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Effect of organic acid treated drinking water on growth of broiler chickens

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Abstract

An experiment was conducted to determine the effect of treating drinking water with different organic acids on growth performance of broiler chickens. The organic acids were acetic, butyric, citric and formic acids. One hundred and fifty (150) day old Abor Acre chicks were used. The experiment was divided into five treatments with treatment 1 serving as the control, 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 with 10 birds per replicate. Feed and water were offered ad libitum. The experiment was arranged as completely randomized design (CRD). Results shows that except for BA organic acids significantly (P<0.05) improved final weight, daily weight gain, and protein efficiency ratio with AA having the highest (P<0.05) value at the starter phase. Also at the starter phase, daily water intake was significantly (P<0.05) reduced by BA, CA and FA. At the finisher phase, final body weight and daily gain were improved (P<0.05) by all the organic acids except BA. Final weight was better in AA compared to BA. There was no difference (P>0.05) in final weight between BA, Ca and FA. Daily feed and protein intakes were not affected (P>0.05). All the organic acids significantly (P<0.05) produced better feed: gain ratio. Only AA gave better protein efficiency ratio compared to the control. While AA, CA and FA encouraged water consumption, it was reduced (P<0.05) by BA. It is concluded that AA, CA and FA could be added in the drinking water for broilers for improved performance.

Keywords: drinking, water, broiler chickens, growth performance, organic acids.

Introduction

The demand for broiler chickens is increasing worldwide and efforts are being made to produce broiler chickens of heavy body weight at a short period of time. This is to reduce cost of production and mortality due to long confinement of broilers in congested environment which modern broiler production is known. Though good feed and *ad libitum* feeding have been suggested as good management practices to achieve this (Obioha, 1992; Oluyemi and Roberts, 2000), but due to challenges posed by both the micro and macro environment of the chicken, extra nutritional strategy is required. This is because though good feed and *ad libitum* feeding are essential for adequate growth, it may not guarantee adequate utilization of the feed by the chicken.

One of the nutritional strategies towards enhancing the rapid growth of broilers had been the addition of additives like the pharmaceutical antibiotics to feed (Windisch, *et al*., 2007). But recent concerns about the antibiotics resistance in livestock industry have indicated the need for alternative strategies to improve animal health and performance without the use of antibiotics (Chen *et al*., 2005). Some dietary products are therefore being evaluated to replace antibiotics in poultry diets. These products include probiotics (Cheeson, 1994), prebiotic (Patterson and Burkholder, 2003), yeast culture (Gao *et al.,* 2008; Oyede *et al*., 2008), essential oils (Lee *et al*., 2004a), spices (Lee *et al*., 2004b; Windisch *et al*., 2007), herbs (Botsoglou *et al*., 2004) and organic acids (Leeson *et al.,* 2005). Organic acids (carboxylic acids) have been used for decades in feed preservation, protecting feed from bacterial and fungal destruction (Mchan, 1992; Alshawabkeh and Tabbaa 2002; Paul *et al.,* 2007). Evidence of potentials of organic acids to support growth of broilers has been reported to be due to their antibacterial effect and stimulation of villi growth (Debevere, 1987; Waldroup *et al*., 1995; Canibe *et al*., 2008).

Recently, organic acids were reported to improve both digestibility and growth of broiler chickens when added to the feed at the starter phase (Ndelekwute *et al*., 2010; Ndelekwute *et al*., 2011). More also, some other reports on effectiveness of organic acids to enhance the growth of broiler chickens showed that feeding of birds with treated diets started at the starter phase was feasible (Leeson *et al.,* 2005; Paul *et al.,* 2007).

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).

This research studied the effect of organic acids added in the drinking water on growth of starter and finisher 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, Nigeria. Umudike is situated on latitude 5^{o} 28^{1}N and longitude 7^{o} 32^{1}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% (The information was obtained from the Meteorology Department of the National Root Crops Research Institute, Umudike, Nigeria). The average ambient temperature of the poultry house was 28^{oC}.

