Evaluation of Productive Performance, Egg Production, Quality and Hatchability by Dietary Prebiotic and Organic Acid in Local Quails

Rebin Aswad Mirza
Animal Resource Department, College of Agricultural Engineering Sciences, Salahaddin University – Erbil, Iraq
Rebin A. Mirza, Mob.: 07504703477, E. mail: rebin.mirza@su.edu.krd

ABSTRACT

Numerous studies have demonstrated that feed additives increase livestock productivity by improving their intake, effectiveness and overall health. Inulin acts as a prebiotic supplement that modifies the ecosystem of intestinal microbes. The current study was investigated the influence of inulin from Jerusalem artichoke as a prebiotic on the performance and quality of eggs in laying local quails. Two hundred quails, 10 weeks old were randomly divided into four treatments (each 50 birds) each treatment includes five replicates in the measuring cages (60×30×25 cm) for eight weeks of experiment. The following was the design of the dietary treatments; control diet, control diet + 1% of prebiotic (Jerusalem artichoke that contain inulin as a prebiotic source) additive, 0.1% of organic acid additive and combination of 0.5% prebiotic + 0.05% organic acid additives. The results indicated that all additive supplementation significantly increased the total egg production and egg mass compared with the control. However, no significant effect was observed for the parameters of egg weight. The hatchability was increased in organic acid with total eggs, while the fertile egg indicated that there were no significant differences among all treatments except the combination between prebiotic and organic acid. While, chick weight of prebiotic and organic acid was increased significantly compared to the control. Although, there was no significant effect on dead embryo. This investigation has found that addition of inulin as prebiotic had a significant effect on some external and internal quality parameters of local quails .

Keywords: Prebiotic, Organic acid, Quails, Egg quality.

Introduction

Antibiotics have been added to quails feed for the past forty years in an effort to boost growth and egg production as well as shield quails from harmful microbes. The need for research on botanical feed additives has increased due to the general prohibition on the use of feed antibiotics as microbial performance boosters, which is anticipated to be implemented more broadly globally in the upcoming years (Mirza and Kareem, 2023). Probiotics, prebiotics, organic acids, and vegetable or condensed matter such as growth-promoting vegetable oils, are examples of these supplements (Cakir et al., 2008, Fouladi et al., 2018). In order to enhance animal health, productivity, and immunological function as well as to affect the gut microbiota, different prebiotics are currently being introduced to livestock feed (White et al., 2002; Lemieux et al., 2003). Because they can positively change the colonic microbiota and are not digested in the upper part of gastrointestinal tract, inulin was considered as prebiotic substances (Biggs et al., 2007, Mirza, 2015.(

According to Gibson et al. (2017), a prebiotic is a substrate that host bacteria preferentially

ISSN 2072-3857

use to provide health benefits. It has been demonstrated that adding inulin as a prebiotic to poultry has positive biological benefits in the field of animal production. There are many studies on the using of prebiotics in broilers (Mirza, 2015; Tavaniello et al., 2018; Akter et al., 2019). Nonetheless, there are still few research on the effectiveness of dietary inulin as a prebiotic in laying hen nutrition, and most of them were carried out on laying hens at the peak time production (Meng et al. 2010; Yan et al. 2010; Swiatkiewicz et al. 2013). Therefore, the application limitation of inulin from Jerusalem artichoke was overcome.

According to several studies (Cakir et al., 2008; Gunal et al., 2006; Mirza and Kareem, 2023) organic acids may eventually take the place of antibiotics as growth promotion agents. Additionally, broiler chickens' intestines can have fewer harmful compounds when organic acids are added to their diets (Langhout, 2000; Denli et al., 2003; Fouladi et al., 2014; Liu et al., 2018). The most promising substitutes for poultry are organic acids as citric, formic, acetic, and propionic acids. Therefore, the aim of this research was to investigate the influence of prebiotic and organic acid as feed additives on the growth productive performance, egg quality and hatchability of total and fertile and the post-hatching improvement of chick’s weight of local quails.

