Research Article

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Effect of dietary organic acids on nutrient digestibility, faecal moisture, digesta pH and viscosity of broiler chickens

Abstract

An experiment was carried out to investigate the effect of feeds acidified with different organic acids on apparent nutrient digestibility, faecal moisture, digesta pH and digesta viscosity of broilers. The organic acids were acetic, butyric, citric and formic acids. One hundred and fifty (150) day old Arbor-acre chicks were used. There were five treatments (T). T1 which served as control consumed feed without the organic acids, while treatments (T2, T3, T4 and T5) were offered feed treated with 0.25% acetic, butyric, citric and formic acids respectively for seven weeks. 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 and digesta pH were reduced ($P<0.05$) by the organic acids. Digestibility of protein, ether extract and crude fibre were improved. Feeding of acetic and butyric acids resulted to significant reduction of digesta viscosity in the duodenum. Nitrogen free extract digestibility was reduced ($P<0.05$) by the acids. There was no effect ($P>0.05$) of the acids on energy utilization. In conclusion, the organic acids could be used in diets for broilers for better gut performance.

Keywords: apparent nutrient digestibility, digesta viscosity, faecal moisture, pH, organic acids

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Introduction

Finishing broiler chickens at a reasonable period of time will guarantee profit maximization which is the target of poultry farmers. According to Ndelekwute et al.[1] provision of both quality and adequate feed to broiler chickens is essential for optimum performance. They maintained that quality feed is one which supplies all the nutrients required for productivity while adequate feeding means provision of the daily feed requirement free choice. It has been suggested that access to quality feed and attainment of daily requirement was better ways to achieve faster growth in broilers.[2] The quality and quantity of feed cannot guarantee optimum productivity if the feed so supplied is not well utilized by the animal.[3] Digestion plays a significant role in nutrient utilization. All the nutrients which are contained in the feed must be broken down into simpler forms so that the gut can absorb them for metabolic processes.

The gastro intestinal tract (GIT) otherwise known as the gut must be in a good condition in order to be able to carry out its responsibility of nutrient breakdown and absorption.[4] Hence the physiology and anatomy of the gut play a very significant role in carrying out this role. Also there are conditions which favour nutrient digestion and absorption by the gut. For instance low pH in the proventriculus is required for adequate protein digestion and general reduction in bacteria community in the different segments of the gut.[5] High pH in the gut results to proliferation pathogenic microbiota which is detrimental to both growth and health of chickens.[4] Presence of pathogenic bacteria results to nutrient fermentation which leads to high faecal moisture content and loss of vital nutrients. Nutrient fermentation in the gut can be aided by the viscosity of the digesta.[6] High digesta viscosity means that the digesta will stay in the duodenum longer than necessary thereby giving room for the pathogenic bacteria to ferment the digesta. The level of nutrient absorption depends among other factors on the condition of the absorptive machineries of the gut which are the villi.[6]

Now that our chickens are produced in environments that are contaminated it becomes expedient to aid the natural gut to adequately perform its functions. Hence the gut can be modulated to achieve an improved performance of chickens. Feeding strategy to achieve this has been the use of feed grade enzymes, prebiotics, probiotics, spices, essential oils and recently organic acids.[7–11] Therefore, the objective of this research was to determine the effect of dietary organic acids (acetic, butyric, citric and formic acids) on nutrient digestibility, faecal moisture, digesta pH and viscosity of broiler chickens.

Materials and methods

Site of experiment

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

Experimental design

Completely randomized design (CRD) was used. One hundred and fifty (150) day old Abor-acre chicks were used. There were divided into five treatments (T) groups which were each replicated three times with each replicate having 10 birds. Basal starter and finisher diets (Table 1) were formulate. The basal diets without any of the organic acids formed the control diets. Other treatments were formed by adding to the basal diets 0.25% acetic acid, butyric acid, citric acid and formic acid to represent T2–T5 respectively. The starter feed was fed for four weeks while the finisher feed was fed for three weeks. Water and feed were given ad libitum for the seven weeks the experiment lasted.

Management of birds

At day old, the chicks were weighed. Glucose was added to their drinking water the first day for faster energy intake. From the second day, vitamin and mineral preparation was added to their drinking water for seven days. Heat was supplied by using kerosene stove in order to maintained adequate temperature needed for the first three weeks. Feeding of the organic acids started from day old. Feed and water were supplied free choice. The birds were vaccinated against Newcastle and Gumboro diseases. The birds were fed starter diet for the first four weeks and finisher diet for the last three weeks.

