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Europ.Poult.Sci., **78.** 2014, ISSN 1612-9199, © Verlag Eugen Ulmer, Stuttgart. DOI: 10.1399/eps.2014.46

Effects of supplementation of different levels of organic acids mixture to the diet on performance, egg quality parameters, serum traits and histological criteria of laying hens

Einfluss der Zulage einer Mischung von Organischen Säuren zum Futter in unterschiedlicher Höhe auf Leistung, Eiqualitätsmerkmale, Blutserum-Kennwerte und Dünndarmmorphologie von Legehennen

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Manuscript received 10 June 2013, accepted 20 July 2013

Introduction

Non-antibiotic alternatives to antibiotic growth promoters have been proposed for use in animal diets due to concerns about the safety in both animals and humans,. These include organic acids (OAs), probiotics, prebiotics and herbal products (ISLAM, 2012). Among the candidate replacements for antibiotics are organic acids, both individual and blends of several acids (DIBNER and BUTTIN, 2002) the most promising ones. OAs which are generated from animals, plants or microorganisms in nature are known to control harmful microorganisms in respiratory and digestive organs of poultry (PARK et al., 2009; TALEBI et al., 2010). Approximately 60 organic acid classes, including lactic acid, citric acid, formic acid, fumaric acid, and various mixed agents, have been reported (PARK et al., 2009).

OAs permeate the cell membranes of pathogenic bacteria due to their biochemical characteristics and lower the pH value inside the cells (ADIL et al., 2010), killing pathogenic bacteria by depleting of metabolic energy, decreasing of cell membrane metabolism, outflowing of cell fluids, and blocking the use of nutrients (KIRCHGESSNER and ROTH, 1982). Adding OAs to feed can lower gastric pH which accelerates the conversion of pepsinogen to pepsin, thereby improving the absorption rate of proteins, amino acids, and minerals (PARK et al., 2009). OAs have several additional effects that go beyond those of antibiotics. These effects include reduction of digesta pH, increased pancreatic secretion, and trophic effects on the gastrointestinal mucosa (DIBNER and BUTTIN, 2002). Other effects of OAs include the enhanced performance of the immune response of birds (GRASHORN, 2010) and of the solubility of minerals (SWIATKIEWICZ et al., 2010).

Although acidification has proven effective and beneficial as an antimicrobial agent, its use in animal feeds is limited because of several properties, such as the corrosiveness and odor of some OAs. For their increased use in livestock feed there is a need for an improved form that is less corrosive, safe, effective, and easy to use. For this purpose, Borregaard LignoTech has specifically developed softAcid, a unique and patented technology. SoftAcid is a product range that consists of OAs (such as formic acid, propionic acid, and citric acid) and modified lignosulphonic acid. Due to the presence of the latter, the product was named “Soft” as lignosulphonic acid moderates the aggressive nature of OAs (ANONYMOUS, 2013).

The aim of this study was to investigate the effects of organic acid mixture at different levels of supplementation in the diet of laying hens on egg production, egg quality, duodenal villus height, villus width, intestinal crypt depth and tunica mucosal width.

Materials and Methods

Animals and Diets

Twenty-six-week-old Lohman layers (n = 72) were blocked according to the location of their cages (50 × 46 × 46 cm), and then randomly assigned to four dietary treatments for 12 weeks. Each dietary treatment was replicated in six cages, each containing three hens. The birds were fed either a control diet or the control diet supplemented with 1.5, 3.0, 4.5 kg/t of feed organic acidss mixture (OAM). OAM consists of 70% propionic acid, 5% citric acid and 25% soft acid (modified lignosulphonic acid) and is provided by Sinerji Tarım AŞ, İzmir, Turkey. Table 1 lists the ingredients and calculated values of the control diet. During the 12-week experiment, the hens received feed and water *ad libitum*. The ratio of light to dark was 17 h/7 h throughout the experimental period.

