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Response of broiler chickens fed graded levels of four organic acid blend on carcass characteristics, digesta pH and internal organs measurements

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Abstract

Organic acids are either simple mono-carboxylic acids such as formic, acetic, propionic and butyric acids or carboxylic acids with the hydroxyl group such as lactic, malic, tartaric and citric acids or short-chain carboxylic acids containing double bonds like fumaric and sorbic acids. The study was aimed at evaluating the effects of graded levels of four organic acid blend on carcass characteristics, digesta pH and internal organs measurements of broiler chickens fed graded levels of four organic acids blends. Two hundred unsexed day old, Cobb 500, broiler chicks with 37.4 g average initial body weight were used. The chicks were divided randomly into five dietary treatments T1 (basal diet or control) and basal diet supplemented with organic acid mixture, at a level of 0.5 g/kg (T2), 1.5 g/kg (T3), 2.5 g/kg (T4) and 3.5 g/kg (T5). No antibiotics was administered during the rearing period which lasted for seven weeks. The five treatment diets were replicated four times and each replicate was assigned with 10 birds making a total of 40 birds per treatment group in a completely randomized design (CRD). Data collected were subjected to One-Way Analysis of Variance (ANOVA). Means were separated using Duncan's Multiple Range Test (DMRT) procedure. The results showed that digesta pH in different segments of the GIT were not affected significantly (P>0.05) at any level of organic acids supplementation during both starter and finisher periods. Dressed carcass weight percentage, dressing percentage, gizzard weight, leg weight and caeca length were significantly higher (P<0.05) in those groups received diet supplemented with organic acid mixtures at 2.5 g/kg of the feed compared to those on control diet. However, results of the other internal organs were not also affected by organic acids supplementation. The cost of total feed intake (₦) and feed cost per kg gain was not affected (P>0.05) by organic acids supplementation in both starter and finisher period. From the results of the current study, it may be concluded that feeding of graded levels of the four Organic acids (Formic, propionic, Citric and orthophosphoric acids) blend between 2.5 to 3.5 g/kg in a diet of broiler chickens did improve carcass characteristics and hence could be recommended.

Key words: Organic acids, blend, carcass, gastrointestinal tract, internal organs

Running title: Broiler chickens fed four organic acid blend

Réponse des poulets de chair nourris avec des niveaux progressifs de mélange de quatre acides organiques sur les caractéristiques de la carcasse, le pH du digesta et les mesures des organes internes

Résumé

Les acides organiques sont soit des acides monocarboxyliques simples comme les acides formique, acétique, propionique et butyrique, soit des acides carboxyliques avec le groupe hydroxyle comme les acides lactique, malique, tartrique et citrique ou des acides carboxyliques à chaîne courte contenant des doubles liaisons comme les acides fumarique et sorbique. . L'étude visait à évaluer les effets de niveaux gradués d'un mélange de quatre acides organiques sur les caractéristiques des carcasses, le pH du digesta et les mesures des organes internes de poulets de chair nourris avec des niveaux gradués de mélanges de quatre acides organiques. Deux cents poussins de chair Cobb 500, âgés d'un jour, non sexés et pesant 37,4 g de poids

