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PERFORMANCE AND PHYTATE UTILIZATION OF MEAT-TYPE CHICKENS FED VARIED LEVELS OF ACIDIFIED DIETS

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ABSTRACT

This study focuses on the performance and phytate utilization of meat-type chickens fed varied levels of acidified diets. Anti-nutrients such as phytate can inhibit growth performance in chickens; hence the need to supplement additives such as feed grade acidifiers that enhance digestibility and feed utilization. Three hundred and sixty day old broiler chicks were assigned to five treatment groups of three replicates each assigned with 24 and 20-chickens at both starter and finisher phases respectively, in a completely randomized design. The control treatment had diet optimal in available phosphorus at 0.5% while treatments two to five were fed sub-optimal available phosphorus diets at 0.4% in addition to acidifiers supplemented at 0.1, 0.2, 0.3 and 0.4% respectively. Results showed that 0.3%feed acidification was significantly (P<0.05) better than other levels of supplementation and the control in performance characteristics. Increasing the level of supplementation beyond 0.3% elicited a decline in weight gain, feed conversion ratio and feed cost per kilogram gain. These performance indicators also declined as feed acidification reduced from 0.3% to the acid control group. In conclusion, 0.3% supplementation of acidifiers in broiler diets can significantly (P<0.05) improve phytate hydrolysis, growth performance and other productive parameters. Supplementation of feed grade organic acid at 0.3% is recommended for broiler diets as it competes favourably with phytate improving its hydrolysis and enhancing utilization of feed components.
Key words: Phytate, broiler, organic acid, utilization
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INTRODUCTION

Phytate is present in most oil seeds and cereal grains used in feed formulation for poultry chickens (Park *et al*. 2009). It is the primary storage form of phosphate in seeds and by its structure attracts feed nutrients in a hexaphosphate ring on its inositol molecule, making nutrients less available to simple stomach animals as reported by Abdoulaye *et al.* (2011). Phytate has been reported by Catalá-Gregori *et al.* (2006), to form insoluble complex with protein, starch, minerals and vitamins thereby affecting digestibility and utilization. Protein, minerals and vitamins are attracted to the negative charges on phytate molecule which are the binding site used to complex feed nutrients as reported by Julian (2005). Julian (2005), further asserted that the negative charges on phytate increases as feed moves from the acidic crop, proventriculus and gizzard to the small intestine which is basic in pH. This increases phytate ability to react with protein and other positively charged multivalent cations present in feedstuffs primarily the divalent and trivalent cations such as calcium, iron, magnesium, zinc and copper. The net result of this interaction is the formation of stable salts which then precipitate out of solution and become unavailable to simple stomach animals such as poultry (Woyengo and Nyachoti, 2013).

Though phytate has greater affinity for cations such as copper and zinc, it is the molecule's affinity for calcium that is of greatest concern in poultry nutrition (Waldenstedt, 2006). This is because dietary calcium requirement for broiler chickens increases from 0.60 to 0.95% when phytate-phosphorus level in diet increases from 0 to 0.25%. Dibner and Buttin (2002), stressed that leg weakness, lameness and other bone abnormalities are common problems encountered by rapidly growing meat-type chickens due to phytate's ability to strongly bind with feed minerals with particular emphasis on agents of skeletal mineralization (calcium, phosphorus and magnesium). Similarly, Williams *et al*. (2000), reported that the bones in modern broiler lines are characterized by poor calcification and high porosity which may cause an increased affinity for bone damage. Hence, the reduced walking ability that results from bone disorders can affect feed intake and body weight gain.

Liem *et al.*(2007), reported that the pH reducing property of organic acids creates a weakly acidic pH in the small intestine and this reduces the negative charges on phytate, consequently limiting its chelating capacity with feed nutrients. Boling *et al.* (2000b), also asserted that organic acids being powerful chelators compete favourably with phytate in the lumen of the gut, forming soluble complexes with feed nutrients, hence improving nutrient bioavailability.

Some nutritionists have tailored their research towards finding alternative feed ingredients that are cheap and affordable (Abeke, 2005; Idachaba, 2012 and Abdullahi, 2012). However, there should be a focus geared towards improving the bioavailability of already existing feed ingredients.