Table 1. Composition and analyzed contenst of nutrients of experimental diets

Zusammensetzung und analysierte Nährstoffgehalte der Versuchsrationen

Ingredients	(%)	Chemical composition	
Corn	52.81	Dry matter, (%)	89.40
Soybean meal, (48% CP)	18.13	Crude protein, (%)	17.14
Wheat	6.00	Crude fibre, (%)	3.43
Fish meal	1.65	Ether extract, (%)	3.18
Vegetable fat	7.50	Crude ash, (%)	13.3
Dicalcium phosphate[1]	2.04	Calcium, (%)	3.65
Marble	1.60	Available P, (%)	0.37
Vitamin-mineral premix[2]	6.82	Non-Nitrogenous Constituents*, (%) (%)	52.35
Salt	0.30	Metabolizable energy* (kcal/kg)	2720
Methionine[3]	2.65		
Lysine[4]	0.15		

[1] Each kilogram contained: Ca, 24% and P, 17.5%

[2] The premix provided per 1 kg of diet: Vitamin A, 15.000 IU; cholecalciferol, 1500 ICU; DL-α-tocopheryl acetate, 30 IU; menadione, 5.0 mg; thiamine, 3.0 mg; riboflavin, 6.0 mg; niacin, 20.0 mg; panthotenic acid, 8.0 mg; pyridoxine, 5.0 mg; folic acid, 1.0 mg; vitamin B_{12}, 15 µg; Mn, 80.0 mg; Zn, 60.0 mg; Fe, 30.0 mg; Cu, 5.0 mg; I, 2.0 mg; and Se, 0.15 mg.

[3] DL-methionine.

[4] L-lysine hydrochloride.

* Calculated value

Sampling and Measurements

Body weights were recorded at the beginning and at the end of the study. Feed intake and egg production were recorded daily and egg weight was measured bi-weekly. Feed conversion ratio (FCR) was calculated as kilogram of feed consumed per kilogram of eggs produced. Egg quality measurements were conducted monthly using 12 eggs from each experimental group. The eggs used for this purpose were stored for 24 h at room temperature. The traits used to measure egg quality included the shape index, shell strength, shell thickness, albumen index, yolk index, yolk color (DSM Yolk Color Fan, Switzerland), and Haugh unit. The eggs were assessed according to the method used by KAYA and MACIT (2012).

At the end of the experiment, blood samples taken from the subcutaneous vena ulnaris were collected from two hens in each cage and then stored in blood tubes containing a cloth activator. Following centrifugation at 3,000 g for 10 min at 20°C, serum was obtained and kept at −20°C until the laboratory analyses were performed. Serum parameters containing albumin, triglyceride, cholesterol, high density lipoprotein (HDL-C), total protein, glucose, ALP, AST, and ALT were measured using commercial kits (DDS® Spectrophotometric Kits, Diasis Diagnostic Systems Co., İstanbul, Turkey) with an autoanalyzer (Vitros 5.1FS).

For the histological analysis at the end of the experiment five layers were chosen randomly from each group and then slaughtered. The tissue samples from the duodenum part of the small intestine were collected and fixed in 10% buffered formalin saline. The tissues were dehydrated by immersing through a series of alcohol at increasing concentrations, infiltrated with xylene, and then embedded in paraffin. Sections 5 µm thick were cut and stained using the haematoxylin and eosin staining method. The values of villus length, villus width, intestinal crypt width,

and tunica mucosa thickness, selected randomly from five different regions of each sampled tissue were measured with an oculometer at 10x magnification under a light microscope fitted with a stage micrometer. Each group was photographed using the Olympus BX-51 research microscope.

Statistical Analysis

The experimental diets were allocated in a completely randomized block design. The data were analyzed using the General Linear Models procedure of SPSS software ($P < 0.05$; SPSS 10.01, 1996). Linear and quadratic polynomial contrasts were used to evaluate the effects of the treatment.

Results

Table 2 shows the effects of the supplemental levels of OAM on the performance of the laying hens. Egg production, final body weight and body-weight change did not differ across the experimental diets ($P > 0.05$). Increasing levels of OAM supplementation promoted a cubic effect on feed consumption, egg weight, and feed conversion ratio.

