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Ravinder Dahiya
Assistant TAM, Cargill India Pvt. Ltd.

Kapil Dev
Ph.D. Scholar, Department of Animal Genetics and Breeding, Luvas, Hisar, India

Correspondence
Kapil Dev
Ph.D. Scholar, Department of Animal Genetics and Breeding, Luvas, Hisar, India

The effects of supplementation of salts of different organic acids in layer's ration on serum parameters and egg quality traits: A review

Ravinder Dahiya and Kapil Dev

Abstract
The poultry industry is a well-organized and fast growing sector of Indian economy. Introduction of improved breeds, nutritional standards, knowledge of disease prevention and scientific management practices have increased meat and egg production significantly. Now the poultry sector is continuously searching for new feed additives in order to improve the feed efficiency with minimum deleterious effects on animal health. Organic acids have made a great contribution to profitability in poultry production and also provided people with nutritious poultry products A modernistic challenge in the poultry production is to exploit the use of specific dietary supplements to boost the intrinsic potential of poultry birds in order to perform better.

Keywords: organic acids, egg quality, growth promoters, poultry

Introduction

India is emerging as the world's 2nd largest poultry market with an annual growth of more than 14%, producing 61 million tones or 3.6% of the global egg production and annual growth rate of egg production is 5-8%. Apart from this, India ranks 6th in broiler production with an annual output of 2.39 million tones of broiler meat (4th International Poultry and Livestock Expo, 2015) [11]. Annual per capita availability of eggs and meat is 57 and 2.9 kg, respectively (ICAR rating feature June 2014), however, according to National Institute of Nutrition recommendation per capita requirement of eggs and meat is 180 and 11 kg per year, respectively (ICMR-2012) [12]. In search of efficient alternative to antibiotic growth promoters, a number of agents were being tried; among them organic acids have been found to be one of the most promising alternatives (Gunal *et al*., 2006) [8] in animal production. Organic acids associated with specific antimicrobial activity are short chain acids (C_1-C_7) which are widely distributed in nature as normal constituents of plants or animal tissues and also formed through microbial fermentation of carbohydrates predominantly in the caeca of poultry (Van Immerseel *et al*., 2006) [26]. Organic acids are simple monocarboxylic acids such as formic, acetic, propionic, butyric acid or carboxylic acid bearing hydroxyl group such as citric, tartaric, lactic and malic acid. Many are also available as sodium, potassium or calcium salts important role by restoring the function of damaged cells that are resulted from fat deposition.

Eggshell quality is one of the most important issues in the poultry industry, influencing the economic profitability of egg production and hatchability. High breaking strength of eggshell and absence of shell defects are essential for protection against the penetration of pathogenic bacteria such as *salmonella sp.* into eggs (Swiatkiewicz *et al.*, 2010) [23]. It affects the hatchability, regulates the gaseous exchange during incubation and affects the number of hatching eggs to be set in incubation. One of the main concerns is a decrease in egg shell quality as the hen ages, due to an increase in egg weight without an increase in the amount of calcium carbonate deposited in the eggshell. For this reason, the incidence of cracked eggs could even exceed 20% at the end of the laying period (Nys, 2001) [18]. Supplying the hen with an optimal Ca intake is the crucial in order to ensure the proper calcification of the eggshell, but increasing the Ca level in the diet to above 3.6-3.8% usually has no beneficial effect on eggshell quality. Organic acids salts are beneficial to increase uptake of minerals from gut to improve eggshell quality (Swiatkiewicz *et al.*, 2010) [23]. Previous studies reported that organic acids such as propionic, fumaric, ascorbic and lactic acids and their salts have shown variable effects on egg production and egg quality parameters.

Review on effect of organic acid salts on egg quality and serum parameters

Yalcin *et al.* (2000) [28] reported that albumen index and yolk index were significantly (P<0.05) improved by supplementing the diet with 1% lactic acid in laying hens. Gama *et al.* (2000) [5] observed that Haugh unit was significantly (P<0.05) reduced in hens receiving diet supplemented with 0.05% organic acid. Park *et al.* (2002) [20] observed that eggshell quality and Haugh unit were non-significantly improved by feeding organic acid mixture and yeast culture in the layers' diet. Yesilbag and Colpan (2006) [29] reported that shell thickness, Haugh unit and the total egg composition (evaluated by yolk index and albumen index) were not significantly improved by addition of the organic acid mixture into diets and had no effect on average egg weight.