Material and Methods

Ethics Approval

The Scientific Ethical Committee of Salahaddin University's Animal Resources Department College of Agricultural Engineering Sciences approved this work on May 14, 2023 (No.: 3/5/5756.(

Layout of the Experimental Design

This experiment was designed in Grdarasha Field Research, College of Agricultural Engineering Sciences, Salahaddin University, Erbil. The research was done to investigate the influence of prebiotic, organic acid and their combination on productive performance and egg quality of local quail (Coturnix coturnix japonica). A number of 200 ten weeks old local quails were randomly distributed into four treatments (each 50 birds) with five replicates per each treatment in cages (60×30×25 cm) for eight weeks of trial. The dietary treatments were design as follows; control diet, control diet + 1% of prebiotic (Jerusalem artichoke that contain inulin as prebiotic source) additive, 0.1% of organic acid additive (including formic acid and propionic acid) and 0.5% of prebiotic + 0.05% organic acid additives ((Mirza, 2015). The chicks were allowed to eat and drink ad libitum. The control diet's composition is shown in (Table 1.(

Table 1: The composition of standard diet for the experiment.(%)

Ingredients	Composition (%)
Maize	11.8
Soybean meal	25.0
Wheat	55.8
Limestone	1.4
Premix[1]	2.5
Di calcium phosphate	0.3
Enzyme	0.1
Anti-oxidant	0.1
Oil	3.0
Total	100
Calculated values[2]	
ME (kcal/kg)	3150
Crude Protein %	20
Lysine %	0.99
Methionine %	0.44
Calcium %	0.71
Available phosphate %	0.39

1Premix: each 1 kg contain: Crude protein15%. Crude fat 2%. Crud fiber4%. Calicium4% Phosphorus(Av.) 8.6%. Methionine5.2%. Methionine+cystine5.4%. Lysine2.5%. sodum5%. VitA480.000IU. VitD3120.000IU. VitE1000mg. Vit K80mg. Vit B180mg. Vit B240mg. Vit B3,600mg. Vit B6,120mg. Vit B12 1mg. Niacin1.200mg. Folic acid, 40mg. Biotin,6mg. CholinChlorid12.000mg. Iron,2.800mg. Zinc2.400mg. Copper320mg. Manganese3.000mg. Iodine1100mg. Selenium 8mg.

2Food requirements were estimated according to (NRC, 1994.(

Growth Performance

Egg weight and Feed intake was measured during the whole experiment, and the formula for calculating feed conversion ratio (FCR) was derived by dividing feed intake per unit by egg weight increase. The influences of additives on hatchability percentage, dead embryo and chicks' weight were estimated .

Incubation and Hatching

A total of 800 eggs with a weight value of 12.06±0.27 g (200 eggs per treatment) from 17 weeks old were collected in sterile conditions. The influences of additives of hatching egg on hatchability percentage of total and fertile eggs, dead embryo and chick weight were estimated.

Determination of external and internal egg quality:

At 18 weeks of age egg samples (9 eggs per replicate) were collected and analysed for external and internal quality characteristics of egg. The length and width of eggs, shell thickness, albumen height, and yolk height (mm) were calculated using an electronic digital calliper. While, the whole egg weight (g), albumen, yolk, and egg shell weight were

ISSN 2072-3857

measured using an electronic digital balance. The egg shape index was determined using the formula egg width/egg length x 100. The shell percentage was calculated using shell weight / egg weight x 100, along with the egg shell ratio. Additionally, Sezer (2007) determined the egg surface area (cm2) to be 3.9782W0.7056, where W is the egg weight. Each egg's individual weight as well as the weight of its constituent parts were used to compute the albumen and yolk ratios. The Haugh Unit was measured according the following equation:

Haugh Unit = 100 log (Albumen height + 7.57 - 1.7 x egg weight 0.37) ………. (Haugh, 1937(

Statistical Analysis

One-way ANOVA analysis was used to evaluate the data using software that used SPSS version 27 (SPSS, 2020). The summary statistics data comprised means and standard error. The significant differences between the various parameters were determined using the Duncan's test at 0.05 levels (Duncan, 1955). Pearson correlation was used to determine the correlation between interior and exterior egg quality.