Table 2. Performance parameters of laying hens fed diets including OAM at different levels

Leistungsdaten der Legehennen bei Fütterung mit Rationen mit unterschiedlich hohen Zusätzen einer Mischung aus Organischen Säuren (OAM)

	Response variables						
					Body weigth		
					Initial	Final	Change
Treatment	Feed consumption (g/d)	Egg production (%)	Egg weight (g)	FCR[1] (kg feed/kg egg)	(g)		
Control	130	91.1	61.4	2.34	1464	1633	169
1.5	121	93.7	60.9	2.12	1480	1642	162
3	153	90.0	62.7	2.75	1465	1648	183
4.5	130	93.3	61.1	2.32	1466	1649	183
SEM	6.75	2.13	0.49	0.11	10.5	18.6	18.9
L	0.30	0.76	0.70	0.25	0.84	0.54	0.47
Q	0.32	0.86	0.24	0.34	0.49	0.82	0.88
C	0.01	0.16	0.01	0.01	0.33	0.98	0.57

[1] FCR = feed conversion ratio (kg feed consumed per kg egg produced). L = Linear, Q = Quadratic, C = Cubic.
SEM = Standart error of mean

The changes in egg quality parameters in response to the experimental diets are presented in Table 3. Except for shell strength and yolk color, none of the egg quality parameters, such as shape index, shell thickness, shell weight, yolk index, albumen index, and Haugh unit was affected by the dietary treatments ($P > 0.05$). As the level of OAM supplementation increased, shell strenght (cubic) and yolk color (linear) increased.

Table 3. Egg quality parameters of laying hens fed diets supplemented with OAM at different levels

Merkmale der Eiqualität bei Fütterung mit Rationen mit unterschiedlich hohen Zusätzen einer Mischung aus Organischen Säuren (OAM)

	Response variables							
Treatment	**Shape index (%)**	**Shell strength (kg/cm^2)**	**Shell thickness ($mmx10^{-2}$)**	**Shell weight (g)**	**Yolk color**	**Yolk index (%)**	**Albumen index (%)**	**Haugh unit**
Control	76.4	2.71	0.37	7.80	11.9	42.1	8.17	81.0
1.5	76.3	3.07	0.36	7.70	12.1	41.7	8.12	81.6
3	77.7	2.94	0.36	7.82	12.4	43.0	8.73	82.9
4.5	76.3	3.08	0.37	7.57	12.4	42.8	8.21	81.6
SEM	0.39	0.09	0.01	0.13	0.18	0.52	0.38	1.40
L	0.94	0.04	0.44	0.34	0.02	0.16	0.67	0.61
Q	0.71	0.52	0.33	0.54	0.56	0.83	0.55	0.51
C	0.45	0.01	0.59	0.31	0.42	0.16	0.29	0.58

L = Linear; Q = Quadratic; C = Cubic.
SEM = Standart error of mean

As Table 4 shows, there was no polynomial effect of OAM supplementation on the blood parameters of the hens, except for glucose, ALP (alkaline phosphatase), calcium, and phosphorus ($P > 0.05$). Statistical analysis of the obtained data revealed that increasing AOM levels increased serum glucose (linear), ALP (linear), calcium concentration (cubic) and serum phosphorus (quadratic).

Table 4. Blood parameters of laying hens fed diets including OAM at different levels

Blutkennwerte der Legehennen nach Fütterung mit Rationen mit unterschiedlich hohen Zusätzen einer Mischung aus Organischen Säuren (OAM)

	Response variables									
Treatment	**Alb[2]**	**Chol[1]**	**HDL[1]**	**TP[2]**	**Glu[1]**	**ALP[3]**	**AST[3]**	**ALT[3]**	**Ca[1]**	**P[1]**
Control	1.85	116	24.5	5.1	235	112	246	19.3	27.8	6.1
1.5	1.87	111	25.0	5.7	231	107	245	22.0	32.3	5.5
3	1.70	104	22.1	4.7	237	157	246	24.0	26.8	4.6
4.5	1.97	108	21.0	5.3	255	158	242	19.7	32.7	6.4
SEM	0.08	8.87	2.76	0.28	5.94	15.8	20.1	2.56	0.88	0.37
L	0.63	0.45	0.31	0.87	0.04	0.03	0.92	0.80	0.03	0.89
Q	0.16	0.63	0.78	0.22	0.10	0.85	0.95	0.21	0.59	0.01
C	0.13	0.73	0.69	0.16	0.99	0.18	0.95	0.63	0.01	0.10