corporel initial moyen ont été utilisés. Les poussins ont été répartis au hasard en cinq traitements alimentaires T1 (régime de base ou contrôle) et un régime de base complété par un mélange d'acides organiques, à raison de 0,5 g/kg (T2), 1,5 g/kg (T3), 2,5 g/kg (T4) et 3,5 g/kg (T5). Aucun antibiotique n'a été administré pendant la période d'élevage qui a duré sept semaines. Les cinq régimes de traitement ont été répétés quatre fois et chaque répétition a été affectée à 10 oiseaux, soit un total de 40 oiseaux par groupe de traitement dans un plan complètement randomisé (PCR). Les données collectées ont été soumises à une analyse de variance unidirectionnelle (ANOVA). Les moyennes ont été séparées à l'aide de la procédure de DMRT (Multiple Range Test) de Duncan. Les résultats ont montré que le pH du digesta dans différents segments du GIT n'était pas affecté de manière significative (P > 0,05) quel que soit le niveau de supplémentation en acides organiques pendant les périodes de démarrage et de finition. Le pourcentage de poids de carcasse habillée, le pourcentage d'habillage, le poids du gésier, le poids des pattes et la longueur des caeca étaient significativement plus élevés (P < 0,05) dans les groupes recevant un régime complété par des mélanges d'acides organiques à raison de 2,5 g/kg d'aliment par rapport à ceux recevant un régime témoin. Cependant, les résultats des autres organes internes n'ont pas été également affectés par la supplémentation en acides organiques. Le coût de la consommation alimentaire totale (₦) et le coût de l'alimentation par kg de gain n'ont pas été affectés (P > 0,05) par la supplémentation en acides organiques pendant la période de démarrage et de finition. D'après les résultats de la présente étude, on peut conclure que l'administration de niveaux progressifs des quatre acides organiques (acides formique, propionique, citrique et orthophosphorique) mélangés entre 2,5 et 3,5 g/kg dans un régime alimentaire de poulets de chair a amélioré les caractéristiques des carcasses. et pourrait donc être recommandé.

Mots-clés : Acides organiques, mélange, carcasse, tractus gastro-intestinal, organes internes

Introduction

Organic acids are either simple mono-carboxylic acids such as formic, acetic, propionic and butyric acids or carboxylic acids with the hydroxyl group such as lactic, malic, tartaric and citric acids or short-chain carboxylic acids containing double bonds like fumaric and sorbic acids (Shahidi *et al.,* 2014). Organic acids are weak acids and are only partly dissociated. Most organic acids with antimicrobial activity have a pKa (the pH at which the acid is half dissociated) between 3 and 5. A wide range of organic acids with variable physical and chemical properties exists, of which many are used as drinking water supplements or as feed additives (acidifiers). Many are also available as sodium, potassium or calcium salts (and/or partially esterified). The advantage of salts over acids is that they are generally odorless and easier to handle in the feed manufacturing process owing to their solid and less volatile form. They are also less corrosive and may be more soluble in water (Huyghebaert *et al*., 2011).

The use of some antibiotics as growth promoter creates a huge problem for environmental conditions and health of consumers (include up-to-date references to support this claim). Therefore, animal nutritionists are trying to substitute these antibiotics with different natural feed additive materials, such as Organic Acids (OA) and Probiotics. Organic acids are not antibiotics, but if used correctly along with nutritional, managerial and bio-security measures, they can be a powerful tool in maintaining the health of the gastrointestinal tract of poultry, resulting in improving their performances (Dibner and Buttin, 2002).

Organic acids are used in feeds for their various beneficial effects on gut function and microflora, feed preservation from microbial

invasion, inhibition of pathogenic bacteria, enhancing mineral absorption, accelerating recovery from cage fatigue, and improvement of nutrient digestibility (Jahanian and Golshadi, 2015; Abdel-Azeem *et al*., 2000; Dibner and Buttin, 2002). As a result, these beneficial effects will enhance the growth performance and profitability of poultry production. Most of the previous studies have evaluated a single OA as a dietary supplement. However, few studies have been conducted to evaluate the effect of mixture of different OA and their effect on broiler chickens (Hassan *et al*., 2010).

The objective of the current study was to evaluate the response of broiler chicken fed graded levels of four organic acids blend on carcass quality, digesta pH and internal organs measurements.

Materials and methods

Site of experiment

The research was conducted at Gesse Derdirabe Farms located at Opposite Afcott Nigeria Limited, Numan Road, Ngurore Yola, Adamawa State, Nigeria. It is located between latitudes 9° 30^{I} and 11° North of the equator and longitudes 13° and 13° 45^{I} east of the Greenwich meridian. The temperature regime in Yola South area is warm to hot throughout the year, however, there is usually a slight cold period between November and February. There is a gradual increase in temperature from January to April. The minimum and maximum temperatures of the area are 18.1°C and 32.8 °C respectively. The mean annual rainfall ranges from 900 to 1050 mm (Adebayo, 2004).

