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Meat quality of broiler chickens fed diets with or without supplemental vitamin-mineral premix at the finisher phase

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Target Audience: *Poultry farmers, Poultry scientists, Researchers, and Animal nutritionists*

Abstract

The effects of withdrawing supplemental dietary vitamin-mineral premix (DVMP) on meat quality attributes of finisher broiler chickens were investigated in this study. In a completely randomized design, 240 unsexed Arbor Acres broiler chicken strain at day 28 were randomly allotted to two treatments, each replicated ten times, a replicate had 12 chicks. Treatment 1 (T_1) was the control diet with supplemental DVMP, while Treatment 2 (T_2) was without any supplemental DVMP. The diets were fed to the respective chicks for 14 days. Meat colour, flavour, texture and juiciness were not significantly affected (p>0.05) by the DVMP withdrawal. Conversely, meat tenderness (3.8 and 7.0) was significantly higher (P<0.05) for the broiler meat from T_2 than T_1, while the overall acceptability (7.9 and 6.30) was significantly higher (P<0.05) for meat from T_1. There was no significant effect of the treatment (p>0.05) on meat shear force, however, cooking loss and water holding capacity were significantly higher (p<0.05)for T_2. Except for ash content which was significantly higher (p<0.05) for T_1 (4.01%) than T_2 (2.4%), other proximate indices were similar (p>0.05). There was no effect of the treatment (p>0.05) on other chemical indices of meat (pH and thiobarbituric acid reactive substances). Therefore, DVMP was invaluable for the meat quality indices of finisher broilers.

Keywords: Dietary vitamin-mineral premix, Meat lipid peroxidation, Arbor Acre chicken, Meat quality characteristics, Overall acceptability

Description of Problem

In Nigeria, the higher price of feed ingredients has contributed to the increasing cost of animal feeds with a resultant low-profit margin to the farmers. Feeds and ingredients costs have not been commensurate with the prevailing market price of live broilers and eggs -the main poultry products. This, therefore, calls for an urgent need to explore alternative cheaper feed formulations to sustain poultry enterprises. Assiduous research attempts at producing cheaper feeds which hitherto constitute humongous 70–80% of the production cost of any poultry enterprises have yielded diverse outcomes (1, 2, 3).

The DVMP remained one of the most expensive ingredients used in formulating diets of poultry (4). The DVMP is also one of the feed ingredients that attracted the greatest attention in broiler production. It is believed that the reduction or entire removal of DVMP from the diets of broiler chicken diets could be a veritable tool for lowering the broiler feed cost (5, 6). The dietary vitamin-minerals of the poultry could be from the innate vitamin-minerals of the ingredients or the usually expensive obligate supplemental nutrients (7, 8) imputed to complement the requirements of poultry (9).

Dietary vitamins and minerals are needed for animal physiological functions such as the development, growth, maintenance and reproduction as well as the optimum nutrition of poultry. Biochemical cofactors also exert catalytic functions which facilitate nutrient synthesis, thus controlling metabolism which impact greatly on performance and health of poultry (10). Most vitamins and minerals also cannot be synthesized by the poultry to meet their requirements (9). (11), however, observed that a short period of vitamin and mineral restriction in the growing phase of broiler chickens may not affect the performance characteristics of birds.

Previous attempts at feed costs reduction through partial or total removal of supplemental vitamin-mineral for the finisher broilers (10, 12, 13, 14, 15) revealed that DVMP removal from corn-soya based broiler finisher diets did not significantly affect performance or humoral immune responses of chickens (16, 17). Subsequent observation (12), showed that DVMP withdrawal at days 42 to 49 of broiler production did not significantly affect feed intake and weight gain of chickens but increased the feed conversion ratio. More recent reports on the effects of serial DVMP withdrawal on performance (5), and carcass characteristics as well as organ weights of broiler chickens (6) conformed to earlier submissions. Further studies are imperative to ventilate the dearth of documentation on consumers' perceptions of the meats of broiler chickens when fed diets devoid of DVMP, which were the objectives of this endeavour.

