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Review on the Effect of Organic Acids on Production Performance of Broilers and Layer Chickens

Dessalegne Mengesha Muleta

Department of Animal Sciences,
Jimma University College of Agriculture and Veterinary Medicine, Ethiopia

Abstract: This current topic shows a review on the effects of organic acids on chicken's production performance. Antibiotic feed additives have long been applied to poultry feed as growth promoters to regulate intestinal microbial flora, enhance overall efficiency and avoid some particular intestinal pathologies. However, owing to the advent of antibiotic-resistant microbes which are used to treat human and animal infections, the European Commission (EC) agreed to phase out the promotion and use of antibiotics as growth promoters in feed and finally to ban them on January 1, 2006. The use of organic acids and their salts in poultry production has been approved by the European Union because they are usually considered safe. Organic acids are acidifying nutrients that can be used in poultry feed to prevent or combat harmful microbial populations so that they can organically enhance the health and efficiency of birds. The use of feed additives in poultry feeding has assumed a primary role and has become compulsory because it increases feed efficiency and growth rate, which typically leads to lower egg or meat production costs. Future research should be investigated to the alternative to antibiotics like organic acids without causing adverse effects on production performance of chickens.

Key words: Organic Acid · Broiler · Layer · Production Performance

INTRODUCTION

The benefit for the poultry industry depends largely on the quality of the feed, as feed accounts for about 70-75% of the total production cost [1] and is a vital tool for optimizing the genetic potential of birds, as it provides all the nutrients required to boost bird growth and health. High production levels and efficient conversion of feed are a requirement for the modern poultry industry, which could, to some degree, is accomplished by the use of various feed additives. Antibiotics are commonly used to promote animal growth and it is noted that have a detrimental effect because their residual effect on poultry products causes many human health problems [2]. Antibiotic feed additives have long been applied to poultry feed as growth promoters to regulate intestinal microbial flora, enhance overall efficiency and avoid some particular intestinal pathologies [3]. However, owing to the advent of antibiotic-resistant microbes which are used to treat human and animal infections, the European Commission (EC) agreed to phase out the promotion and use of antibiotics as growth promoters in feed and finally to ban them on January 1, 2006.

Organic acids can be used in the poultry diet as a growth promoter [4] and could also serve as alternatives to pharmaceutical antibiotics and are recommended for dietary inclusion in broiler chickens [5]. The use of feed additives in poultry feeding has assumed a primary role and has become compulsory because it improving the feed conversion ratio and growth rate, which typically leads to lower egg or meat production costs and the market for antibiotic-free products is rising with increasing consumer understanding of antimicrobial resistance and antimicrobial residue in the products. Alternative antibiotic additives to increase poultry production need to be investigated and organic acids can be used effectively as an alternative to antibiotics growth promoters [6].

The removal of antibiotics has led to problems with poultry results in declines in feed conversion and an

Corresponding Author: Dessalegne Mengesha Muleta, Department of Animal Sciences, Jimma University College of Agriculture and Veterinary Medicine, Ethiopia. E-mail: dessalegnmengesha6@gmail.com.

increase in the occurrence of some poultry diseases. The researchers were forced to investigate the effectiveness of other non-therapeutic substitutes, such as organic acids, antioxidants, probiotics, prebiotics, spices, essential oils and immune stimulants, as feed additives in poultry development. Therefore, this review provides organized information on the effects of organic acids on chicken's production performance.

History and Definition of Organic Acids: In the preservation of feed, organic acids have been used for decades either to protect feed from microbial and fungal destruction or to improve the preservation effect of fermented feed, such as silage. Their positive effects on feed quality and animal efficiency have been recognized for decades and there is a growing need to identify the various acids and their salts and to differentiate between their strengths and weaknesses as they increasingly attract the attention of the feed industry. The word 'organic acid' refers to a broad class of compounds used in the body's basic metabolic processes and chemically share the typical characteristics of water solubility, acidity, etc. Both carboxylic acids with or without keto, hydroxyl, or other non-amino functional groups are commonly considered to be included in the definition, although most amino acids are not included. Organic acids with the chemical structure of R-COOH, including fatty acids, may be defined as carboxylic acids with acidic properties. Short-chain fatty acids such as acetic, propionic, butyric, lactic and formic acid have been given preference as growth enhancers in poultry diets due to specific chemical and physical properties.