Experimental bird, diets and management

A total of One hundred and fifty (150) day old chicks of Abor Acre strain were used for this experiment. They were divided into five treatments replicated three times with 10 birds per replicate. Each treatment group received acetic acid (AA), butyric acid (BA), citric acid (CA) and formic acid (FA) at 0.25% level of the drinking water, while the control group received ordinary water. Starter and finisher diets were formulated (Table 1). Trial and error method according to Olomu (1995) was used to formulate the diets. Birds were fed *ad libitum.*

At day old, the chicks (Abor acre strain) were weighed. They were stabilized for one week in the brooding room. At the end of the one week stabilization period the birds were transferred to a rearing house where brooding continued till third week. At the second week, 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 10th and 17th 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 finisher diet to the end of the experiment which lasted for seven weeks. The birds were managed in a deep litter with wood shavings as bedding materials in an open sided wire mesh building with zinc roof.

Data Collection

Data were collected on feed intake, water intake and body weight. Feed and water intakes were determined daily by subtracting the leftover from the quantity given the previous day. The difference is the intake. At the end of the week, they were summed up and divided by the number of birds per replicate. The value obtained was then divided by 7 to give average daily feed or water intake per bird. The Body weight was measured weekly.

Data Analysis

At the end of the experiment, data collected were subjected to analysis of variance (ANOVA) for completely randomized design. Significant means were separated using Duncan New Multiple Range Text (DNMRT) according to Steel and Torrie (1980).

Table 1: Experimental Diets

Ingredients	Starter	Finisher
Maize	55.00	56.00
Soya bean meal	28.00	26.00
Palm kernel cake	10.30	14.30
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 D_3 13000 iu, thiamin 2mg, Riboflavin 6mg, pyridoxine 4mg, Niancin 40mg, cobalamine 0.05g, Biotin 0.08mg, chooline 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, 0001.u., vitamin D_3 12,0001.u. Vitamin E 201.U., Vitamin K 2.5mg, thiamine 2.0mg, Riboflavin 3.0mg, pyridoxine 4.0mg, Niacin 20mg, cobalamin 0.05mg, pantthemic 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

Results and Discussion

Table 2 shows the effect of organic acids on performance of starter broiler chicks. Addition of organic acids in the drinking water had significant (P<0.05) influence on some of the performance parameters measured. The final weight was significantly (P<0.05) influenced by organic the acids. Acetic acid produced the highest final weight followed by citric and formic acids than the control and butyric acid. There was no significant difference between the weight of the control group and that of butyric acid. Unlike final weight, butyric acid, citric acid and formic acids had similar daily weight gain when compared to the control. Only acetic acid treated diet significantly (P<0.05) produced better daily weight gain than the control.

The result of the final weight was in line with the report of Islam *et al*. (2008) who observed increase in final body weight and weight gain, when formic acid treated drinking water was offered to broiler chickens. This result was also in tandem with the earlier report that butyric acid in water did not significantly improve body weight (Leeson *et al*., 2005). There were no significant differences (P>0.05) in daily feed intake indicating that the organic acids except butyric acid achieved better final weight over the control without significant increase in feed intake. Hence, it could be opined that apart from feed intake which is known to have significant influence on body weight, other factors such as conditions of the gut ecosystem (such as microbiota population and endogenous secretions which influence nutrient utilization) could have influenced the growth performance of the birds. This is in consonant with the report of Leeson *et al*. (2005) which indicated that organic acids in drinking water improved final weight with insignificant feed intake. However, low feed intake resulting to poor growth was reported by Oviedo (2006).

Feed: gain ratio was significantly (P<0.05) better in acetic, citric and formic acids than in the control and butyric acid groups. The superior feed: gain ratios reflected in their final body weight. Butyric acid group and the control statistically posted the same values. Lesson *et al.* (2005) had also reported better feed: gain ratio of birds feed formic acid treated water.

Though protein intake was not significant, addition of acetic, citric and formic acids significantly influenced protein utilization (P<0.05). Birds that consumed acetic, citric

Table 2: Effect of Organic Acid treated Drinking Water on Performance of Starter Broilers

