Effect of a Combination of Propionic-Acetic Acid on Body Weight, Relative Weight of Some Organs, Lactic Acid Bacteria and Intestinal pH of Neonatal Broilers

ABSTRACT

This study was designed to determine the effect of a combination of propionic-acetic acid on body weight, the relative weight of some organs, lactic acid bacteria, and intestinal pH of neonatal broilers. A total of 60 1-day-old Ross 308® broiler chickens were randomly placed in metabolic cages to two treatments, three replicates, and ten birds per replicates. The treatments consisted of a control diet (CD) and CD + 0.03% of propionic acid and acetic acid in the drinking water at a rate of 4 ml/L of water. The combination of organic acids depressed the body weight in neonatal broilers (p<0.05) and increased the relative weight (p<0.05) of gizzard, proventriculus, small intestine, and liver; also acidified the cecum with a significant decrease (p<0.05) of the pH. Also, these organic acids increased (p<0.05) the count of green bacilli with a white halo in the small intestine and decreased (p<0.05) the proliferation of irregular flat green bacilli in the cecum, although for both intestinal portions, the total lactic acid bacteria count was not different (p>0.05) between treatments. The combined use in the diet and drinking water of the propionic and acetic organic acids, respectively, reduced the bodyweight of neonatal broilers (10 days) and the cecal pH, as well as modified the relative weights of some digestive organs and the growth of some morphological groups of lactic acid bacteria.

INTRODUCTION

In recent years, global chicken production has been influenced by a growing demand due to the increase in the world population and the greater need for this animal protein, which is cheaper than red meat (FAO, 2017). In 2017, chicken meat accounted for 36.55% of world meat production. For 2020, the production was projected to reach 100.5 million tons of chicken meat, despite the global trade in meat being trimmed due to emerging threats from the spread of the COVID-19 virus, which makes this item an important part of world food production (USDA, 2020). In order to cover the demand, the poultry industry has technified and intensified its processes; however, this has caused an increase in the susceptibility, incidence and severity of bacterial diseases, attributed to the lack of biosecurity measures and the easy propagation of them under intensive conditions (Saleem et al. 2015).

For the prevention of diseases, from the 1950s to date, antibiotics have been used in sub-therapeutic doses as growth promoters to improve the daily weight gain of birds (Gadde et al., 2017). Many studies have shown that the use of antibiotics causes bacterial resistance in broilers, and there is a potential risk that this resistance will be transmitted to humans (Fascina et al., 2017). The poultry industry is increasingly facing
legislative pressures to eliminate the use of antibiotics, since January 2006, the European Union banned the use of antibiotics in animal feed (Adil et al., 2010). The elimination of preventive antibiotics in Europe has led to problems in performance, in the feed conversion rate, and in the incidence of certain animal diseases. This topic has been a subject of discussion throughout the world; researchers and nutritionists have increased their interest in finding other alternatives that eliminate or minimize the use of antibiotics without depressing the growth performance of broiler (Martínez et al., 2013; Gadde et al., 2017).

There are different growth promoters of natural origin that do not have residual effects on the final product, such as prebiotics, probiotics, plant extracts and organic acids that have been investigated in poultry, these reduce pathogens and improve the immune response (Vuong et al., 2016; Valenzuela-Grijalva et al., 2017; Yang et al., 2019). Organic acids have been used for more than 30 years, mainly because they have disinfecting effects on the digestive tract and are compounds that occur naturally in cellular metabolism, which have been used as growth promoters (Saleem et al., 2015).

The organic acids have impacts on growth, nutrient utilization, mineral availability, gut microbiota, and disease resistance (Mohammed et al., 2018). Dehghani-Tafti & Jahanian (2016) found that the use of organic acids causes non-pathological intestinal acidification that reduces the population of Enterobacteriaceae and increases the secretion of gastric enzymes, the functionality of the intestine and the absorption of nutrients. Therefore, the development and health of the gastrointestinal tract is an essential part of good performance in broilers (Fascina et al., 2017). Organic acids, such as propionic and acetic, have been the most used individually in broiler production (Adil et al., 2010).

The individual use of propionic and acetic acids has been reported to improve the performance and the health status of birds, as an effective alternative to the use of sub-therapeutic antibiotics (Alshawabkeh & Tabbaa 2001; Haque et al., 2009; Attia et al., 2013). However, recent researches have focused on combining various organic acids to enhance the functional activity of these compounds. In this sense, studies of Gunal et al. (2006) reported a decrease in cecal gram-negative bacteria without positive effects on body weight when they used an organic acid mixture (propionic and formic acids) in broiler diets. Similarly, Dehghani-Tafti & JaHanian (2016) have shown an increase in performance using dietary supplementation with an organic acid mixture (citric + butyric). Meanwhile, Mohammed et al. (2018) and Beier et al. (2019) have shown that the use of acetic acid in drinking water and propionic acid in the diet improved the growth performance and the health condition of neonatal birds. Despite the beneficial effects of organic acids, to our knowledge, few studies have evaluated the combined use of these organic acids to improve the productivity and physiological activity of broilers. The objective of the study was to evaluate the effect of a combination of propionic-acetic acid on body weight, the relative weight of some organs, lactic acid bacteria, and intestinal pH of neonatal broilers.