Organic acids are acidifying nutrients that can be used in poultry feed to prevent or combat harmful microbial populations so that they can organically enhance the health and efficiency of birds [7]. In reducing the bacterial load (antimicrobial ability and preservation of product quality), cost-effectiveness and convenience, organic acids are effective sanitizers. Therefore, the use of organic acids in decontamination procedures is one of the world's oldest and most common. Organic acids are naturally occurring, carbon-containing (hence organic) compounds with acidic properties (often referred to as volatile fatty acids, fatty acids, carboxylic acids, or weak acids).Organic acids are weak acids that are dissociated only partly. Organic acids have between 3 and 5 pKa value. The pKa value is one tool used to denote an acid's intensity and a stronger acid is indicated by a lower pKa value. That is, the lower value suggests the acid more thoroughly dissociates in water. There is a broad range of organic acids with different physical and chemical properties, many of which are used as supplements for drinking water or feed additives (acidifiers). Most are available as sodium, potassium, or calcium salts (and/or partially esterified). The advantage of salts over acids is that, due to their solid and less volatile form, they are usually odorless and easier to handle in the feed production process [8].

Uses of Organic Acids in Poultry Production: The use of organic acids in animal nutrition has gained considerable significance in the feed industry following the European ban on antibiotic growth promoters (AGPs) in 2006. Organic acids are not antibiotics but can be a powerful tool in preserving the health of the gastrointestinal tract of poultry if used correctly along with nutritional, managerial and bio-security measures, resulting in improving their efficiency [9].

Organic acids can be used as a growth promoter in the poultry diet and have resulted in improved body parts and growth efficiency with decreased bird mortality. Organic acids play a very important role in improving the intestinal health of poultry [10] and organic acids have a proven antimicrobial effect and can minimize microbial problems in the gut, whether by regulating microorganisms in feed, drinking water, or directly in the GI tract.

Organic acids and their salts can inhibit the growth of microorganisms in food and, therefore, to maintain the microbial balance in the gastrointestinal tract and to increase the solubility of feed ingredients, digestion and nutrient absorption by adjusting intestinal pH [11] and dietary organic acids and their salts can inhibit the growth of microorganisms in feed by maintaining the microbial balance of poultry in the gastrointestinal tract [12]. The significance of using organic acid as physiological additives through their physiological action to increase the growth performance and intestinal histomorphology of broilers in inducing the growth and activities of certain endogenous mechanisms responsible for improved efficiency [13].

Effect of Organic Acids on Production Performance of Broiler Chickens: Feeding broilers organic acid dietary supplementation at 1 g/kg improved the growth performance of broilers across the entire rearing period [14] and supplementation had a positive effect on improving body weight gain and feed conversion ratio efficiency, likely due to antimicrobial activity, decreased pH of different gastro intestinal tract segments and

beneficial effects on serum protein concentration and intestinal mucosa of broiler chicken. According to Dittoe *et al*. [15], introducing artichoke extract and/or organic acids to broiler diets has significantly improved growth performance and feed consumption efficiency, resulting in lower feed costs and increased overall benefit. For the efficient performance of broilers, supplementation of organic acids at dose rates of 3 kg/ton and 4 kg/ton is recommended [16] and can be used as a better substitute for antibiotics. As antibiotic growth promoters and probiotics and organic acids are promising alternatives to antibiotics in broiler diets, probiotics and lactic acid have increased the body weight of broilers [17]. Lactic acid alone appears to produce better performance results than the combination of organic acids. The natural lactic acid that bacteria produce could affect similar to that of the chemical one. According to Apaleyeva [18], reported that the use of the organic acid-based acidifier Acidomix AFG had a positive impact on the productivity of broiler chickens by adding 0.3 percent of the acidifier to the feed of the poultry farm during the 1 to 10-day growing period and 0.2 percent during the 11 to 41-day growing period showed the best results.