Materials and methods

Experimental site

The experiment was carried out at the Poultry Unit, Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria, between August and September. The study area lieth in latitude 7^0 2^0 ^{1}N, longitude 3^0 50^0E and 200m above the sea level, in tropical rainforest vegetation zone. The average temperature and relative humidity of the location ranged from 23-42 °C and 60-80%, respectively (18). The analyses were carried out at the Central Agricultural Biochemistry and Meat Processing Laboratories, Department of Animal Science, University of Ibadan, Nigeria.

Experimental Chickens and Diets

Prior to allotment of the chicks to treatments, the birds were subjected to the same feeding and management regime from days 1 to 27. Starter and Grower feeds were both isocaloric and isonitrogenous, fed from days 1-10 and 11-27, respectively. At day 28 of production, 240 unsexed Arbor Acres broiler chicken strain were randomly assigned to two dietary treatments. Each treatment was replicated ten times and a replicate comprised 12 chickens, the experiment lasted for 14 days.

Each partitioned floor pen (which housed the assigned 12 chicks per replicate) was of 100 × 150cm dimension. Chickens were allowed free access to feed and water. The control finisher diet with DVMP (T_1) and another, without DVMP (T_2), both isocaloric and isonitrogenous were, respectively offered free choice to the assigned experimental chickens from days 28 to 42. Details of the gross composition of the starter, grower and experimental finisher diets fed to the chicks are shown in Tables I and 2, respectively.

Table 1. Gross Composition (g/100gDM) of Basal Experimental Starter (days 1-10) andGrower (Days 11-27) Broiler Chickens.

Ingredients	Starter	Grower
Maize	62	60
Palm oil	0.5	0.5
Wheat offal	1.4	6.02
Soya Bean Meal	32.5	30
Oyster shell	1	1
Dicalcium phosphate	1.5	1.5
Salt	0.35	0.3
Lysine	0.25	0.2
Methionine	0.2	0.18
Toxin binder	0.05	0.05
Vitamin-mineral premix	0.25	0.25
Calculated Nutrients[3]		
Crude Protein (%)	22.84	21.75
Metabolizable Energy (kcal/kg)	3146	31.25
Moisture Content (%)	7.04	7.05
Ash (%)	7.36	7.35
Ether Extract (%)	3.05	3.05
Crude Fiber (%)	3.96	4.01

VMP[1] -Vitamin-mineral Premix

[2]- per kg mix of vitamin-mineral premix contains; Vitamin A 10,000,000IU; Vitamin D3 - 2,000,000IU; Vitamin E - 20,000IU; Vitamin K - 2,250mg; Thiamine B1 - 1,750mg; Riboflavin B2 - 5,000mg; Pyridoxine B6 - 2,750mg; Niacin - 27,500mg; Pantothenic acid - 7,500mg; Biotin - 50mg; Choline chloride - 400g; Antioxidant - 125g; Magnesium - 80 g; Zinc - 50 mg; Iron - 20 g; Copper - 5g; Iodine - 1.2 g; Selenium - 200 mg; Cobalt - 200 mg

[3]- values from proximate analysis of the experimental diet.

Preparation and Analysis of meat samples

At day 14 of the experiment, two birds with body weight closest to the group mean weight in each replicate were selected, properly tagged and denied only feed for eight hours. The birds were thereafter slaughtered, bled, de-feathered and eviscerated. The wings were removed and lateral cuts were made through the ribs to the shoulder girdle to remove the breast muscles.

Cooking Loss: The cooking loss was determined according to the procedure of (19). Precisely, 20grams of each breast meat was weighed and cooked in boiling water for

20 minutes. The cooked samples were allowed to cool and then re-weighed. Cooking loss was thereafter calculated as:

% Cooking loss = $\frac{\text{Initial weight of the samples-Final weight of the samples}}{\text{Initial weight of the samples}} \times \frac{100}{1}$

Sensory Analysis: Organoleptic properties (i.e, colour, tenderness, flavour, juiciness and overall acceptability) of the breast muscles samples were evaluated by trained (n=20) panelist using a nine-point hedonic scale (19). The scale had a maximum score of 9 (best), while the lowest score of 1 (poorest).