Experimental stock and their management

The house temperature of the rearing pen was monitored using a room thermometer and set at 34ºC during the first week, then reduced by 3ºC per week until 22ºC was reached. It was then maintained at this level until the end of the experiment. Two hundred Cobb 500 strain day-old broiler chicks with average body weight of 37.4g were purchased from the commercial hatchery unit of Olam Farm Kaduna, Nigeria. The birds were brooded and managed on deep litter system, with each pen providing a space of 0.06 m^2 /bird. The broiler chicks were vaccinated against Gumboro at 1 and 3 weeks of age and Newcastle disease at 2 and 4 weeks of age, respectively. The experimental broiler starter diet was fed *ad-libitum* from the day of their arrival for 28 days, while the broiler finisher diet was used for the remaining 28 days. Clean drinking water was also supplied *ad libitum* throughout the period of the experiment, with only vitamin-mineral supplement without antibiotics. Fresh wood shavings at a depth of 10 cm was used as bedding material. The birds total initial body weight and average body weights per replicate were determine on arrival and subsequently on weekly basis. Similarly, feed intake, water intake and feed conversion ratio were determined every week.

Source of organic acid and its composition

The blended organic acids were purchased in blended form from Jubaili Agrotec Nigeria Limited. The composition and the concentration of acids in the organic acid blend are shown below:

Formic Acid – 23.8%
Propionic Acid- 21.10%
Citric Acid +Orthophosphoric Acids – 19.2%
Natural growth promoter- 2.8%
Calcium – 25%
Metabolizable Energy – 5,000Mj/kg

Experimental diet

The experimental diets comprised of maize, soya bean meal, groundnut cake, fish meal, wheat bran, palm kernel cake, vegetable oil and other additives. Isocaloric and isoproteineous diets were formulated based on National Research Council (NRC, 1994) recommendation for Broiler Starter and Finisher nutrients requirements. The ingredients composition of the starter diet (0-28 days) and finisher diet (29-56 days) are shown in Tables 1 and 2, respectively. The experimental diets consisted of five treatment groups containing 0.0, 0. 5, 1.5, 2.5, and 3.5 g/kg of blended Organic acids, presented as treatments 1(control), 2, 3, 4 and, 5

respectively. Each treatment group was replicated four times with 10 birds per replicate, making a total of 40 birds per treatment.

Table 1: Ingredient composition of the experimental broiler chicken diets (starter)

	Dietary treatments (blends of organic acids)				
Ingredients (%)	T1(0.0g/kg)	T2(0.5g/kg)	T3(1.5g/kg)	T4(2.5g/kg)	T5(3.5g/kg)
Maize	52.20	52.07	51.78	50.6	52.05
Groundnut cake	19.00	19.00	19.40	19.50	19.15
Soyabean meal	19.20	19.50	19.19	19.19	19.18
Wheat offal	1.30	1.40	1.30	1.30	1.20
Vegetable oil	0.77	0.80	0.82	0.85	0.81
Limestone	1.29	1.18	1.15	1.10	1.33
Bone meal	1.80	1.64	1.73	1.81	1.50
Dicalcium phosphate	0.01	0.01	0.01	0.01	0.01
Common salt	0.25	0.25	0.25	0.25	0.25
Fish meal	0.58	0.40	0.52	0.55	0.55
Palm kernel de-oil cake	2.90	3.00	3.00	3.00	2.95
Premix*	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Lysine-HCl	0.30	0.30	0.30	0.30	0.30
Organic acids blend	0.00	0.05	0.15	0.25	0.35
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis					
Crude Protein (%)	23.15	23.19	23.29	23.17	23.18
Crude fibre (%)	4.04	4.08	4.06	4.05	4.04
Crude fat (%)	5.57	5.61	5.65	5.66	5.62
ME (kcal/kg)	3002.22	3002.20	3002.21	3002.31	3002.23
Calcium (%)	1.47	1.33	1.38	1.39	1.38
Phosphorus (%)	0.60	0.57	0.59	0.60	0.55
Sodium (%)	0.14	0.14	0.14	0.14	0.14
Lysine (%)	1.55	1.55	1.55	1.55	1.55
Meth +Cystine (%)	1.06	1.06	1.06	1.06	1.06

