The effects of kaolin, bentonite and zeolite dietary supplementation on broiler chickens meat quality during storage

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Abstract

The experiment was conducted to determine the effects of broiler chickens dietary kaolin, bentonite and zeolite supplementations on broiler thigh meat water holding capacity (WHC), lipid oxidation (TBARS), pH, and meat color during frozen storage. A total of 448-day-old sexed broiler cockerels were randomly assigned into 28 experimental units. A corn-soybean meal basal diet with 0, 15 and 30 g/kg kaolin, bentonite and zeolite as feed additive were added to control and 6 dietary treatments. Chickens were slaughtered and the left thighs kept at –20°C and analyzed after 1 and 150 days of storage. Experimental treatments had no effect on meat WHC, pH and color. Freezing at –20°C for 150 days impaired meat quality and caused chicken rancidity; however, lipid oxidation measured by TBARS value was significantly lower in chickens received diets including 15 g/kg bentonite and kaolin comparing to control diet after 150 days of frozen storage ($P<0.05$). It was concluded that though adding silicate minerals did not significantly influence WHC, pH and color in experimental treatments, they had influenced lipid oxidation and decreased chicken meat rancidity during frozen storage period.

Introduction

Poultry meat plays an important role in meeting protein needs of modern communities. It consists of high protein, necessary unsaturated fatty acids, as well as minerals; therefore, the consumption rate dramatically increased comparing to other types of meat.[1] In recent years, consumers look for meat quality and more focus on features such as color, taste and nutritional facts.[2]

Silicate minerals are natural feed additives are applied in poultry dietary due to special and desirable chemical and physical characteristics.[3] Enhancing the performance, increasing the yield[4,5] improving the health,[6,7] and utilize as a toxin binder and antioxidant[8,9] are some objectives of using silicate minerals in poultry nutrition. There are also a few studies about using silicate minerals in poultry dietary on the quality of meat indicating reduction in intramuscular fat and abdominal fat.[10,11] Lipids oxidation is recognized as one of the main problems in meat industry which ultimately leads to rancidity and losing nutritional values in long term storage.[12] Poultry meat includes much more unsaturated fatty acids with double bond in domestic animals and is more sensitive to oxidation.[13] Therefore, giving some solutions to maintain and preserve the quality of meat in storage time are of crucial importance. One way to increase meat-keeping time, by investigating effective factors of meat quality and lasting stability, is to decrease fat amounts and lipid oxidation.[14] There are various ways to avoid initiating meat lipids oxidation or to decrease it. Industrial antioxidants are used in meat and meat production industry to reduce meat oxidation; however, recently, resistance has been increased due to some carcinogen properties of these antioxidants. Now, natural antioxidants and other natural feed additives are being more mentioned.[15]

According to characteristics of silicate minerals, the present research, for the first time, studied the effect of kaolin, bentonite and zeolite on meat quality during storage. Therefore, this research was designed to evaluate the effects of kaolin, bentonite and zeolite dietary supplementation on broiler thigh meat water holding capacity, lipid oxidation, pH, and meat color during frozen storage.

Materials and Methods

Birds and diets

A total of 448 day-old sexed broiler cockerels were randomly assigned into 28 experimental units (replicates) of sixteen chicks each. A corn-soybean meal basal diet with 0, 15 and 30 g/kg kaolin, bentonite and zeolite were added to control and 6 dietary treatments as feed additives, respectively. Each diet was randomly fed to 4 experimental units for 42 days. The chicks were permitted to use the feed and water ad libitum throughout the experiment. All diets were formulated to be isonitrogenic and isocaloric during the starter and grower periods according to National Research Council (NRC)[16] recommendation (Table 1). Chickens were reared in a light, temperature and moisture controlled room up to 42 days of age.

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Sample collection and storage

Three 42 days old broilers of each replicate, following 12 h fasting, were selected according to pen average body weight. They were individually weighed and slaughtered; further, left thighs eviscerated. Chicken thighs immediately carried to the laboratory under iced (4°C) condition. The thigh muscles were cut into two parts, first part used to evaluate meat factors on day 1 and the second part stored in plastic bags at –20°C for analysis on day 150.

