Effect of organic acids fed through drinking water on carcass and internal organs of broiler chickens

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Abstract

A Six week study was carried out to investigate effect of different organic acids (OAs) fed through drinking water on carcass yield and internal organs weight of broiler chickens. The OAs were acetic acid (AA) butyric acid (BA), citric acid (CA) and formic acid (FA). One hundred and fifty (150) day old AborAcre-plus chicks were used. There were five treatments. Treatment 1 which served as control (CON) consumed water with no organic acid, while treatments 2, 3, 4 and 5 respectively were offered drinking water treated with 0.25% acetic acid (AA), butyric acid (BA), citric acid (CA) and formic acid (FA). Each treatment was replicated three times each having 10 birds arranged in completely randomized design (CRD). Feed and water were offered *ad libitum*. Results showed that dressed carcass weight and breast weight were improved by all the organic acids. While only AA positively influenced the thigh weight, all the OAs drinking water fed resulted to smaller drumstick compared to the CON. Feeding of AA, BA and FA through drinking water increased ($P<0.05$) deposition of abdominal fat. Weight of pancreas, small intestine, caecum and large intestine was significantly ($P<0.05$) higher in CON. The gall bladder was significantly ($P<0.05$) bigger in all the OA groups. Conclusively, OAs could be fed through the drinking water for improved percentage carcass yield, breast meat and larger gall bladder and invariably bile volume.

Keywords: carcass, drinking water, internal organ, organic acids

Introduction

Provision of both quality and adequate feed to broiler chickens is essential for optimum performance. Quality feed is one which supplies all the nutrients required for productivity while adequate feeding means provision of the daily feed requirement free choice. Access to quality feed and attainment of daily requirement has been suggested to be better ways to achieve faster growth in broiler chickens (Obioha, 1992; Oluyemi and Roberts, 2000). But the quality and quantity of feed cannot guarantee optimum productivity if the feed so supplied is not well utilized by the animal. The breakdown of each macro nutrient (starch, protein and fat) of the feed into their respective micro forms (glucose,

amino acids and fatty acids absorbable by the chicken is important. This process is known as digestion.

Maynard *et al.* (1981) defined digestibility as the amount of the feed fed that disappeared from the digestive system expressed as the percentage of the quantity fed. Digestibility is affected among other factors by certain endogenous secretions such as enzymes, hydrochloric acid and bile (Maynard *et al.*, 1981). Even after feed is fully digested it must be absorbed for effective utilization. Level of absorption depends among other factors on the number of villi, height of villi and crypt depth (Choct, 2009). The gut according to Patterson and Burkholder (2006) and Paul *et al.* (2007) could be modulated to enhance

performance of chickens. To this end, feeding strategies to improve performance of broiler chickens have been employed. Feed grade enzymes have been reported to increase digestibility in monogastrics (Al-Harthi, 2006). Others include probiotics (Patterson and Burkholder, 2006), prebiotic (Simmering and Blaut, 2001), yeast (Raju *et al.*, 2006) essential oils (Windisch *et al.*, 2007); spices (Chudhury, 2002).

Recently report showed that acetic acid, citric acid and formic acid enhanced growth performance of broiler chicks (Ndelekwute *et al.*, 2010). Earlier, Waldroup *et al.* (1995), Patten and Waldroup (1988) and Dibner (2004) had emphasized the essential of organic acids in nutrient utilization of broilers which was attributed to both low pH and viscosity in the *proventriculus* and *duodenum* respectively (Ndelekwute *et al.*, 2013b). But it is worthy of note that dietary composition could affect the carcass yield and invariably the market value of the carcass. The internal organs could also be influenced by diet which in turn could affect nutrient absorption and utilization. The conventional way of feeding organic acids has been through the feed hence it has been suggested that drinking water for birds should be sanitized with organic acids for better performance (Marco, 2008). Therefore, the objective of this research was to determine the effect of drinking water treated with organic acids (acetic, butyric, citric and formic acids) on carcass yield and internal organs of broiler chickens.

