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Influence of cinnamon (*Cinnamomum cassia*) powder as additive on jejenal histomophometry, growth performance, haemato-biochemical indices, carcass traits and breast meat lipid profile of broiler chickens

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Abstract

Due to negative impacts (drug residues in animal products and antimicrobial resistance) of excessive use of antibiotics in animal production. This led to search for antibiotics alternatives to address consumers health concerns associated with over dependence on utilization of antibiotics by farm animals' producers. In the study the roles of cinnamon (Cinnamomum cassia) powder as additive on jejenal histomophometry, growth performance, haemato-biochemical indices, carcass traits and breast meat lipid profile of broiler chickens were assessed. A total of 200 Cobb day old broiler chicks were used for the study for six weeks period. The chicks at day old (DOC), were randomly allotted by weight equalization into five dietary cinnamon powder (CMP) treatments (40 birds per treatment) with each replicated four times (10 birds per replicate) in a completely randomized design. The five dietary treatments consist of: control; 2% cinnamon powder/kg of feed; 4% cinnamon powder/kg of feed; 6% cinnamon powder/kg of feed and 8% cinnamon powder/kg of feed. Cinnamon powder dietary additive for the chicks commenced immediately at day old for 3 days in a week for treatments 2%, 4%, 6%, 8% cinnamon powder/kg feed while feed without cinnamon powder or antibiotic was administered to birds in the control. Thereafter, feed without dietary additive were offered to birds in all the treatments for remaining four days of each week throughout the experimental duration. The birds were intensively managed in deep-litter housing with provision of feed and water ad-libitum. Data collected on the response variables were subjected to one way analysis of variance. The results showed that at 4 weeks of age significantly improved muscular wall thicknesses of 262.20 µm and 257.31 µm were observed in birds subjected to 6% and 8% CMP when compared to other treatments. Also, at 6 weeks of age, cinnamon dietary additive lead to significantly ($p<0.05$) higher villus height (1424.10µm) in birds exposed to 6% CMP as against 943.09µm in birds under 2% CMP; with significantly ($p<0.05$) lowered and better crypt depth of 137.92µm also recorded in birds under 6% CMP relative to higher crypt depths of 311.42µm and 279.84µm in birds subjected to 4% CMP and 8% CMP, respectively. Inclusion of dietary CMP did not significantly influence any of the growth performance indices and carcass traits measured. Packed cell volume of birds subjected to 8 % CMP was significantly improved (29.67%) when compared to other treatments; while 6% (82.33 mg/dl) and 8% (80.33 mg/dl) CMP treatments also resulted to significantly lowered blood triglycerides in the broiler chickens. Dietary additive of CMP at 4% significantly (21.07mg/dl) reduced the breast meat low-density lipoprotein (LDL) in the broiler chickens. In conclusion, cinnamon powder dietary additive at the rate of 4% has a nutritional benefit of reduced breast meat LDL; 6 % inclusion level of CMP stimulated marked improvements in the jejenal histomophometry (villus height and muscular wall thickness) at both starter and finisher phases, while CMP inclusion up to 8% is beneficial for improved PCV without any detrimental health implications on the broiler *chickens.*

Keywords: Broilers, cinnamon, histomorphometry, growth, haemato-biochemical and carcass

Influence de la poudre de cannelle (Cinnamomum cassia) en tant qu'additif sur l'histomophométrie jéjenale, les performances de croissance, les indices hémato-biochimiques, les caractéristiques de la carcasse et le profil lipidique de la viande de poitrine des poulets de chair

Résumé

En raison des impacts négatifs (résidus de médicaments dans les produits animaux et résistance aux antimicrobiens) de l'utilisation excessive d'antibiotiques en production animale. Cela a conduit à rechercher des alternatives aux antibiotiques pour répondre aux problèmes de santé des consommateurs associés à une dépendance excessive à l'utilisation des antibiotiques par les producteurs d'animaux de ferme. Dans l'étude, les rôles de la poudre de cannelle (Cinnamomum cassia) en tant qu'additif sur l'histomophométrie jéjenale, les performances de croissance, les indices hémato-biochimiques, les caractéristiques de la carcasse et le profil lipidique de la viande de poitrine de poulets de chair ont été évalués. Un total de 200 poussins de chair Cobb d'un jour ont été utilisés pour l'étude pendant une période de six semaines. Les poussins à l'âge d'un jour (PAJ) ont été répartis au hasard par égalisation de poids en cinq traitements diététiques de cannelle en poudre (CNP) (40 oiseaux par traitement) avec chacun répliqué quatre fois (10 oiseaux par réplicat) dans un design complètement randomisé. Les cinq traitements diététiques consistent en : contrôle ; 2% de cannelle en poudre/kg d'aliment ; 4% de cannelle en poudre/kg d'aliment ; 6% de cannelle en poudre/kg d'aliment et 8% de cannelle en poudre/kg d'aliment. L'additif alimentaire en poudre de cannelle pour les poussins a commencé immédiatement à l'âge d'un jour pendant 3 jours par semaine pour les traitements à 2 %, 4 %, 6 %, 8 % de poudre de cannelle/kg d'aliment tandis qu'un aliment sans poudre de cannelle ni antibiotique a été administré aux oiseaux du groupe témoin. . Par la suite, des aliments sans additif alimentaire ont été proposés aux oiseaux dans tous les traitements pendant les quatre jours restants de chaque semaine pendant toute la durée expérimentale. Les oiseaux ont été gérés de manière intensive dans des logements à litière profonde avec fourniture de nourriture et d'eau à volonté. Les données recueillies sur les variables de réponse ont été soumises à une analyse de variance à un facteur. Les résultats ont montré qu'à l'âge de 4 semaines, des épaisseurs de paroi musculaire significativement améliorées de 262,20 µm et 257,31 µm ont été observées chez les oiseaux soumis à 6 % et 8 % de CNP par rapport à d'autres traitements. De plus, à l'âge de 6 semaines, l'additif alimentaire à base de cannelle a entraîné une hauteur de villosités significativement ($p<0,05$) plus élevée (1424,10 µm) chez les oiseaux exposés à 6 % de CNP contre 943,09 µm chez les oiseaux de moins de 2 % de CNP ; avec une profondeur de crypte significativement ($p<0,05$) abaissée et meilleure de 137,92 µm également enregistrée chez les oiseaux de moins de 6 % de CNP par rapport à des profondeurs de crypte plus élevées de 311,42 µm et 279,84 µm chez les oiseaux soumis à 4 % de CNP et 8 % de CNP, respectivement. L'inclusion de CNP alimentaire n'a influencé de manière significative aucun des indices de performance de croissance et des traits de carcasse mesurés. Le volume d'hématies des oiseaux soumis à 8 % de CNP a été *significativement amélioré (29,67 %) par rapport à d'autres traitements ; tandis que 6 % (82,33 mg/dl) et 8 % (80,33 mg/dl) de traitements CNP ont également entraîné une baisse significative des triglycérides sanguins chez les poulets à griller. L'additif alimentaire de CMP à 4% (21,07 mg/dl) a réduit de manière significative les lipoprotéines de basse densité (LBD) de la viande de poitrine chez les poulets de chair. En conclusion, l'additif alimentaire en poudre de cannelle au taux de 4% a un avantage nutritionnel de réduction du LDL de la viande de poitrine; Un taux d'inclusion de 6 % de CNP a stimulé des améliorations marquées de l'histomophométrie jéjenale (hauteur des villosités et épaisseur de la paroi musculaire) aux phases de démarrage et de finition, tandis que l'inclusion de CNP jusqu'à 8 % est bénéfique pour l'amélioration du PCV sans aucune incidence néfaste sur la santé des poulets de chair.*