Results

Table 2 shows the results of production performance of local Japanese quail supplemented with prebiotic, organic and their combination. All additive supplementation significantly (P<0.05) increased the total egg production and egg mass (eggs/bird/day) compared with control group. While, no significant effect was observed (P>0.05) for the parameters of egg weight/bird/day.

Table (2): Effect of different additive supplementations on total egg production, egg weight and egg mass during production (Mean±SE.(

Treatment	**Total Egg Production (%)**	**Egg Weight (g)**	**Egg Mass (g)**
Control	76.90±1.54 ^{b}	11.87±0.63 ^{a}	9.59±0.21 ^{b}
Prebiotic	96.43±0.20 ^{a}	13.12±0.17 ^{a}	11.42±0.54 ^{a}
Organic acid	98.21±0.41 ^{a}	12.67±0.21 ^{a}	12.19±0.09 ^{a}
Mixed	97.85±0.20 ^{a}	12.43±0.24 ^{a}	12.30±0.35 ^{a}
P. value	<0.001	0.155	0.001

a,b Different superscripts indicate different means within the same column (P<0.05 .(

Table 3 shows the results of feed intake and FCR of local Japanese quail supplemented with prebiotic, organic and their combination. No significant effect was observed (P>0.05) for the parameters of feed intake and feed conversion ratio in the use of prebiotic and organic acid source compared to the control group

Table (3): Effect of different additive supplementations on feed intake and FCR during production (Mean±SE.(

Treatment	**Feed Intake (Bird/Day)**	**FCR**
Control	34.37±0.20 ^{a}	2.87±0.15 ^{a}
Prebiotic	33.79±0.19 ^{a}	2.60±0.03 ^{a}
Organic acid	34.16±0.18 ^{a}	2.73±0.03 ^{a}
Mixed	34.70±0.22 ^{a}	2.77±0.04 ^{a}
P. value	0.060	0.228

ISSN 2072-3857

The results of hatchability based on total and fertile eggs varies significantly, as seen by the results in **Table 4**. With the exception of the combination of prebiotic and organic acid, there were no significant (P>0.05) differences between any of the treatments, but the hatchability of the organic acid increased by 96.67% with the total number of eggs. **Table 4** demonstrated that the number of dead embryos during the hatching period was lower in organic and mixed, but not considerably (P>0.05). However, when compared to the control group, the chick weight of organic acid and prebiotic was considerably higher (P<0.05).

Table (4): Effect of different additive supplementations on hatchability percentages, dead embryo and chick weight (Mean±SE).

Treatment	Hatchability (%)		Dead embryo	Chicks weight (g)
	Hatchability of total eggs (%)	Fertile eggs (%)		
Control	94.44±0.55 ^{b}	96.67±0.01 ^{a}	2.22±0.55 ^{a}	8.42±0.11^{c}
Prebiotic	94.44±0.55 ^{b}	96.67±0.02 ^{a}	2.22±0.53 ^{a}	8.52±0.11^{b}
Organic acid	96.67±0.04 ^{a}	97.77±0.55 ^{a}	1.16±0.56 ^{a}	8.75±0.02^{a}
Mixed	91.11±0.51 ^{c}	92.22±0.54 ^{b}	1.11±0.57 ^{a}	8.57±0.01^{b}
P. value	<0.001	<0.001	0.330	<0.001

a,b,c Different superscripts indicate different means within the same column (P<0.05 .(

Table 5 was presented as an effect of prebiotic and organic acid on external and internal egg quality characteristics of local quails at 18 weeks of age. There were positive effects observed among the treatment on the egg weight, egg surface area as external characteristics, egg weight and egg surface area of prebiotic and organic acid significantly (P<0.05) higher compared with control group. Also, shell weight increased in all additive supplementations compared with control group but not statistically. On the other hand, there was no significant difference in other external traits at the end of the experiment. However, when comparing the internal parts of eggs from various additives to the control group, only albumin weight was significantly (P<0.05) larger in all additive supplementations. The other internal parameters showed no significant differences (P>0.05 .(

