Research Article

Apparent nutrient digestibility, gut pH and digesta viscosity of broiler chickens fed acidified water

Abstract

A Six week study was carried out to investigate effect of different organic acids fed through drinking water on nutrient digestibility, faecal moisture, gut pH and digesta viscosity of broiler chickens. The organic acids were acetic acid, butyric acid, citric acid and formic acid. One hundred and fifty (150) day old Anak chicks were used. There were five treatments. Treatment 1 which served as control consumed water with no organic acid, while treatments 2, 3, 4 and 5 were offered drinking water treated with 0.25% acetic acid, butyric acid, citric acid and formic acid respectively. Each treatment was replicated three times with 10 birds per replicate. The experiment was arranged in completely randomized design (CRD). Feed and water were offered ad libitum. Results showed that faecal moisture, dry matter and nitrogen free extracts digestibility, gut pH and duodenum digesta viscosity were significantly (P<0.05) reduced by organic acids. Protein, ether extract and fibre digestibility coefficients were significantly (P<0.05) improved by organic acids. In conclusion, the organic acids could be used through the drinking water to improve digestibility, reduce faecal moisture, gut pH, digesta viscosity of broilers and invariably their productivity.

Keywords: digesta viscosity, drinking water, pH, nutrient digestibility, organic acids

Volume 5 Issue 4 - 2018

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Received: June 15, 2018 | **Published:** July 23, 2018

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.[1] Earlier reports indicated that access to quality feed and attainment of daily requirement has been suggested to be better ways to achieve faster growth in broiler chickens.[2,3] But the quality and quantity of feed cannot guarantee optimum productivity if the feed so supplied is not well utilized by the animal.[4] The breakdown of each macro nutrient (starch, protein, fats and oils) 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 which is measured as digestibility.

Maynard et al.,[5] 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. 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.[6] The gut according to Patterson & Burkholder[7] and Paul et al.,[8] could be modulated to achieve enhanced performance of chickens. To this end, feeding strategies to improve digestibility have been employed. Feed grade enzymes, probiotics, prebiotics, yeast, spices and essential oils, have been reported to increase digestibility in monogastric animals.[9–11]

Recently, Ndelekwute et al.,[12] and Mohammed[13] reported that organic acids enhanced growth performance of broiler chicks. Earlier, Waldroup et al.,[14] Patten & Waldroup[15] and Dibner[16] had emphasized the essentials of organic acids in nutrient utilization by broilers. Nutrient utilization could be affected by the pH of the feed, intestinal pH and movement of digesta (transit time) in the gastro intestinal tract. The movement of digesta in the gut depends largely on the viscosity which could affect nutrient absorption. The conventional way of feeding organic acids has been through the feed. The quality of the drinking water also need to be considered according to Oviedo.[17] Hence it has been suggested that drinking water for birds could be sanitized with organic acids for better performance.[18] Better performance here include the faecal moisture which could be a reflection of digested nutrient conditions in the gut.

Therefore, the objective of this research was to determine the effect of drinking water acidified by organic acids (acetic, butyric, citric and formic acids) on nutrient digestibility, faecal moisture, digesta pH and viscosity at final stage of broiler chickens.

Materials and methods

Site of experiment

The experiment was conducted at the Teaching and Research Farm of Department of Animal Science and Forage Science, Michael Okpara University of Agricultulture, Umudike, Nigeria.

Experimental design

Completely randomized design (CRD) was used. One hundred and fifty (150) day old Anak chicks were used. There were divided into five treatments replicated three times with 10 birds per replicate. Each treatment group received acetic acid, butyric acid, citric acid or formic acid at 0.25% level of the drinking water, while the control group received neither of the organic acids. Birds were fed ad libitum with starter and finisher diets formulated according to nutrient requirement of broilers as shown in Table 1.

Management of birds

At day old, the chicks were weighed, after which they were transferred into the brooding room. Glucose was added to their drinking water the first day for faster energy intake. From the second day, vitamins and minerals were added to their drinking water for seven days. They were stabilized for one week in the brooding room. Heat was supplied by kerosene stove placed under a hover. At the end of the one week stabilization period the birds were randomly allotted to treatment groups in a rearing house, covered with water proof material. Heat supply continued to the third week of age. Feeding of organic acids through the drinking water started from second week. Starter and finisher feeds and the acidified water were supplied free choice. The birds were vaccinated against Newcastle and Gumboro diseases.