Mots clés : Poulets de chair, cannelle, histomorphométrie, croissance, hémato-biochimique et carcasse

Introduction

Poultry production has been identified as the easiest means of forestalling protein deficiency predominant among populace in most developing countries. As an illustration, in Nigeria the protein intake of an average Nigerian is about 53.8 g with only 6.0-8.4 g/head/day from animal origin below the recommended level of 27 g/head/day (Egbunike, 1997); relative to what is obtainable in developed countries of the world. Broiler chicken's production has contributed immensely in the area of food production, employment generation as well as overall socio-economic development in Nigeria. However, main constrains identified as limitations to expansion of the poultry sector in Nigeria include high cost of feed, medication, poultry equipment and occasional occurrence of diseases outbreak without required personnel technicality to handle the on-farm situations. Over 60 years ago, antibiotics have been recognized and incorporated into the poultry industry as aid to enhance feed efficiency, growth rates in meat type chickens, improved egg production in egg laying chickens as well as preventing negative influences of many avian diseases (Bermudez, 2003). However, negative side effects associated with wrong usage of antibiotic in animal production have been brought to the fore through research efforts, hence, the ban on its utilization for animal production by the European Union in 2006. Antibiotics pose serious threats to human health due to unregulated exposure of some bacteria to antibiotics which renders the antibiotics ineffective (resistant development); hence the bacteria are concealed in animal muscles fibre causing numerous diseases when consumed by man. *Salmonellosis, Escherichia coli* and *Campylobacter* are bacterial infections attributed to several food-borne illnesses in the world. Angeles and Gonzallez (2017) affirmed excessive use of antibiotics led to drug residues in animal products. Tetracycline residue in poultry muscle fibre have been shown to affect development of teeth in children (Kummerer, 2009). In view of the negative human health implications associated with wrong antibiotics use in animal production, phytobiotics have therefore gained increasing attention among farmers as natural growth promoting feed additives in poultry production in recent years (Grashorn, 2010). An example of such natural growth promoter is cinnamon. Cinnamon is a valuable medicinal herb with important constituents including cinnamaldehyde, trans-cinnamaldehyde, eugenol, cinnamyl alcohol, cinnamyl acetate and carvacrol present in its essential oil, thus contributing to fragrance, health benefits and its numerous biological activities (Goni *et al.,* 2009; Yeh *et al.,* 2013). Chang *et al.* (2001); Singh *et al.* (2014) stated that cinnamon have several effects on animals including appetite stimulation, increased digestive enzymes secretion, immuno-stimulant, bactericidal, antiviral, and antioxidants properties. Cinnamon (*cinnamomum cassia*) inclusion in broilers diet enhanced their growth performance (Lee *et al.,* 2004; Al-Kassie, 2009). On the contrary, Rasika and Tapattu (2013) found no effect of cinnamon bark powder on growth performance of broiler chicken. Koochaksaraie *et al*. (2011) reported that addition of cinnamon at 500 to 2000 mg/kg diet had no effect on growth performance of broiler chicken. Toghyani *et al.* (2011) reported that dietary inclusion of cinnamon at 2 g/kg diet improve body weight and suggested that it could serve as alternative to antibiotic growth promoters in broilers. Ebrahimi *et al.* (2011) found that the body weight of broilers was higher in the group supplemented with cinnamon. Sang-Oh *et al.* (2013) observed that growth performance and meat quality were significantly enhanced when broiler diets were supplemented with 3, 5 and 7 percent of cinnamon powder relative to birds on control diet. Safa-Eltazi (2014) reported that dietary inclusion of cinnamon at 5% had higher body weight gain, feed intake and best feed conversion ratio. Hasan and Ahmet (2018) also reported that addition of cinnamon to poultry diet increases high-density lipoprotein, reduces low-density lipoprotein and very low-density lipoprotein. **Shirzadegan (2014) reported non-**significant effects in cholesterol and triglyceride contents in birds that received dietary cinnamon powder, which was attributed to antioxidant property of cinnamon which prevent lipid peroxidation of tissue lipids, especially polyunsaturated fatty acids. Ciftci *et al*. (2009) found that dietary inclusion of cinnamon oil (500, 1000 ppm) decreased serum cholesterol levels in birds. Arising from positive previous reports on the impacts of cinnamon on performance of broiler chickens; this study therefore investigated the roles of powdered cinnamon (*Cinnamomum cassia*) dietary additive on jejenal histomophometry, growth performance, haemato-biochemical indices, carcass traits and breast meat lipid profile of broiler chickens in Nigeria.

Material and methods

Experimental location

Field trial for the experiment was carried out at the Poultry Unit of the Teaching and Research Farm; while laboratory studies were undertaken at the Departmental laboratory of Veterinary Physiology and Pharmacology; Federal University of Agriculture, Abeokuta, Ogun State, Nigeria located on Latitude 7° 15' N, Longitude 3° 26' E (Google earth, 2020).

