- tocopherol acetate) and (T3) 1 gm zinc oxide/ liter of water. Vitamins and minerals mixture were added according to the requirements by NRC [9]. Each kilogram of the experimental diets contained 0.13, 0.10 and 0.08 mg inorganic selenium and 26.12, 25.39 and 24.45 mg inorganic zinc for starter, grower and finisher diets respectively. Chicks were housed in galvanized cages. Average of indoor ambient temperature (35.70C ±0.98) and relative humidity (24.2 RH (%) ±1.32) were recorded using electronic digital thermo-hygrometer. Lighting program was controlled to provide 24 hours light throughout the experimental period (5 weeks).

At the end of experiment, four chickens from each treatment were randomly selected based on similar body weight for slaughtering. Slaughtered birds were scalded in hot water bath, plucked and eviscerated manually. Chicken meat from thigh and abdominal muscles were collected, packed and frozen at -18ºC until further analyses.

2.2. Preparation of chicken burger

Chicken meat from each treatment was ground through a 3mm plate grinder. Chicken burger samples were prepared as reported by Mikhail et al. [10]. Batches of 2kg of each dietary treatment were handily mixed and formed by using manual burger press machine (1cm thickness, 10cm diameter and 65±2g weight). Burgers were placed in plastic foam trays packed in polyethylene bags and frozen at -18ºC±1until further analysis.

2.3. Physical analysis

*pH value:*Ten grams of raw chicken meat and burger were homogenized with 100ml distilled water and measured using a digital pH-meter Jenway 3310 conductivity and pH meter as described by Hood [11].

Cooking measurements: Chicken meat samples of each treatment were cooked in a water bath at 85°C until the internal temperature reached 78°C (Meek et al. 2000) [12]. Cooked meat samples were cooled in running tap water for 1 h and then cooked samples were reweighed. Chicken burger samples of each treatment were cooked in preheated grill at120°C (to an internal temperature 75°C±2). The cooking loss was determined as reported by Naveena et al.[13].

$$\text{Cooking loss (\%): } = \frac{\text{(Uncooked sample weight) - (Cooked sample weight)} \times 100}{\text{(Uncooked sample weight)}}$$

Water holding capacity: W.H.C of samples were measured using the method of Wierbicki and Deatherage (1958) [14].

Shear force: Cooked meat and burger samples were sheared for three times at different positions by using Instron Universal Testing Machine (Model 2519-105, USA). The average shear force was calculated from the three obtained results (Kg/f).

2.4. Color measurements: Color of raw chicken meat and burger samples was measured by Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer (CIE) [15]. The color was expressed as L* (lightness), a* (the redness) and b* (the yellowness). The average of three spectral readings at different locations was obtained for each treatment.

2.5. Sensory evaluation

Chicken burger was subjected to organoleptic evaluation as described by AMSA [16]. Twenty

trained panelists of staff members of Food Sciences Department, Faculty of Agriculture, Ain-Shams University were scored appearance, texture, juiciness, flavor, tenderness and overall acceptability using a 9-point hedonic scale. The mean scores of the obtained results of organoleptic evaluation were then statistically analyzed.

2.6. Statistical analysis

Analysis of variance (ANOVA) was used to test the obtained data using the general linear modeling procedure (SAS) [17]. The used design was one way analysis. Duncan's multiple tests [18] were applied for comparison of means

3. Results and discussions

3.1. Physical properties

Physical properties including, pH value, water holding capacity (WHC), cooking loss and shear force of chicken meat and burger processed from broiler fed on diets supplemented with trace elements are shown in Table 2.

pH value: Supplementation of trace elements had a significant effect on pH values in both chicken meat and burger. Control (T1) had the higher pH value followed by (T3), the lowest pH value was found in (T2). Liu et al. found that the 24-h pH value was increased in thigh muscle of broiler chicken supplemented with Zn but pH values of breast meat were not affected by zinc supplementation [6]. The same results were found by Selim et al. they found that pH values were significantly affected by zinc sources [19].