Premix* (Animal Care) supplies the following per 2.5 kg:Vitamin A=1,000,000 Miu, Vit D_3= 2,000,000 Miu, Vit E, 25,000mg, Thiamine= 2g, Riboflavin B_2= 5g, Pyrodoxine B_6= 3g, Cobalamin B_{12}=15g, Biotin 50 mg, Niacine = 27.5g, Panthotenic acid = 7.5g, Folic acid=,6 mg, cobalt 250 mg, selenium 250 mg, iodine 1,200 mg, iron 40,000 mg, manganese 70,000 mg, copper 8,000 mg, zinc 60,000 mg and chloride 200,000 mg

Carcass characteristics

At day 56, four birds from each replicate were randomly selected and tagged according to the treatment groups (16 birds per treatment). The birds were fasted overnight and slaughtered by cutting through the jugular vein and carotid artery to allow for quick bleeding before scalding (Akinwumi *et al.,* 2017). Each bird was weighed separately and slaughtered, after proper bleeding, it was weighed and recorded as bled weight. The slaughtered birds were scalded and manually defeathered (Sobayo *et al.,* 2018). The carcass weight was also recorded, then carefully eviscerated and split open to remove the gastrointestinal tracts for organ measurements. The gastrointestinal contents of each bird from each replicate were used for measurements of digesta pH. Live weight, bled weight, defeathered weight, carcass weight, small and large intestine and their corresponding lengths and weight were recorded respectively. Organ weights such as proventriculus, crop, gizzard, heart, liver, and

Table 2. Ingredient composition of the experimental broiler chicken diets (finisher)

	Dietary Treatments (blends of organic acids)				
Ingredients (%)	T1(0.0g/kg)	T2 (0.5g/kg)	T3(1.5g/kg)	T4 (2.5g/kg)	T5 (3.5g/kg)
Maize	58.13	58.08	58.30	58.20	58.25
Groundnut cake	16.00	15.90	15.00	14.80	15.74
Soyabean meal	14.85	14.90	15.90	15.70	14.75
Wheat bran	2.90	2.90	2.20	2.70	2.80
Vegetable oil	1.96	1.99	2.05	1.99	1.97
Limestone	1.00	0.92	1.14	1.11	1.05
Bone meal	1.20	1.30	1.50	1.10	1.10
Dicalcium phosphate	0.01	0.01	0.01	0.01	0.01
Common salt	0.25	0.25	0.25	0.25	0.18
Fish meal	0.10	0.10	0.20	0.29	0.20
Palm kernel de-oil cake	3.00	3.00	2.70	3.00	3.00
Premix*	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Lysine HCl	0.20	0.20	0.20	0.20	0.20
Organic acid blend	0.00	0.05	0.15	0.25	0.35
Total	**100**	**100**	**100**	**100**	**100**
Calculated Analysis					
Crude Protein (%)	20.29	20.26	20.21	20.21	20.19
Crude fibre (%)	3.97	3.97	3.89	3.97	3.95
ME (kcal/kg)	3114.92	3114.26	3114.48	3114.43	3114.21
Calcium (%)	1.01	1.01	1.16	1.06	1.02
Phosphorus (%)	0.44	0.46	0.49	0.43	0.43
Na (%)	0.12	0.12	0.12	0.12	0.12
Lysine (%)	1.19	1.19	1.20	1.20	1.19
Meth +Cystine (%)	0.98	0.98	0.98	0.98	0.98

Premix* (Animal Care) supplies the following per 2.5 kg:Vitamin A=1,000,000 Miu, Vit D_3= 2,000,000 Miu, Vit E, 25,000mg, Thiamine= 2g, Riboflavin B_2= 5g, Pyrodoxine B_6= 3g, Cobalamin B_{12}=15g, Biotin 50 mg, Niacine = 27.5g, Panthotenic acid = 7.5g, Folic acid=,6 mg, cobalt 250 mg, selenium 250 mg, iodine 1,200 mg, iron 40,000 mg, manganese 70,000 mg, copper 8,000 mg, zinc 60,000 mg and chloride 200,000 mg

pancreas, were separated and weighed. The weight of each part were expressed as the percentage of the respective live weight.