A potential productive effect is associated with a decrease in feed component acid binding ability and buffer capacity, increasing the function of protein-digesting secreted enzymes. Also, the intestinal villi are activated due to the action of organic acids, as a result of which feed nutrients are better consumed and feed conversion to products decreases. According to Nguyen, . and Kim [19], dietary supplementation of the protected blend of organic acids and medium-chain fatty acids improved growth efficiency and nutrient digestibility.

Effect of Organic Acids on Feed Consumption and Feed Conversion Ratio of Broilers: According to Paul *et al.* [20], stated that the combination of acidifiers given by birds showed lower feed intake but comparable body weight gain after 6 weeks compared to birds treated with antibiotics. Supplementation tends to strengthen body weight gain and feed conversion ratio in the starter phase because of organic acids or probiotics alone or in combination in their diets [21]. In addition, improved feed conversion ratio and essential oils and organic acids treatment by Acidifier may decrease harmful bacteria, promote short chain fatty acid concentration and digestive enzyme activity [22] and 0.3 percent butyric acid wa-9s on par with antibiotics in maintaining body weight gain and considered superior to feed conversion ratio.

Effect of Organic Acids on Body Weight and Growth Rate of Broiler Chickens: According to Agboola *et al.* [23], in the start phase and overall period, the use of organic acid and probiotic alone in diets without antibiotics increased body weight gain. Organic acid, probiotics and a mixture of the two improved gut morphology increased pancreatic weight and decreased gut pathogenic bacteria. It was recorded that when compared to the groups fed diets supplemented with 2 percent levels, the 3 percent inclusion levels were found to be better in promoting weight gains. By adding 0.5% of the mixture of microencapsulated organic acids (citric and sorbic acids) and essential oils (thymol and vanillin) to broiler chickens, the overall mortality rate was reduced and the growth rate was positively affected in the last growing cycle period, thus also improving the feed conversion ratio.

Effect of Organic Acids on Carcass and Meat Characteristics of Broiler Chickens: According to Stamilla *et al*. [24], reported that the combination of formic and butyric acids increased the relative back weight of broilers and the supplementation of dietary organic acids increased the PH values of broiler meat and decreased drip loss and the potential to improve the quality of broiler meat. Butyric acid increased the moisture content and the protein content of meat was reduced. Formic acid increased, while butyric acid and the combination of formic and butyric acid decreased breast meat lightness and meat yellowness with organic acid supplementation increased. Therefore the treatment of organic acids can be helpful to avoid the pale, soft and exudative like condition of broiler meats.

Dietary supplementation of organic acids in broilers has a beneficial effect on carcass yield and percentage of dressing and Sugiharto *et al*.[25], concluded that organic acid supplementation not only preserves efficiency but also increases carcass yield in the broiler diet and concluded that 0.3 percent butyric acid could fully replace antibiotics in the diet of broiler chicken. Natural compounds (nutmeg, mace and cardamom) and organic acids (acetic, citric and lactic acids) can be concluded to have an antibacterial effect on *Salmonella typhimurium* and can therefore be used for the poultry meat decontamination process.

Effect of Organic Acids on Immunity, Gut Health and Economics Broiler Productions: Supplementation of 0.5% mixture of microencapsulated organic acids (citric and sorbic acids) and essential oils (thymol and vanillin)

in broiler chickens was found to affect gut morphology in different intestinal segments during the last growing phases and increased villi height, villi width, mucosal thickness and villus number after 25 days of supplementation. The antimicrobial, anti-catabolic and antioxidant effects of butyric acid together enhance lipid metabolism, mineral absorption and birds' immune status [26].

The administration of the combination of essential oil of cloves and organic acids has been recorded to have a positive impact on gut health and to boost immunity, with a concomitant improvement in the economy of broiler production. Feeding benzoic acid to a level of inclusion of up to 0.8 percent improved the immune response by increasing the weight of the Fabricius bursa and increasing the level of blood globulin, but had no significant effect on the growth performance of broiler chickens. According to Deepa *et al*. [27], showed that the use of organic acid mixture as an alternative antibiotic in broiler chick feed can substantially reduce *Salmonella typhimurium* and boost bird growth efficiency, indicating that 0.9% organic acid mixture is an acceptable level of treatment to preserve feed hygiene and Salmonella infection/contamination.