Soltan (2008) [22] reported that eggshell thickness and yolk index were significantly (P<0.05) improved but albumen index was significantly (P<0.05) reduced by supplementing the diets with organic acids mixture and had no effect on egg shape index and average egg weight. Similarly, Rahman *et al.* (2008) observed that basal diet supplemented with organic acids mixture had no significant effect on shape index, yolk index, Haugh unit and average egg weight but eggshell thickness was significantly (P<0.05) improved by dietary supplementation. However, albumen index was significantly (P<0.05) reduced by the treatments when compared with control group.

Kadim *et al.* (2008) [14] studied the effect of supplementation of the diet with various levels (200, 400 and 600 ppm) of acetic acid in commercial Brown Leghorn laying hens and found that length and width of eggs were significantly (P<0.05) improved at 600 ppm level of inclusion as compared with control and other inclusion levels (200 ppm and 400 ppm) and it was also reported that albumen height and Haugh unit of the eggs were significantly (P<0.05) increased at 400-600 ppm levels of acetic acid supplementation in the layers' diet. Yin *et al.* (2008) reported that cholesterol content of white leghorn's egg yolk is 13.2 mg/g yolk can be modified with nutrition of layers.

Wang *et al.* (2009) [27] reported that dietary supplementation of phenyl lactic acid had no significant effect on eggshell thickness and egg weight and it was also found that Haugh unit was significantly (P<0.05) improved in hens fed diet supplemented with 0.2% phenyl lactic acid. Swiatkiewicz *et al.* (2010) [23] reported that there was non-significant difference in eggshell thickness among treatments by supplementing the diets with prebiotics and organic acids in brown laying hens of 36 weeks of age. Bonos *et al.* (2011) [4] observed that egg shape index was significantly (P<0.05) decreased by dietary addition of mannan-oligosaccharides and calcium formate in the diet of Japanese quails but had no effect on average egg weight. Ozek *et al.* (2011) [19] studied the effect of dietary herbal essential oil mixture and organic acid in laying hens and observed that albumen height and Haugh unit were significantly (P<0.05) affected by dietary treatments.

Grashorn *et al.* (2012) [7] studied the influence of dietary organic acid supplementation in 24 Hisex Brown laying hens of 30 weeks age and found that egg weight was significantly (P<0.05) improved by the treatments when compared with control group. Youssef *et al.* (2013) [30-31] observed no significant effect on shape index, yolk index, albumen index and Haugh unit by supplementing the basal diet with probiotics, prebiotics and organic acids in the layers but egg weight and eggshell thickness were significantly (P<0.05) improved by the treatments as compared with control group. Youssef *et al.* (2013) [30-31] supplemented the basal diet with various levels (0.1, 0.2 and 0.3%) of sodium formate in 96 laying hens aged 53 weeks under heat stress condition and found that eggshell thickness was significantly (P<0.05) improved by supplementing the diet with 0.2% and 0.3% levels of sodium formate when compared with control group (basal diet).

Kaya *et al.* (2013) [16] studied the effect of zeolite and organic acid mixture supplementation in the layers' diet and found that shape index, yolk index, albumen index and Haugh unit were not significantly affected by dietary treatments but eggshell thickness was significantly (P<0.05) increased as compared with control group. Similarly, Attia *et al.* (2013) [2] studied the effect of supplementation of the diet with various levels (0, 1.5, 3 and 6%) of acetic acid in Japanese quails and revealed that egg shape index was not significantly affected by dietary treatments but yolk index and Haugh unit were significantly (P<0.05) increased by supplementing the diet with 3% level of acetic acid in the Japanese quails.