Materials and Methods

Site of Experiment

The experiment was conducted at the Teaching and Research Farm of Department of Nutrition and Forage Science of the Michael Okpara University of Agriculture Umudike; Abia State,

Nigeria. Umudike is situated on latitude 5° 28'N and longitude 7° 32'E and lies at an altitude of 122 metres above sea level, with average rainfall of 2000 mm. The average relative humidity during the experiment was over 72% and average ambient temperature of 28°C.

Experimental Diets and Management of Birds

Starter and finisher diets were formulated (Table 1). Trial and error method according to Olomu (1995) was used to formulate the diets. At day old, the chicks were weighed, after which they were transferred into the brooding room. Glucose was added to their drinking water on the first day to cushion the effect of stress due to transportation and heat from the sun. From the second day, vitamin was added to their drinking water for five days. Feed and water were supplied free choice. They were stabilized for one week in the brooding room during which water free of the test organic acids was provided. Heat was supplied using kerosene stove placed under a metal hover. At the end of the one week stabilization period the birds were transferred to a rearing house, into a portion of the house that was covered with water proof material. Brooding continued to the third week of age.

They were randomly separated into treatment groups and weighed. Feeding of organic acids through the drinking water started from the second week. The birds were vaccinated against Newcastle disease at day old intraocularly and lasota at the 18th day through the drinking water. Infectious bursal (gumboro) disease vaccine was administered twice on the 9th and 16th day. The birds were fed the same formulated starter diet to the fourth week. At the end of the fourth week, they were fed the same finisher diet to the end of the experiment.

Table 1: Experimental Diets

Ingredients	Starter	Finisher
Maize	55.00	55.00
Soya bean meal	28.00	26.00
Palm kernel cake	10.30	13.30
Fish meal	3.00	2.00
Bone meal	3.00	3.00
Salt (NaCl)	0.25	0.25
Lysine	0.10	0.10
Methionine	0.10	0.10
Premix*	0.25	0.25
Total	100.00	100.00
Calculated composition (%)		
Crude protein	22.10	20.65
Energy (MJME/kg)	11.99	12.03
Ether extract	3.92	6.16
Crude fibre	5.01	6.00
Ash	7.04	6.80
Calcium	1.2	1.11
Phosphorus	1.01	0.88
Lysine	1.12	1.05
Methionine	0.55	0.50

*Starter Premix supplied per kg diet: vitamin A 15,000 I.U., vitamin D₃ 13000 iu, thiamin 2mg, Riboflavin 6mg, pyridoxine 4mg, Niacin 40mg, cobalamine 0.05g, Biotin 0.08mg, choline chloride 0.05g, Manganese 0.096g, Zinc 0.06g, Iron 0.024g, Copper 0.006g, Iodine 0.014g, Selenium 0.24mg, Cobalt 0.024mg and Antioxidant 0.125g. CON = control, AA = acetic acid, BA = butyric acid, CA = citric acid, FA = formic acid.

*Finisher Premix supplied per kg diet vitamin 10, 000I.u., vitamin D₃ 12,000I.u. Vitamin E 20I.U., Vitamin K 2.5mg, thiamine 2.0mg, Riboflavin 3.0mg, pyridoxine 4.0mg, Niacin 20mg, cobalamin 0.05mg, panthemic acid 5.0mg, Folic acid 0.5mg, Biotin 0.08mg, choline chloride 0.2mg, Manganese 0.006g, Zinc 0.03g, Copper 0.006g, Iodine 0.0014g, Selenium 0.24g, cobalt 0.25g and antioxidant 0.125g

The birds were managed in a deep litter having wood shavings as bedding materials in an open sided wire mesh building.

Carcass and Internal Organ

Analysis

At the end of the feeding experiment, 30 birds, two from each replicate of a treatment were selected and used for carcass analysis. The birds were fasted for 18 hours. After weighing, each bird was slaughtered by severing the throat with sharp knife and both the trachea and oesophagus were cut. To achieve complete bleeding, each slaughtered bird was hung with legs up till

cessation of dropping of blood. Hot water was used to defeather the birds. Birds were immersed in 60°C hot water for 30 seconds according to Mountney (1966) cited by Oluyemi and Roberts (2000). The loosed feathers were immediately plucked by hand.