Parameters	Level of Organic Acids (0.25%)					
	CON	AA	BA	CA	FA	SEM
Initial body weights (g)	115.20	116.75	114.46	116.56	116.29	2.88
Final body weight (g)	730.09^{c}	869.07^{a}	747.22^{c}	807.41^{b}	803.70^{b}	14.11
Daily weight gain (g)	29.28^{b}	35.82^{a}	30.13^{b}	32.90^{ab}	32.73^{ab}	2.00
Daily feed intake (g)	56.04	57.31	57.32	57.71	57.21	3.16
Feed: gain ratio	1.91^{a}	1.06^{b}	1.90^{a}	1.75^{b}	1.75^{b}	0.14
Daily protein intake (g)	12.00	12.27	12.27	12.36	12.25	1.76
Protein efficiency ratio	2.44^{b}	2.92^{a}	2.46^{b}	2.66^{a}	2.67^{a}	0.10
Daily water intake (ml)	130.56^{a}	122.88^{ab}	107.54^{c}	118.23^{bc}	117.51^{bc}	71.00
Water: feed ratio	2.33^{a}	2.14^{b}	1.88^{c}	2.05^{b}	2.05^{b}	0.11

abc- means along the same row with different superscripts are significantly different (P < 0.05)
Sem = Stantard error mean. CON = Control. AA = Acetic acid, BA = Butyric acid, CA = Citric acid, FA = Formic acid.

and formic acid significantly (P<0.05) utilized protein better than the control and butyric acid treated group. Both the control and butyric acid had similar protein efficiency ratios. The improved final weight of acetic, citric, and formic acids could be linked to the efficient utilization of protein. The importance of protein for the growth performance of young broiler chicks has been stressed (Obioha, 1992; Olomu, 1995; Oluyemi and Roberts, 2000).

Daily water intake was significantly (P<0.05) lowered by butyric, citric and formic acids. There was no significant difference (P>0.05) between that of the control and acetic acid. Control group significantly (P<0.05) produced the highest water: feed ratio. Within the organic acid groups, butyric acid had the least, while that of acetic, citric and formic acids were statistically the same. The reduction in water consumption by birds fed acid treated water could be ascribed to change in taste. Butyric and formic acids were reported to add strong taste to drinking water (Oviedo, 2006).

Table 3 shows the effect of organic acid treated drinking water on performance of broiler finisher birds. Exposure of finisher broiler chickens to drinking water treated with organic acids resulted to significant differences (P<0.05) in most of the performance parameters except feed and protein intakes. Final weight was significantly (P<0.05) influenced by organic acids. Acid treated water except that with butyric acid significantly (P<0.05) produced heavier final weight than the control. There were no significant differences (P>0.05) in final weight of birds that consumed butyric, citric and formic acids. Acetic acid significantly (P<0.05) produced better final weight than butyric acid. Daily weight gain was statistically equal within the organic acid groups. All the organic acid groups except butyric acid significantly (P<0.05) posted better daily gain than the control.

Though the initial weight was significantly different, it seems that it may not have significantly contributed to the final body weight of the birds during this phase. This is because the initial body weight of acetic acid which was significantly heavier than those of citric and formic acids did not significantly improve over them at the end of the finisher phase. Similar observation was made between citric, formic and butyric acids. This indicates that prolonged exposure to certain organic acids in drinking water could increase the body weight of broiler chickens, especially for butyric acid. This also expresses positive carry over effect.

Improved Final weight observed could be connected to the better nutrient digestibility reported by Ndelekwute *et al*., (2011). Other reported factors that could have resulted to this include reduction in gram negative pathogenic bacteria populations in the gut and the pH. Positive effect of organic acids fed through drinking water on body weight as observed in this study has been reported (Leeson *et al.,* 2005; Oviedo, 2006; Islam *et al.,* 2008).

Organic acids did not significantly (P>0.05) influence feed intake. Leeson *et al*. (2005) feeding 0.2% butyric acid through the drinking water observed no significant difference in feed intake. However, at 0.4% they noticed a significant reduction in feed intake. Contrary to this result, acetic and citric acids were reported to favour feed intake when added to the drinking water (Islam *et al*., 2008).

Feed: gain ratio was significantly (P<0.05) better in organic acid treatment groups than in the control. Daily protein intake was not significant (P>0.05) but significantly (P<0.05) better utilized by acetic acid

Table 3: Effect of Organic Acid treated Drinking Water on Performance of Finisher Broilers