Dietary supplementation of Citric acid on production performance and economic of broiler birds higher body weight, body weight gain and feed intake, significantly ($P<0.05$) better feed conversion efficiency, dressing percentage, performance index and overall net profit per kg live weight. In terms of live weight, live weight gain, feed conversion effectiveness, dressing percentage, performance index and total net benefit per kg live weight; citric acid supplementation at the rate of 3.2 mg/kg feed in the broiler diet was found to be the best [28]. The reduction in GIT pH by diet acidification contributes to an increase in the use of nutrients and inhibition of pathogenic growth of bacteria [29].

Effect of Organic Acids on Production Performance and Egg Quality of Layer: According to Kim *et al.* [30], in laying hens, the addition of probiotics, prebiotics, symbiotic or organic acids greatly increased the yield of eggs, egg mass and egg quality (eggshell thickness and yolk color) and was economically beneficial. According to Youssef *et al*. [31] reported that the use of encapsulated essential oils and organic acids (EOA) in green feed additives will serve as a promoter for laying hens by improving efficiency and egg quality, improving the structure and function of the intestine and reducing the risk of disease. Organic acid supplementation of 0.5 ml/l results in improved production of eggs, better feed conversion, the higher thickness of the eggshell, yolk dry matter, percentage of yolk protein and percentage of yolk ash [32].

According to Kabir *et al*. [33], the supplementation of salts of organic acids in the diet of layers significantly improved production efficiency (percent hen-day egg production and egg mass production) and feed conversion ratio (feed intake per dozen eggs and per kg egg mass). Supplementation of sodium butyrate at 1.5 percent increased hen-day egg production, egg mass production and feed intake per dozen eggs, while 0.5 percent improved egg weight and feed intake per kg egg mass production and sodium butyrate and calcium propionate supplementation improved lay persistence, egg weight and feed conversion ratio.

According to Dahiya *et al*. [34], reported from an economic point of view that the addition of organic acid (520 ppm) to the basal diet could result in an increase in the economic efficiency of layer productivity between 67 and 74 weeks at an older age. Supplementation of dietary organic acids induced positive effects on the production of eggs and feed quality and less affected protein metabolism in laying hens, organic acids when used in laying hen diets.

An experiment on the addition of citric acid to layer diets was performed by Ardianto *et al*. [35] and showed a very significant effect on egg development and feed conversion, but did not have a significant impact on feed consumption and egg weight. The addition of citric acid provides improved egg production and feed conversion at a level of 0.6 per cent.

Effect of Organic Acids on Feed Intake and Feed Conversion Ratio of Layer Chickens: The inclusion in the diet of 1.5 kg/t of Organic Acid mixture (OAM) feed resulted in a better FCR than that of the control and other treatment groups and it can be stated that 1.5 kg/t OAM can be used in laying hen diets, improved shell strength and yolk color [36]. Feed intake and egg weight were not affected by the addition of citric acid to feed and the addition of 0.6 percent citric acid resulted in a better performance ratio for egg production and feed conversion [37]. Because of decreased palatability, butyric acid in its salt form has been found to have beneficial effects on feed intake relative to the acid form [38]. Giving up to 0.9% citric acid in quail feed did not affect feed intake and egg weight, but on the other hand, giving 0.6% citric acid could increase laying quail production and feed conversion ratio.

Effect of Organic Acids on Body Weight of Layer Chickens: Organic acid supplementation at laying hens diet level 780 ppm enhances live body weight, improves lay persistence and increases daily egg mass production, food conversion ratio, quality of eggshell and blood serum protein and calcium concentration over the 54-70 week age period of hens. Variations in gut flora and environmental factors may confuse the variable effect of the inclusion of organic acids in laying hen diets [39]. It is strongly recommended that poultry producers should take good care by adding anti-heat stress feed and water additives such as organic acids to prevent the negative effects of heat stress on their poultry populations, especially during hot seasons [40].

Effect of Organic Acids on Storage Duration of On Egg Quality of Layer Chickens: According to Palupi *et al.* [41] reported that in the third phase of production, there is no effect between butyric acid administration and storage duration on the quality of laying hens' eggs. The inclusion of butyric acid in the rations does not affect the quality of hens laying eggs during the third stage of production during storage. The addition of 300 mg/L of citric acid caused a mild change in pH and had a positive effect throughout the 4-week storage period on the preservation of protein solubility in liquid whole eggs (LWE) [42].