Table 2. Gross Composition and calculated analysis of the basal diets fed to broilers in their final growing period (28 to 42 days) g/100gDM

Ingredients	Diet with VMP[1]%	Diet without VMP[1]%
Maize	51	51
Palm oil	1	1
Wheat offal	16.52	16.77
Soya Bean Meal	28	28
Oyster shell	1	1
Dicalcium phosphate	1.5	1.5
Salt	0.35	0.35
Lysine	0.15	0.15
Methionine	0.18	0.18
Toxin binder	0.05	0.05
Vitamin-mineral premix[2]	0.25	-
Calculated nutrients[3]		
Crude Protein (%)	19.82	19.82
Metabolizable energy (kcal/kg)	3155	3157
Moisture Content (%)	7.15	7.12
Ash (%)	7.40	6.85
Ether Extract (%)	3.60	3.65
Crude Fiber (%)	5.85	5.92

VMP[1] -Vitamin-mineral Premix

[2]- per kg mix of vitamin-mineral premix contains; Vitamin A 10,000,000IU; Vitamin D3 - 2,000,000IU; Vitamin E - 20,000IU; Vitamin K - 2,250mg; Thiamine B1 - 1,750mg; Riboflavin B2 - 5,000mg; Pyridoxine B6 - 2,750mg; Niacin - 27,500mg; Pantothenic acid - 7,500mg; Biotin - 50mg; Choline chloride - 400g; Antioxidant - 125g; Magnesium - 80 g; Zinc - 50 mg; Iron - 20 g; Copper - 5g; Iodine - 1.2 g; Selenium - 200 mg; Cobalt - 200 mg

[3]- values from proximate analysis of the experimental diet.

Meat Tenderness: The tenderness of the meat samples was determined using the Warner Bratzler shear force procedure. This procedure measures the force required to shear through or penetrate a standard meat sample. Three cores of 0.5cm diameter were removed from each cooked meat, and samples of each core were shared at three locations parallel to the orientation of the muscle fibre (20). The shear values were obtained and recorded in kg/cm.

Water Holding Capacity (WHC): The water-holding capacity of each meat sample was determined by the filter-press method (21). Samples were pressed between two filter papers with plexiglass for over 1 minute using a table device. The amount of moisture released from the samples was obtained by measuring the area of the filter paper wetted relative to the area covered by the meat samples. A pencil was used to trace out the area covered by meat and moisture, respectively on the filter paper and later transferred onto a graph sheet. The area covered by meat and moisture was used to calculate the water-holding capacity of the samples. The water-holding capacity was calculated as follows:

Water-holding capacity=

$$\frac{\text{Area covered by meat}}{\text{Area covered by water}} \times 100$$

pH Determination: The pH was determined using a digital pH meter (SCHOTTL 6880, Lab pH) by directly thrusting of the PH meter probe into the breast muscle samples (22).

Lipid Peroxidation: The lipid peroxidation of the meat samples was analyzed 10 days after slaughter by measuring the thiobarbituric acid reactive substance [TBARS(mg MA/g)] concentration with the spectrophotometrically. Samples (250µl each) were deproteinized with 500µl 10% trichloroacetic and centrifuged at 900rpm for ten minutes. The supernatants were mixed with 750µl of 0.67% TBARS. The mixtures were heated for 15 minutes in the oven at 35°C and then cooled. The organic phase containing a pink chromogen was extracted with 750µl of n-butanol and used to measure the absorbance at 535nm using a Beckman spectrophotometer (model DU 640, Fullerton, CA, USA). The TBARS are represented as malondialdehyde (MDA) equivalent/mg protein and reported as a percentage of the control (23).

Proximate Analysis: The proximate composition of the meat samples was carried out using official method (24). Each meat sample was dried in an oven until a constant weight was attained. The samples were thereafter ground and subjected to laboratory analysis.

Statistical Analysis

Data were subjected to descriptive analysis and analysis of variance. Means were separated using Duncan's multiple range test option of the statistical package (25).