After washing, the legs, head and the neck were cut and the crop gently removed. The abdomen was cut open and holding the gizzard the viscera was pulled out. The abdominal fat was removed. The wings were removed by cutting anteriorly, severing at the humero-scapula joint; the

drumstick was cut at the tibio-tarso-metatarsus and humero-tibia joints; the thigh cutting was at the humero-tibia and humero-ilium joints. To separate the backcut (distance between the ileum and ischium) and the breast meat (distance between the sternum and the keel), a cut was made across the rib joints connecting them. Applying a gentle force, they were separated from each other. Weight of the carcass parts, abdominal fat and internal organs were determined.

Dressed carcass weight, internal organs and abdominal fat were expressed as percentage live weight while weights of different cut-parts were expressed as percentage of dressed carcass weight according to Abaza *et al.* (2008). Carcass analysis was performed based on procedure outlined by Scott *et al.* (1969).

Data Transformation and Statistical Analysis

Data collected which were expressed as percentage were transformed using Arc Sine as outlined by Preston (1996). All data were then subjected to analysis of variance (ANOVA). Significant means were separated using Duncan New Multiple Range Test according to Steel and Torrie (1980).

Results and Discussion

Carcass Yield

There were significant effects on all the parts except the back-cut and wing (Table 2). Drinking water containing organic acids significantly ($P < 0.05$) produced heavier dressed percentage and breast weight than the control drinking water. Similar result was reported by Ndelekwute *et al.* (2012a) and attributing it to better utilization of nutrients by broiler chickens fed diets treated with the same organic acids and their ability to better transform nutrients to muscle. Thus the organic acids could be good additives to promote breast meat yield which is a premium part of the carcass (Ndelekwute *et al.*, 2013a). Only the birds that were fed drinking water containing acetic acid significantly ($P < 0.05$) produced heavier thigh than those that consumed control drinking water. The drumstick was significantly ($P < 0.05$) heavier in control group than in all the organic acid groups. Acetic, butyric and formic acids in drinking water significantly ($P < 0.05$) produced more abdominal fat than the control. This could be as a result of organic acids being involved in energy metabolism (lipogenesis) in the body (Bender and

Table 2: Effect of organic acid treated drinking water on carcass yield of broilers.

Parameters (%)	CON	AA	BA	CA	FA	SEM
Slaughtered Weight (g)	1996.82	2072.98	2023.77	2055.25	2028.98	
Dressed carcass	58.86 ^d	64.40 ^b	60.98 ^c	66.61 ^a	61.87 ^c	2.03
Breast weight	29.08 ^d	31.12 ^b	31.87 ^a	29.90 ^c	29.90 ^c	1.01
Backcut	23.49	20.20	21.36	21.93	22.40	1.07
Wing	10.42	12.27	12.44	12.42	12.35	1.02
Thigh	18.04 ^{bc}	18.73 ^a	17.51 ^{cd}	17.22 ^d	18.41 ^{ab}	0.98
Drumstick	19.31 ^a	17.68 ^c	16.81 ^d	18.42 ^b	16.94 ^d	1.01
Abdominal fat	0.76 ^c	0.98 ^a	0.97 ^a	0.75 ^c	0.85 ^b	0.02

Means along the same row with different superscripts are significantly ($P < 0.05$) different. CON = Control, AA = Acetic acid, BA = Butyric acid, CA = Citric acid, FA = Formic acid.

Table 3: Effect of organic acid treated drinking water on internal organs of broilers.