Effect of Organic Acids on Immunity, Gut Health and Economics of Layer Chickens: Supplementing the mixture of essential oil and organic acid in the layer diet helps to improve Newcastle disease virus antibody responses [43]. Synergistic modulation effects on immunity and gut health have been shown by essential oil combined with organic acid administration in feed, which is very important for the discovery of new alternatives to antibiotic growth promoters in broiler production. The administration of clove essential oil and the organic acid combination has a beneficial impact on gut health and increases immunity with a concomitant increase in the economy of broiler production [44].

Salts of organic acid supplementation at a level of 0.5 percent improve the performance of the layers without affecting the consistency of the eggs. From an economic point of view, the production of eggs was more profitable at 0.5 percent sodium butyrate and 0.5 percent calcium propionate levels, which decreased the cost of feed per dozen eggs and per kg of egg mass production without affecting the quality of the eggs [45].

CONCLUSIONS

The benefit for the poultry industry depends largely on the quality of the feed, as feed accounts for about 70-75% of the total production cost. Antibiotics are commonly used to promote animal growth and it is noted that antibiotics have a detrimental effect because their residual effect on poultry products causes many human health problems. The European Commission agreed to phase out the promotion and use of antibiotics as growth promoters in feed and finally to ban them on January 1, 2006. Alternative antibiotic additives to increase poultry production need to be investigated and organic acids can be used effectively as an alternative to AGP. Organic acids with an R-COOH chemical structure can be defined as carboxylic acids with acidic properties. Short-chain fatty acids such as acetic, propionic, butyric, lactic and formic acid have been given priority as growth enhancers in poultry diets due to specific chemical and physical characteristics. Organic acids can be used as a growth promoter in the poultry diet and have resulted in improved body parts and growth efficiency with decreased bird mortality. Organic acids inhibits pathogenic bacteria, particularly zoonotic bacteria, from growing, e.g. Campylobacter, *E. coli* and Salmonella.

The demand for organic animal products that do not contain antibiotics and synthetic chemicals is growing and it is agreed that organic acids are an attractive option for improving the digestibility of nutrients in the swine and poultry industry. Organic acid and probiotic supplementation alone increased the proportion of weight gain and feed conversion. It also reduced abdominal fat, serum cholesterol and E. coli counts compared to the group given antibiotics. The use of organic acid mixture in the feed of broiler chickens as an antibiotic substitute would significantly reduce *Salmonella typhimurium*. Butyric acid has been commonly used as a feed additive for broiler chickens. Citric acid is a promising supplement that can be used in poultry feed to improve growth and feed efficiency. Salts of organic acid, sodium butyrate (SB) could be a potential option to improve intestinal health and substitute antibiotics. The expensive antibiotics cost could be reduced by the addition of organic acids in the poultry diets and they reduce the cost of treatment, boost animal performance and production parameters and provide a wider range of activities.

Prospects (Future Line of Work):

- The results from the cited literature showed that the use of organic acids at different dose rates are positive effects on the production performance of chickens and it should be used in poultry production.
- It is should be recommended to use organic acids in a broiler and layer diet as a cheap and efficient growth-promoting agent without residual effects, increased growth performance, reduced diseases, like antibiotic growth promoters.
- Depending on different works of literature, the removal of antibiotics has led to problems with poultry results declines in feed conversion and an increase in the occurrence of some poultry diseases, as well as the use of antibiotics, are commonly promoting animal growth and it is noted that have a detrimental effect because their residual effect on poultry products causes many human health problems. Future research should be investigated to the alternative to antibiotics like organic acids without causing adverse effects on production performance of chickens.