Source, processing and storage of cinnamon (Cinnamomum cassia) powder

Dried barks of cinnamon (*Cinnamomum cassia*) were purchased from a local market in Abeokuta, Ogun State, Nigeria. The barks were ground with the aid of hammer mill into powdery form. Thereafter, the cinnamon powder was stored in airtight polythene bag until dietary incorporation in the birds' diet.

Experimental birds and management

A total of 200 Cobb, one day old broiler chicks were purchased at Zartech Farm, Ibadan, Oyo State, Nigeria, and were used for the study for 6 weeks period. Before arrival of the chicks, the pen was cleaned, washed, and disinfected. Feeders, drinkers, and other equipment necessary for management were provided. The birds were intensively managed (deep-litter) with the provision of feed and water *ad-libitum*. The birds were fed formulated starter (2800 kcal/kg Metabolizable energy, 21.00 % crude protein, 4.00 % ether extract, and 5.00 % crude fibre) and finisher (2900 kcal/kg

Metabolizable energy, 18.00 % crude protein, 4.28 % ether extract, and 4.64 % crude fibre) diets.

Description of dietary treatments and experimental design

Five (5) dietary treatments assessed in the experiment consist of: control; 2% cinnamon powder/kg of feed; 4% cinnamon powder/kg of feed; 6% cinnamon powder/kg of feed and 8% cinnamon powder/kg of feed. The two hundred (200) day old chicks were divided into 5 treatments of 40 chicks each with 4 replicates per treatment (10 chicks per replicate). Prior to distributing the birds into replicates at day old, the birds were weighed and randomly allocated into the five treatment groups in a completely randomized design. Cinnamon powder dietary additive for the chicks commenced immediately at day old for 3 days in a week for treatments 2%, 4%, 6%, 8% cinnamon powder/kg feed while feed without cinnamon powder or antibiotic was administered to birds in the control. Feed without dietary additive were offered to the birds in all the treatment groups for the remaining 4 days of each week throughout the 42 days experimental period.

Data collection

Determination of jejunal histomorphometry

The jejunal histomorphometry of the birds were evaluated at 4th and 6th weeks of age; At these respective ages, two birds of average weight per replicate were selected. The birds were slaughtered by cervical dislocation and their intestines were removed. After removing the intestinal contents, 3 cm length from the jejunum was cut for measurements of villus length (μm), width (μm) and crypt depth (μm) which were based on at least eight complete villi per section/bird, using a microscope and image analysis system (Olympus DP72 microscope digital camera; Olympus NV, Aartselaar, Belgium). Measurements taken include: villus height, width, muscular wall thickness. villus height and crypt depth measured were used to calculate villus height-crypt depth ratio.

Growth performance

The following growth performance indices were measured and recorded on weekly basis at starter and finisher phases.

Feed intake: this was measured weekly and recorded for each replicate. Feed left over was subtracted from the amount of feed offered to the birds weekly to determine the feed intake. Average feed consumed by a bird was calculated by the formula:

Feed intake = *total feed offered – total left over feed*

$$\text{Average feed intake (g/bird)} = \frac{\text{feed intake}}{\text{Number of birds per replicate}}$$

Body weight gain: average weight gain per bird was calculated by deducing the difference between the final body weight and initial body weight and dividing this value by the number of birds per replicate.

$$\text{Average body weight gain (g/bird)} = \frac{\text{Final weight (g)} - \text{initial weight (g)}}{\text{Number of birds per replicate}}$$

Feed conversion ratio (FCR): The feed conversion ratio was calculated by dividing the feed intake by the weight gain.

$$\text{FCR} = \frac{\text{Total feed consumed (g)}}{\text{Body weight gain (g)}}$$

Mortality Percentage: The number of dead birds per replicate was also expressed as a percentage of the total number of birds alive to obtain the percentage mortality.

Blood collection and determination of haemato-biochemical indices

Four millilitres (4 ml) of blood samples were collected with the use of hypodermic needle and syringe through the jugular vein from two birds per replicate at six weeks of age for quantifying blood parameters. Two millilitres (2 mL) blood sample for haematological indices evaluation was deposited into a labeled EDTA tube, while the other 2 ml of blood from the same bird was deposited into a plain bottle.

Haematological parameters measured include: Red blood cell (RBC), Pack cell volume (PCV), haemoglobin (Hb) and white blood cell (WBC). The Red blood cell (RBC) and White blood cell (WBC) counts were determined by hemocytometer method using Natt–Herrick solution; Haemoglobin (Hb) values were measured by microhaematocrit and cyanmethaemoglobin methods, respectively (Kececi *et al.,* 1998). While packed cell volume (PCV) was determined by spinning about 75 µl of each blood samples in heparinised capillary tube in a haematocrit centrifuge for about 5 min and read on haematocrit reader (Benson *et al.,* 1989).Biochemical indicesthat were determined from the collected blood are: albumin, total protein, cholesterol, triglyceride, urea, creatinine, globulin. The serum total protein was determined by the Biuret method (Reinhold, 1953) using a commercial kit, while albumin value was obtained by bromocresol green method (Doumas and Biggs, 1971). The globulin was determined according to the method of Coles (1986). The serum creatinine was estimated by de-proteinisation method, using a commercial kit. Also, the cholesterol was determined by nonane extraction and enzymatic colorimetric methods, respectively using commercial kit (Quimica Clinica Applicada, S.A).

Evaluation of carcass traits

At 6th week of age, three birds of average weight from each replicate were sacrificed through cervical dislocation to evaluate the dressed weight, organs and cut-partsyield (breast, back, drumstick, thigh etc). These carcass traits were expressed as percentage of the live weight.

Assessment of breast meat lipid profile

Fifty grams (50g) of meat samples were collected each from the breast region of birds selected for carcass characteristics for the determination of total cholesterol, triglyceride, High-Density Lipoprotein (HDL), Low Density Lipoprotein (LDL) and Very Low-Density Lipoprotein (VLDL).

Evaluation of total cholesterol

Breast meat total cholesterol was determined spectrophotometrically adopting the methods of Allain *et al.* (1974).

Procedure: Three clean test tubes labelled blank (B), standard (S), and test (T) were arranged in a test tube rack. A volume of 10ml of distilled water, standard cholesterol and serum was added to each test tube, respectively. A volume of 1ml of reagent was added to all the test tubes. The reaction mixtures were mixed and incubated for 10 min at room temperature and the absorbance of the sample was read at 550 mm wavelength against the blank.