Phytate affects growth and other performance indices in chickens because it forms insoluble complex with feed nutrients (Park *et al*., 2009). It results to increased faecal losses of nutrients due to poor feed utilization. This can affect farmers cost of production as chickens may have to increase their feed intake to meet nutrient requirement and compensate for nutrient losses in faeces. Maize and soy bean are among the conventional feed sources containing high amount of phytate as reported by Ravindran *et al*. (2000). This implies that despite the adequacy of both ingredients in formulated rations, anti-nutrients such as phytate can inhibit growth performance in chickens. Hence the need to supplement additives such as feed grade acidifiers that enhance digestibility and feed utilization which is the focus of this study. Acidifiers are additives that can displace phytate in the lumen of the gut thereby forming soluble complexes with feed nutrients that are readily utilized by chickens (Liem *et al.,*2007). Acidifiers also function by lowering gut pH thereby reducing the growth and colonization of pathogenic microorganisms that compete with the host animal for digested nutrients.

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The study is guided by the following specific objectives:

i. determine the growth performance and phytate utilization of broiler chickens fed diets supplemented with graded levels of organic acid; and
ii. determine the optimum level of supplementation of organic acid in broiler diets.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the poultry unit of the Teaching and Research Farm, Department of Animal Science, Ahmadu Bello University, Samaru Zaria. The farm is located on latitude 11^0 $9'$ $45''$ N and longitude 7^0 $38'$ $8''$ E, at an altitude of 610m above sea level (Institute for Agricultural Research Meteorological Unit, 2012).

Source of organic acid

The feed grade acidifier Fysal® containing a cocktail of organic acids i.e. ascorbic, lactic, propionic, ascorbic and citric acid was purchased from commercial feed milling outlets in Kaduna state.

Experimental diets

Five maize/soybean meal based broiler starter and finisher diets were formulated. The control diet (T_1) had optimal available phosphorus at 0.50% while treatments two to four (T_2-T_5) had sub-optimal level at0.40%. Treatment one was the control without supplemental organic acids while it was supplemented at 0.1, 0.2, 0.3 and 0.4% for treatments two to five respectively. The diets were formulated as follows; T_1 (Basal diet adequate in available phosphorus), T_2 (Basal diet, 0.40% available phosphorus, 0.1% Acidifier), T_3(Basal diet, 0.40% available phosphorus, 0.2% Acidifier), T_4 (Basal diet, 0.40% available phosphorus, 0.3% Acidifier)and T_5(Basal diet, 0.40% available phosphorus, 0.4% Acidifier).

Experimental design and management of birds

Three hundred and sixty (360) day old broiler chicks of Arbor Acre breed were allotted to five treatment groups each replicated thrice with twenty four (24) chicks per replicate in a completely randomized design. After 28-days of the feeding trial, chickens in replicates of their respective treatments were pooled together and fed a common diet for one week after which they were weighed and randomly assigned to four experimental treatments of 20 chickens per replicate and used for the finisher phase. At both phases, the chickens were raised on deep litter with feed and water provided *ad libitum*. Parameters measured were initial weight, final weight, weight gain, feed intake and mortality as it occurred. Data obtained from the parameters mentioned were used to calculate feed conversion ratio and feed cost per kilogram gain.

Data analyses

Data obtained were subjected to statistical analysis using the General Linear Model (GLM) procedure of SAS (2001), software for analysis of variance. Duncan (1955), multiple range test was used to determine differences between treatment means.

RESULTS AND DISCUSSION

Performance, Phytate Utilization and Optimum Level of Supplementation of Organic Acids in Broiler Diets (0-4 weeks)

The performance, phytate utilization and optimum level of supplementation of organic acids in broiler diets is presented in Table 3. The highest weight gain observed for chicks fed diets supplemented with 0.2 and 0.3% organic acid showed that feed acidification at both levels improved performance by enhancing feed utilization. This is in agreement with the observation of Sheikh *et al.* (2010), who reported higher weight gain by broiler chicks fed 0.3% acidified diet. Weight gain observed for chicks fed 0.1% acidified diet was significantly ($P<0.05$) better than the control group. Owens (2008), reported that supplementation of organic acids in broiler diets significantly improved body weight gain compared to chickens fed diets without organic acid supplementation. As feed acidity increased, weight gain declined at 0.4% level of feed acidification and was similar to the control group because the level of acidity was high and may have suppressed utilization.

Organic acids have been reported to have strong taste and high levels of supplementation may affect feed palatability and depress weight gain as reported by Salgado-Tránsito (2011).The chicks tolerated the increasing levels of organic acid supplementation from 0.1 to 0.3% as they increased intake and showed significant ($P<0.05$) reduction in feed consumption at 0.4% level of feed acidification. This is similar to the report of Runho *et al.*(1997), and Garcia *et al.*(2007), who observed increased feed consumption by broiler chicks up to 0.3% level of organic acid supplementation.