Alb = Albumin; Chol = Cholesterol; HDL = High density lipoprotein. TP = Total protein; Glu = Glucose; ALP: alkaline phosphatase, AST: aspartate aminotransferase, ALT: alanine aminotransferase, Ca = Calcium; P = Phosphorus; L = Linear; Q = Quadratic; C = Cubic.
SEM = Standart error of mean
[1] mg/dL,
[2] g/dL,
[3] Unit/L

Table 5 summarizes the effects of dietary organic acid supplementation on the morphological criteria of the hens. The illustrations are displayed visually in Figures 1, 2, 3 and 4. The inclusion of different percentages of OAM into the diet of the laying hens did not affect the villus height. In response to increasing levels of OAM supplementation villus width increased linearly. A significant cubic effect was noted on the intestinal crypt depth and tunica mucosal width of the hens fed diets supplemented with increasing OAM levels.

Table 5. Histological criteria of laying hens fed diets supplemented with OAM at different levels (mμ)

Histologische Merkmale des Dünndarms der Legehennen nach Fütterung mit Rationen mit unterschiedlich hohen Zusätzen einer Mischung aus Organischen Säuren (OAM)

Treatment	VH	VW	CD	TMW
Control	1526	170	187	156
1.5	1532	232	284	221
3	1637	202	200	192
4.5	1462	251	225	201
SEM	48.9	16.5	11.8	11.4
L	0.70	0.01	0.56	0.04
Q	0.07	0.69	0.01	0.02
C	0.10	0.03	0.01	0.01

VH: Villus Height; VW: Villus Width; CD: Intestinal Crypt depth; TMW: Tunica Mucosal Width; L = Linear; Q = Quadratic; C = Cubic.
[a-b] Means within a column with different superscripts are significantly different ($p < 0.05$). SEM: Standard error of mean.



Figure 1. Villi photomicrographs in the duodenum of laying hens fed with control feed (Hematoxylin and eosin staining; bar = 200 µm)

Mikroskopisches Foto der Villi im Duodenum der Legehennen nach Fütterung mit der Kontrollration (Haematoxylin und Eosin Färbung; Balken = 200 µm)



Figure 2. Villi photomicrographs in the duodenum of laying hens fed with basal feed plus 1.5 kg OAM per ton feed (hematoxylin and eosin staining; bar = 200 µm)

Mikroskopisches Foto der Villi im Duodenum der Legehennen nach Fütterung mit der Ration mit einem Zusatz von 1,5 kg OAM/t (Haematoxylin und Eosin Färbung; Balken = 200 µm)