Cholesterol Concentration in meat (mg/dl) =

$$\frac{\text{Absorbance of test} \times \text{Concentration of STD}}{\text{Absorbance of STD}}$$

Determination of HDL

Three clean test tubes were marked, labelled blank (B), standard (S) and test (T) and placed in a test tube rack. To each of these tubes was added 1.0 mL of working reagent and 0.05 ml distilled water, HDL standard and super nutrient was added to each test tube. The mixture was incubated for 5 minutes at 37°C. The absorbance of the standard (Abs. S) and test samples Abs. T) against the blank were measured within 60 minutes spectrophotometrically. Below is the formula for calculating HDL.

HDL cholesterol (mg/dl) =

$$\frac{\text{Abs. T} \times \text{con. of STD}}{\text{Abs. S}}$$

Determination of LDL

Three clean test tubes labelled blank (B), standard (S), and test (T) were arranged in a test tube rack. A volume of 100 mL of cholesterol reagent was added to each test tube, 50 mL of water, cholesterol standard and super nutrient was added to each test tube. The reaction mixture was incubated at

25°C for 10 minutes, and the absorbance of the test (Abs. T) and standard samples (Abs. S) were measured against the blank (B). The formula below was used for determining LDL.

Conc. of LDL = $\frac{\text{Abs. T} \times \text{conc. of STD}}{\text{Abs. S}}$

Determination of VLDL

The concentration of very low-density lipoprotein (VLDL) cholesterol was calculated according to modification of Freidwald's formulae, as shown below.

VLDL – Cholesterol = triglyceride value ÷ 5

Statistical analysis

The data collected were subjected to one-way analysis of variance (ANOVA) using the general linear model of SPSS version 23 and significantly different mean was separated using Duncan multiple Range Test.

Results

Effect of dietary additive of cinnamon powder (CMP) on jejunal histomorphometry of broiler chickens at 4th and 6th weeks of age

Table 1 shows the effects of cinnamon powder (CMP) as a dietary additive on jejunal histomorphometry of broiler chickens at 4th and 6th weeks of age. At 4th week of age, dietary inclusion of cinnamon powder significantly ($p<0.05$) affects only the muscular wall thickness in all the histomorphometry variables considered. The higher muscular wall thickness of 262.20 µm and 257.31 µm were observed in birds subjected to 6% CMP and 8% CMP when compared to 114.56 µm in birds under 2% CMP.

At 6 weeks of age, the effects of dietary inclusion of cinnamon powder (CMP) on jejunal histomorphometry of broiler chickens revealed that the dietary inclusion of cinnamon powder significantly ($p<0.05$) affect the villus height and crypt depth. The significantly ($p<0.05$) higher villus height of 1424.10µm was recorded in birds subjected to 6% CMP as against 943.09µm in birds under 2% CMP. Also, significantly ($p<0.05$) higher crypt depth of 311.42µm and 279.84µm were observed in birds subjected to 4% CMP and 8% CMP, respectively when compared to lowered and better crypt depth of 137.92µm in birds under 6% CMP.

Table 1: Roles of dietary additive of cinnamon powder (CMP) on jejenal histomorphometry of broiler chickens

	Varying levels of Cinammon powder (CMP)				
Parameters	**Control**	**2% CMP**	**4% CMP**	**6% CMP**	**8% CMP**
At 4th week of age					
Villus height (µm)	1176.28?139.19	844.46?51.86	1215.64?44.14	1277.52?296.18	947.56?33.39
Crypt depth (µm)	212.47?87.01	127.20?18.83	174.57?30.52	169.10?15.42	141.55?2.71
Villus height: Crypt depth	6.00?2.00	6.50?1.50	7.00?1.00	7.50?2.50	7.00?0.00
Muscular wall thickness (µm)	219.33?37.64^{ab}	114.56?0.55^{b}	193.47?27.87^{ab}	262.20?26.44^{a}	257.31?53.10^{a}
Villus width (µm)	99.02?3.39	101.06?1.12	87.58?12.75	92.48?3.30	89.30?38.30
At 6th week of age					
Villus height (µm)	1298.98?196.77^{ab}	943.09?21.71^{b}	1263.37?32.88^{ab}	1424.10?130.98^{a}	1269.81?116.79^{ab}
Crypt depth (µm)	239.46?26.61^{ab}	249.55?45.88^{ab}	311.42?49.89^{a}	137.92?11.47^{b}	279.84?37.10^{a}
Villus height: Crypt depth	5.44?0.50	3.89?0.50	4.09?0.50	10.37?2.00	4.50?0.50
Muscular wall thickness (µm)	200.53?17.37	142.40?17.99	197.75?74.73	225.06?17.21	206.15?20.15
Villus width (µm)	105.78?28.16	108.00?17.79	98.94?0.77	108.16?7.72	116.61?12.46

^{a,b}: Means with different superscript across the row are significantly ($p<0.05$) different

Effect of dietary inclusion of cinnamon powder (CMP) on growth performance of broiler chickens

The influence of dietary inclusion of cinnamon powder on growth performance of broiler chicken is shown in Table 2. The effect of dietary inclusion of cinnamon powder did not significantly affect ($p>0.05$) all the growth performance parameters of broiler chickens, measured at the starter (1-21days); finisher phases (22-42 days) and the overall period of production (1-42 days).

However, at the starter phase, FCR was numerically lower (better) at 6% dietary inclusion of cinnamon powder (1.83) compared to the control (1.98). At the finisher phase (22-42 days), dietary inclusion of 6% cinnamon powder resulted to numerically higher final body weight of 2042.68g/bird while the numerically lower final body weight was recorded in the control (1939.09g/bird). In the overall production period (1-42 days) a numerically lower (2.20) (better) FCR was recorded in birds subjected to 8% CMP relative to other treatment groups.