Determination of digesta pH of gastrointestinal tract (GIT)

The pH measurement was performed by inserting the pH meter probe into the distal sections of the proventriculus, crop, gizzard, duodenum, and caecum. Based on the method of Manzanilla (2006) when this author studied effects of sodium butyrate in the GI tract in which a pH probe with electrode was inserted through small incisions made in the gut wall of different segments (Zou *et al*., 2010).

Chemical analysis:

Proximate composition of the experimental diets were determined using the procedures of AOAC (2010).

Experimental design and statistical analysis

The experiment was conducted using completely randomized design (CRD) with five treatments, each treatment replicated four times. Data collected were analyzed using

one-way analysis of variance (ANOVA) procedure according to Steel and Torrie (1980). Means differences were separated using Duncan's Multiple Range Test Procedure (Duncan,1955) using SAS (2000) package.

Results and discussion

Effects of organic acid blend treated diets on pH of different segments of the gastrointestinal tract (GIT)

There was no significant difference (P>0.05) found in pH of different segments of the GIT tract due to supplementation of organic acids blend compared with the birds fed control diet (Table 3). These findings are in agreement with the observation of Izat *et al.*. (1990), Mathew *et al.* (1991) and Hernandez *et al.* (2006) who reported insignificant pH reduction in different segment of the GIT. It is also in harmony with the report of Al-Natour and Alshawabkeh (2005) who found non-significant reduction on intestinal pH. This may be as a result of strong buffering action of the GIT by the organic acid in the Feed. However, the result of the present study showed inconsistency in reduction of pH in the proximal part of the Gastrointestinal tract (Crop, Gizzard and proventriculus) when compared with the distal part of the GIT (Duodenum, Caeca and large intestine). Conversely, Panda *et al.* (2009), reported a significant pH reduction in the crop, gizzard and proventriculus. The present study was also not in agreement with the findings of (Pakhira and Samanta, 2006; Samanta *et al*., 2010) who reported that pH of the GIT is lowered by the organic acids thus leading to better utilization of nutrients.

Table 3. Effects of graded levels of four dietary organic acids blend on the pH of upper and lower part of the gastrointestinal tracts (8 weeks of age)

	Dietary Treatments (blends of organic acids)					
Parameters	T1(0.0g/kg)	T2(0.5g/kg)	T3(1.5g/kg)	T4(2.5g/kg)	T5(3.5g/kg)	SEM
Crop pH	4.44	4.80	4.45	4.72	4.27	0.18^{NS}
Gizzard pH	3.36	3.00	3.35	3.16	3.68	0.22^{NS}
Proventricular pH	4.47	4.42	4.75	4.66	4.71	0.28^{NS}
Duodenum pH	5.71	5.93	5.96	5.86	5.54	0.14^{NS}
Caeca pH	6.29	6.55	6.77	6.48	6.39	0.26^{NS}
Large Intestine pH	6.26	6.26	5.80	6.43	5.77	0.15^{NS}

SEM= Standard Error of Mean

NS= Not significant P>0.05

Effects of four organic acids blend treated diets on carcass characteristic and internal organs measurements

The liveweight, bled weight, defeathered weight and eviscerated weight were also similar in all treatments. The result of this study on liveweight, bled weight, defeathered weight and eviscerated weight did not observed any significant difference on carcass quality.

The dressing percentage and the carcass weight percentage were significantly (P<0.05) different among the treatment means. This result was in agreement with the report of Abdelrahim *et al*. (2018) who reported significant difference in birds fed organic acids supplemented diets on dressing percentage and carcass yield. The results also are in agreement with the report of Islam *et al*. (2008) and Sultan *et al.* (2015) who reported that organic acids have positive effects on dressing percentage and carcass weight percentage.

The organic acids supplementation did not affect significantly (P>0.05) the internal organs measurement such as the pancreas, the liver, heart, small intestine length and the weight, large intestine length and the weight, and caeca weight. However, caeca length and gizzard weight, relative to liveweight, differed

significantly (P<0.05) with the control and other treatment groups. The result of the present study is in line with the report of Abdelrahim *et al.* (2018) who reported significant reduction in gizzard and caeca weight percentage with birds fed organic acids mixture. The effects of organic acids used in this study were associated with growth stimulation, enhanced nutrient digestion and absorption, which translated to better carcass yield though, it has not affected pancreas weight.