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REFERENCES

1. Abd El-Hack, M., M. Alagawany, M. Farag and K. Dhama, 2015. Use of maize distiller's dried grains with soluble in laying hen diets: Trends and advances. Asian Journal of Animal Veterinary Advance, 10: 690-707.
2. Donoghue, D.J., 2003. Antibiotic residues in poultry tissues and eggs: Human health concerns, in Poultry Science. Poultry Science Association, 618-621. doi:10.1093/ps/82.4.618.
3. Hassan, H.M.A., A.W. Youssef, H.M. Ali and M.A. Mohamed, 2015. Adding phytogenic material and/or organic acids to broiler diets: Effect on performance, nutrient digestibility and net profit, Asian Journal of Poultry Science, 9(2): 97-105. doi: 10.3923/ajpsaj.2015.97.105.
4. Jha, A.K., M.H. Azad, M.S. Ali, P.Alam, N. Sheikh, H. Ali and K. Ansari, 2019. Evaluation of Growth and Carcass Characteristics of Broiler Chickens (Cobb 500) Feed on Different Level of Organic Acids Inclusion in Diet at Parwanipur. Nepalese Veterinary Journal, 36: 137-147. doi:10.3126/nvj.v36i0.27773.
5. Ndelekwute, E.K., G.E. Enyenihi and E.B. Essien, 2018. Effect of Organic Acid Treated Diets Fed During Finisher Phase on Gut Microbiota and Blood Profile of Broiler Chickens, Dairy and Vet. Sci. J., 5(4): 16. doi:10.19080/JDVS.2018.05.555668.
6. Ahmed, A., M. Dhumal, M. Nikam, P. Nandedkar and V. Ingle, 2019. Effect of Supplementation of Organic Acids and Their Combination as an Alternative to Antibiotic Growth Promoter on Performance, Gut Health, Immune Status and Economics of Broiler Production, International Journal of Livestock Research, 9(2): 154-165 DOI: 10.5455/ijlr.20180812074616.
7. Hajati, H., 2018. Application of organic acids in poultry nutrition, International Journal of Avian & Wildlife Biology, 3(4): 1-9. DOI: 10.15406/ijawb.2018.03.00114.
8. Khan, S.H. and J. Iqbal, 2016. Recent advances in the role of organic acids in poultry nutrition. Journal of Applied Animal Research, 44(1): 359-369. doi:10.1080/09712119.2015.1079527.
9. Hassan, R.I.M. and G.S.E.A. Raheem, 2016. Effect of Feeding Benzoic acid on Performance of Broiler Chickens. Journal of Advanced Veterinary Research, 6(4): 118-122.
10. Broom, L.J., 2015. Organic acids for improving intestinal health of poultry. World's Poultry Science Journal, 71(4): 630-642, doi: 10.1017/S0043933915002391.
11. Yesilbag, D. and I. Çolpan, 2006. Effects of Organic Acid Supplemented Diets on Growth Performance, Egg Production and Quality and on Serum Parameters in Laying, Revue Méd. Vét., 157(5): 280-284.