Parameters	Level of Organic Acids (0.25%)					
	CON	AA	BA	CA	FA	SEM
Initial body weights (g)	730.09[C]	869.07[a]	747.22[c]	807.41[b]	803.76[b]	14.11
Final body weight (g)	1762.32[C]	2050.96[a]	1851.55[bc]	1969.52[ab]	1956.41[ab]	66.76
Daily weight gain (g)	49.15[b]	56.28[a]	52.59[ab]	55.34[a]	54.89[a]	3.76
Daily feed intake (g)	130.37	133.68	130.10	134.09	133.49	3.44
Feed: gain ratio	2.65[a]	2.38[b]	2.47[b]	2.42[b]	2.43[b]	0.16
Daily protein intake (g)	25.88	26.54	25.82	26.62	26.50	1.88
Protein efficiency ratio	1.90[b]	2.12[a]	2.04[ab]	2.08[ab]	2.07[ab]	0.09
Daily water intake (ml)	269.97[b]	309.59[a]	260.48[b]	315.02[a]	306.35[a]	5.76
Water: feed ratio	2.07[b]	2.32[a]	2.00[b]	2.35[a]	2.29[a]	0.11

abc- means along the same row with different superscripts are significantly different ($p < 0.05$). SEM = Stantard error mean. CON = Control. AA = Acetic acid, BA = Butyric acid, CA = Citric acid, FA = Formic acid

treated group than the control. Other organic acid groups showed only marginal superiority over the control group. At this phase, there was improvement in water intake of the organic acid groups except butyric acid over the control showing some level of adaptation. Acetic, citric and formic acids significantly (P<0.05) encouraged water intake. In terms of daily intake, all the acid groups except butyric acid significantly (P<0.05) had higher values than the control. Butyric acid significantly (P<0.05) induced negative effect on water intake. Influence of treatment on water: feed ratio followed the same pattern as daily water intake.

The ability of the organic acids in drinking water to increase water consumption was reported by Marco (2008) and Islam *et al*. (2008). Using butyric acid as a drinking water sanitizer, Leeson *et al*. (2005) observed increased water intake at 0.1%, non significant effect at 0.2% and reduced water intake at 0.4%. This is an expression that effect of organic acids is depended on their concentration in water and relative to the acid. This reduction could have emanated from the foul odour (butyric acid treated water smelled like fermented cassava) produced by butyric acid. Generally, the performance of the organic acid fed-birds could be ascribed to the reported capacity of organic acids in general to sanitize water (Dalsgaard *et al.,* 1997), activate pancreatic activities (Dibner, 2004).

Conclusion.

Addition of acetic, citric and formic acids in drinking water improved performance of broiler chickens over the control and are therefore recommended.

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References

Alshawabkeh, K. and Tabbaa, J. 2002. Using dietary propionic acid to limit *Salmonella gallinarum* colonization in broiler chicks. *Asian-Aust. J. Anim. Sci.* 15(2): 243 – 246.

Botsoglou, N.A., Christaki, E., Florou-Paneri, P., Giannenas, I., Papageorgiou, G. and Spais, A.B. 2004. The effect of a mixture of herbal essential oils or alpha-tocopheryl acetate on performance parameters and oxidation of body lipid in broilers. *S. Afr. J. Anim. Sci. 52 - 61.*

Canibe, N., Emberg R.M. and Jensen, B.B. 2008. An overview of the effect of organic acids on gut flora and gut health. Danish Institute of Agricultural Sciences Bulletein No. 23: 4 - 7

Cheeson, A. 1994. Probiotics and other intestinal mediators. In: Principles of pig science. (Cole, D.J.A., Wiseman, J. and Varley, M.A. eds.). Nottingham University press. 197 – 214.

Chen, Y.J., Son, K.S., Min, B.J., Cho, J.H., Kwon O.S. and Kim, I.H. 2005. Effectsof dietary probiotic on growth performance, nutrients digestibility, blood characteristics and fecal noxious gas content in growing pigs. *Asian – Aust. J. Anim. Sci.* 18 (10): 1464 – 1468

Dalsgaard, A., Reichert, P., Mortensen, H.F., Sandstrom, A., Kofoed, P.E., Larsen, J.L. and Molbak, K. 1997. Application of lime (*Citrus aurantifolia*) juice to drinking water and food as cholera – preventative measure. *J. Food Protection*. 60 (11): 1329 - 1333.

Debevere, J.M. 1987. The use of buffered acidulant systems to improve the microbiological stability of acid foods. *J. Food Microbiol*. 4: 105 - 113.