On the other hand, Yang et al. found that no significant differences were found in pH value broiler chicken meat fed supplemented with selenium and control group [20]. Also, Khan et al. found that no significant differences were found in pH values between control and selenium selenite supplemented group [21]. Visha et al. found that pH value of control and selenium supplemented broiler chicken meat were not significant, also they indicated that the different level of selenium had no significant effect on pH value [22]. The same results were found by Perić et al. [23]. Also, Boiago et al. they indicated that supplementation with different levels of selenium had no effect on pH value of broiler meat [24]. Conversely, Medeiros et al. found that increased selenium level increased the pH value of breast broiler meat [25].

*Water holding capacity (WHC):*WHC for meat supplemented with zinc (T3) and selenium (T2) were better than and control group. However, the differences in WHC among the dietary treatments were not significant. Chicken burger of (T2) treatment had the highest WHC value followed by burger of treatment (T3) while burger of control group had the lowest WHC value. These results are close to that obtained by Khan et al. reported that broiler chicken supplemented with selenium selenite showed better WHC and lower drip loss than control one [21]. While, Boiago et al. they indicated that selenium supplementation with different levels not significantly affected on WHC [24]. Yang et al. found that chickens fed diets supplemented with Zn at 40 mg/kg showed the highest WHC in breast muscle [26]. While, Saenmahayak et al. found that supplementation with complexed zinc not significantly different on the WHC of broiler meat samples [27]. Chicken burger of (T2) treatment had the highest WHC value. These may be due to the lower pH value. Our results are coincided with Qiao et al. they investigate the relationship between broiler breast meat pH and water-holding capacity (WHC) and they indicated that pH values of broiler meat had a significant positive correlation with WHC [28]. Also, Karunanayaka et al. they reported that broiler chicken had lower WHC due to its lower pH value [29]. The same results were found by Barbut [30].

Shear force: Supplemented with selenium (T2) and zinc (T3) were not affected on shear force value of broiler chicken meat. The results resembled, to some extent, those Yang et al. they found that feeding broiler on different forms of selenium had no significant effect on shear force value of meat [20]. Khan et al. they indicated that no significant differences were found in shear force values of breast meat between control and selenium selenite [21]. Also, Boiago et al. they indicated that supplementation with different levels of selenium had no effect on shear force value of broiler meat samples [24]. Medeiros et al. found that increased the level of selenium significantly improved the shear force value (increased tenderness) in broiler breast meat. On the other hand, burger of zinc group had the lower shear force than other group [25]. These results are consonance with that obtained by Liu et al. reported that birds fed diet supplemented with Zinc had lower shear force in thigh muscle than control group [6].

Cooking loss: Cooking loss of broiler chicken meat containing selenium (T2) and zinc (T3) showed the lower cooking loss than control one. The higher cooking loss was found in chicken burger from (T2) while slight differences were found between control and (T3) samples. Addition of selenium and zinc had a significant effect on cooking loss of broiler chicken meat. These results are close to that found by Yang et al. they indicated that breast and leg meat of broiler chicken fed diet containing 0.3ppm organic and inorganic selenium had lower cooking loss than control samples [20]. Also Almeida et al. indicated that meat of broiler chicken supplemented with selenium reducing cooking loss compared to control sample [31].

Contrariwise, Miezeliene et al. indicated that cooking loss % of breast and thigh chicken meat was not significantly affected by selenium supplementation in broiler chicken diet [32].

Table 1. Feed ingredients and chemical analyses of experimental diets

Ingredients	Starter diet (0-10 days)	Grower diet (11-21 days)	Finisher (22-35 days)
Yellow corn	59.7	61.54	65.2
Soybean meal 44%	27.33	27.46	25.3
Corn gluten meal 60%	7.6	4.5	3
Sunflower oil	1.5	2.8	3.3
Calcium carbonate	1.1	1	0.93
Di-calcium phosphate	1.8	1.69	1.47
L-Lysine	0.35	0.25	0.18
DL-Methionine	0.12	0.16	0.12
Salt	0.25	0.30	0.30
Vit.&Min. Premix*	0.25	0.30	0.25
Total	100	100	100
Calculated composition			
Crude protein %	21.81	20.1	18.53
ME (kcal/kg)	3037	3111.8	3178.7
Calcium %	0.91	0.84	0.76
Available P %	0.45	0.43	0.38
L-Lysine %	1.32	1.20	1.06
DL-Methionine %	0.51	0.50	0.43
Selenium (mg)	0.13	0.10	0.08
Zinc (mg)	26.12	25.39	24.45
Folic acid (mg)	0.61	0.62	0.60