Table 1 Experimental diets

Ingredients	Starter diet	Finisher diet
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	100
Calculated composition (%)		
Crude protein	22.1	20.65
Energy (MJME/kg)	11.99	12.03
Ether extract	3.92	6.16
Crude fibre	5.01	6
Ash	7.04	6.8
Calcium	1.2	1.11
Phosphorus	1.01	0.88
Lysine	1.12	1.05
Methionine	0.55	0.5

*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 A 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.

Determination of faecal moisture and apparent nutrient digestibility

Total collection method was used using metabolism cages which 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. Male birds were used and weight of the birds used were similar to reduce possible effect of sex and weight on digestibility. They were acclimatized for four days during which each treatment group was fed its diet. At the end of the acclimatization period, during which the birds had mastered the act of feeding and drinking in the new cage environment, a known quantity of the feed was given daily to each bird. To minimize feed wastages, feeding was done in the morning by 8.00 hours GMT in the afternoon by 1.00 hours and in the evening by 6.00 hours making sure the birds did not lack feed at any point in time. Each morning before feeding commenced, leftover feeds were 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.[12] Faecal moisture and apparent nutrient digestibility was calculated thus;

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

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

The percentage faecal moisture was determined by weighing a wet sample and the weight was noted. The wet sample was thereafter dried to a constant weight in an electric oven. The difference between the weight of the wet sample and the weight of the dry sample was taken to be the weight of the moisture. It was later converted to percentage by dividing the weight of the moisture by the weight of the wet sample and multiplied by 1.

Determination of viscosity and pH of digesta

Digesta obtained from the duodenum, ileum and caecum was used to measure the viscosity. Cone/plate geometry according to Lee et al.[6] was applied with cone angle 1o and diameter 40mm at 37°C. The digesta was suspended in 5mls distilled water. It was mechanically stirred for two hours at room temperature (30°C). 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. One gramme of the digeta was taken and mixed with 10mls of distilled deionized water. The pH was measured according to Nisbet et al.[13]

Data transformation and statistical analysis

All the data obtained were subjected to analysis of variance (ANOVA). Significant means were separated using Duncan New Multiple Range Text (DNMRT) according to Steel & Torrie[14]

Results

Table 2 shows the effect of organic acid containing diets on faecal moisture and nutrient digestibility of broiler chickens. There was significant ($P<0.05$) reduction of faecal moisture by all the acidified diets. Addition of the organic acids had significant ($P<0.05$) effect on digestibility of all the nutrients except crude ash, nitrogen free extract and energy utilization. All the diets containing different organic acids significantly improved digestibility of dry matter, crude protein, crude fibre and ether extract. Inclusion of the organic acids in the diets negatively affected digestibility of nitrogen free extract. Though the organic acids did not improve digestibility of crude ash and energy utilization there were no negative effect on them as their respective values were similar to those of the control.

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The result of the effect of the diets on pH of the gastro intestinal tract (Table 3) indicates that feeding of diets containing organic acids resulted to significant (P<0.05) differences in digesta pH except in the crop and ileum where there was no dietary effect on pH. The pH was significantly reduced in proventriculus and duodenum by all the organic acid diets compared to the control. In the gizzard, acetic, citric and formic acid diets produced lower pH than the control diet while that of the butyric acid diet was similar to the control. All the organic acid diets produced lower pH than the control diet in the duodenum. The pH in caecum was significantly reduced by acetic and butyric acid diets compared to the control while that produced by citric and formic acid diets was similar to that of the control.

Table 2 Effect of organic acids on digestibility and faecal moisture of the broilers

Parameters (%)	T1	T2	T3	T4	T5	SEM
Faecal moisture	67.50^{a}	57.53^{b}	58.40^{b}	56.76^{b}	58^{b}	4.97
Dry matter	64.11^{b}	70.02^{a}	69.92^{a}	70.04^{a}	68.87^{a}	4.03
Crude protein	63.68^{b}	69.22^{a}	68.65^{a}	71.13^{a}	70.08^{a}	5.11
Crude fibre	32.20^{b}	39.18^{a}	38.30^{a}	38.90^{a}	40.07^{a}	4.65
Ether extract	74.88^{b}	79.01^{a}	80.13^{a}	78.45^{a}	81.21^{a}	5.02
Crude ash	57.18	58.24	61.8	60.48	62.69	4.11
NFE	68.11^{a}	62.64^{b}	61.41^{b}	60.15^{b}	60.20^{b}	6.03
Energy	69	68.05	67	67.98	66.98	4.78

abc Means along the same row with different superscripts are significantly (p<0.05) different. T1, Control; T2, acetic acid; T3, butyric acid; T4, citric acid; T5, formic acid