Analysis of meat quality

Water holding capacity (WHC) was determined using method described by Castellini and colleagues[17] as follows. One g of the meat sample placed on tissue paper in a tube and was centrifuged for 4 minutes at 1500 g. The water remained after centrifugation was measured by drying meat samples at 70°C overnight. WHC was calculated as:

$$WHC= [(\text{Weight after centrifugation} - \text{Weight after drying}) / \text{Initial weight}] \times 100$$

Lipid oxidation was estimated by measuring thiobarbituric acid reactive substances (TBARS) through using the method described by Grau and coworkers.[18] TBARS amounts were calculated on days 1 and 150 for thighs meat. The thigh muscle pH was determined using a digital pH meter (WTW-720 Inolab, Weilheim, Germany) following homogenizing

10g meat sample in 50 mL of distilled water for 1 minute.

Color was measured by Lovibond Tintometer Cam-System 500 (Amesbury, UK) through using a D65 illuminant and CIE 10 standard observer. The instrument was calibrated by a white-and-black tile prior to analysis in accordance with International Commission on Illumination. The measures were declared as CIELAB L* (lightness) a* (redness) and b* (yellowness) chromaticity coordinates.

Statistical analysis

Data were analyzed by analysis of variance in a factorial arrangement (2×7) with two times and seven dietary treatments in a completely randomized design using GLM procedures described by Statistical Analyses System (SAS).[19] The significant differences of experimental treatment means were compared using Duncan's multiple range test at 5% probability level.

Results

The effects of dietary kaolin, bentonite and zeolite supplementation and storage time on WHC, TBARS and pH of thigh meat are presented in Table 2. TBARS value showed no significant difference (P>0.05) between treatments on day 1; whereas, on day 150 value of TBARS was significantly lower in chickens received diets including 15 g/kg bentonite and kaolin comparing to control diet (P<0.05). In dietary treatments containing silicate minerals on days 1 and 150, meat water holding capacity and pH were better than control; however, the differences were numerically not statistically significant (P>0.05).

The results in Table 3 show the effects of dietary kaolin, bentonite and zeolite supple-

Table 1. Ingredients and chemical composition of basal diets.

Treatment	Starter (0-21 day)	Grower (21-42 day)
Feed ingredients		
Corn	587.3	648.1
Soybean meal	360.3	300.9
Soybean oil	14.3	17.5
Dicalcium phosphate	14.1	10.5
Limestone	12.5	13.4
Salt	4.3	3.2
Vitamin premix*	2.5	2.5
Mineral premix°	2.5	2.5
DL-Methionine	1.5	0.7
Salinomycine	0.5	0.5
Vitamin E	0.2	0.2
Nutrient composition		
Metabolizable energy, Kcal/kg	2900	3000
Crude protein	208.5	187.5
Ca	9.1	8.4
Available P	4.1	3.3
Na	1.8	1.4
Lys	11.2	9.8
Met + Cys	8.2	6.9

*Each kilogram of vitamin premix contained: vitamin A, 3,500,000 IU; vitamin D_3, 1,000,000 IU; vitamin E, 9000 IU; vitamin K_3, 1000 mg; vitamin B_1, 900 mg; vitamin B_2, 3,300 mg; vitamin B_3, 5,000 mg; vitamin B_5, 15,000 mg; vitamin B6, 150 mg; vitamin B9, 500 mg; vitamin B_{12}, 7.5 mg; biotin, 500 mg; choline chloride, 250,000 mg. °each kilogram of mineral premix contained: Mn, 50,000 mg; Fe, 25,000 mg; Zn, 50,000 mg; Cu, 5,000 mg; I, 500 mg, Se, 100 mg.

Table 2. Effects of dietary silicate mineral supplementation on water holding capacity (WHC), thiobarbituric acid reactive substances (TBARS) and pH of thigh meat.

Treatments	WHC		TBARS		pH	
	Day 1	Day 150	Day 1	Day 150	Day 1	Day 150
Control	62.57	57.86	0.48	1.29[a]	6.19	6.12
Kaolin, 15 g/kg	64.02	59.15	0.43	0.89[b]	6.11	6.02
Kaolin, 30 g/kg	64.84	60.32	0.46	1.06[ab]	6.16	6.10
Bentonite, 15 g/kg	63.76	58.95	0.41	0.86[b]	6.14	6.05
Bentonite, 30 g/kg	63.08	58.28	0.45	1.02[ab]	6.12	6.02
Zeolite, 15 g/kg	63.52	58.77	0.53	0.98[b]	6.10	5.96
Zeolite, 30 g/kg	63.63	58.87	0.44	1.03[ab]	6.11	6.00
SEM	1.46	1.60	0.05	0.09	0.06	0.07

Means within columns with different superscripts show significant difference (P<0.05).