*Vitamins and minerals premix, each kg contains: Vit A 12000 IU, Vit D3 3000 IU, Vit E 12 mg, Vit K 1 mg, Vit B12 0.02 mg, Vit B1 1 mg, Vit B2 4 mg, Vit B6 1.5 mg, Nicotinic acid 20 mg, Folic acid 1 mg, Biotin 0.05 mg, Choline chloride 160 mg, Copper 3 mg, Iron 30 mg, Manganese 40 mg, Zinc 45 mg and Selenium 3 mg.

Table 2. Physical properties of chicken meat and burger

Treatment	pH	W.H.C (cm^2)	Shear force ($kg/_f$)	Cooking loss (%)
		Meat		
T1	6.17 ± 0.012^a	2.73 ± 0.06^b	1.51 ± 0.26^b	31.77 ± 0.62^a
T2	5.96 ± 0.021^c	2.40 ± 0.36^b	1.40 ± 0.10^b	27.36 ± 0.74^b
T3	6.07 ± 0.01^b	2.16 ± 0.38^b	1.57 ± 0.09^b	23.25 ± 0.34^c
SEM	0.04	0.23	0.15	0.72
		Burger		
T1	6.09 ± 0.04^a	1.16 ± 0.06^c	1.54 ± 0.32^b	53.09 ± 0.40^b
T2	5.87 ± 0.01^c	2.20 ± 0.20^a	2.02 ± 0.35^a	58.18 ± 2.01^a
T3	5.95 ± 0.03^b	1.60 ± 0.10^b	1.18 ± 0.24^c	53.90 ± 0.18^b
SEM	0.04	0.44	0.32	0.35

$^{a-c}$ means within the same column with different superscripts letters are different ($p<0.05$).
T1, T2 and T3: Treatments for (T1) control (basal diet – without additives), (T2) 0.8 mg sodium selenite / liter of drinking water and (T3) 1 gm zinc oxide/ liter of water. Means ± standard deviation. SEM: standard error of means.

Table 3. Color measurements of chicken meat and burger

Treatment	L*	a*	b*
	Meat		
T1	53.40±0.02^{b}	8.76±0.03^{b}	6.61±0.03^{c}
T2	55.53±0.05^{a}	9.29±0.02^{a}	11.04±0.02^{b}
T3	52.39±0.02^{c}	8.52±0.01^{b}	12.48±0.01^{a}
SEM	0.19	0.11	0.75
	Burger		
T1	40.72±1.16^{b}	7.58±0.68^{b}	8.31±0.10^{a}
T2	45.41±2.08^{a}	9.21±0.12^{a}	9.72±1.93^{a}
T3	41.96±2.70^{b}	7.95±0.14^{b}	9.42±0.14^{a}
SEM	0.44	0.30	0.42

$^{a-c}$ means within the same column with different superscripts letters are different ($p<0.05$).
T1, T2 and T3: Treatments for (T1) control (basal diet – without additives), (T2) 0.8 mg sodium selenite / liter of drinking water and (T3) 1 gm zinc oxide/ liter of water. Means ± standard deviation. SEM: standard error of means.