MATERIALS AND METHODS

The study was carried out in July 2019, at the Poultry Research Center of the Zamorano Pan-American Agricultural School (Zamorano University), located 30 km southeast of Tegucigalpa, in the municipality of San Antonio de Oriente, department of Francisco Morazán, Honduras. The average annual temperature is 26 °C, and the average rainfall is 1100 mm per year.

A total of 60 1-day-old Ross 308® broiler chickens were randomly placed in metabolic cages to two treatments, three replicates, and ten birds per replicates. The treatments consisted of a control diet (CD) and CD + 0.30% of propionic acid and the addition of acetic acid in the drinking water at a proportion of 4 mL in a liter of water according to commercial house recommendations. We used propionic acid in the feed and acetic in drinking water of broiler according to the findings of Dittoe et al. (2008) and Mohammed (2018), respectively. The diets were formulated according to the requirements of the genetic line (Table 1).

The broilers in metabolic cages with dimensions of 0.70 m wide x 1 m long were housed, at the rate of 10 chickens per cage, with a density of 10 chickens/0.7 m². Feed and water were offered ad libitum in linear feeder and nipple drinkers, respectively. In the drinking water of the control group and propionic+acetic group, the temperature (26.33 ± 0.057 and 26.37 ± 0.057, respectively) and pH (7.42 ± 0.25 and 4.01 ± 0.06, respectively) was determined using portable Multiparameter Meter, Orion Star A3290 (Thermo Scientific) according to APHA methods (1995). Also, bacteriological analysis (negative results) was performed by the Petrifilms method (E. coli/Coliform Count Plates-3M™ Petrifilm™ Plates, Minneapolis, USA). During the 10 experimental days, the broilers received 23 hours of light with an intensity of 30-40 lux.
Table 1 – Ingredients and contributions (0-10 days; as fed).

| Ingredients                        | Percentage (%) |
|------------------------------------|----------------|
| Cornmeal (CP, 7.79%)               | 49.57          |
| Soymeal (CP, 48.0%)                | 39.54          |
| Mineral and vitamin premix         | 0.50           |
| Sodium chloride                    | 0.50           |
| Crude palm oil                     | 6.15           |
| Colin                              | 0.08           |
| DL-Methionine                      | 0.38           |
| L-Threonine                        | 0.10           |
| L-Lysine                           | 0.25           |
| Calcium carbonate                  | 1.13           |
| Biophos                            | 1.58           |
| Mycofix plus 5.0                   | 0.12           |
| Enzymes Lumis Lbzyme X50           | 0.05           |
| Coccidiostato                      | 0.05           |
| **Contributions (%)**              |                |
| Metabolizable energy (kcal/MS)     | 3000           |
| Crude protein                      | 23.43          |
| Crude Fiber                        | 2.39           |
| Ashes                              | 6.36           |
| Ca                                 | 0.96           |
| P available                        | 0.48           |
| Methionine+Cystine                 | 0.95           |
| Threonine                          | 0.86           |
| Valine                             | 0.91           |
| Isoleucine                         | 0.80           |
| Leucine                            | 1.60           |
| Lysine                             | 1.28           |
| Histidine                          | 0.51           |
| Arginine                           | 1.30           |
| Tryptophan                         | 0.24           |
| Phenylalanine                      | 0.80           |

1 Each kg contains: vitamin A, 13,500 UI; vitamin D3, 3,375 UI; vitamin E, 34 mg; B2, 6 mg; pantothenic acid, 16 mg; nicotinic acid, 56 mg; Cu, 2,000 mg; folic acid, 1.13 mg; vitamin B12, 34 mg; Mn, 72 mg; Zn, 48 mg.

At 10 days- of age, 10 broilers per treatment were sacrificed by the bleeding method of the jugular vein after six hours of feed fasting (water was offered ad libitum) to collect samples. The viscera (liver and heart), immune organs (thymus, spleen, and bursa of Fabricius), and the intestines (small and large) were removed and a digital scale Truweigh Blaze digital scale BL-100-01-BK with accuracy ± 0.1 g were weighed (Martinez et al., 2013). In the slaughter (10 days- of age), the small intestine and left cecum of 10 broilers per treatment were taken, and the pH was determined using an Oakton® digital pH potentiometer model 700, calibrated with pH buffer solutions at 1.68, 4.01, 7.00, 10.01, and 12.45 (Molina et al., 2019).