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, 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 D3 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

Digestibility study

Total collection method was used. Before the birds were introduced, both the metabolism room and cages were thoroughly washed and disinfected. At the end of the feeding experiment, one bird from each of the three replicates of a dietary group giving a total of 15 birds were randomly assigned to a metabolism cage each, in a metabolism room. Male birds were used and weights of the birds used were similar to reduce possible effect of sex and weight on digestibility. The birds were both fed and watered ad libitum. They were acclimatized for four days. At the end of the acclimatization period, a known quantity of feed was given daily to each bird. To minimize feed wastages, feeding was done in the morning by 8.00hrs; in the afternoon by 1.00hrs and in the evening by 6.00hrs making sure the birds did not lack feed at any point in time. Each morning before feeding commenced, leftover feed was recorded and feed intake noted.

Faeces was collected and weighed for four days. Collected faeces were immediately taken to the laboratory where they were oven dried at 60°C to constant weight. Dry faecal samples were ground to pass 1mm sieve. The four days faecal collection was pooled and thoroughly mixed together. A portion was taken from each treatment, stored in a refrigerator from which proximate analysis was carried out according to AOAC.[19] Faecal moisture and apparent nutrient digestibility were calculated as shown below;

$$Faecal\ moisture = \frac{Weight\ of\ wet\ faeces\ -\ Weight\ of\ dry\ faeces}{Weight\ of\ wet\ faeces} \times \frac{100}{1}$$

$$Apparent\ nutrient\ digestibility = \frac{Nutrient\ in\ feed\ -\ Nutrient\ in\ faeces}{Nutrient\ in\ feed} \times \frac{100}{1}$$

Determination of viscosity and pH of Digesta

5g of digesta obtained from the duodenum, ileum and caecum was used to measure the viscosity using cone/plate geometry according to Lee et al.,[20] with cone angle 1o and diameter 40mm at 37°C. The digesta was suspended in 5mls distilled water and mechanically stirred for two hours at room temperature (28°C). Immediately, the viscosity was measured using a Viscometer (Bohlin CS 50 Rheometer, manufactured by Bohlin Reologi, Muhlacker, Germany).

A pH meter was used to determine the pH. 1g of the digeta was taken and mixed with 10mls of distilled deionized water and the pH immediately measured according to Nisbet et al.[21]

All the data were subjected to analysis of variance (ANOVA). Significant means were separated using Duncan New Multiple Range Text (DNMRT) according to Steel & Torrie.[22]

Results

Table 2 shows the effect of acid treated drinking water on faecal moisture and nutrient digestibility. The Organic acids significantly ($P<0.05$) reduced faecal moisture. The digestibility of protein, fibre and ether extract were significantly ($P<0.05$) improved by the organic acids. Addition of the organic acids did not improve dry matter and nitrogen free extract digestibility, rather the digestibility of dry matter and nitrogen extract were significantly ($P<0.05$) reduced by addition of the acids. There was no significant ($P>0.05$) effect of the organic acids on digestibility of ash and energy utilization.

Effect of organic acid treated drinking water on the pH of different segments of the gastro intestinal tract (Table 3) is indicating that the pH was significantly ($P<0.05$) reduced by the organic acids in all the segments except in the duodenum. In the duodenum, only butyric acid produced similar pH as compared to the control.

Citation: Ndelekwute EK, Assam ED, Assam EM. Apparent nutrient digestibility, gut pH and digesta viscosity of broiler chickens fed acidified water. *MOJ Anat & Physiol.* 2018;5(4):250–253. DOI: 10.15406/mojap.2018.05.00203

The influence of the organic acids on digesta viscosity is indicated in Table 3. There were no significant (P>0.05) differences in viscosity at the caecum compared to the control. At the duodenum, acetic and citric acids significantly (P<0.05) reduced digesta viscosity. At the ileum only citric acid significantly reduced the viscosity (P<0.05) in comparison to the control.