Table 4. Sensory evaluation of chicken burger

Treatment	Appearance	Texture	Juiciness	Flavor	Tenderness	Overall acceptability
T1	7.71±0.49^{a}	7.71±1.38^{a}	7.57±1.27^{a}	7.71±1.50^{a}	7.28±1.38^{a}	7.57±1.27^{a}
T2	7.42±1.27^{a}	7.85±0.69^{a}	6.85±0.69^{a}	7.71±0.76^{a}	7.71±0.84^{a}	7.50± 0.76^{a}
T3	8.00± 0.58^{a}	8.14±0.58^{a}	6.35±1.44^{a}	8.14±1.44^{a}	7.00±0.76^{a}	7.71±0.76^{a}
SEM	0.32	0.42	0.55	0.52	0.55	0.41

Means within the same column with different superscripts letters are different ($p<0.05$).
T1, T2 and T3: Treatments for (T1) control (basal diet – without additives), (T2) 0.8 mg sodium selenite / liter of drinking water and (T3) 1 gm zinc oxide/ liter of water. Means ± standard deviation. SEM: standard error of means.

The same results were found by Boiago et al. they indicated that the levels of selenium supplementation had no significant effect on cooking loss of broiler chicken meat [24]. On the other hand, Saenmahayak et al. indicated that supplementation of zinc had no significant effect on coking loss of broiler chicken meat [27].

3.2. Color measurements: Data of Table (3) represented the color measurements of chicken meat and burger supplemented with dietary trace elements. Meat from (T2) treatment (selenium supplemented) in both meat and burger had the higher a* value (more red) than the other dietary groups. Data indicated that selenium supplementation significantly improved red color of both broiler chicken meat and burger compared with zinc and control groups.

These results are agree with Yang et al. they indicated that broiler fed diet supplemented with selenium increased the red color of meat (a* value) than control group [20].

Also, Miezeliene et al. [32] reported that diet containing selenium had a significant effect on the color values for fresh breast chicken meat. Lightness of meat samples significantly decreased but redness and yellowness significantly increased. Khan et al. [21] indicated that a significant increase in red and yellow values and a decrease in lightness of breast meat supplemented with Selenium selenite compared with control group. This may be due to the antioxidant activity of selenium which reduced the oxidation of myoglobin and stabilized the pink color of meat. Also, Wang et al. found that increased the level of selenium to 0.60 mg of Se/kg treatment significantly increased a* value compared with 0 and 0.30 mg of Se/kg treatments [33]. While, Cai et al. showed that broiler fed on different nano- selenium levels had no significant differences in meat color compared with control treatment [34]. Yang et al. [26] they found that a* values in leg muscles were not affected by diet supplemented with zinc and control, also, they found that diet supplemented with30 mg /kg zinc had no significant effect in redness (a* value) of thigh and breast meat while, lightness and yellowness of breast and thigh

samples were significantly increased. Our results are disagree with Liu et al. they found that broiler chicken supplemented with zinc had higher a* value than control treatment [6]. Saenmahayak et al. found that no significant differences were found in broiler chicken meat supplemented with zinc. [27].

3.3. Sensory evaluation

Sensory attributes of broiler chicken burgers are showed in Table (4).No significant differences were found in sensory scores of chicken burger supplemented with selenium and zinc compared with control group. These results are close to that obtained by Bou et al. indicated that consumer acceptability scores of chicken meat supplemented with zinc and selenium were not significantly different even under different storage conditions [35]. Haug et al. found no significant differences were found among dietary selenium groups on sensory quality of cooked broiler meat [36].

Miezeliene et al. reported that broiler chicken fed diet containing selenium had no significant effect on sensory attributes of broiler meat [32]. The same results were found by Selim et al. found that feeding broiler chicken on different levels or sources of zinc had no significant differences on sensory properties of chicken meat [19]. On the other hand, Khan et al. [21] reported that sensory characteristics of breast meat were significantly improved with selenium supplemented compared with controls one.

4. Conclusion

The purpose of the current study was to evaluate the quality characteristics of chicken meat and burger processed from broiler chicken fed on trace elements. The addition of selenium and zinc as supplementation in broiler diets had no negative effects on the quality traits of chicken meat and burger. Further studies on the effects of feeding broiler chicken on dietary trace elements on the processing and quality characteristics of chicken meat products are suggested.

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Conflict of interest: Authors have declared that no competing interests exist.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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