Table 2: Influence of dietary additive of cinnamon powder (CMP) on growth performance of broiler chickens

	Varying levels of Cinammon powder (CMP)				
Parameter	**Control**	**2 % CMP**	**4 % CMP**	**6 % CMP**	**8 % CMP**
Starter phase (1-21 days)					
Initial weight (g/bird)	46.92?0.59	47.44?0.68	47.69?0.22	46.410±0 .26	47.18±0.51
Final weight (g/bird)	670.51? 11.39	680.77? 5.88	683.33?10.01	680.77±24.42	664.36± 8.99
Total weight gain (g/bird)	623.59? 10.90	633.33?5.66	634.62?11.71	634.36±24.43	616.92± 9.07
Daily weight gain (g/bird)	29.69?0 .52	30.16?0 .27	30.22?0.56	30.21±1.16	29.38±0.43
Total feed intake (g/bird)	1234.99?20.77	1203.00?32.03	1210.87?38.39	1158.16±39.53	1151.70±15.49
Daily feed intake (g/bird)	58.81?0.99	57.29?1.53	57.66?1.83	55.15±1.88	54.84±0.74
Feed conversion ratio	1.98?0.06	1.89?0.03	1.91?0.09	1.83±0.04	1.87±0 .02
Mortality (%)	0.00?0.00	0.00?0.00	0.00?0.00	0.00?0.00	0.00?0.00
Finisher phase (22-42 days)					
Initial weight (g/bird)	670.51? 11.39	680.77? 5.88	683.33?10.01	680.77±24.42	664.36± 8.99
Final weight (g/bird)	1939.09?91.64	2041.11? 29.82	1961.11?32.04	2042.68±80.08	2020.83±20.83
Total weight gain (g/bird)	1191.23? 103.39	1303.61? 36.15	1248.61? 32.48	1282.83±90.00	1301.11±25.28
Daily weight gain (g/bird)	56.73? 4.92	62.08?1.72	59.46?1.55	61.08±4.29	61.96±1.20
Total feed intake (g/bird)	3294.06?175.28	3174.75? 69.77	3096.97?128.21	3178.39±73.51	3100.64±49.64
Daily feed intake (g/bird)	156.86?8.346	151.18?3.32	147.47? 6.11	151.35±3.50	147.65±2.36
Feed conversion ratio	2.84?0.42	2.44 ?0 .12	2.48±0.13	2.49±0.14	2.39±0.08
Mortality (%)	2.78?2.78	0.00?0.00	0.00±0.00	2.78±2.78	0.00±0.00
Overall (1-42 days)					
Initial weight (g/bird)	46.92?0.59	47.44?0.68	47.69?0.22	46.410±0 .26	47.18±0.51
Final weight (g/bird)	1939.09? 91.64	2041.11? 29.82	1961.11?32.04	2042.68±80.08	2020.83±20.83
Total weight gain (g/bird)	1892.17? 91.05	1993.68? 30.01	1913.42?31.83	1996.2±79.93	1973.65±20.32
Daily weight gain (g/bird)	45.05?2.17	47.47?0 .71	45.56?0.76	47.53±1.90	46.99±0.48
Total feed intake (g/bird)	4672.15?215.68	4478.00?104.42	4408.75?142.22	4472.64±147.04	4348.31±60.41
Daily feed intake (g/bird)	111.24?5.14	106.62?2.49	104.97?3.39	106.49± 3.50	103.53±1.44
Feed conversion ratio	2.49?0 .24	2.25?0.09	2.30?0.06	2.24 ±0.04	2.20±0.05
Mortality (%)	2.78?2.78	0.00?0.00	0.00?0.00	2.78±2.78	0.00±0.00

Roles of dietary inclusion of cinnamon powder (CMP) on haemato-biochemical indices of broiler chickens

In Table 3, the effect of cinnamon powder (CMP) dietary inclusion on haemato-biochemical parameters of broiler chickens at 6 weeks of age are presented this result indicated that cinnamon powder administration significantly ($p<0.05$) affected Packed cell volume (PCV), white blood cell (WBC), heterophils, lymphocytes, triglyceride, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and very-low density lipoprotein (VLDL) of the broiler chickens at 6 weeks of age. The higher packed cell volume (29.67%) was observed in birds administered 8% CMP while lower packed cell volume (24.33%) was recorded in birds fed 4% CMP. Significantly ($p<0.05$) higher white blood cell values of $13.20\times\mathbf{10}^{19/L}$ and $12.93\times\mathbf{10}^{19/L}$ were noted in birds administered 8% and 4% CMP, relative to a lower WBC ($9.20\times\mathbf{10}^{19/L}$) recorded in birds administered 6% CMP. Heterophils were higher in birds resulting from dietary administration of 4 % CMP (34.67 %) and control (37.67 %) when compared to 26.67 % in birds subjected to dietary 2 % CMP. Lymphocyte count was observed to be higher (72.00 %) in birds subjected to dietary 2 % CMP relative to 61.33 % observed in birds under the control. In all the biochemical indices considered significant differences ($p>0.05$) was only observed in the triglyceride. Significantly lower triglyceride contents (82.33 and 80.33 mg/dl) were recorded in birds subjected to 6 and 8% CMP, while a higher triglyceride (121.00**mg/dl) was** recorded in birds under control.

Table 3: Influence ofdietary additive of cinnamon powder (CMP) on haemato-biochemical indices of broiler chickens