Table 2 Effect of organic acid treated drinking water on digestibility coefficient and feacal moisture of the broilers

Parameters (%)	T1 (CON)	T2 (AA)	T3 (BA)	T4(CA)	T5 (FA)	SEM
Faecal moisture	67.50^{a}	57.53^{bc}	53.50^{c}	57.75^{bc}	59.65^{b}	3.88
Dry matter	75.23^{a}	66.51^{b}	66.26^{b}	67.67^{b}	68.38^{b}	4.76
Crude protein	63.68^{c}	68.28^{b}	69.73^{b}	75.43^{a}	74.37^{a}	4.08
Crude fibre	32.20^{c}	37.78^{b}	40.32^{a}	38.26^{ab}	39.67^{ab}	2.77
Ether extract	62.88^{c}	75.01^{b}	83.13^{a}	77.45^{ab}	80.21^{ab}	5.02
Crude ash	57.18	58.24	61.8	60.48	62.69	2.07
NFE	71.87^{a}	63.74^{b}	64.38^{b}	67.19^{b}	64.90^{b}	3.01
Energy	68.45	66.85	69.2	67	65.98	2.78

abc, 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 ph and viscosity of digesta of the broilers

Parameters	T1 (CON)	T2 (AA)	T3 (BA)	T4 (CA)	T5(FA)	SEM
pH (-Log H^{+})						
Crop	5.37^{a}	4.45^{c}	4.99^{b}	4.37^{c}	4.67^{bc}	0.56
Gizzard	3.87^{a}	3.17^{b}	3.21^{b}	3.14^{b}	3.27^{b}	0.67
Duodenum	6.53^{a}	6.14^{bc}	6.32^{ab}	6.01^{c}	6.17^{bc}	0.24
Ileum	6.79^{a}	6.61^{b}	6.64^{b}	6.60^{b}	6.5^{5b}	0.54
Caecum	5.95^{a}	5.59^{b}	5.47^{b}	5.39^{b}	5.50^{b}	0.56
Viscosity (Pa/s)						
Duodenum	1.36^{a}	1.27^{b}	1.37^{a}	1.27^{b}	1.32^{ab}	0.02
Ileum	1.84^{a}	1.79^{ab}	1.84^{a}	1.74^{b}	1.76^{ab}	0.05
Caecum	1.99	1.96	1.93	1.91	1.89	0.02

abc, 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

Discussion

The ability of the organic acids to reduce faecal moisture could be due to the improved fibre digestibility. Poor digestibility of fibre has been reported to cause watery faeces in broiler chickens.[2,3,6] Watery faeces due to poor digestibility of fibre was explained by Choct[6] to be due to fermentation of undigested fibre by microbiota in the gastro intestinal tract. This suggests that the organic acids could have rendered the intestinal bacteria incapacitated to ferment the gut digesta. This is in line with the report of Ndelekwute et al.,[23] that organic acids fed through feed reduced bacterial load of the intestine especially in the duodenum. The ability of acetic and citric acids to reduce digesta viscosity in the duodenum is an indication that they could be used to fasten digesta movement in the gut to reduce nutrient fermentation. High viscosity leads to slower movement of digesta thereby giving more room for nutrients fermentation.[6] Organic acids were reported to induce pancreatic secretions whose content include enzymes such as trypsin and chymotrypsin that are required for the hydrolysis of protein in the duodenum.[16] This could be linked to the better digestibility of protein observed in birds that were fed acidified drinking water. The reduced gut digesta pH could also be accounted for the better protein digestibility. Protein was reported to digest better in acidic medium.[16,24] The reduced digestibility of nitrogen free extract by organic acids could be due to reduction in the activities of amylase. MacDonald et al.,[25] maintained that the activities of amylase which digests starch is reduced in low pH (acidic medium) as recorded in present report. This result is in consonant with Makkink[26] and Ndelekwute et al.,[23] who reported that organic acids though fed through the diets of monogastric animals improved digestibility.

Conclusion

The present report indicates that the test organic acids (acetic, butyric, citric and formic acids) reduced faecal moisture, gut pH and apparent nutrient digestibility. Acetic and citric acids reduced digesta viscosity of the duodenum. Therefore, these organic acids could be added to broiler chickens drinking water to improve their productivity.

Acknowledgements

None.

Conflict of interest

The author declares no conflict of interest.

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