Table (5): Effect of different additive supplementations on external and internal egg quality characteristics of local quails at 18 weeks of age (Mean±SE.(

Parameters	Treatment				P. value
	Control	Prebiotic	Organic acid	Mixed	
Egg weight (g)	11.80±0.31 ^{c}	13.13±0.17 ^{a}	12.70±0.12 ^{ab}	12.40±0.22 ^{bc}	0.001
Egg length (mm)	34.43±0.26 ^{a}	35.88±0.41 ^{a}	34.81±0.30 ^{a}	35.28±0.68 ^{a}	0.131
Egg width (mm)	27.26±0.22 ^{a}	27.63±0.22 ^{a}	27.51±0.25 ^{a}	27.39±0.27 ^{a}	0.788
Egg surface Area (cm^3)	22.68±0.42 ^{c}	24.47±0.22 ^{a}	23.91±0.16 ^{ab}	23.50±0.29 ^{bc}	0.001
Egg shape index	79.22±0.60 ^{a}	77.06±0.81 ^{a}	79.07±0.68 ^{a}	77.96±1.39 ^{a}	0.322
Shell Weight (g)	1.33±0.05 ^{a}	1.50±0.04 ^{a}	1.49±0.03 ^{a}	1.48±0.05 ^{a}	0.066
Shell %	11.26±0.28 ^{a}	11.46±0.30 ^{a}	11.73±0.22 ^{a}	11.93±0.38 ^{a}	0.438
Albumin Weight	6.23±0.19 ^{c}	7.14±0.11 ^{a}	6.78±0.09 ^{ab}	6.69±0.16 ^{b}	0.001

(g)					
Albumin %	52.87±1.03 ^{a}	54.40±0.63 ^{a}	53.39±0.73 ^{a}	53.95±0.92 ^{a}	0.604
Albumin Height (mm)	5.34±0.20 ^{a}	5.69±0.14 ^{a}	5.71±0.15 ^{a}	5.62±0.19 ^{a}	0.441
Yolk weight (g)	4.23±0.15 ^{a}	4.48±0.12 ^{a}	4.43±0.10 ^{a}	4.22±0.11 ^{a}	0.320
Yolk %	35.86±0.87 ^{a}	34.12±0.67 ^{a}	34.87±0.69 ^{a}	34.12±0.79 ^{a}	0.334
Yolk Height (mm)	13.21±0.19 ^{a}	13.64±0.15 ^{a}	13.37±0.16 ^{a}	13.33±0.19 ^{a}	0.383
Yolk Diameter (mm)	28.02±0.32 ^{a}	28.60±0.28 ^{a}	28.01±0.33 ^{a}	27.49±0.79 ^{a}	0.458
Yolk Index	47.24±0.92 ^{a}	47.73±0.64 ^{a}	47.89±0.98 ^{a}	49.10±1.67 ^{a}	0.687
Haugh Unit	86.39±0.86 ^{a}	86.34±0.62 ^{a}	87.18±0.59 ^{a}	86.66±0.48 ^{a}	0.795

a,b,c Different superscripts indicate different means within the same column (P<0.05 .(

The correlation between internal and external egg quality in the current investigation is displayed in Table 6. The findings showed that albumen weight (0.787, 0.789, and 0.373) and yolk weight (0.646, 0.643, and 0.481) were positively correlated with egg weight, egg surface area, and shell weight, respectively. Additionally, there were substantial variations (P<0.001) in the positive association between yolk diameter and the egg width and egg shape index. However, there was a negative correlation between egg width and the Haugh unit (-0.432) and albumin ratio (-0.405). However, there was only a positive (P<0.05) correlation between albumin weight and egg length .

Table (6): Correlation coefficients among the external and internal egg quality traits in Japanese quails with different additive supplementations.