Also, the small intestines and right cecums of 10 broilers per treatment were taken, and the mucosa with a scalpel was scraped for microbiological culture. Each sample’s cecal content was placed in a sterile tube; weight was recorded and diluted with Butterfield’s phosphate-buffered dilution water to a 1:9 ratio (w:v). Diluted cecal contents were homogenized, and serial dilutions (1/10) were made from it until dilution 10^-5. Aliquots of 0.1 ml of each dilution were spread plated on the surface of MRS agar (Neogen Acumedia, Mich.) supplemented with methylene blue (0.016 g/1000 ml) at 37 °C with a pH of 5.6 for 48 hours in anaerobiosis (Gas Pak system, BBL, Cockeysville, USA). Counts of lactic acid bacteria were reported as Log CFU/g by colonies’ morphology on MRS + MB agar. Gram stain and catalase activity was tested on each type of colonies reported (Molina et al., 2019). The microbiological tests were performed in the Food Microbiology Laboratory of the Zamorano University.

The results are expressed as mean and ± SEM. An unpaired T-student test was performed using SPSS 23.0 (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Table 2 shows the body weight and relative weight of the digestive organs, viscera, and lymphoids in broilers when acetic acid was used in the drinking water and propionic acid in broiler diet (10 days). The use of these combined organic acids significantly decreased (p<0.05) the body weight (10 days). However, this combination of organic acids increased (p<0.05) the relative weight of the proventriculus, gizzard, small intestine, and liver, although without significant changes (p>0.05) among treatments for the relative weight of the cecum, pancreas, bursa of Fabricius, heart, spleen, and thymus.

Table 2 – Effect of a mixture of propionic-acetic acid on relative weight of digestive organs, viscera and lymphoid organs in neonatal broilers (10 days).

| Items                  | Experimental groups | SEM± | p value |
|------------------------|---------------------|------|---------|
| **Body weight (g)**    | Control             | 187.97 | 153.13 | 7.810 | 0.005 |
| Proventriculus (g/kg)  | 0.94                | 1.30  | 0.056  | <0.001 | |
| Gizzard (g/kg)         | 5.54                | 6.72  | 0.261  | 0.005 | |
| Small intestine (g/kg) | 8.50                | 10.22 | 0.459  | 0.016 | |
| Cecum (g/kg)           | 1.26                | 1.51  | 0.118  | 0.143 | |
| Pancreas (g/kg)        | 0.66                | 0.60  | 0.040  | 0.336 | |
| Heart (g/kg)           | 0.70                | 0.73  | 0.030  | 0.518 | |
| Liver (g/kg)           | 2.84                | 3.43  | 0.12   | 0.003 | |
| Spleen (g/kg)          | 0.07                | 0.10  | 0.009  | 0.059 | |
| Thymus (g/kg)          | 0.13                | 0.15  | 0.017  | 0.457 | |
| Bursa of Fabricius (g/kg) | 0.17               | 0.13  | 0.013  | 0.058 | |

The goal of this study was to determine whether the combination of propionic and acetic as one of the most frequent organic acids in the poultry industry could influence any biological indicators in broilers.
The results showed that the group with organic acids depressed the body weight (Table 2), perhaps due to the excessive acidification of the drinking water (4.01) and the cecum of the broilers (Table 3). Authors as Gunal et al. (2006), Houshmand et al. (2012) and Fascina et al. (2017) found no benefits on body weight and intestinal histomorphometry of broilers supplemented with mixtures of organic acids such as fumaric+propionic, formic+lactic+citric, and lactic+benzoic+formic+citric+acetic, respectively. According to Jiang et al. (2012) the intestinal villus and crypt are correlated with gut health and growth in birds and are affected by diet and intestinal health. In this sense, Sayrafi et al. (2011) when using butyric acid in the diets of chickens found no changes in the gain and villi height in the duodenum and jejunum. However, Adil et al. (2010) indicated that the use of fumaric acid and lactic acid improved the performance and increased villus height in the small intestines of broiler chickens. Likewise, Panda et al. (2009) reported that the dietary use with 0.4% butyric acid increased the body weight and villus development in broilers; however, a higher supplementation of this organic acid reduced the productive response due to an excessive reduction in intestinal pH and a lower activity of digestive enzymes. Authors such as Kum et al. (2010) demonstrated that the use of organic acids increased the villi width, villus height, villus area, and goblet cells in the small intestine. Apparently, a positive response to the use of organic acids in chickens is mediated by intestinal health, especially by changes in the structures of the villi and crypts.

On the other hand, Pinchasov et al. (1994) conducted a study to evaluate the anorexic effect of propionic and acetic acids in chicks from 7 to 21 days. The authors found that these organic acids significantly decreased the voluntary intake; the higher the dose, the more the intakes were depressed. It is observed that the combination of the two organic acids caused some digestive disorders, which reduced the use of nutrients in the intestinal lumen, despite the fact that these organic acids acidified the cecum and modified the relative weight of the small intestine, liver, cecum, and gizzard and proventriculus (Tables 2 and 3).