The findings on the reducing effect of organic acids blend on gizzard and caeca weight percentage could be attributed in part to the partial hydrolysis and destruction of cell wall components of feed ingredients, thereby reducing the work and grinding action of the gizzard and its relative weight (Leeson *et al*., 2005; Jahanian and Golshadi, 2015). The antibacterial effect of organic acid is also believed to mainly take place in the upper part of the digestive tracts like crop and gizzard (Canibe *et al*., 2001). Therefore, the decrease in gizzard weight could be explained in part by the decrease in microbial populations of upper parts by dietary organic acid supplementation (Dehghani-Tafti and Jahanian, 2016).

Table 4. Effects of graded levels of four dietary organic acids blend on carcass characteristic and internal organ weights of broiler chicken (8 weeks of age)

Parameters	Dietary Treatments (blends of organic acids)					
	T1 (0.0g/kg)	T2 (0.5g/kg)	T3 (1.5g/kg)	T4 (2.5g/kg)	T5 (3.5g/kg)	SEM
Live weight (g)	2345.8	2521.3	2543.3	2621.3	2860.8	127.5^{NS}
Bled weight (%)	96.31	96.34	96.06	94.30	97.15	0.86^{NS}
De-feathered (%)	92.29	92.19	93.45	92.30	92.99	0.59^{NS}
Carcass percentage (%)	68.58^{b}	71.66^{ab}	73.44^{ab}	73.85^{a}	72.92^{ab}	2.10*
Eviscerated percentage (%)	76.03	77.57	78.25	72.65	78.96	3.34^{NS}
Dressed percentage (%)	68.61^{b}	71.26^{ab}	73.04^{b}	73.75^{ab}	72.72^{b}	1.10*
Leg	4.60^{a}	3.82^{ab}	2.97^{b}	3.82^{ab}	3.69^{ab}	0.25*
Internal organs (% Liveweight)						
Gizzard (%)	3.04^{a}	$2\text{-}53^{ab}$	2.33^{b}	2.67^{ab}	2.22^{b}	0.13*
Pancreas (%)	0.15	0.17	0.12	0.16	0.18	0.02^{NS}
Liver (%)	1.86	1.63	1.80	1.37	1.77	0.09^{NS}
Heart	0.46	0.44	0.43	0.42	0.38	0.02^{NS}
Caeca (%)	0.97^{a}	0.81^{ab}	0.52^{b}	0.50^{b}	0.62^{ab}	0.08*
Small intestine weight (%)	4.75	4.29	3.68	3.80	4.50	0.63^{NS}
Large intestine weight (%)	0.10	0.11	0.10	0.13	0.22	0.03^{NS}
Caeca weight (%)	1.08	1.03	0.99	0.88	0.91	0.11^{NS}
Large intestine length (Cm)	0.42	0.43	0.35	0.40	0.42	0.06^{NS}
Small intestine length (cm)	9.14	7.05	7.46	8.37	6.28	0.70^{NS}

Means with different superscripts in the same row were significantly different (P<0.05)
SEM= Standard Error Mean, NS= Not Significant (P>0.05)

Conclusion

The study conducted investigate the effects of four graded levels of organic acids blend in diets on carcass characteristics, digester pH of different segments of GIT and internal organ measurements of broiler chickens. In the present study, Organic acid blend supplementation significantly influenced ($P<0.05$) carcass weight, dressing percentage, Gizzard weight and caeca length compared to the control diet. Eviscerated weight, defeathered weight, bled weight, Pancreases' weight, small intestine and large intestine were not significantly ($P>0.05$) influenced by the treatment diets. From the results of the current study, it could be concluded that inclusion of graded levels of four Organic acids (Formic, propionic. Citric and orthophosphoric acids) blend at between 2.5 to 3.5g/kg in a diet of broiler chickens did improve carcass characteristics and dressing percentage. Hence, inclusion of organic acid blend at up to 3.5g/kg in the diet of broiler chicken could be recommended.

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