Feed conversion ratio and feed cost per kilogram gain were significantly ($P<0.05$) better for chicks fed 0.2 and 0.3% acidified diets as compared to other levels. This implied that feed acidity at both levels reduced the binding effect of phytate on nutrients and therefore improved nutrient availability. According to Sheikh *et al.* (2010), organic acids improve nutrient utilization by reducing the production of growth depressing metabolites in broiler chickens. Hence, 0.1% feed acidification, may have been insufficient to liberate phytate bound nutrients while 0.4% may have been too high as evidenced by reduced intake and weight gain. No mortality was observed across the treatment groups.

Performance, Phytate Utilization and Optimum Level of Supplementation of Organic Acids in Broiler Diets (5-8 weeks)

The performance, phytate utilization and optimum level of supplementation of organic acids in broiler diets is presented in Table 4.The significantly ($P<0.05$) higher weight gain observed for chickens fed 0.3% organic acid indicated that feed acidification at that level was sufficient to liberate nutrients bound by phytate. As supplementation reduced from 0.2 to 0.1% weight gain significantly (P<0.05) declined in same order, thus showing that phytate was more bound to feed nutrients at 0.1%. Leeson *et al.* (2005), observed better weight gain as the levels of organic acid supplementation increased in broiler diets. Similarly, Boling *et al.* (2000a), Abdel-Azeem *et al.*(2000), and Kommera *et al.* (2006) showed that feed acidification enhanced nutrient utilization and improved body weight gain. Apparently, the peak acid tolerance for improved productive parameters was reached at 0.3% as weight gain reduced at 0.4% and was similar to the control group.

The highest (P<0.05) feed intake observed for chickens fed the control diet is attributed to have occurred as a compensatory increase in consumption to meet their nutrient requirement. This is because phytate forms stable complexes with feed nutrients by limiting their bioavailability to simple stomach animals as reported by Catala-Gregori *et al.* (2006). Among the acid supplemented treatments, feed intake increased from 0.1 to 0.3% level of feed acidification and declined at 0.4% as was the same order in weight gain. This shows that 0.3% was the level at which the highest feed nutrients were liberated from phytate; nutrient requirement may have been met at this level. This was further evidenced by the drop in feed intake at 0.4% probably because the level of acidification was too high. Salgado-Tránsito (2011), reported that organic acids have strong taste and high levels of supplementation may affect feed consumption, palatability and weight gain.

Feed conversion ratio and feed cost per kilogram gain improved as the levels of organic acid supplementation increased, showing that feed acidifiers are potent at enhancing phytate hydrolysis by their ability to compete favourably with phytate in the lumen of the gut. Sonet *et al.* (2002), stressed that acidifiers slow down passage rate of feed through the digestive system leading to increased retention time and better nutrient utilization. Kommera *et al.* (2006), suggested that reducing the rate of emptying of the gastrointestinal tract could be a mechanism geared towards improved protein, mineral and energy digestion. The poorest (P<0.05) results were observed in the control and 0.4% feed acidification.

Conclusion and Recommendation

Organic acid supplementation at 0.3% showed the best results in weight gain, feed to gain ratio and feed cost per kilogram gain. As the levels of supplementation decreased, growth performance declined .. At 0.4% level of feed acidification, performance declined, showing that the peak was attained at 0.3%. Supplementation of feed grade organic acid at 0.3% is recommended for broiler diets as it competes favourably with phytate improving its hydrolysis and enhancing utilization of feed components.

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APPENDIX

Table 1: Composition of Experimental Broiler Diets Supplemented with Varied Levels of Organic Acids (0-4weeks)

		Acidifier(%)			
Parameters	0.0	0.1	0.2	0.3	0.4
Maize	56.00	56.00	56.00	56.00	56.00
Soya cake	24.00	24.00	24.00	24.00	24.00
Groundnut cake	14.00	14.00	14.00	14.00	14.00
Maize offal	1.05	1.25	1.25	1.25	1.25
Limestone	1.05	1.65	1.65	1.65	1.65
Bone meal	2.90	2.10	2.10	2.10	2.10
Common salt	0.30	0.30	0.30	0.30	0.30
Vitamin premix*	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Crude protein (%)	22.08	22.10	22.10	22.10	22.10
Ether extract (%)	4.62	4.63	4.63	4.63	4.63
Crude fibre (%)	4.17	4.20	4.20	4.20	4.20
Calcium (%)	1.22	1.22	1.22	1.22	1.22
Av. Phosphorus (%)	0.50	0.40	0.40	0.40	0.40
Lysine (%)	1.24	1.24	1.24	1.24	1.24
Methionine (%)	0.60	0.60	0.60	0.60	0.60
Cost/kg diet (₦)	70.56	72.07	71.18	71.34	72.34