Dibner, J. 2004. Organic acids: Can they replace antibiotic growth promoters. *Feed Int*. 25(12): 14 – 16

Gao, J., Zhang, H.J., Yu, S.H., Wu, S.G., Yoon, I., Quigley, J., Gao, Y.P. and Qi, G.H. 2008. Effects of yeast culture in broiler diets on performance and immunomodulatory functions**.** *Poult Sci.* 87: 1377 – 1384.

Islam, M.Z., Khandakar, Chowdhury, S.D. and Islam, K.M.S. 2008. Effect of citric acid and acetic acid on performance of broilers. *J. Bangladesh Agric. Univ*. 6(2): 315 - 320.

Lee, K.W., Everts, H., Kappert, H.J. Van Der Klien, J., Lemmens, A.G.,Frehner, M. and Beynen, A.G. 2004a. Growth performance, intestinal viscosity, fat digestibility and plasma cholesterol in broiler chickens fed a rye-containing diet without or with essential oil components. *Int. J. Poult. Sci.* 3(9): 613 – 618.

Lee, K.W., Everts, H. and Beynen, A.C. 2004b. Essential oils in broiler nutrition. Int. *J. Poult. Sci.* 3(12): 738 – 252.

Leeson, S., Namkung, H., Ankongiovanni, H. and Lee, E.H. 2005. Effect of butyric acid on the performance and carcass yield of broiler chickens. *Poult. Sci.* 84: 1418 – 1422

Marco, Q. 2008. Water quality and broiler performance. Broiler Supervisor's Short Course. Bulletein, New Carolina, USA. 11 - 13

McHan, F. 1992. Effects of butyric and lactic acids on continued colonization of *Salmonella typhimurium* in chick ceca when added to chick diets. *Poult. Sci.* 71 (sup. 1): 115.

Ndelekwute E. K., Amaefule, K. U., Onen, G. E., Anigbogu, N. M. and Opara, J. U. 2010. Effect of diets treated with organic acids on the performance of starter broiler chicks. 15th Annual Conf. Animal Science Assoc. Nig. Uyo, Nigeria.

456 - 458

Ndelekwute E. K., Amaefule, K. U., Onen, G. E., Anigbogu, N. M. and Onen, G.E. 2011. Effect of organic acid-treated diets on nutrient digestibility and fecal moisture of broiler chickens. Proc. 36th Annual Conf. Nig. Soc.Anim. Prod, Abuja, Nigeria. 731 – 733

Obioha, F.C. 1992. A Guide to Poultry Production in the Tropics. 1st ed. Ecena Pub. Enugu, Nigeria. 88 – 95.

Olomu, J.M. 1995. Monogastric Animal Nutrition: Principles and Practice. Jachem Pub. Benin, Nigeria. 80 – 98.

Oluyemi J.A. and Roberts, F.A. 2000. Poultry Production in Warm Wet Climate. 2nd ed. Spectrum Books Ltd. Ibadan, Nigeria. 210.

Oviedo, E.O. 2006. Important factors in water quality to improve broiler performance. Coop. Ext. Serv. Bulletin, North Carolina, USA. 15 – 19

Oyede, T.O., Ajayi, H.I. and Egere, T. 2008. Effect of increasing levels of yeast culture (Levucel SB) in a high fibre diet on the performance and nutrient retention of broiler chicks. Asian *J. Poult. Sci.* 53: 57 - 60.

Patterson, J.A. and Burkholder, K.M. 2003. Application of prebiotics, and probiotics in poultry production. *Poult. Sci.* 82: 627 – 631.

Paul, S.K., Samanta, G., Halder, G. and Biswas, P. 2007. Effect of a combination of organic acid salts as antibiotic replacers on the performaRunce and gut health of broiler chickens. *Livestock Res. Rural Dev.* 19 (11): 60 – 65.

Steel, G.D. and Torrie, J.H. 1980. Principles and Procedures of Statistics. 2nd ed. McGraw – Hill Book Co. Inc. New York.

Waldroup, A., Kaniawati, S. and Mauromoustakos, A. 1995. Performance characteristics and microbiological aspects of broilers feed diets supplemented with organic acids. *J. Food Protection.* 58 (5): 482 – 489.

Windisch, W., Schedle, K., Plitzner, C. and Kroismayr, A. 2007. Use of phytogenic products as feed additives for swine and poultry. *J. Anim. Sci*. 86 (E. Suppl.). E 10 – E14

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