Table 3. Effects of dietary silicate mineral supplementation on lightness (L*), Redness (a*) and Yellowness (b*) of thigh meat

Treatments	Hunter L*		Hunter a*		Hunter b*	
	1	150	1	150	1	150
Control	62.49	47.37	9.55	13.30	2.74	3.15
Kaolin, 15 g/kg	63.64	49.61	9.36	13.15	2.80	2.90
Kaolin, 30 g/kg	64.71	50.41	9.11	12.38	2.78	2.95
Bentonite, 15 g/kg	63.07	47.38	9.65	13.90	2.53	2.75
Bentonite, 30 g/kg	62.79	45.88	9.57	13.33	2.18	3.25
Zeolite, 15 g/kg	64.61	52.51	9.35	12.30	2.05	2.00
Zeolite, 30 g/kg	65.08	47.42	9.09	13.60	2.23	2.50
SEM	1.18	2.08	0.30	0.61	0.47	0.78

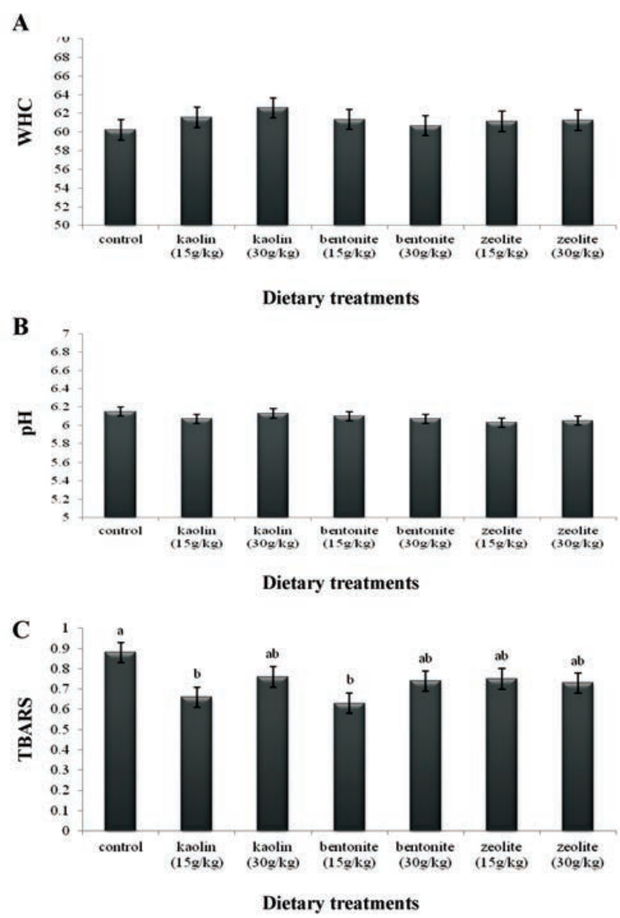

Figure 1. A-C) Effect of each dietary treatment on average values of meat quality characteristics for all the periods. The different superscripts show significant difference (P<0.05).