Dahiya (2015) reported cumulative values of egg weights (g) ranged from 51.64 (T_4, 1.5% sodium-butyrate) to 54.67 (T_5, 0.5% calcium-propionate). The results of the study unveiled that egg weight (g) was significantly (P<0.05) higher in T_2 (0.5% sodium-butyrate) and T_5 (0.5% calcium-propionate) groups as compared to T_1 (Control), T_3 (1.0% sodium-butyrate), T_4 (1.5% sodium-butyrate), T_6 (1.0% calcium-propionate) and T_7 (1.5% calcium-propionate) groups, indicating that egg weight was significantly (P<0.05) increased at 0.5% level of supplementation of salts of organic acids in the diet of layers. This improvement in egg weight at 0.5% level might be due to lower per cent hen day egg production at 0.5% level which, consequently increased the weight of eggs because these two traits are negatively correlated (Tomar, 2014) [25].

Serum parameters

Yesilbag and Colpan (2006) [29] supplemented the basal diet with various levels (0.5, 1.0 and 1.5%) of organic acids mixture in laying hens and observed that dietary supplementation of organic acids mixture (1% and 1.5%) significantly increased the serum total protein and albumin concentrations (P<0.01 and P<0.05, respectively) but other serum parameters (cholesterol, HDL, triglyceride, VLDL, total lipid concentration and ALT activity) were not significantly affected by the treatments. Soltan (2008) [22] supplemented the control group 1 with 260 ppm (group 2), 520 ppm (group 3) and 720 ppm (group 4) of organic acids mixture in laying hens and found a linear increase of serum calcium concentration with the inclusion levels of organic acids mixture in layers' diet as compared to control group. However, serum total protein and albumin concentration were significantly (P<0.01) improved in the laying hens of group 3 and group 4 when compared with the control group 1.

Wang *et al.* (2009) [27] observed that total protein and albumin levels were significantly (P<0.05) increased by supplementing the diet with phenyl lactic acid in 240 Brown 36-wks-old layers. Nourmohammadi *et al.* (2011) [17] studied the effect of citric acid and microbial phytase in broiler chicks and found that cholesterol and phosphorus concentrations in plasma were significantly (P<0.05 and P<0.01, respectively) decreased by the treatments but had no effect on calcium and magnesium concentrations in plasma. Ozek *et al.* (2011) [19]

observed non-significant difference in serum total cholesterol level by supplementing the diets with herbal essential oil mixture and organic acid in layers.

Attia *et al.* (2013) [2] studied the effect of supplementation of the diet with various levels (0, 1.5, 3 and 6%) of acetic acid in Japanese quails and revealed that the plasma albumin concentration was significantly (P<0.05) higher in Japanese quails fed diets supplemented with 3% level of acetic acid than that of Japanese quails fed diet supplemented with level 1.5 and 6% acetic acid but plasma total protein and globulins were not significantly affected by different levels of acetic acid in the diets of Japanese quails. Kaya *et al.* (2013) [16] studied the effects of zeolite and organic acids mixture supplementation in the layers' diet and observed that serum albumin and calcium levels were significantly (P<0.05) reduced by dietary treatments but had no effect on serum cholesterol, total protein and phosphorus levels.

Youssef *et al.* (2013) [30-31] reported that plasma calcium and phosphorus concentrations were significantly (P<0.05) improved by addition of sodium formate in 96 laying hen aged 53 weeks during summer season.

Kamal *et al.* (2014) [15] studied the effects of dietary supplementation of different types of organic acids on the performance and blood biochemistry of broiler chicken. The control (T_1) group was fed the basal diet, whereas in other treatment groups basal diet was supplemented with 3% butyric acid (T_2), 3% fumaric acid (T_3) and 3% lactic acid (T_4) and found a significant (P<0.05) reduction in total cholesterol and LDL level of serum in broilers fed supplemented diets as compared to basal diet.