Biomix chick premix provide per kg of diet vitA, 10,000 i.u; vit D3, 2000 i.u; vit. E 23mg; vit K, 2.mg; calcium pantothenate, 7.5mg; B12, 0.015mg; folic acid, 0.75mg; choline chloride, 300mg; vit B1, 1.8mg; vit B2, 5mg; vit B6, 3mg; manganese, 40mg; iron, 20mg; zinc, 53.34mg; copper, 3mg; iodine, 1mg; cobalt, 0.2mg; selenium, 0.2mg; zinc, 30mg

Table 2: Composition of Experimental Broiler Diets Supplemented with Varied Levels of Organic Acids(5-8weeks)

		Acidifier (%)			
Parameters	0.0	0.1	0.2	0.3	0.4
Maize	59.50	57.70	57.70	57.70	57.70
Soya cake	20.00	24.00	24.00	24.00	24.00
Groundnut cake	16.00	14.00	14.00	14.00	14.00
Limestone	0.60	1.20	1.20	1.20	1.20
Bone meal	2.90	2.10	2.10	2.10	2.10
Common salt	0.30	0.30	0.30	0.30	0.30
Vitamin premix*	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Calculated analysis	100.00	100.00	100.00	100.00	100.00
ME Kcal/kg	2915	2901	2901	2901	2901
Crude protein (%)	21.38	21.39	21.39	21.39	21.39
Ether extract (%)	4.56	4.57	4.57	4.57	4.57
Crude fibre (%)	3.93	3.93	3.93	3.93	3.93
Calcium (%)	1.05	1.06	1.06	1.06	1.06
Av. Phosphorus (%)	0.50	0.40	0.40	0.40	0.40
Lysine (%)	1.16	1.24	1.24	1.24	1.24
Methionine (%)	0.61	0.60	0.60	0.60	0.60
Cost/kg diet (₦)	79.42	82.15	82.10	82.25	84.15

Biomix chick premix provide per kg of diet vitA, 10,000 i.u; vit D3, 2000 i.u; vit. E 23mg; vit K, 2.mg; calcium pantothenate, 7.5mg; B12, 0.015mg; folic acid, 0.75mg; choline chloride, 300mg; vit B1, 1.8mg; vit B2, 5mg; vit B6, 3mg; manganese, 40mg; iron, 20mg; zinc, 53.34mg; copper, 3mg; iodine, 1mg; cobalt, 0.2mg; selenium, 0.2mg; zinc, 30mg

Table 3: Performance, Phytate Utilization and Optimum Level of Supplementation of Organic Acids in Broiler Diets (0-4weeks)

			Acidifier (%)			
Parameters	0.0	0.1	0.2	0.3	0.4	SEM
Initial weight (g/b)	45.10	45.13	45.13	45.20	45.06	0.07
Final weight (g/b)	409.27^{d}	454.15^{c}	502.20^{b}	549.83^{a}	408.12^{d}	9.29
Weight gain (g/b)	364.28^{c}	393.96^{b}	456.96^{a}	504.84^{a}	363.16^{c}	8.14
Feed intake (g/b)	588.84^{b}	620.20^{a}	616.00^{a}	606.20^{a}	587.32^{b}	7.32
FCR	1.61^{c}	1.57^{c}	1.36^{b}	1.20^{a}	1.62^{c}	0.07
Cost/kg Diet (₦)	70.56	72.07	71.18	71.00	72.34	0.72
Feed cost/kg gain(₦)	113.60^{b}	113.15^{b}	96.80^{a}	85.20^{a}	117.19^{b}	6.98
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00

a, b, c, d=Means with different superscript on the same row differ significantly (P<0.05) SEM= Standard error of mean, FCR= Feed conversion ratio

Table 4: Performance, Phytate Utilization and Optimum Level of Supplementation of Organic Acids in Broiler Diets(5-8weeks)

			Acidifier (%)			
Parameters	0.0	0.1	0.2	0.3	0.4	SEM
Initial weight (g/b)	508.11	508.12	508.11	508.13	508.12	0.08
Final weight (g/b)	1863.30^{c}	2193.70^{b}	2340.20^{b}	2550.50^{a}	1853.21^{c}	77.91
Weight gain (g/b)	1355.20^{d}	1685.88^{c}	1832.04^{b}	2042.32^{a}	1345.40^{d}	30.58
Feed intake (g/b)	3846.36^{a}	3755.08^{c}	3768.24^{c}	3796.80^{b}	3736.04^{c}	10.46
FCR	2.84^{c}	2.23^{b}	2.06^{a}	1.89^{a}	2.78^{c}	0.10
Cost/kg Diet (₦)	79.42	82.15	80.10	82.25	84.15	2.89
Feed cost/kg gain(₦)	225.55^{c}	183.19^{b}	165.01^{a}	155.45^{a}	233.94^{c}	7.41
Mortality (%)	0.00	0.00	0.00	0.00	0.00	0.00

a, b, c, d=Means with different superscript on the same row differ significantly (P<0.05) SEM= Standard error of mean, FCR= Feed conversion ratio