	Varying levels of Cinammon powder (CMP)				
Parameter	**Control**	**2 % CMP**	**4 % CMP**	**6 % CMP**	**8 % CMP**
Haematological parameters					
PCV (%)	26.67 ± 1.20^{ab}	28.67 ± 2.03^{ab}	24.33 ± 1.20^{b}	26.67 ± 1.20^{ab}	29.67 ± 1.86^{a}
Hb (g/dl)	10.90±1.65	12.43±1.79	9.30±1.16	11.13 ±1.55	11.57±1.58
RBC (X $10^{12/L}$)	2.73±0.41	3.13±0 .44	2.30±0.29	2.80±0.38	2.90±0.40
WBC (X $10^{9/L}$)	11.67 ± 0.79^{ab}	11.03 ± 0.72^{ab}	12.93 ± 1.30^{a}	9.20 ± 0.67^{b}	13.20 ± 1.24^{a}
Heterophils (%)	37.67 ± 1.67^{a}	26.67 ± 2.19^{b}	34.67 ± 1.76^{a}	34.00 ± 4.04^{ab}	31.00 ± 0.58^{ab}
Lymphocytes (%)	61.33 ± 2.19^{b}	72.00 ± 2.08^{a}	64.67 ± 1.45^{ab}	64.33 ± 4.33^{ab}	67.67 ± 1.45^{ab}
Eosinophils (%)	0.00±0.00	0.00±0 .00	0.00±0 .00.	0.33±0 .33	0.67±0 .67
Basophils (%)	0.33±0.33	0.67±0.67	0.00±0.00	0.33±0.33	0.00±0 .00
Monocytes (%)	0.67±0.67	0.67±0.67	0.67±0.33	1.00±0.58	0.67±0.67
MCV (fl)	101.07±12.17	93.60±7.63	107.93±8.47	97.60±8.89	105.07±11.46
MCH (pg)	39.87±0 .30	39.63±0.35	40.47±0.07	39.70±0.15	39.90±0.25
MCHC (g/dl)	40.50± 4.48	42.93±3.48	37.97±2.99	41.43± 3.89	38.97±4.47
Biochemical indices					
Total protein (g/dl)	2.97±0 .15	3.40±0.75	3.17±0.29	3.57± 0 .48	4.00±0.74
Albumin (g/dl)	1.43±0.09	1.50±0.06	1.53±0.19	1.53±0.15	2.00±0.38
Globulin (g/dl)	1.53±0.12	1.90±0.70	1.63±0.12	2.03±0.38	2.00±0.36
Creatinine (mg/dl)	0.97±0.05	0.71± 0.15	1.05±0.11	0.67±0.31	0.70± 0.09
Triglyceride (mg/dl)	121.00 ± 5.69^{a}	99.00 ± 14.80^{ab}	95.67 ± 13.62^{ab}	82.33 ± 10.71^{b}	80.33 ± 2.40^{b}
Total cholesterol (mg/dl)	113.33± 2.40	100.00±7.55	102.67±3.18	110.33±3.18	108.33±4.67
AST	52.33±1.67	56.00±3.06	46.33±0.88	64.67±16.60	68.33±12.72
ALT	29.33±0.88	29.00±2.65	29.67±1.20	30.00±8.66	38.00± 6.08
ALP	29.33±3.84	29.67±1.45	36.67±1.76	32.33±1.76	35.33±3.18

[a,b,c]: Means with different superscript across the row are significantly ($p<0.05$) different.. PCV: Packed cell volume; Hb: Haemoglobin; RBC: Red blood cell; WBC: White blood cell; MCV: Mean corpuscular volume; MCH: Mean corpuscular haemoglobin; MCHC: Mean corpuscular haemoglobin concentration; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; ALP: Alkaline phosphatase.

Influence of dietary additive of cinnamon powder (CMP) on carcass traits of broiler chickens

Table 4 shows the effects of dietary additive of cinnamon powder (CMP) on carcass traits of broiler chickens. There was no significant difference in all the carcass traits measured. However, Birds under 4% and 6% dietary inclusion of cinnamon powder had the numerically highest live weight of 2016.67g/bird respectively, relative to other treatment groups. The percentage weight of the birds' organs as well as prima cuts measured were not significantly different (P>0.05) as statistically similar values were obtained in all the treatment groups.

Table 4: Effects of dietary additive of cinnamon powder (CMP) on carcass traits of broiler chickens

	Varying levels of Cinammon powder (CMP)				
Parameter	**Control**	**2% CMP**	**4% CMP**	**6% CMP**	**8% CMP**
Live weight (g/bird)	1966.67±33.33	1993.33±6.67	2016.67±33.33	1983.67.33±92.80	2017.67±33.33
Dressed weight (g/bird)	1440.00±83.27	1400.00±104.08	1366.67±33.33	1416.67±83.33	1433.33±44.10
Dressing percentage	73.16±3.42	70.21±5.10	67.75±0.54	71.35±1.10	71.04±1.15
Organs[1]					
Proventriculus	0.50±0.04	0.39±0.04	0.49±0.63	0.43±0.76	0.41±0.01
Heart	0.43±0.01	0.41±0.05	0.43±0.01	0.46±0.08	0.41±0.04
Liver	1.94±0.18	2.07±0.17	1.69±0.13	2.06±0.21	2.20±0.24
Gizzard	1.75±0.16	1.42±0.09	1.95±0.08	2.04±0.36	1.85±0.07
Thymus	0.41±0.11	0.17±0.06	0.28±0.42	0.39±0.09	0.32±0.66
Spleen	0.06±0.01	0.07±0.01	0.10±0.02	0.10±0.02	0.07±0.02
Primal cut[2]					
Neck	3.78±0.50	2.92±0.51	3.31±0.19	2.69±0.19	3.24±0.39
Breast	20.06±0.31	22.64±1.64	19.63±0.57	23.10±1.76	20.27±0.49
Drumstick	9.53±0.41	8.42±0.15	9.42±0.37	9.47±0.86	9.48±0.38
Thigh	10.65±0.40	9.40±0.17	9.62±0.24	10.16±0.19	10.08±0.37
Back	13.41±1.24	13.86±1.92	12.08±0.55	13.51±0.49	14.84±0.43

[1,2]: Values are expressed as percentage of live weight; [a,b,c]: Means with different superscript across the row are significantly (p<0.05) different..

Effects of dietary additive of cinnamon powder (CMP) on breast meat lipid profile of broiler chickens

The effect of dietary additive of cinnamon powder on breast meat lipid profile of broiler chickens is presented in Table 5. Significant differences were observed only in low density lipoprotein (LDL) of the lipid profile parameters measured. The significantly (P<0.05) highest LDL content of 31.47 mg/dL was recorded in chickens administered 2 % CMP when compared to the lowest LDL of 21.07 mg/dL observed in birds subjected to 4 % CMP dietary inclusion. However, statistical similarities were observed in the values of LDL in control (25.67 mg/dl); 6 % CMP (25.03 mg/dl) as well as 8 % CMP (23.07 mg/dl). Other parameters showed no influence of the inclusion of cinnamon powder in the diet of the broiler chickens. However, total cholesterol level of the broiler chicken meat ranged from 86.70 mg/dl (in birds from 4% CMP) to 108.77 mg/dl (in 2% CMP), triglyceride level ranges from 101.33 mg/dl (in birds from 4% CMP) to 121.67 mg/dl (in control), HDL level ranges from 45.43mg/dl (in 4% CMP) to 48.43 mg/dl (in control) and VLDL level ranges from 20.27 mg/dl (in birds from 4% CMP) to 24.33 mg/dl (in control).