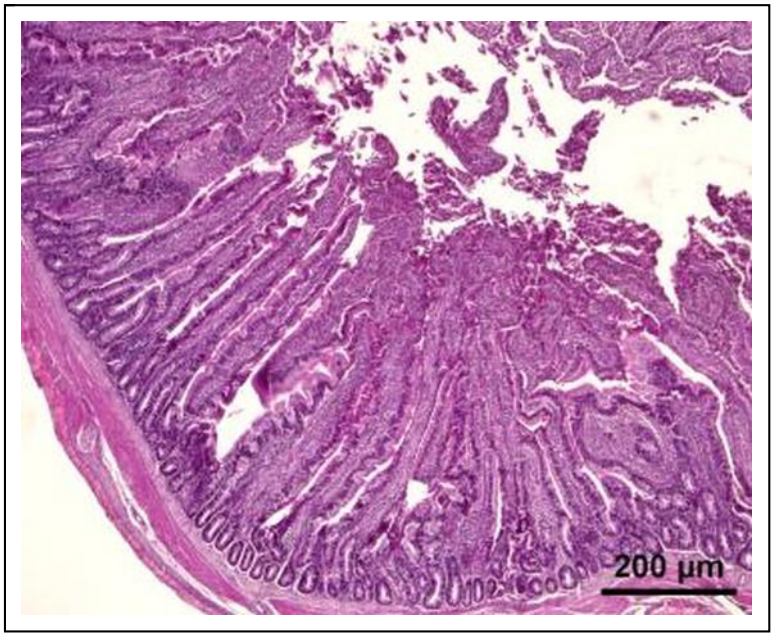


Figure 3. Villi photomicrographs in the duodenum of laying hens fed with basal feed plus 3 kg OAM per ton feed (hematoxylin and eosin staining; bar = 200 µm)

Mikroskopisches Foto der Villi im Duodenum der Legehennen nach Fütterung mit der Ration mit einem Zusatz von 3,0 kg OAM/t (Haematoxylin und Eosin Färbung; Balken = 200 µm)



Figure 4. Villi photomicrographs in the duodenum of laying hens fed with basal feed plus 4.5 kg OAM per ton feed (hematoxylin and eosin staining; bar = 200 µm)

Mikroskopisches Foto der Villi im Duodenum der Legehennen nach Fütterung mit der Ration mit einem Zusatz von 4,5 kg OAM/t (Haematoxylin und Eosin Färbung; Balken = 200 µm)

Discussion

Laying Performance

Previous studies reported no effects of AOs supplemented to the diets on feed intake of hens (SWIATKIEWICZ et al., 2010; YESILBAG and COLPAN, 2006; RAHMAN et al., 2008), quail (SACAKLI et al., 2006), or broiler (ADIL et al., 2010). In the present study, although there was a cubic effect of OAM levels on feed intake values, the group fed a diet including 3.0 kg OAM/t of feed showed higher feed consumption than that of the control at 1.5 kg OAM/t of feed. The group at 1.5 kg OAM/t of feed had the lowest feed intake value. We estimated that high amounts of OAM supplementation might affect the feed consumption because of changes in diet palatability. MARTINEZ DO VALE et al. (2004) compared the effects of an OAM (formic [70%] and propionic acid [30%]) supplementation at 0, 0.25, 0.5, 1.0, and 2.0% in the ration on broiler performance from 0 to 21 and 42 d. They found similar results as in the present study, which showed that feed intake was affected in a quadratic form according to the level of OAM. As a feed preservative, propionic acid reduces the pH of feed and improves its hygienic condition and palatability, which ultimately increases feed intake; however, higher levels of OAM have been shown to reduce feed intake (HAQUE et al., 2009). It was reported that when propionic acid was included in the feed up to levels of 100 g/kg from 0 to 28 days in broilers the voluntary feed intake of broiler chicks decreased with increasing dietary levels of acid (CAVE, 1984). PINCHASOV and JENSEN (1989) studied several organic acids, including formic and propionic, and reported that only propionic acid had a significant action in reducing feed intake.

With regard to usage levels the OAM supplementation did not affect body weight in this study. In fact, egg production increased with the supplementation of 1.5 and 4.5 kg/t OAM into the laying hens' diet, but the differences were not significant. A similar effect was found on body weight when the laying hens were fed a diet supplemented with an organic acid mixture (formic acid, propionic acids and their ammonium salts) at 0.5, 1.0, 1.5% levels (YESILBAG and COLPAN, 2006). The results of the present study regarding egg production were not in agreement with the findings of SOLTAN (2008), RAHMAN et al. (2008) and GAMA et al. (2000), whereas they were consistent with PARK et al. (2009).

In our study, egg weight and feed conversion ratio were affected in a cubic form by the inclusion of OAM in the diet. Results of the current study concerning egg weight did not comply with results obtained by GAMA et al. (2000), RAHMAN et al. (2008) and YESILBAG and COLPAN (2006). SWIATKIEWICZ et al. (2010) reported that organic acid supplementation had no effect on the average egg weight compared with the control group that was fed a basal diet. The results regarding the feed conversion ratio are in agreement with those obtained by SOLTAN (2008), who

observed that the feed conversion ratio showed significant improvement in laying hen groups that were fed the basal diet supplemented by 260 and 780 ppm organic acid, compared with the untreated group. Whereas, the layer group that was fed a diet supplemented by 520 ppm organic acid showed a non-significant improvement. The effect of acetic acid supplementation on FCR in Japanese quail was also reported by ATTIA et al. (2013), who found that acetic acid at 1.5, 3.0, and 6.0% significantly improved FCR compared to the control group.