Parameters	Egg Weight (g)	Egg Surface Area (cm^2)	Egg Width (mm)	Egg Length (mm)	Egg shape Index (%)	Shell Weight (g)	Shell Ratio (%)
Albumen Weight (g)	0.787***	0.789***	0.184	0.284*	-0.176	0.373**	-0.079
Albumen %	0.013	0.017	-0.160	0.044	-0.189	-0.280*	-0.395**
Albumen height (mm)	0.110	0.109	0.087	-0.073	0.143	0.251	0.267*
Yolk Weight (g)	0.646***	0.643***	0.263*	0.165	0.039	0.481***	0.173
Yolk %	-0.097	-0.101	0.014	-0.077	0.113	-0.028	0.034
Yolk Height (mm)	0.202	0.198	0.282*	0.058	0.145	0.242	0.189
Yolk Diameter (mm)	0.202	0.197	0.514***	-0.198	0.528***	0.304*	0.250
Haugh Unit	-0.291*	-0.293*	0.056	-0.140	0.178	0.004	0.217

*Significant at level (P<0.05), ** significant at level (P<0.01) and *** significant at level (P<0.001.(

ISSN 2072-3857

DISCUSIONS

The chicken industry has made extensive use of organic acids and probiotics to enhance the health and performance of hens since antimicrobial growth boosters are banned in several production systems. Numerous studies and applications have been conducted on organic acids, such as fumaric, formic, lactic, butyrate, propionic, and citric acids (Yang et al., 2018; Widya et al., 2024). while, the prebiotic not used widely (Lemos et al., 2014; Rusdi et al., 2023.(

Considering the inulin effects as prebiotic, the improved intestinal environment (fewer harmful bacteria and more friendly bacteria), lower pH of intestinal, and increased digestive enzyme activity in broilers could all account for the increased nutrient digestibility (Huang et al. 2005; Liu et al., 2018). There were no significant differences among treatment on the feed intake and FCR in the present study. Concerning the impact of citric acid on production performance, the findings did not support those of Boling et al. (2000) who found that adding 4% citric acid to laying hens' diets decreased feed consumption and improved FCR. Layer chickens' egg production was greatly increased by the addition of organic acids (Yesilbag and Colpan, 2006; Youssef et al., 2013.(

According to the results by Rusdi et al. (2023) on the effect of different level of chitosan-oligosaccharide as prebiotic additives on the production performance and eggs quality of laying quails. The findings of the trial demonstrated that adding prebiotics to the diet greatly increased feed intake, egg weight, eggshell thickness, HU values ($P<0.05$), and egg production. However, there was no significant difference in the albumen and yolk indices ($P>0.05$.(

While there was no discernible impact on eggshell quality indices, prior research on the quality of eggs in layers revealed that prebiotics had favourable effects on internal egg quality traits includes color of yolk and Haugh unit in layers through the peak production period (Meng et al. 2010; Yan et al. 2010.(

The increase in egg weight in the present study may be due to the addition of prebiotic and organic acid partly concluded by the increase in weight of the shell. A positive effect of prebiotic on egg shell quality parameters in laying hens had been reported by (Swiatkiewiez et al., 2010). This is may be due to stimulating of mineral availability. While according to the research by Lemos et al. (2014) there were no significant observed on the production and egg quality of Japanese quails .

However, prebiotic-rich diets have been shown to increase lactic acid bacteria, which creates an acidic environment in the gastrointestinal system and facilitates the absorption of minerals .

Our findings on the impact of organic acid on shell quality improvement are in line with those of Youssef et al. (2013) who found that adding organic acids (Galliacid) to laying hens' diets at a rate of 0.06% increases shell thickness. Similarly, laying hens' egg shell weight and quality were enhanced by feeding citric acid at 0.2%, according to (Al-Harthi & Attia, 2015). According to Youssef et al. (2013) increasing the absorption of minerals and proteins may result in a thicker shell, which is then reflected in the deposition of calcium and protein in the shell, further improving the quality of the shell .