Results and Discussion

The cooking loss, shear force and water-holding of meat samples from the experimental chickens are shown in Table 3. The cooking loss and water-holding capacity of meat samples from T_1 were significantly lower ($p<0.05$) than T_2. (26) similarly observed lower water-retaining capacity and cooking loss in the meat of broilers fed diets supplemented with optimal vitamin regime. This observation could be attributed to involvements of vitamin E in the maintenance of cell integrity. (27) however established that low pH, high temperature of the meat after slaughter and a low level of antioxidants, vitamin E in particular as the main factors responsible for WHC decrease. There was no significant difference in the shear force of the meat from T_1 and T_2. contrary to earlier observation (26) on lower shear force of meat cuts and consequently, more tender meat when broiler chickens were fed diets of restricted vitamin regime. Observation here could also be due to the differences in the strain of the experimental broiler chickens, age of the birds as well as the duration of DVMP restrictions.

The colour, flavour, texture, tenderness, juiciness and overall acceptability of meat of broiler chicks fed diets with or without DVMP are shown in Table 4. There was no significant effect ($p>0.05$) of the treatment on meat colour flavour and texture (chewiness, cohesiveness, firmness, hardness, and resilience). This implied that the attributes of meat were not affected by the DVMP withdrawal. (28) posited earlier that nutrient levels would not significantly affect (p>0.05) the texture of breast meat. (29) however observed that increased dietary vitamin E levels would contribute to maintaining the original flavour of meat products and extend the shelf-life of broiler meat.

Table 3. pH, physical characteristics and TBA reactive substances (TBARS) of meat samples of broilers fed with or without DVMP

Parameter	T_1	T_2	SEM
pH	6.01±0.19	5.95±0.26	0.14
Cooking loss	23.80^a±2.54	29.00^b±3.19	1.81
Shear force	0.20±0.05	0.55±0.12	0.06
WHC	34.94^a±6.15	46.96^b±6.40	3.97
TBARS (mgMDA/Kg)	0.41±0.11	0.47±0.11	0.07

$^{a, b}$ - Means with different superscripts on the same rows are significantly different (P<0.05);
SEM - Standard Error of Means
T_1: meats of the treatment fed diet with vitamin-mineral premix
T_2: meat from the treatment fed diet without vitamin-mineral premix
WHC: Water Holding Capacity
TBARS: Thiobarbituric acids reactive substances measured as malonaldehyde in mg/Kg (lipid peroxidation).

Table 4: Sensory evaluation of the breast meat

Parameter	**T_1**	**T_2**	**SEM**
Color	7.50±0.53	7.60± 0.84	0.43
Flavor	4.70 ± 1.25	4.70 ± 1.25	0.79
Texture	6.70 ± 1.42	5.80 ± 1.62	0.96
Tenderness	3.80^a ± 1.16	7.00^b ± 1.03	0.69
Juiciness	4.30 ± 1.80	6.50 ± 1.42	1.01
Overall acceptability	7.90^a ± 0.74	6.30^b ± 0.82	0.49

$^{a, b}$ - Means with different superscripts on the same rows are significantly different (P<0.05); SEM - Standard Error of Means; T_1: meats of the treatment fed diet with vitamin-mineral premix; T_2: meat from the treatment fed diet without vitamin-mineral premix.

Conversely, there was significant effect (p<0.05) of supplemental DVMP on meat tenderness (Table 4). Meat samples from chickens on T_2 (without supplemental DVMP) had significantly higher (p<0.05) tenderness than those on T1 (diet with supplemental DVMP). This may be due to the interplay of DVMP in relation to the metabolic processes *in vivo*. Slower metabolism, incident on paucity of key cofactors in DVMP deficient broilers may elicit dearth of important metabolites like poly unsaturated fatty acids and the needed amino acids for the muscles (protein) accretion (30, 31). Observation for the meat tenderness in this study conformed with earlier report of (6) for the meat from broiler chicken on a restricted DVMP regime. However, meat samples from both treatments had similar (p>0.05) scores for juiciness. Tenderness and juiciness of meat are usually influenced by the levels of fat and collagen (connective tissue) contained in any particular tasted cuts. Thus, dearth of required fats sequel to DVMP withdrawal may also have affected fat affect deposition and the connective tissues integrity of the broiler meat samples as earlier surmised (30, 31). The overall acceptability was however significantly higher ($p<0.05$) for the meat samples from T_1 (7.90) than in T_2 (6.30), which therefore showed that meat from T_1 was more acceptable. Sensory attributes as revealed by the overall meat acceptability are predicated on the measured meat physical characteristics.