Egg Quality

The statistical analysis of egg quality traits revealed that there were no significant differences among the treatment groups in terms of shape index, shell thickness, shell weight, yolk index, albumen index, and Haugh unit. Similar to the results of the present study YESILBAG and COLPAN (2006) found that OAM added to the diet at different levels did not affect albumen index, yolk index, Haugh unit, or shell thickness. Contradictory results were found by SOLTAN (2008), who reported that the inclusion of organic acids at different levels in diets improved egg shell thickness and yolk index, but significantly reduced the albumen index. In the present study, shell strength increased with increasing OAM levels. The improvement in shell strength may be related to an increase in Ca concentration in the serum or to the stimulating effect of organic acids on intestinal histological criteria, which can be attributed to the beneficial effect of organic acids on Ca and P absorption. In contrast to the results of the present study, YESILBAG and COLPAN (2006) found that supplementation of organic acid mixture in the diet of laying hens did not affect shell-breaking strength. In the present study, the results regarding shell strength were in agreement with the findings of SWIATKIEWICZ et al. (2010), who reported that the addition of 2.5 g/kg of medium chain fatty acids (caproic + capric acid) or to a lesser extent 5.0 g/kg of short chain fatty acids (a blend of formic, propionic and acetic acid), improved breaking strength, at 46, 58, and 70 weeks of age in laying hens. Similar to shell strength, yolk color also linearly increased as OAM supplementation levels increased. A possible reason for the increased yolk color may be the increase in absorption of carotenoids in maize along with decreased pH in intestinal lumens by supplementation of OAM. Alternatively, the integrity of the reproductive organs might have improved. The results obtained from the current study concerning yolk color were not in agreement with RAHMAN et al. (2008), who concluded that organic acid supplementation at 0, 260, 520 and 780 mg/kg levels had no significant effect on yolk color score.

Serum Parameters

Increasing levels of OAM supplementation linearly increased serum glucose and ALP levels in this study. In agreement with the current study, FUSHIMI et al. (2001) reported that rats fed a diet supplemented with acetic acids at different levels had significantly higher serum glucose concentrations, and the authors concluded that dietary acidification might stimulate glycogenesis by increasing the influx of glucose 6-phosphate (G-6-P) into the glycogen synthesis pathway through the inhibition of glycolysis caused by an increase in citrate levels.

In the present study, serum parameters containing albumin, cholesterol, high-density lipoprotein, total protein, AST and ALT did not change as OAM levels increased. However, ALP (linear), glucose (linear), blood Ca (cubic) and P (quadratic) concentration increased because of increased OAM levels in the diet of the laying hens. This could be attributed to the favorable environment with decreased pH in the intestinal tract caused by the feeding of organic acid, which might have increased the absorption of calcium and phosphorus from the gut into the blood stream. The addition of 20 g/kg citric acid into broiler diets also increased Ca and P and their retention by 3.3 (BRENES et al., 2003). A study conducted by ABDEL-FATTAH et al. (2008) reported that broiler chicks fed a diet supplemented with organic acids containing acetic acid, citric acid, or lactic acid at 1.5 and 3.0% levels had significantly higher Ca and P blood concentrations. The results of several model studies with rats showed that reducing intestinal pH, increases the activity of digestive enzymes and the solubility of minerals. Thus, organic acids may have a positive effect on mineral absorption, primarily of calcium (SWIATKIEWICZ and ARCZEWSKA-WLOSEK, 2012). Similar to the present experiment, a study also reported no changes in serum parameters, such as cholesterol, HDL, triglyceride, and total lipid concentrations (YESILBAG and COLPAN, 2006). ATTIA et al. (2013) also reported that plasma total protein, globulin, AST and ALT measured at different ages were not significantly affected by different concentrations of acetic acids. In disagreement with the present results, other studies reported elevations in the serum protein and albumin of laying lens that were fed organic acid (SOLTAN, 2008) and in Japanese quail receiving bacteria (Lactobacillus bulgaricus) that were able to produce lactic acid as probiotics (ARSLAN and SAATCI, 2004). ABDEL-FATTAH et al. (2008) found that liver functions as measured by AST and ALT enzymes, total protein, albumin and globulin were not adversely affected by acetic, citric, and lactic acids at 1.5 and 3.0% in broiler diets. The findings of other studies showed that organic acid supplementation had no effect on blood metabolites in broilers (HERNANDEZ et al., 2006;