Generally, the positive effects of organic acids reported in the literature are inconsistent. Factors such as the environment, feed palatability, buffer capacity of the diet, concentration of organic acid used, management, gut health, presence of other antimicrobial compounds, water pH, and genetic expression of poultry are factors responsible for the variability of the results (Houshmand et al., 2012; Fascina et al., 2017). Moreover, Angel (2005) claims that, in a favorable environment, and in totally healthy animals, organic acids have no effect. It is known that the proventriculus has a glandular function and the gizzard a muscle function; both sections are directly related, since, together, they are integral parts of the gastrointestinal tract (Martínez et al., 2013). In this sense, Svi hus (2011) indicated that the use of feed additives improves the disposition of nutrients, which promotes the development of the proventriculus and gizzard in broilers. According to Van Immerseel et al. (2006), the supplemental acids are most likely to affect in the proventriculus and gizzard rather than the intestines; these authors showed that formic acid and propionic acid increased the activity of these organs, being similar to the results shown in Table 2. However, Dehghani-Tafti & Jahanian (2016) have reported a decrease in the relative weight gizzard in broilers due to the dietary supplementation with a mixture of organic acids (citric+butyric acids). Likewise, Abdel-Fattah et al. (2008) found no notable differences in the relative weight of the gizzard when they used lactic, acetic, and citric acid on broiler diets. It is important to note that, although the combined use of organic acids (propionic acid + acetic acid) increased the relative weight of some digestive organs (proventriculus, gizzard, small intestine and liver), this did not promote the growth of broilers. Similar results were found by Martínez et al. (2013) and Savón et al. (2015), who indicated that in apparently healthy birds, a higher relative weight of some digestive organs does not always translate into a greater productive response, especially since these organs increase their activity to maintain homeostasis due to extrinsic factors such as high fiber content, antinutritional factors, feed granulometry and intrinsic factors such as enzymatic activity, gut dysbiosis, pH and inflammation in the gastrointestinal tract, apparently these organic acids caused an intestinal disturbance (with lower pH and lower cecal lactic acid bacteria count) which directly affected this productive indicator (body weight), however more research is needed to justify this hypothesis.

On the other hand, the fast-growing and small bowel development is one of the factors that define the genetic expression of broilers (Martínez et al., 2013). In their first days of age (until 10 days), the length of the intestine increases, however, few are efficient to digest nutrients due to the immaturity of the digestive tract, however a higher development of their villi improves the digestibility of nutrients (Abdel et al., 2012). The
results showed that the use of organic acids increases the relative weight of the small intestine (Table 2). In this regard, Paul et al. (2007) found similar results when they were using organic acid salt on broiler diets. According to Fascina et al. (2017), the functionality and absorption of nutrients in the intestine may be influenced by the slightly acidic conditions of this organ. Also, Peng et al. (2016) and Dittoe et al. (2018) reported that propionic and acetic acids decrease pH throughout the gastrointestinal tract, inhibiting pathogen growth and improving cellular production, which facilitates the absorption of nutrients transported to the bloodstream. According to Ruhnke et al. (2014) and Lv et al. (2015), an increase in the epithelial surface leads to a higher capacity when transporting nutrients, which could stimulate the development of the digestive organs. In this sense, Murry et al. (2004) determined that volatile fatty acids produced by *Lactobacillus salivarius* and *Lactobacillus plantarum* decrease the pH of the intestinal environment, which influences the relative weight of the small intestine. However, Tahmiz et al. (2015) found that excessive acidification in the gastrointestinal tract causes intestinal disturbances, with a decrease in the absorption of nutrients and enzymatic activity. The changes in the relative weight of the digestive organs due to the use of organic acids (acetic and propionic) seem to decrease the functionality of the digestive organs and the ability to absorb nutrients, which reduced the body weight in the neonatal broilers.

The function of the cecum in broilers is to ferment nutrients such as starch, protein, and fiber that was not digested in the small intestine and absorb some of the water contained in the digested feed (Martínez et al., 2013). Once these nutrients enter the cecum, fermentation begins to produce volatile fatty acids (AGV), transfer them to the bloodstream and be used as energy (Svihus et al., 2013). Studies by Gunal et al. (2006) have reported that mixture with organic acids, antibiotics, and probiotics modified the cecum relative weight in broilers. However, we did not find changes in the relative weight of this organ (Table 2); apparently, the combination with acetic acid in drinking water and propionic acid in the diets was not enough to modify the relative weight of this organ.

The liver is the largest gland in the endocrine system, its function in birds is to secrete bile fluid for the digestion of lipids and proteins; besides, it eliminates toxic agents and degrades residual and hormonal products. Liver growth may be associated with a higher metabolic rate also caused by the increase in the relative weight of the small intestine, which has a stimulating effect on the production of bile acid for the digestion of lipids (Adil et al., 2010). The results of this study are consistent with those obtained by Ullah et al. (2016), who obtained significant differences \( p < 0.05 \) in liver development when using acetic acid. They also agree with those obtained by Mohammadi et al. (2012), where they found significant differences \( p < 0.05 \) in favor of organic acids in the liver relative weight.