Parameters (%)	CON	AA	BA	CA	FA	SEM
Slaughtered weight (g)	1996.82	2072.98	2023.77	2055.25	2028.98	
Crop	1.23 ^a	1.19 ^{ab}	1.18 ^{ab}	1.16 ^b	1.17 ^{ab}	0.01
Proventriculus	0.46 ^a	0.35 ^{bc}	0.43 ^a	0.33 ^c	0.38 ^b	0.02
Gizzard	2.32 ^{ab}	1.91 ^b	2.55 ^a	2.16 ^b	2.47 ^a	0.04
Liver	1.23 ^d	1.68 ^d	2.32 ^a	1.80 ^e	2.09 ^b	0.02
Heart	0.42 ^{ab}	0.33 ^c	0.41 ^b	0.39 ^b	0.45 ^a	0.01
Pancreas	0.30 ^a	0.20 ^b	0.22 ^b	0.17 ^d	0.19 ^c	0.02
Kidney	0.84 ^a	0.71 ^b	0.81 ^a	0.69 ^b	0.83 ^a	0.03
Lung	0.62 ^b	0.37 ^c	0.92 ^a	0.50 ^d	0.55 ^c	0.02
Spleen	0.08 ^c	0.12 ^b	0.20 ^a	0.08 ^c	0.11 ^b	0.01
Gall bladder	0.04 ^b	0.06 ^a	0.06 ^a	0.06 ^a	0.05 ^a	0.003
Small intestine	5.64 ^a	3.77 ^c	4.10 ^c	3.84 ^d	4.43 ^b	0.75
Caecum	1.19 ^a	0.51 ^c	0.55 ^{bc}	0.53 ^{bc}	0.62 ^b	0.03
Large intestine	0.45 ^a	0.20 ^{bc}	0.24 ^b	0.29 ^{bc}	0.19 ^{bc}	0.02

abc means a long the same row with different superscript are significantly different ($p < 0.05$).

CON = Control, AA = Acetic acid, BA = Butyric acid, CA = Citric acid, FA = Formic acid.

Mayes, 2006).

Organ Characteristics

Effect of organic acids fed through drinking water on internal organs as shown in Table 3 indicates that all the organs were significantly ($P < 0.05$) influenced by diets. The pancreas, small intestine, caecum and large intestine were significantly larger in control than in the organic acid groups. Similarly, the weight of the liver and gall bladder were significantly smaller in control than in organic acid groups. The spleen was also smaller in control than in the organic acid groups except citric acid.

The heavier caecum, small and large intestines in the control group could be attributed to activities of bacteria which could increase the intestinal mass as reported by Kroismayr (2008) and Choct (2009). Organic acids have been reported to have antibacterial effect (Dibner, 2004; Ndelekwute *et al.*, 2012b), therefore they could have helped to reduce the bacterial load and activities and invariably the intestinal mass of treated groups. Waldroup *et al.* (1995) also reported that organic acids reduced bacterial load in the

gastro intestinal tract of broilers. Heavier gall bladder in organic acid treated groups could be that the organic acids induced production of more bile which caused expansion of the bladder to be able to contain the bile according to Ndelekwute *et al.* (2013a). Dibner (2004) reported that organic acids could induce secretion of bile. Smaller pancreas could mean that the organic acids might have enhanced secretions by the pancreas as reported by Mroz *et al.* (1997) and Ndelekwute *et al.* (2012c), thereby reducing the stress the organ could have experienced according to Ndelekwute *et al.* (2012b). Hence the organic acids could be regarded as bile secretion boosters.

Liver is known to enlarge in response to foreign bodies such as toxins or chemicals, thus this could be a reason for the heavier liver in the acid groups in response to the presence of the organic acids in the diets. Except the gizzard, where there were no significant ($P > 0.05$) differences between the organic acid groups and the control, there were significant differences in the other organs compared to the control.

Control diet significantly produced heavier crop than the citric acid., heavier *proventriculus* than acetic, citric and formic acids; heavier heart than acetic acid; heavier kidney than acetic and citric acids and smaller lung than butyric acid. Reasons for these cannot be clearly ascertained, however, small kidney observed in acetic and citric acid groups could be linked to the ability of organic acids to reduce the effect of toxin producing micro organisms such as gram negative (pathogenic) bacteria. Toxin produced by these pathogens was reported to cause enlargement of the kidney (Sun, 2004; Choct, 2009). This result is in variance with Islam *et al.* (2008) who reported no significant effect of organic acids on internal organs of broiler chickens, but agreed with the report of Ndelekwa *et al.* (2012a) as regards to the kidney, pancreas and liver.

Conclusion

In conclusion, organic acids especially citric acid could be fed through the drinking water to broiler chickens because of its positive effect on dressed weight percentage, compared to the other organic acids.

Acknowledgement We acknowledge the financial support of University of Uyo, Uyo, Nigeria and the Education Trust Fund (ETF) of Nigeria for their Research Grant which we benefited.

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Received: 20/02/12

Accepted: 10/02/14