ADIL et al., 2010). SALGADO-TRÁNSITO et al. (2011) also reported that ALT and AST concentrations in serum were affected at the end of an experiment in which broilers received four dosages of the citric acid (6.25, 12.5, 25, and 50 g/kg).

Histological Criteria

Villi are important structures in the small intestine, mainly involved in nutrient absorption (CHWEN et al., 2013). The data obtained from the present study indicated increases in villus width (linearly), intestinal crypt depth and tunica mucosal width of hens (cubic) fed diets supplemented with increasing OAM levels. However, increasing dietary OAM levels did not influence villus height. Similar to the results of the present study, ESMAEILIPOUR et al. (2011) studying citric acid levels of 0, 20, 40 g/kg also did not observe effects on the small intestine villus length in broilers. Other studies, however, reported that OAM supplementation into diets markedly increased the villus height of broilers (SENKOYLU et al., 2007; GARCIA et al., 2007; ADIL et al., 2010). PAUL et al. (2007) also reported that dietary organic acid salts increased villus height in different segments of the small intestines of broilers compared with the controls. SMULIKOWSKA et al. (2010) indicated that OAM (6.0 g/kg) added to diet depressed villi height and crypt depth. Intestinal crypts are invaginations of the epithelium around the villi and are lined by epithelial cells that secrete enzymes. The base of the crypts is constantly dividing to maintain the structure of the villi. Therefore, an increase in crypt depth would produce more developed villi (CHWEN et al., 2013). The results of the present study are in disagreement with SAKI et al. (2012), who reported that compared to the control group, feeding broiler chickens with a diet supplemented with an OAM that included malic, formic, citric, ortophosphoric, lactic and acetic acids (basal diet supplemented with 1.0 kg/ton) did not impair villus height, width, or crypt depth. OWENS et al. (2008) also did not evidence a significant difference in ileum histology according to the organic acid dietary supplementation in broilers. ADIL et al. (2010) reported that crypt depth and muscularis thickness in the duodenum, jejunum and ileum were not affected when broilers were fed on diets that included butyric, fumaric and lactic acid at levels of 2.0 and 3.0%. Unlike the present study, SENKOYLU et al. (2007) found reduced crypt depth and villus weight, but no changes in the thickness of the lamina muscularis mucosae in broiler chicks fed a diet containing 3.0 g/kg organic acid. The differences between the present results and those of other studies may be due to differences in the type or level of organic acids and to the types of animals studied.

Conclusion

In conclusion, the inclusion of 1.5 kg/t of feed OAM in the diet resulted in better FCR than those of the control and other treatment groups. The results reported in the present study also indicated that shell strength in group 1.5 was similar to that of group 4.5 and was superior to that of control and group 3. In addition, the inclusion of OAM in the diets exhibited benefits to intestine histology. However, further studies are required to investigate the effects of OAM levels in the diet of laying hens on performance, egg quality parameters, serum traits, and histological criteria. In conclusion, it can be said that 1.5 kg/t OAM may be used in diets of laying hens.

Summary

This study was conducted to determine the effects of an organic acid mixture (OAM) (70% propionic acid, 5% citric acid, 25% soft acid) supplementation at various levels on performance, egg quality parameters, serum traits, and histological criteria in laying hens. Lohman layers (N = 72) were divided into four groups. The treatment groups were placed in six cages containing three hens each. The hens were fed either a control diet or the control diet supplemented with OAM (0, 1.5, 3.0 or 4.5 kg/t of feed) from 26 to 38 weeks of age.