Contrary to the results of this study (Table 2), Abdel-Fattah et al. (2008) reported an increase in the relative weight of the pancreas of broilers by adding acetic acid in the drinking water, in the same way, these authors affirm that the development of the small intestine is correlated with a higher enzymatic activity of the pancreas and liver. However, Fascina et al. (2017) reported that a mixture of organic acids decreased the relative weight of the pancreas in broilers. On the other hand, the relative weight of the heart did not show significant changes with the use of organic acids in drinking water (acetic acid) and feed (propionic acid) (Table 2). Other authors working with mixtures of organic acids on bird diets did not find significant variations in the relative weight of this organ (Abdel-Fattah et al., 2008; Maty & Hassan, 2020).

Birds during evolution have developed a unique immune system characterized by the activity of lymphoid organs, such as bursa of Fabricius, thymus, and spleen (Verduzco et al., 2010; Senthilkumar et al., 2018). As observed in Table 2, the addition of organic acids did not affect the development of lymphoid organs; these results are consistent with those obtained by Fascina et al. (2017), who found no effect with the use of organic acids in the development of immune organs. However, Abdel-Fattah et al. (2008) reported a mild hyperplasia in the lymphoid organs of broilers supplemented with citric acid with an increase in the immune response. According to Senthilkumar et al. (2018), the increase in the relative weight of lymphoid organs is an indicator of a better immune response and disease resistance. However, Martinez et al. (2013) did not find a relationship between a higher relative weight of the immune organs and weight gain, which could be related to an increase in energy expenditure for the production of immune cells, which reduces the body weight in pullets (Table 2).

Table 3 shows the effect of acetic (drinking water) and propionic (diets) acids on pH and lactic acid bacteria (BAL) in the small intestine and cecum in neonatal broilers (10 days). No significant differences
(p>0.05) were found between the treatments for the pH of the small intestine; however, a significant decrease in the cecal pH (p<0.05) was found with the use of the organic acids. Likewise, these natural products increased (p<0.05) the count of the green bacilli with the white halo in the small intestine. On the contrary, a significant decrease in irregular flat green bacilli (p<0.05) was observed in the cecum. The other morphological groups of lactic acid bacteria did not differ (p>0.05) between the experimental treatments.

Table 3 – Effect of a mixture of propionic-acetic acid on pH intestinal and lactic acid bacteria in neonatal broilers (10 days).

| Items (log 10 CFU/g) | Experimental groups SEM± | p value |
|----------------------|--------------------------|---------|
|                      | Control | Propionic+Acetic |
| pH                   | 6.02    | 5.73    | 0.314 | 0.554 |
| Bacilli               |         |         |       |       |
| Bacilli1              | 7.91    | 8.16    | 0.224 | 0.485 |
| Bacilli2              | 5.74    | 6.90    | 0.547 | 0.209 |
| Bacilli3              | 6.80    | 6.49    | 0.884 | 0.816 |
| Bacilli4              | 6.40    | 7.71    | 0.103 | 0.002 |
| Total                | 8.02    | 8.39    | 0.126 | 0.102 |
| Cecum                |         |         |       |       |
| pH                   | 7.11    | 6.16    | 0.249 | 0.050 |
| Bacilli               |         |         |       |       |
| Bacilli1              | 8.16    | 8.21    | 0.189 | 0.851 |
| Bacilli2              | 7.36    | 5.22    | 0.884 | 0.164 |
| Bacilli3              | 6.86    | 4.77    | 0.565 | 0.050 |
| Bacilli4              | 7.17    | 6.58    | 0.411 | 0.370 |
| Total                | 8.32    | 8.25    | 0.196 | 0.822 |

1 Greens; 2 white; 3 Greens with irregular planes; 4 Greens with white halo.

It is known that the material that reaches the cecum, undergoes anaerobic degradation that produces mainly volatile fatty acids (VFA) that influences the entire digestive tract, the majority of VFAs are found in the cecum. According to Jozeffs et al. (2011), the predominant acids in the cecum of the broilers are acetic acid (65%), butyric acid (16%) and propionic acid (12%). Thus, due to the large amount of volatile fatty acid (VFA), the pH is usually slightly acidic, below 6.5. The efficient production of AGV in the cecum occurs after seven days-old in broilers, and because of their immaturity, they do not reach the full fermentation capacity before 28 days of age when a neutral pH is observed in the cecum (Svihus, 2013).

Also, authors such as García et al. (2008) indicate that a higher presence of cecal lactic acid bacteria decreases the pH due to the greater presence of VFAs. In this research, the addition of organic acids reduced the cecal pH to 6.16 (Table 3). The pH variations in the cecum are related to the volatile fatty acids produced and the different additives used in the diet (Paul et al., 2007). In this sense, Molina et al. (2019) reported a cecal pH of 6.10 at 10 days- of age with the use of Ganoderma lucidum mushroom in broiler diets.

The results showed that the use of organic acids in broilers increased the count of lactic acid bacteria in the small intestine of broiler (Table 3). However, the opposite happened in the cecum; in this intestinal portion, the lactic acid bacteria decreased their population (Table 3). In this sense, the cecum or “cecum pouch” is the first portion of the large intestine that is primarily responsible for intestinal health, nutrient fermentation, and modulation of the intestinal microbiota (Svihus et al., 2013). Yu et al. (2007) concluded that chickens inoculated with Lactobacillus spp. had a higher concentration of lactic acid and a decrease in the pH of the cecum pouch. Despite changes in cecum pH, the use of acetic acid in drinking water and propionic acid in the diet reduced cecal BALs (Table 3).