Table 5: Effects of dietary additive of cinnamon powder (CMP) on breast meat lipid profile of broiler chickens

	Varying levels of Cinammon powder (CMP)				
Parameter	**Control**	**2 % CMP**	**4 % CMP**	**6 % CMP**	**8 % CMP**
Total cholesterol (mg/dl)	98.43±6.25	108.77±3.91	86.70±8.96	97.83±11.86	99.97±12.52
Triglyceride (mg/dl)	121.67±13.68	107.00±6.11	101.33±4.70	102.67±8.35	104.33±6.89
HDL (mg/dl)	48.43±8.27	55.90±3.00	45.43±6.60	52.27±8.75	56.03±8.99
LDL (mg/dl)	25.67±25.67^{ab}	31.47±31.47^{a}	21.07±21.07^{b}	25.03±25.03^{ab}	23.07±23.07^{ab}
VLDL (mg/dl)	24.33±2.75	21.40±1.22	20.27±0.94	20.53±1.67	20.87±1.40

HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low-density lipoprotein
^{a,b}: Means with different superscripts across the row are significantly ($p<0.05$) different

Discussion

Growth, development and optimum health condition of chicken is partly dependent on the functionality of the digestive system as it affects digestion of feed, nutrients absorption and conversion of feed into useful products (meat or egg) for human consumption. The gastro-intestinal tract (GIT) of chicken consists of organs with important roles in ensuring digestion of complex molecules in feed into utilizable form(s) for productive purpose. In chickens GIT, crypts and villi of the absorptive epithelium, play essential roles in nutrient digestion and assimilation (Liu *et al.,* 2010). Montagne *et al.* (2003) affirmed villus: crypt ratio as an indicator of the digestive capacity of small intestine. Higher villus height, low crypt depth and high villus height /crypts depth ratio are required parameters for better absorption of nutrients in poultry (Xu *et al.,* 2003). Additionally, improved villus height translates to larger surface area for absorption of nutrients, while deeper crypt indicates fast cellular turnover to permit villus renewal necessary in response to inflammation resulting from negative influence of pathogens (Yason *et al.*, 1987). At 4th week of age, higher muscular wall thickness observed in birds subjected to 6% dietary **cinnamon powder (**CMP) and 8% CMP as well as significantly ($p<0.05$) higher villus height recorded in birds on 6% CMP with improved crypt depths in the jejunal segment of birds exposed to 4% CMP and 8% CMP at 6th weeks of age is indicative of proper functionality of the intestine for nutrients absorption (Yasar and Forbes, 1999). The resulting positive influence of cinnamon powder on jejunal histomorphometry is due to the growth enhancing attribute of cinnamon powder owning to its most important bioactive components (cinnamaldehyde and trans-cinnamaldehyde contributing to its diverse biological activities) which stimulate secretion of growth hormone (Sang-Oh *et al.,* 2013; Yeh *et al.,* 2013) to improve the intestinal cells and tissues growth in the broiler chickens. Dhama *et al.* (2014) documented that cinnamon have multiple effects on chickens including increased digestive enzymes secretion; enlarge pancreatic and intestinal lipase activity. Previous studies also reported similar outcomes with the present study with respect to gut histomorphometry including that of Garcı́a *et al.* (2007) who found increased villus height in broiler chickens fed diets supplemented with formic acid and plant extracts. Awaad *et al.* (2014) observed that supplementation of specific combination of carvacrol, cinnamaldehyde and Capsicum oleoresin positively improved villus height and villus height/crypt depth ratio and decreased crypt depth in ileum as relative to the control. The effect of dietary inclusion of cinnamon powder resulted to insignificant difference in all the growth performance indices measured at starter, finisher and the overall production period (1-42 days). This implies that introduction of dietary cinnamon to the broiler chickens from day old and for three days in a week during the growing period did not result to marked differences in the growth performance indices. This result can be attributed to several factors including the duration of exposure to the cinnamon dietary treatment and rate or dose of administration (Sampath and Atapattu, 2013) which may not be at optimum rate required to effect positive influences on the growth rate. This outcome on growth performance is similar with that of Koochaksaraie *et al*. (2011) who utilized different levels (250, 500, 1000 or 2000 mg/kg) of cinnamon powder and discovered that total body weight gain, total feed intake and feed conversion ratio of broiler chickens were not significantly affected. Ciftci *et al*. (2009) discovered that supplementation of cinnamon oil (500–1000 ppm) had no significant effect on feed intake and final body weight of broilers. Barreto *et al*. (2008) also incorporated cinnamon extract (1000 ppm) in the diet of broiler chickens and reported no significant effect on growth performance parameters (total body weight gain, total feed intake and feed conversion ratio). Body weight gain of broilers was not significantly affected after the dietary supplementation with cinnamaldehyde (100 ppm) as reported by Lee *et al*. (2003). Toghyani *et al*. (2011) also obtained no significant variations in total feed intake and FCR of broiler chicken after dietary addition of cinnamon powder (2–4 g/kg diet). On the contrary, Sang-oh *et al*. (2013) reported that the final body weight of the treatment groups with cinnamon powder were increased significantly when compared to the control group. Jamroz and Kamel (2002) found that broilers fed with a combination of herbal oils (capsaicin, carvacrol and cinnamaldehyde) showed higher body weight gain compared with the control group. Al-Kassie (2009) also showed that the supplementation of 200 ppm oil extract derived from thyme and cinnamon in broiler diets significantly improved live weight gain and feed conversion ratio during a growing period of 6 weeks. Shirzadegan (2014) found that the administration of cinnamon powder positively influenced final body weight, body weight gain, feed intake and feed conversion ratio (FCR) of broiler chickens.