Dahiya (2015) reported mean values of total cholesterol; HDL and LDL in egg yolk ranged between 12.38 (T_3, 1.0% sodium-butyrate) to 13.42 (T_1, control group), 5.62 (T_1, control group) to 6.84 (T_6, 1.0% calcium-propionate) and 5.48 (T_6, 1.0% calcium-propionate) to 7.24 (T_1, control group) mg/g egg yolk, respectively. The results of the study depicted that egg yolk concentration of total cholesterol and LDL were significantly (P<0.05) reduced by supplementing the diets with 1.0% and 1.5% levels of salts of organic acids in their different dietary combinations and HDL value was significantly (P<0.05) higher in laying hens fed diets supplemented with 1.0% and 1.5% than hens fed control diet.

Dahiya (2015) reported that concentrations of various serum parameters (Total proteins, albumin, globulin, calcium, magnesium and phosphorus) were significantly (P<0.05) improved by supplementation of salts of organic acids in the diets of layers. This could be attributed to the favourable environment in intestinal tract due to supplementation of salts of organic acids, reducing pH of gastro-intestinal tract which increased the digestibility of proteins and facilitates the uptake of minerals from gut into the blood stream (Soltan, 2008) [22].

Nutrient digestibility and metabolizability

Thirumeigmanam *et al.* (2006) [24] fed birds with control diet (C), control diet with doxymycin (DOX) @ 0.5 mg/ton, organic acids (Acifed-FS) @ 0.5kg/ton (AFS1), 1kg/ton (AFS2) or 1.5kg/ton (AFS3) and found that ileal digestibility of nutrients was significantly (P<0.05) higher in AFS2 and AFS3 as compared to C and DOX group. The N, Ca and P retentions were also significantly (P<0.01) higher in AFS2 and AFS3 as compared to other groups. Smulikowska *et al.* (2009) [21] reported that nitrogen retention was significantly (P<0.01) increased by supplementing the diets with two fat-coated organic acid salts preparation sodium butyrate (SB) and blend G in the wheat-based basal diet of broilers.

Ghazalah *et al.* (2011) [6] supplemented the diets with different type and levels of organic acids being formic (0.25, 0.5, 1.0%), fumaric (0.5, 1.0 and 1.5%), acetic (0.25, 0.5 and 0.75%) and citric acid (1, 2 and 3%) and evaluated that dietary organic acids improved both metabolizable energy and nutrients digestibility of the experimental diets compared to control.

Dahiya (2015) reported that dry matter metabolizability (%) and nitrogen retention (%) were significantly (P<0.05) improved by different dietary treatments as compared to control (T_1). Further it was also observed that supplementation of salts of organic acids at all the levels of inclusion had a significant (P<0.05) positive effect on nitrogen corrected ME (kcal/kg) and gross energy metabolizability (%) among different dietary treatments. The value of nitrogen corrected ME (kcal/kg) and gross energy metabolizability (%) were significantly (P<0.05) higher in treatment T_3 (1.0% sodium-butyrate) and T_6 (1.0% calcium-propionate) as compared to all other treatments and this improvement might be due to reduction in pH of gastro-intestinal tract due to salts of organic acids and preservation of microbial balance which leads to improved metabolism and absorption of nutrients (Adam, 1999 and Hyden, 2000) [1, 10].

Conclusion

The poultry sector in India is one of the fastest growing and less susceptible to natural uncertainties. In the words of Dr. M.S. Swami Nathan, "The achievements and growth in poultry are comparable to the advances made in the wheat production" which has led nation to the path of red revolution. Layers are special types of birds for egg production due to their high feed utilization capacity but under present farm practices in India they are always under stress. Most of researchers noticed supplementation of salts of organic acids had no effect on average feed consumption and body weight gain in layers. Supplemented diets improved the egg quality traits i.e. egg weight, shell thickness, shape index, Haugh unit and reduced egg yolk cholesterol level. Supplementation of salts of organic acids significantly (P<0.05) improved nutrients metabolizability, energy metabolizability and serum parameters concentrations (Total proteins, albumin, globulin, calcium, magnesium and phosphorus) and significantly (P<0.05) reduced cholesterol level in serum. From economical point of view, egg production was more profitable at 0.5% level of sodium-butyrate and 0.5% level of calcium-propionate which reduced the feed cost per dozen eggs and per kg egg mass production without affecting the egg quality.

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