Apparently, the combined use of two sources of organic acids decreased the cecal BAL population (mainly irregular flat green bacilli), which shows that...
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Fascina VB, Pasquali GAM, Carvalho FB, Muro EM, Vercese F, Aoyagi MM, et al. Effects of phytygenic additives and organic acids, alone or in combination, on the performance, intestinal quality and immune responses of broiler chickens. Revista Brasileña de Ciencia Avícola 2017;19:497-508.

Gadde U, Kim WH, Oh ST, Lillehej HS. Alternatives to antibiotics for maximizing growth performance and feed efficiency in poultry: a review. Animal Health Research Reviews 2017;18(1):26–45.

García Y, Álvaro A, Albino N, Herrera FR, Núñez O, Dieppa O. Growth of lactic acid bacteria and yeasts during the liquid fermentation of chicken fat excreta to obtain probiotics. Cuban Journal of Agricultural Science 2008;42(2):195–197.

Gunal M, Yayıli G, Kaya O, Karahan N, Sulak O. The effects of antibiotic growth promoter, probiotic or organic acid supplementation on performance, intestinal microflora and tissue of broilers. International Journal of Poultry Science 2006;5(2):149–155.

Hamid H, Shi HQ, Ma GY, Fan Y, Li WX, Zhao LH, et al. Influence of acidified drinking water on growth performance and gastrointestinal function of broilers. Poultry Science 2018;97(10):3601–3609.

Kum S, Eren U, Onol A, Sandikci M. Effects of dietary organic acid supplementation on the intestinal mucosa in broilers. Revue Médicine Vétérinaire 2010;10:463-468.

Haque MN, Chowdhury R, Islam KMS, Akbar MA. Propionic acid is an alternative to antibiotics in poultry diet. Bangladesh Journal of Animal Science 2009;38:115–122.

Houshmand M, Azhar K, Zuikiifi I, Bejo MH, Kamyab A. Effects of non-antibiotic feed additives on performance, immunity and intestinal morphology of broilers fed different levels of protein. South African Journal of Animal Science 2012;42:22–32.

Jiang JF, Song XM, Huang X, Zhou WD, Wu JL, Zhu ZG, et al. Effects of alfalfa meal on growth performance and gastrointestinal tract development of growing ducks. Asian-Australasian Journal of Animal Science 2012;25(10):1445-1450.

Jozefak D, Sip A, Rawski M, Rutkowski A, Kaczmarek S, Hojberg O, et al. Dietary divercin modifies gastrointestinal microbiota and improves growth performance in broiler chickens. British Poultry Science 2011;52(4):492-499.

Khan RU, Chand N, Akbar A. Effect of organic acids on the performance of Japanese quails. Pakistan Journal of Zoology 2016;48(6):1799–1803.

Lv M, Yan L, Wang Z, An S, Wu M, Lu Z. Effects of feed form and feed particle size on growth performance, carcass characteristics and digestive tract development of broilers. Animal Nutrition 2015;1(3):252–256.

Martínez Y, Martínez O, Liu G, Ren W, Rodríguez R, et al. Effect of dietary supplementation with Anacardium occidentale on growth performance, carcass traits and digestive tract development of broilers. Animal Nutrition 2018;4(2):1340–1347.

Maty HN, Hassan AA. Effect of supplementation of encapsulated organic acid and essential oil Gallant® on some physiological parameters of Japanese quails. Iraqi Journal of Veterinary Sciences 2020;34(1):181-188.

Mohammadi GM, Hosseindoust A, Kim IH. Evaluating the effect of microencapsulated blends of organic acids and essential oils in broiler chickens diet. Journal of Applied Poultry Research 2015;24(4):511–519.

Mohammed HA. Effect of organic acids supplanted in drinking water during pre-starter and starter feeding phase on broiler performance. Polytechnic Journal 2018;8(2):60–69.

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a decrease in cecal pH (Table 3) is not always related to the growth of beneficial bacteria in this intestinal portion. Studies by Martinez et al. (2013) found that the use of natural products lowered the intestinal pH without an improvement in the productive response of young birds. A decrease in cecal BALs (Table 3) considerably reduces the production of VFAs (Peng et al., 2016), which are energy sources for the cell; however, other studies are necessary to corroborate this hypothesis.

The combination of propionic (diets) and acetic (drinking water) acids reduced the body weight in neonatal broilers and modified the relative weight of the proventriculus, gizzard, small intestine, and liver and the growth of some morphological groups of lactic acid bacteria. In addition, organic acids used acidified the cecal pH, with no noticeable changes in the pH of the small intestine.

**REFERENCES**

Abdel RSM, Abd ASM, Hassanein KM. The effects of probiotic, probiotic and symbiotic supplementation on intestinal microbial ecology and histomorphology of broiler chickens. International Journal for Agro Veterinary and Medical Sciences 2012;6(4):277–289.