12. Baghban-Kanani, P., B. Hosseintabar-Ghasemabad, S. Azimi-Youvalari, M. Ragni, V. Laudadio and V. Tufarelli, 2019. Effects of using Artemisia annua leaves, probiotic blend and organic acids on performance, egg quality, blood biochemistry and antioxidant status of laying hens. Journal of Poultry Science, 56: 120-127. doi:10.2141/jpsa.0180050
13. Mohammadagheri, N., R. Najafi and G. Najafi, 2016. Effects of dietary supplementation of organic acids and phytase on performance and intestinal histomorphology of broilers, Veterinary Research Forum, 7(3): 189-195.
14. Sabour, S., S.A. Tabeidian and G. Sadeghi, 2019. Dietary organic acid and fiber sources affect performance, intestinal morphology, immune responses and gut micro fl ora in broilers, Animal Nutrition, 5(2): 156-162. DOI: 10.1016/j.aninu.2018.07.004.
15. Dittoe, D.K., S.C. Ricke and A.S. Kiess, 2018. Organic Acids and Potential for Modifying the Avian Gastrointestinal Tract and Reducing Pathogens and Disease, Frontiers in Veterinary Science, 5: 1-12. DOI: 10.3389/fvets.2018.00216.
16. Saleem, K., Saima, A. Rahman, T.N. Pasha, A. Mahmud and Hayat Zafar, 2020. Effects of dietary organic acids on performance, cecal microbiota and gut morphology in broilers, Tropical Animal Health and Production, 52(6): 3589-3596. DOI: 10.1007/s11250-020-02396-2.
17. Youssef, I.M.I., A.S. Mostafa and M.A. Abdel-Wahab, 2017. Effects of dietary inclusion of probiotics and organic acids on performance, intestinal microbiology, serum biochemistry and carcass traits of broiler chickens. Journal of World's Poultry Research, 7(2): 57-71.
18. Apaleyeva, M.G., 2020. The effectiveness of the acidifier on the productivity of broiler chickens, Agrarian Bulletin of the Urals, 3(194): 45-48.
19. Nguyen, D.H. and I.H. Kim, 2020. Protected organic acids improved growth performance, nutrient digestibility and decreased gas emission in broilers. Animals, pp: 10. doi:10.3390/ani10030416.
20. Paul, S.K., G. Samanta, G. Halder and P. Biswas, 2007. Effect of a combination of organic acid salts as antibiotic replacer on the performance and gut health of broiler chickens. Livestock Research for Rural Development, 19(11): 1-8.
21. Rodjan, P., K. Soisuwan, K. Thongprajukaew, Y. Theapparat, S. Khongthong, J. Jeenkeawpieam and T. Salaeharae, 2017. Effect of organic acids or probiotics alone or in combination on growth performance, nutrient digestibility, enzyme activities, intestinal morphology and gut microflora in broiler chickens. J. Anim. Physiol. Anim. Nutr., 1-10. https://doi.org/10.1111/jpn.12858.
22. Yang, X., Y. Liu, F. Yan, C. Yang and Yang Xia, 2017. Effects of encapsulated organic acids and essential oils on the intestinal barrier, microbial count and bacterial metabolites in broiler chickens, Poultry Science, 98(7): 2858-2865. DOI: 10.3382/ps/pez031.
23. Agboola, A.F., B.R. Omidiwura, O. Odu, I. Popoola and E.A. Iyayi, 2015. Effects of organic acid and probiotic on performance and gut morphology in broiler chickens. South African Journal of Animal Sciences, 45: 494-501. doi:10.4314/sajas.v45i5.6.
24. Stamilla, A., A. Messina, S. Sallemi, L. Condorelli, F. Antoci, R. Puleio, G.R. Loria, G. Cascone and M. Lanza, 2020. Animals Effects of Microencapsulated Blends of Organics Gut Morphology and Microbiology, Animals, pp: 33.
25. Sugiharto, S., T. Yudiarti, I. Isroli, E. Widiastuti, H.I. Wahyuni, T.A. Sartono, N. Nurwantoro and A.N. Al-Baarri, 2019. Effect of dietary supplementation of formic acid, butyric acid or their combination on carcass and meat characteristics of broiler chickens, Journal of the Indonesian Tropical Animal Agriculture, 44(3): 286-294. DOI: 10.14710/jitaa.44.3.286-294.
26. Ali, N., S. Alkassar and A. Alka Sar, 2018. The Effect of Using Organic Acid as an Alternative to Antibiotics Drugs on Productive and Physiological Performance of Broilers Ross- 308, Advances in Animal and Veterinary Science, 6(9): 359-365. doi:10.17582/journal.aavs/2018/6.9.359.365.
27. Deepa, K., M.R. Purushothaman, P. Vasanthakumar and K. Sivakumar, 2018. Butyric acid as an antibiotic substitute for broiler chicken-A review. Advances in Animal and Veterinary Sciences, 6(2): 63-69. doi:10.17582/journal.aavs/2018/6.2.63.69.
28. Adhikari, P., S. Yadav and W.K. Kim, 2020. Effect of the organic acid mixture on growth performance and *Salmonella typhimurium* colonization in broiler chickens. Poultry Science, 99: 2645-2649. doi:10.1016/j.psj.2019.12.037.
29. Archana, K., R. Zuyie and V.K. Vidyarthi, 2019. Effects of Dietary Addition of Organic Acid on Performance of Broiler Chicken, Livestock Research International, 7(2): 71-76. Available at: www.jakraya.com/journa/lri.