ISSN 2072-3857

Conclusions

Inconclusion, the additives significantly increased the total egg production and egg mass compared with control. The hatchability was increased in organic acid with total eggs, Also, chick weight of prebiotic and organic acid was increased significantly compared to the control. This investigation has found that addition of inulin as prebiotic had a significant effect on some external and internal quality parameters of local quails .

Conflict of interests

There is no conflict of interest .

Authors contribution

The author has written, drafted, analyzed data, and finalized the manuscript.

Funding

The author has not received any funds for this work.

References

Akter, M., Asaduzzaman M., Islam M.S. and Patoary M.M.U. (2022). Effects of Probiotics and Prebiotics on Growth Performance of Commercial Broiler. Iranian Journal of Applied Animal Science.12(4); 761-770 .

Al-Harthi MA, Attia YA. (2015). Effect of citric acid on the utilization of olive cake diets for laying hens. Italian Journal of Animal Science. 14(3):3966 .

Biggs P, Parsons C.M. and Fahey G.C. (2007). The effects of several oligosaccharides on growth performance, nutrient digestibilities, and cecal microbial populations in young chicks. Poultry Science. 86(11): 2327-36 .

Boling S, Douglas M, Snow J, Parsons C, Baker D. (2000). Citric acid does not improve phosphorus utilization in laying hens fed a corn-soybean meal diet. Poultry Science, 79(9):1335-7 .

Cakir, S., Midilli, M., Erol, H., Simsek, N., Cinar, M., Altintas, A., Alp, H., Altintas, L., Cengiz, Ö. And Antalyali, A. (2008). Use of combined probiotic-prebiotic, organic acid and avilamycin in diets of Japanese quails, Revue de Medecine Veterinaire, 159(11): 565-569 .

Denli M, Okan F, Celik K. (2003). Effect of dietary probiotic, organic acid and antibiotic supplement to diets on broiler performance and carcass yield. Pakistan Journal of Nutrition. 2:89-91 .

Duncan, D. B. (1955). Multiple range and multiple “F” test. Biometrics.11,1-42 .

Fouladi P, Ebrahimnezhad Y, Aghdam Shahryar H, Maheri N, Ahmadzadeh A. (2018). Effects of Organic Acids Supplement on Performance, Egg Traits, Blood Serum Biochemical Parameters and Gut Microflora in Female Japanese Quail (Coturnix coturnix japonica). Brazilian Journal of Poultry Science. 20(1): 133-144 .

Fouladi P, Ebrahimnezhad Y, Shahryar HA, Maheri SN, Ahmadzadeh AR. (2014). Effects of organic acids supplement on performance and gut parameters in male Japanese quail (Coturnix Coturnix). Journal Biological International. 6(2):102-109 .

Gibson G. R., Robert H., Mary E. S., Susan L. P., Raylene A. R., Seppo J. S., Karen S., Catherine S., Kelly S. S., Patrice D. C., Kristin V. and Gregor R. (2017). The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. Gastroenterology and Hepatology. 14: 491-502 .

Gunal M, Yayli G, Kaya O,Karahan N, Sulak O. (2006). The effects of antibiotic growth

ISSN 2072-3857

promoter, probiotic or organic acid supplementation on performance, intestinal microflora and tissue of broilers. International Journal of Poultry Science. 5(2):149-155 .

Haugh, R. (1937). The Haugh unit for measuring egg quality. U.S. Egg Poult Mag, 43, 552-555, 572-573 .

Huang, R. L., Yin Y. L., Wu G. Y., Zhang T. J., Li L. L., Li M. X., Tang Z. R., Zhang J., Wang B., He J. H. and Nie X. Z. (2005). Effect of dietary oligochitosan supplementation on ileal nutrient digestibility and performance in broilers. Poultry Science, 84:1383-1388 .

Langhout P. (2000). New additives for broiler chickens. World Poultry;16(3):22-27.

Lemieux, F. M., Southern L. L. and Bidner T. D. (2003). Effect of mannan oligosaccharides on growth performance of weanling pigs. Journal of Animal Science, 81:2482-2487 .