Abdel-Fattah SA, El-Hamid AEA, Albelo N, Herrera FR, Núñez O, Dieppa O. Growth of lactic acid bacteria and yeasts during the liquid fermentation of chicken fat excreta to obtain probiotics. Cuban Journal of Agricultural Science 2008;42(2):195–197.

Abdel RSM, Abd ASM, Hassanein KM. The effects of probiotic, probiotic and symbiotic supplementation on intestinal microbial ecology and histomorphology of broiler chickens. International Journal for Agro Veterinary and Medical Sciences 2012;6(4):277–289.

Abdel Fattah SA, El-Sanhoury MH, El-Mednay NM, Abdel AF. Thyroid activity, some blood constituents, organs morphology and performance of broiler chicks fed supplemental organic acids. International Journal of Poultry Science 2008;7(3):215–222.

Adil S, Banday T, Bhat GA, Mir MS, Rehman M. Effect of dietary supplementation of organic acids on performance, histological histomorphology, and serum biochemistry of broiler chicken. Veterinary Medicine International 2010;2010:479485.

Alshawabkeh K, Tabbaa MJ. Using dietary propionic acid to limit Salmonella gallinarum colonization in broiler chicks. Asian-Australasian Journal of Animal Sciences 2001;15:243–246.

APHA. Standard methods for the examination of water and wastewater. 19th ed. New York: American Public Health Association; 1995.

Attia YA, El-Hamid AEA, Elakany HF, Bovere F, Al-Harthi MA, Ghazaly SA. Growing and laying performance of Japanese quail fed diet supplemented with different concentrations of acetic acid. Italian Journal of Animal Science 2013;12:222–230.

Beier RC, Byrd JA, Caldwell D, Andrews K, Crippen TL, Anderson RC, et al. Inhibition and interactions of Campylobacter jejuni from broiler chicken. Journal of Animal Science 2013;222–230.

Beier RC, Byrd JA, Caldwell D, Andrews K, Crippen TL, Anderson RC, et al. Inhibition and interactions of Campylobacter jejuni from broiler chicken. Journal of Animal Science 2013;222–230.

Botello A, Perez K, Martinez Y, Gonzalez A, Martínez O, Liu G, Ren W, Rodríguez R, et al. Effect of dietary supplementation with Anacardium occidentale on growth performance, carcass traits and digestive tract development of broilers. Animal Nutrition 2018;4(2):1340–1347.

Dieppa G, García Y, Elías A, Albelo N, Herrera FR, Núñez O, Dieppa O. Growth of lactic acid bacteria and yeasts during the liquid fermentation of chicken fat excreta to obtain probiotics. Cuban Journal of Agricultural Science 2008;42(2):195–197.

Dieppa G, García Y, Elías A, Albelo N, Herrera FR, Núñez O, Dieppa O. Growth of lactic acid bacteria and yeasts during the liquid fermentation of chicken fat excreta to obtain probiotics. Cuban Journal of Agricultural Science 2008;42(2):195–197.

Jiang JF, Song XM, Huang X, Zhou WD, Wu JL, Zhu ZG, et al. Effects of alfalfa meal on growth performance and gastrointestinal tract development of growing ducks. Asian-Australasian Journal of Animal Science 2012;25(10):1445-1450.

Jozevik D, Sip A, Rawski M, Rutkowski A, Kaczmarek S, Hojberg O, et al. Dietary divercin modifies gastrointestinal microbiota and improves growth performance in broiler chickens. British Poultry Science 2011;52(4):492-499.

Khan RU, Chand N, Akbar A. Effect of organic acids on the performance of Japanese quails. Pakistan Journal of Zoology 2016;48(6):1799–1803.

Lv M, Yan L, Wang Z, An S, Wu M, Lu Z. Effects of feed form and feed particle size on growth performance, carcass characteristics and digestive tract development of broilers. Animal Nutrition 2015;1(3):252–256.

Martínez Y, Martínez O, Liu G, Ren W, Rodríguez R, et al. Effect of dietary supplementation with Anacardium occidentale on growth performance and immune and visceral organs weights in replacement laying pullets. Journal of Food, Agriculture and Environment 2013;11(3-4):1352–1357.

Maty HN, Hassan AA. Effect of supplementation of encapsulated organic acid and essential oil Gallant® on some physiological parameters of Japanese quails. Iraqi Journal of Veterinary Sciences 2020;34(1):181-188.

Mohammadi GM, Hosseindoust A, Kim IH. Evaluating the effect of microencapsulated blends of organic acids and essential oils in broiler chickens diet. Journal of Applied Poultry Research 2015;24(4):511–519.

Mohammed HA. Effect of organic acids supplanted in drinking water during pre-starter and starter feeding phase on broiler performance. Polytechnic Journal 2018;8(2):60–69.
Effect of a Combination of Propionic-Acetic Acid on Body Weight, Relative Weight of Some Organs, Lactic Acid Bacteria and Intestinal $p$H of Neonatal Broilers

Molina D, Gutierrez J, Machado OD, Mas D, Martinez Y. Nutraceutical effect of ganoderma lucidum fungus on neonatal broilers diet. International Journal of Poultry Science 2019;18:641–647.