Table 3 Effect of organic acids on digesta pH and viscosity of broilers

Segments	T1	T2	T3	T4	T5	SEM
pH (-log H^{+})						
Crop	5.4	5.10	5.20	5.20	5.40	0.55
Proventriculus	4.80^{a}	4.02^{b}	4.10^{b}	4.14^{b}	4.21^{b}	0.45
Gizzard	3.73^{a}	3.17^{c}	3.53^{ab}	3.43^{bc}	3.37^{bc}	0.42
Duodenum	6.63^{a}	6.33^{b}	6.27^{b}	6.30^{b}	6.03^{b}	0.28
Ileum	6.40	6.37	6.27	6.23	6.13	0.58
Caecum	5.50^{a}	5.07^{b}	5.17^{b}	5.33^{ab}	5.40^{a}	0.11
Viscosity (Pa/s)						
Duodenum	1.38^{a}	1.29^{b}	1.29^{b}	1.35^{ab}	1.31^{ab}	0.04
Ileum	1.84	1.74	1.74	1.75	1.78	0.22
Caecum	1.91	1.79	1.81	1.83	1.85	0.23

abc means along the same row with different superscripts are significantly different (P<0.05). SEM, Standard error mean; T1, control; T2, acetic acid; T3, butyric acid; T4, citric acid; T5, formic acid

The effect of treatment on digesta viscosity is also shown in Table 3 showed that significant difference (P<0.05) occurred only in the duodenum. Acetic and butyric acid diets significantly reduced the viscosity of the digesta in duodenum more than the control diet. In the same duodenum the digesta viscosity of dietary citric and formic acids was similar to that of the control. However, there were no differences in digesta viscosity within the organic acids.

Discussion

The ability of the organic acids to reduce the faecal moisture could be due to the significant improvement in fibre digestibility. Poor utilization of fibre has been reported to cause watery faeces in broiler chickens.[2,4] Undigested fibre in the gastro intestinal tract forms a substrate for bacteria and could be fermented by bacteria thereby generating water as one of the products. This culminates to high moisture content of faeces. Improving fibre digestibility means reduction in quantity of undigested fibre which would have been fermented by bacteria. The reduction in the faecal content moisture could lead to better litter quality and could be also a good indicator of healthy gut. Organic acids are known to induce pancreatic secretion and also could acidify intestinal digesta leading to reduction in gut pH.[5,15] The acidic nature of the proventriculus which is the stomach of chickens could be linked to the improvement in crude protein digestibility. According to Dibner[5] low pH is essential for protein digestion in chickens and other monogastric animals. Ndelekwute et al.[16] referring to ascorbic and citric acids content of lime juice reported that lime juice improved nutrient digestibility of 7 week old broiler chickens because of the two organic acids it contained.

Going by the present result which shows that the organic acids imparted negatively on the digestibility of nitrogen free extract, it could be opined that the acids could have played a major role. Nitrogen free extract is the starch portion of feeds and feedstuffs and amylase which is the enzyme that breaks down starch is negatively influenced in acidic medium.[17,18] This result is in consonant with the report of Ndelekwute et al.[3] that organic acids fed through drinking water did not improve digestibility of nitrogen free extract in chickens.

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Digesta viscosity indicates the rate digesta flows or moves along the intestine and it has great impact on nutrient absorption and utilization in chickens.[10] The present result shows that acetic and butyric acids could be used to reduce digesta viscosity in the duodenum which is an essential part of the gut where digestion and most absorption of nutrients take place. The insignificant effect of the organic acids on digesta viscosity in the ileum and caecum could be that the acids have been diluted before getting to the hind gut and therefore could not impart on the digesta viscosity. Dilution of concentration of organic acids along the gastro intestinal tract has been reported.[15]

Conclusion and recommendation

The four organic acids showed significant levels of positive effect on reduction of faecal moisture, acidification of the gut, digestibility of crude protein, crude fibre and ether extract. Among the organic acids, acetic and butyric acids indicated greater capacity to reduce the viscosity of digesta in the duodenum. Therefore application of the tested organic acids in feeding of broiler chickens is recommended to poultry farmers to reduce gut digesta pH, faecal moisture, improve nutrient digestibility and use acetic and butyric acids to reduce digesta viscosity in the duodenum.

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None.

Conflicts of interest

The authors declare there is no conflict of interest.

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