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APPENDIX

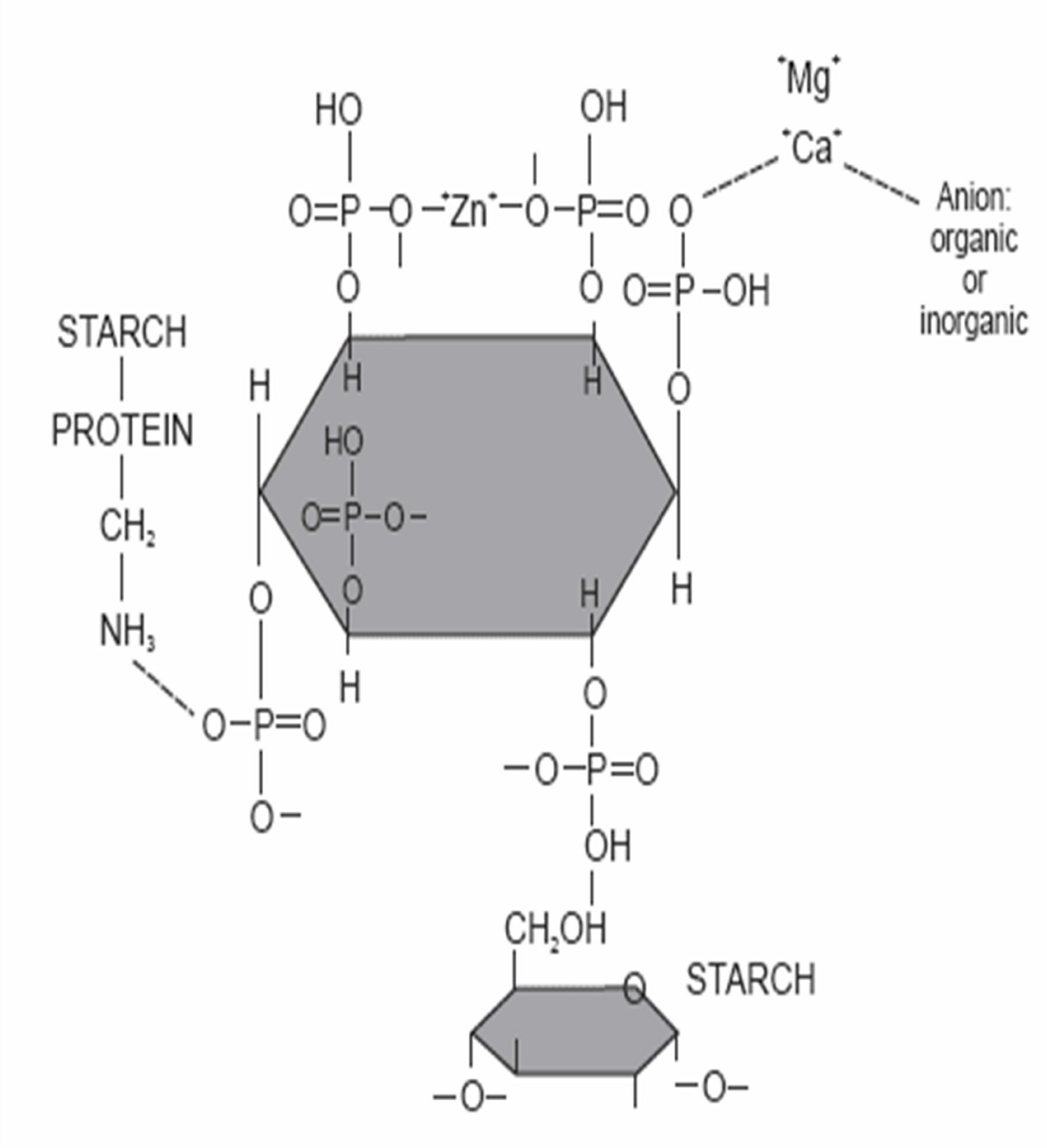

Figure 1: Structure of phytate showing its interaction with feed minerals, starch and protein

Source: Abdoulaye *et al.* (2011)