Haematological parameters and serum biochemical indices serve as indicators of the health conditions of animals and can provide baseline information for conditions associated with nutrient deficiency, physiology and health situation of farm animals (Daramola *et al.,* 2005). From this study it was observed that PCV, WBC, lymphocyte, heterophil differs significantly in broiler chickens at 6 weeks of age due to dietary cinnamon powder inclusion. According to Bashar *et al.* (2010) PCV serves as the quickest indirect means of assessing the value of red blood cells in circulation and it can be used in testing for anemia. A high value of PCV observed in birds subjected to 8% CMP, implied that the administrations of cinnamon powder increased and improved the rate of blood synthesis. According to Kanani *et al.* (2015) increment in PVC was reported to be due to high synthesis of red blood cell in synergy with increase in the concentration of cinnamon powder. This is in contrast with the report of Naderi *et al*. (2014) who stated that the PCV was not significantly affected due to the administration of cinnamon dietary inclusion. The PCV value recorded in the study was consistent with the normal range of 22-35 % recorded by Nworgu *et al.* (2007); Bounous and Stedman (2000). Cinnamon also helps to stimulate the immune system of the birds, and this maybe as a result of its antimicrobial properties which are mainly related to its phytochemical constituents (cinnamaldehyde, eugenol and carvacrol), (Tabak *et al.,* 1999). Cinnamaldehyde and eugenol have been reported to possess antibacterial activity against wide array of bacteria (Chang *et al.,* 2001), antioxidant properties (Gurdip *et al.,* 2007). A high value of WBC was observed in birds subjected to 4% and 8% CMP, the reason for increment of the total counts of WBC may be due to the action of the active components in cinnamon (cinnamaldehyde) in stimulating synthesis and increased production of white blood cells and its differentials (Sura, 2018). The recorded white blood cell was within the physiological range 12-30 $\times \mathbf{10}^{9/L}$ for healthy domestic chicken (Mitruka and Rawnsley, 1977; Bounous and Stedman, 2000). Cinnamon is used as immunity enhancer because it boosts white blood cells and ultimately increases interferon levels. The main physiological functions of the white blood cell and its differentials are to fight infections, defend the body by phagocytocis and to produce, transport as well as distribute antibodies in immune response. (**NseAbasi *et al.,* 2014**). The percentage lymphocyte and heterophil 61.33-72.00% and 37.67% and 34.67% were within the normal ranges (47.2-85.0 % and 10-53.6 %) for healthy chicken as reported by Riddell (2011). Similar report was documented by *Naderi et al. (2014) who* observed significantly increased lymphocytes percentage in broiler chicken administered cinnamon powder at the level of 7.5 g/kg diet compared to control group. The increment in lymphocyte level may be due to the high level of white blood cells which indicate increased synthesis and production of lymphocytes. A significantly lowered triglycerides were observed in group administered 6% and 8% CMP. This is consistent with the findings of Talib *et al.* (2015) who observed reduction in triglyceride levels in chickens that received cinnamon powder in their diets, and stated that this can be explained from the roles of cinnamon in lipid metabolism, lowering hypertriglyceridemia and free fatty acids by its strong lipolytic actions. The level of serum triglyceride is an indication for fat metabolism (Zhan *et al.,* 2006). Normally, triglycerides are broken down into fatty acid and glycerol as a source of metabolic energy (Sato *et al.,* 2006). However, triglyceride level recorded (80.33-121.00mg/dl) in this study was similar to 80-140 mg/dl reported in broiler chickens by Koochaksaraie *et al.* (2011). Administration of dietary cinnamon to the broiler chickens resulted in an insignificant influence in all the carcass traits. This outcome can also be adduced mainly to the quantity of the administered cinnamon which was probably insufficient to effect significant influences on carcass traits as well as growth indices. Similar outcome was also reported by Koochaksaraie *et al.* (2011) who utilized different levels of cinnamon powder in broiler production and found no significant influence on dressing percentage. Also, dietary inclusion of cinnamon oil (500, 1000 ppm) did not significantly influence the live weight and dressing percentage of broiler chickens (Ciftci *et al*., 2009). The varying levels of dietary cinnamon powder also did not significantly influence the internal organs of the broiler chickens (liver, heart, proventiculus and gizzard,). Similar findings were documented by Toghyani *et al*. (2011) who noted insignificant variations in weights of internal organs of broilers after dietary administration of cinnamon powder (2 to 4 g/kg diet). Barreto *et al*. (2008) also found that supplementation of 200 mg of cinnamon extract per kilogram of diet did not affect internal organs percentages of broiler chickens. Lee *et al*. (2003) supplemented the basal diet of broiler chickens with 100 ppm cinnamaldehyde and eventually found no significant effect on gizzard, liver and spleen percentages. However, on the contrary, report by Sang-oh *et al*. (2013) showed that dressing percentage was significantly increased for birds fed with diet containing cinnamon powder relative to the control.

Lipoproteins are complex aggregates of lipids and proteins that makes lipids compatible with aqueous environment of body fluids and ensures proper transport to target tissues in the body (Jonas and Philip, 2008). Significantly lowered LDL content was found in birds subjected to 4 % CMP, this outcome is due to the ability of cinnamon to inhibit hypercholesterolemia owing to its constituent bioactive compound (cinnamate) which have direct influences (inhibits hepatic HMG Co-A reductase activity leading to lowered hepatic cholesterol and hinders lipid peroxidation through improvement of hepatic antioxidant enzyme activity) in lipid metabolism, prevent hypercholesterolemia and hypertriglyceridemia and reduces free fatty acids by its active lipolytic activity. Dietary cinnamate inhibits the hepatic HMG Co-A reductase activity resulting in lower hepatic cholesterol content and suppresses lipid peroxidation via enhancement of hepatic antioxidant enzyme activity (Lee *et al.,* 2003; Rahman *et al.,* 2013). This result is similar to report of Ali ***(2016) that*** LDL concentration were significantly different in broiler chickens subjected to dietary inclusion of 1.5% cinnamon powder. Insignificant variations were recorded in the other lipid profile assessed including total cholesterol, triglyceride, high density lipoprotein, very low-density lipoprotein levels. However, range of values obtained for total cholesterol (86.70-108.77mg/dl), triglyceride (101.33-121.67mg/dl), HDL (45.43-56.03mg/dl), as well as LDL (21.07-24.33mg/dl) are similar to that reported by Agu et al. (2017) who reported total cholesterol range of 118.72 to 123.30mg/dl; triglyceride (59.46-83.14mg/dl), HDL (25.38-56.72mg/dl), and LDL (63.70-78.22mg/dl) in broiler chicken subjected to dietary inclusion of ginger meal. Shirzadegan, (2014) also found insignificant differences in total cholesterol and triglyceride in broiler chicken meat exposed to cinnamon powder (0%, 0.25%, 0.50%, 0.75% and 1.0%) dietary inclusion.

Conclusion

The study showed that cinnamon powder dietary additive at the rate of 4% has a nutritional benefit of reduced breast meat low-density lipoprotein; 6 % inclusion level of cinnamon powder stimulated marked improvements in the jejenal histomophometry (villus height and muscular wall thickness) at both starter and finisher phases, while cinnamon powder inclusion up to 8% is beneficial for improved packed cell volume without any detrimental productive as well as health implications on the broiler chickens.

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