Table 5. The pH and Lipid Peroxidation of the meat from Broiler Chickens Fed Diets with or Without Dietary Vitamin Mineral Premix

Parameters	T1	T2	SEM
TBARS (mgMDA/Kg)	0.41±0.11	0.47±0.11	0.07
pH	6.01±0.19	5.95±0.26	0.14

[a, b] *- Means with different superscripts on the same rows are significantly different (P<0.05); SEM - Standard Error of Means; T_1: meats of the treatment fed diet with vitamin-mineral premix; T_2: meat from the treatment fed diet without vitamin-mineral premix.*

TBARS: Thio-barbituric acids reactive substances measured as malonaldehyde in mg/dl (lipid peroxidation).

Table 6: Proximate composition of breast meat of broilers fed experimental diets

Parameter	T_1	T_2	SEM
Moisture content	75.16±1.66	76.44± 1.40	0.97
Crude protein	22.48± 1.58	21.43± 1.32	0.92
Ether extract	6.57±0.07	6.30±0.08	0.05
Ash	4.01^a±0.27	2.40^b±0.25	0.19

[a, b] - Means with different superscripts on the same rows are significantly different (P<0.05); SEM - Standard Error of Means; T_1: meats of the treatment fed diet with vitamin-mineral premix; T_2: meat from the treatment fed diet without vitamin-mineral premix.

The pH and lipid peroxidation of experimental meat cuts are shown in Table 5. The pH of the meats at 45 minutes after slaughtering were similar ($p>0.05$) showing that DVMP withdrawal did not influence the meat pH after slaughtering. This conforms with the findings of (26) that pH and temperature measurements of the broilers' breast meats taken immediately and 24 hours after slaughtering were not significantly influenced ($p>0.05$) by the presence or absence of vitamin-mineral premix in the diets fed to the broilers. A high pH is associated with poor/shorter meat shelf life in that at this condition, meat will be more prone to bacteria spoilage due to the high environmental temperature (32, 33),. The thiobarbituric acid reactive substances (TBARS) of the fresh breast meat samples expressed as malondialdehyde (MDA) (mg/kg) had no significant difference ($p>0.05$) in the meats from T_2 compared to T_1(Table 5). Report (34) found no significant differences in meat lipid oxidation of chickens fed on corn-soybean based diets supplemented with different levels of vitamin premix. It seems that withdrawal of vitamin-mineral premix did not have significant effects on TBARS of broiler meat, but it may damage the tissues by decreasing the antioxidant (vitamin E) supply for stable quality meat during freezing.

The proximate composition of the meat from broiler chickens fed diets with or without DVMP is shown in Table 6. There was no significant effect (p>0.05) of treatment on the moisture, crude protein, and ether extract composition of the meats from chickens on both treatments. One of the prime nutrients obtainable from the consumption of meat, is protein (35). The similarity in this index of meats from T_1 (22.48) and T_2 (21.43) showed no effect of the DVMP withdrawals on crude protein level of broiler chickens' meat. There was also no effect of withdrawal of vitamin-mineral premix on the moisture content of raw breast meat (Table 6), which agreed with earlier observation (36) on moisture content of meat of broiler chicken fed diets with or without DVMP supplementation.Meat samples from T_1 (4.01) was significantly higher (P<0.05) in ash (%) than T_2 (2.40). it may thus be concluded that feeding broiler chickens on diets supplemented with DVMP, increased the deposition of minerals in the meat. The DVMP consists mainly of the metabolic cofactors responsible for all the biochemical regulations of most minerals and other nutrients (8, 31, 37). As shown in this study, the ensuing optimal metabolism incident on the supply of needed metabolic cofactors which could have engendered increased retainment of muscular minerals in the broiler chickens given diets supplemented with DVMP.

Conclusions and Applications

1. Withdrawal of vitamin-mineral premix had a great influence on the meat quality of broiler chickens. The meat from broiler finishers fed DVMP had more overall acceptability and favourable mineral composition.
2. The withdrawal of vitamin-mineral premix has no influence on the lipid oxidative properties of meat analyzed 10 days after slaughter.

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