Murry JAC, Hinton JA, Morrison H. Inhibition of growth of Escherichia coli, Salmonella typhimurium, and Clostridia perfringens on chicken feed media by Lactobacillus salivarius and Lactobacillus plantarum. International Journal of Poultry Science 2004;3(9):603–607.

Panda AK, Rao SV, Raju MVL, Sunder GS. Effect of butyric acid on performance, gastrointestinal tract health and carcass characteristics in broiler chickens. Asian-Australasian Journal of Animal Sciences 2009;22(7):1026–1031.

Paul SK, Halder G, Mondal MK, Samanta G. Effect of organic acid salt on the performance and gut health of broiler chicken. The Journal of Poultry Science 2007;44(4):389–395.

Peng Q, Zeng XF, Zhu JL, Liu XT, Hou CL, et al. Effects of dietary Lactobacillus plantarum B1 on growth performance, intestinal microbiota, and short chain fatty acid profiles in broiler chickens. Poultry Science 2016;95(4):893–900.

Pinchasov Y, Elmaliah S. Broiler chick responses to anorectic agents: 1. Dietary acetic and propionic acids and the digestive system. Pharmacology Biochemistry and Behavior 1994;48(2):371–376.

Ruhnke I, Rohe I, Goedartl BF, Knorr F, Mader A, Hafeez A, et al. Feed supplemented with organic acids does not affect starch digestibility, nor intestinal absorptive or secretory function in broiler chickens. Journal of Animal Physiology and Animal Nutrition 2015;99:2–35.

Saleem G, Ramzaan R, Khattak FM, Akhtar R. Effects of acetic acid supplementation in broiler chickens orally challenged with Salmonella pullorum. Turkish Journal of Veterinary and Animal Sciences 2016;40(4):434–443.

Samaniego LM, Laurencio M, Perez M, Milian G, Rondon A, Piad R. Probiotic activity of a competitive exclusion mixture on productive indicators in broilers. Ciencia y Tecnologia Alimentaria 2007;5(5):360–367.

Sarraf R, Soltanaliannejad F, Shahrooz R, Rahimi S. Effects of butyric acid glycerides and antibiotic growth promoter on the performance and intestinal histomorphometry of broiler chickens. Journal of Food, Agriculture and Environment 2011;9(3):285-288.

Senthilkumar D, Rao S, Satyanarayana ML, Kumar PG, Anitha N. Ameliorative efficacy of citrus oil in aflatoxin induced changes in lymphoid organs in broilers-A pathomorphological evaluation. Indian Journal of Animal Research 2018;52(10):1462–1468.

Svihus B, Choc M, Clasen HL. Function and nutritional roles of the avian caeca: a review. World’s Poultry Science Journal 2013;69:249–264.

Svihus B. The gizzard: function, influence of diet structure and effects on nutrient availability. World’s Poultry Science Journal 2011;67(2):207–224.

USDA. Livestock and poultry: world markets and trade. Washington: United States Department of Agriculture Foreign Agricultural Service; 2020 [cited 2020 Apr 23], 20120. Available from: https://apps.fas.usda.gov/psdonline/circulars/livestock_poultry.pdf.

Valdés, LS. Physiological aspects of the use of non-traditional feeds for nonruminant species. Cuban Journal of Agricultural Science 2015;49(3):251-278.

Valenzuela-Grijalva NV, Pinelli-Saavedra A, Muhlia-Almazan A, Domínguez-Díaz D, Gonzalez-Rios H. Dietary inclusion effects of phytochemicals as growth promoters in animal production. Journal of Animal Science and Technology 2017;59(8):1–17.

Van Immerseel F, Russell JB, Flythe MD, Gantois I, Timbermont L, Pasmins F, et al. The use of organic acids to combat Salmonella in poultry: a mechanistic explanation of the efficacy. Avian Pathology 2006;35(3):182–188.

Vuong CN, Chou WK, Hargis BM, Berghman LR, Bielek LR. Role of probiotics on immune function and their relationship to antibiotic growth promoters in poultry, a brief review. International Journal of Probiotics & Prebiotics 2016;11(1):1–7.

Wang C, Cui Y, Qu X. Mechanisms and improvement of acid resistance in lactic acid bacteria. Archives of Microbiology 2018;200(2):195–201.

Yang X, Liu Y, Yan F, Yang C, Yang X. Effects of encapsulated organic acids and essential oils on intestinal barrier, microbial count, and bacterial metabolites in broiler chickens. Poultry Science 2019;98(7):2858–2865.

Yu B, Liu JR, Chiuo MY, Hsu YR, Chiuo PWS. The effects of probiotic Lactobacillus reuteri Pg4 strain on intestinal characteristics and performance in broilers. Asian-Australasian Journal of Animal Sciences 2007;20(8):1243–1251.