With the exception of egg production, final body weight and body weight change, there was a cubic effect on feed consumption, egg weight and feed conversion ratio with increasing levels of OAM supplementation. Shell strength (cubic) and yolk color (linear) increased as the level of OAM supplementation increased. There was no polynomial effect of OAM supplementation on blood parameters of the hens, except for glucose, alkaline phosphatase, calcium and phosphorus ($P > 0.05$). The inclusion of different percentages of OAM in the diet of laying hens did not affect villus height, but villus width (linear), intestinal crypt depth and tunica mucosal width (cubic) increased. The inclusion of 1.5 kg/t of feed OAM in the diet resulted in better FCR than in the control and other treatment groups. The results of the present study indicated that in response to increasing levels of OAM supplementation in the diet of laying hens, shell strength and yolk color increased. The inclusion of OAM in the diets exhibited benefits to intestine histology. In conclusion, it can be said that 1.5 kg/t OAM might be used in diets of laying hens.

Key words

Laying hens, feeding, organic acids, egg quality, performance, blood serum, intestinal histology

Zusammenfassung

Einfluss der Zulage einer Mischung von Organischen Säuren zum Futter in unterschiedlicher Höhe auf Leistung, Eiqualitätsmerkmale, Blutserum-Kennwerte und Dünndarmmorphologie von Legehennen

Das Ziel der Studie war die Untersuchung des Einflusses einer Zulage einer Mischung aus Organischen Säuren (OAM; 70% Propionsäure, 5% Zitronensäure, 25% Soft-Säure) in unterschiedlicher Höhe zum Futter auf die Leistung, Eiqualitätsmerkmale, Blutkennwerte und die Dünndarmmorphologie von Legehennen. Hierzu wurden Lohmann Legehennen (N = 72) in Gruppen von drei Tieren auf 24 Käfige verteilt. Jeweils 6 Käfige wurden einer Behandlung zugeordnet. Zwischen der 26. und 38. Lebenswoche wurden die Hennen entweder mit der Kontrollration oder der Kontrollration mit verschiedenen Zulagen der Mischung Organischer Säuren (1,5, 3,0, 4,5 kg/t) gefüttert.

Mit steigender Zulagenhöhe wurde ein kubischer Effekte auf die Futteraufnahme, das Eigewicht und die Futterverwertung registriert. Dagegen lagen keine Effekte auf die Legeleistung, das Gewicht am Versuchsende und die Veränderung des Lebendgewichts während des Versuchs vor. Die Eischalenstabilität (kubisch) und die Dotterfarbe (linear) nahmen mit der Zulagenhöhe der OAM zu. Die Zulage beeinflusste aber nicht die Blutkennwerte der Hennen, außer Glukose, Alkaline Phosphatase, Calzium und Phosphor ($P > 0,05$). In ähnlicher Weise hatte die Zulage der OAM keine deutlichen Effekte auf die Villus-Höhe. Allerdings nahmen der Villus-Querschnitt (linear) und die Kryptentiefe sowie der Querschnitt der Schleimhaut (kubisch) mit der Zulagenhöhe zu. Die Zulage von 1,5 kg OAM/t resultierte in einer günstigeren Futterverwertung als in der Kontroll- und in den anderen Behandlungsgruppen. Die Ergebnisse der vorliegenden Studie deuten darauf hin, dass mit einer steigenden Zulage der OAM zum Futter die Schalenfestigkeit und die Dotterfarbe verbessert werden. Ferner hatte die Zulage einen günstigen Einfluss auf die Darmmorphologie. Es wurde daher zusammenfassend der Schluss gezogen, dass eine Zulage von 1,5 kg OAM/t Legehennenfutter empfohlen werden kann.

Stichworte

Legehenne, Fütterung, Organische Säuren, Eiqualität, Leistung, Blutserum, Dünndarm-Morphologie

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