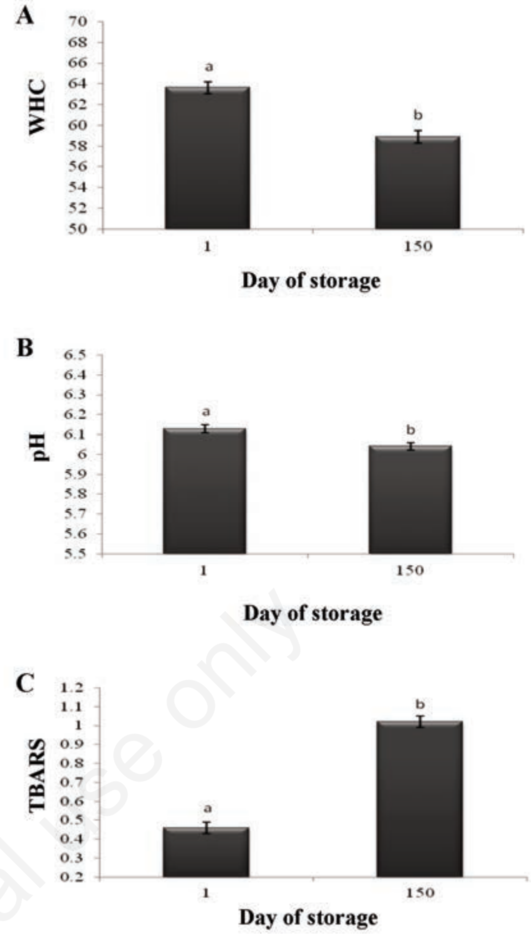

Figure 2. A-C) Effects of all the dietary treatments on average values of meat quality characteristics for each day. The different superscripts show significant difference (P<0.05).

mentation and storage time on CIELab thigh meat color. Dietary treatment did not significantly influence on lightness (L*), Redness (a*) and Yellowness (b*) of thigh meat color (P>0.05). The effect of each dietary treatment on average values of meat quality characteristics for all periods is shown in Figure 1. In dietary treatments containing kaolin, bentonite and zeolite, average values of meat water holding capacity and pH were better than control, but the differences were not significant (P>0.05). The average value of TBARS was significantly reduced in diets including 15 g/kg bentonite and kaolin compared to control diet (P<0.05). The effects of all dietary treatments on average values of meat quality characteristics for each day are given in Figure 2. The water holding capacity and pH average values were decreased significantly (P<0.05) in all dietary treatments since 150 days storage time. The average values of TBARS were significantly higher in all dietary treatments after 150 days frozen storage compared to the first day.

Discussion

According to results, TBARS was lower in chickens received the diets including 15 g/kg bentonite and kaolin compared to control diet after 150 days of storage (Table 2). Meat oxidation developing after slaughter depends on various factors including the amount of meat fat and its fatty acid profile, the levels of meat peroxides and antioxidants, how to process meat (chopped, minced and heated) as well as packaging conditions (light, temperature and duration).[20,21]

The CIELab thigh meat color was not stable during storage time in all dietary treatments (Table 3). Meat color is regarded as an indicator for evaluating meat quality in broilers which myoglobin level, type of muscle, pH, as well as broiler age at slaughter are effective factors on it.[22]

In this experiment, addition of silicate minerals to broiler dietary were effective in improving meat quality characteristics during storage (Figure 1 and 2). It reported that there is a reverse relation between the amount of dietary protein and level of intramuscular fat; further, a direct positive relation seen between dietary energy level and the amount of intramuscular fat indicating that the more intramuscular fat much higher lipid oxidation.[22,23] Our previous studies revealed that adding silicate minerals in broiler dietary may lead to a significant increase in the protein digestibility; while, it showed no significant effect on energy digestibility.[24] Moreover, inclusion silicate minerals to diets may increase meat protein amount and reduce intramuscular fat and abdominal fat in broilers chickens.[15] Hence, silicate minerals cause reduction of lipid oxidation by improving dietary protein digestibility and reducing the amount of intramuscular fat and abdominal fat.

Huff-Lonergan and Lonergan[25] have observed that higher meat oxidation leads to decreasing water holding capacity between myofibrils and intensifying water loss. Lipids and proteins oxidations in addition to all factors of influencing myofibrils proteins status impact meat drip loss. Previous studies reported that water holding capacity and meat drip loss after slaughter depends on pH reduction, myofibrils shortening, myosin denature and forming actomyosin.[26,27] Body metabolic pathways will be stopped after poultry slaughter; however, there still exists some ongoing processes a few minutes after slaughter causing glycogen breakdown in an anaerobic pathway and producing lactic acid. Lactic acid stored in tissues reduces pH from neutral to acidic. The meat pH slightly increased, as amino acid deamination and ammonia released a while after slaughtering.[26] High pH causes decreasing shelf life of frozen meat and low pH causes WHC, as well.[28]

Conclusions

According to research results, it concluded that adding silicate minerals to broiler chicks dietary may increase oxidative stability and meat keeping time in addition to reducing rancidity over storage time. Therefore, it recommended silicate minerals as an effective feed additive for preserving meat quality of broiler chicks during storage. However, determining their effect mechanism on meat quality requires more studying. Furthermore, studying the effect of simultaneous using of different levels of silicate minerals and natural antioxidants on preserving meat quality during storage is recommended for further future study.

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