Lemos, M. J.; Calixto, L. F. L.; Lima C. A.; Reis T. L.; Rego R. S.; Nak, S. Y. And Aroucha R. J. N. (2014). Prebiotic levels in the diet on performance and egg quality of Japanese quail. Rev. Bras. Saúde Prod. Anim., Salvador, 15(3): 613-625 .

Liu, B.Y., Wang A.Y., Yang H.M., Wang X.B., Hu P. and Lu J. (2010). Developmental morphology of the small intestine in Yangzhou goslings. African Journal of Biotechnology. 9(43):7392-7400 .

Meng, Q. W., Yan L., Ao X., Jang H. D., Cho J. H. and Kim I. H. (2010). Effects of chito oligosaccharide supplementation on egg production, nutrient digestibility, egg quality and blood profiles in laying hens. Asian-Australian Journal of Animal Science. 23, 1476-1481 .

Mirza, R. A. (2015). The Effects of Probiotics, Prebiotics and Synbiotics on Gut Flora, Immune Function and Blood Characteristics of Broilers. Ph. D. Thesis, Plymouth University, United Kingdom .

Mirza. R. A. and Kareem K. A. (2023). Bioactive additive in poultry Health and production. Salahaddin University, Erbil, Iraq .

Rusdi, R. , Hasanuddin A., Hafsah, Mulyati, Fatmawati, Sarjuni S. and Nurhaeni (2023). Performance and egg quality of laying quail (Coturnix coturnix japonica) given Chitosan-Oligosaccharide as prebiotic. AIP Conf. Proc. 2628, 030001 .

Sezer, M. (2007). Heritability of exterior egg quality traits in Japanese quail. Journal of Applied Biological Science, 1: 37-40 .

SPSS, IBM (2020). Corp. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp .

Swiatkiewicz, S., Koreleski J. and Arcyewska A. (2010). Laying performance and eggshell quality in laying hens fed diets supplemented with prebiotics and organic acid. Czech Journal of Animal Science.55: 294-304 .

Tavaniello, S., Maiorano G., Stadnicka K., Mucci R., Bogucka J., and Bednarczyk M. (2018). Prebiotics offered to broiler chicken exert positive effect on meat quality traits irrespective of delivery route. Poultry Science. 97:2979-2987 .

White, L. A., Newman M. C., Cromwell G. L. and Lindemann M. D. (2002). Brewers dried yeast as a source of mannan oligosaccharides for weanling pigs. Journal of Animal Science, 80:2619-2628 .

Widya, P. L., Mohammad A. A., Nanik H., Aldhia S., Dynda F. A., Amadea I. Z., Andreas B. Y., Mirni L., Tabita D. M., Ertika F. L., Zein A. B., Aswin R. K., Shendy C. K., Erlycasna B. S. and Abdullah H. (2024). Effect of probiotics and acidifiers on feed intake, egg mass, production performance, and egg yolk chemical composition in late-laying quails. Veterinary World. 17(26): 462-469 .

ISSN 2072-3857

Yan, L. Lee J. H., Meng Q. W., Ao X. and Kim I. H. (2010). Evaluation of Dietary Supplementation of Delta-aminolevulinic Acid and Chito-oligosaccharide on Production Performance, Egg Quality and Hematological Characteristics in Laying Hens. Asian-Australian Journal of Animal Science. 23, (8): 1028-1033 .

Yang, X., Xin, H., Yang, C. and Yang, X. (2018). Impact of essential oils and organic acids on the growth performance, digestive functions and immunity of broiler chickens. Animal Nutrition, 4(4): 388-393 .

Yesilbag, D. and Colpan, I. (2006). Effects of organic acid supplemented diets on growth performance, egg production and quality and on serum parameters in laying hens. Rev. Med. Vet., 157(5): 280-284 .

Youssef, A.W., Hassan, H.M.A., Ali, H.M. and Mohamed, M.A. (2013). Effect of probiotics, prebiotics and organic acids on layer performance and egg quality. Asian Journal of Poultry Science., 7(2): 65-74

.