30. Kim, J.W., J.H. Kim and D.Y. Kil, 2015. Dietary organic acids for broiler chickens?: a review. Revista Colombiana de Ciencias Pecuarias, 28, 109-123. doi:10.17533/udea.rccp.v28n2a01.Summary.
31. Youssef, A.W., H.M.A. Hassan, H.M. Ali and M.A. Mohamed, 2013. Effect of probiotics, prebiotics and organic acids on layer performance and egg quality, Asian Journal of Poultry Science, 7(2): 65-74 DOI: 10.3923/ajpsaj.2013.65.74.
32. Wang, H., S. Liang, Li, Xia, X. Yang, F. Long and Yang Xin, 2019. Effects of encapsulated essential oils and organic acids on laying performance, egg quality, intestinal morphology, barrier function and microflora count of hens during the early laying period, Poultry Science, 98(12): 6751-6760. doi: 10.3382/ps/pez391.
33. Kabir, M.H., M.S. Ali, M. Aftabuzzaman and M. Habib, 2010. Effect of an Organic Acidifier on Layer Performance, Journal Environ. Sci. & Natural Resources, 3(1): 227-231.
34. Dahiya, R., R.S. Berwal, S. Sihag, C.S. Patil and Lalit, 2016. The effect of dietary supplementation of salts of organic acid on production performance of laying hens, Veterinary World, 9(12): 1478-1484. DOI: 10.14202/vet world.2016.1478-1484.
35. Ardianto, R., A.M. Pagala and H. Has Dan, 2020. The Effect Of Citrate Acid On The Production Performance Of The Quail (*Coturnix japonica*), Ind. J. Anim. Agric. Sci., 2(1): 1-4. doi:10.337772/ijaas.v2i2.
36. Kaya, H., A. Kaya and S. Timurkaan, 2014. 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, Europ. Poult. Sci., 78: 1-12. DOI: 10.1399/eps.2014.46.
37. Napirah, A., H. Has, A. Pagala and Nafiu La Ode, 2019. Production performance of laying Japanese quail that given citric acid as an acidifier, IOP Conference Series: Earth and Environmental Science, 287(1): 11-15. DOI: 10.1088/1755-1315/287/1/012002.
38. Hanna, D., 2019. The Effects of Butyric Acid on Performance Parameters, Egg Quality and Nutrient Utilization In Young White Leghorn Hens, A Thesis Presented to the Faculty of The Graduate College at the University of Nebraska, pp: 66.
39. Soltan, M.A., 2008. Effect of Dietary Organic Acid Supplementation on Egg Production, Egg Quality and Some Blood Serum Parameters I n Laying Hens, International Journal of Poultry Sciences, 7(6): 613-621.
40. Kammon, A., S. Alzentani, O. Tarhuni and A. Asheg, 2019. Effect of Some Organic Acids on Body Weight, Immunity and Cecal Bacterial Count of Chicken during Heat Stress, International Journal of Poultry Science, 18(6): 293-300 doi:10.3923/ijps.2019.293.300.
41. Palupi, R., F.N. Lubis and D. Syukrima, 2020. Effect of a combination of organic acid salts as antibiotic replacer on the performance and gut health of broiler Chickens, 19(11): 1-8. DOI: 10.1051/e3sconf /201868010 26.
42. Medic, H. and S. Karlovic, 2020. Effect of citric acid addition on functional properties of pasteurized liquid whole eggs. J. Food Sci Technol., DOI: 10.1007/s13197-020-04613-0.
43. Jadhao, G.M., D.H. Sawai, N.J. Kathale, R.P. Kolhe, H.N. Rewatkar, A.G. Kolaskar, A.D. Thool, A.J. Wankhede and A.P. Bansod, 2019. Effect of different organic acids with probiotic supplementation on gut health of broiler chicken, Journal of Pharmacognosy and Phytochemistry, 9(2): 1569-1573.
44. Gole Mayura, S.J. Manwar, S.P. Chaudhary, S.V. Kawitkar and K.K. Khose, 2020. The impact of feeding clove essential oils and organic acids on immunity, gut health and economics of broiler Production, 9(3): 1417-1422.
45. Dahiya, R., K. Dev and Kiran, 2018. The effects of supplementation of salts of organic acids on production performance in layers?: The Pharma Innovation Journal, 7(7): 278-282.