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Effect of different levels of Labazyme supplementation on production and biochemical traits in quail

A.A. Al-Mjbel[1], A.B. Mohammed[1#], A.S. Abdlwahid[1], T.H. Aljumaily[1], A.M. Mahdi[2], & S.M. Raouf[1]

[1]Department of Animal Production, College of Agriculture, Tikrit University, 34001,Tikrit, Iraq
[2]Agricultural service, the Ministry of Agriculture, Iraq

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Abstract
The study was conducted to determine the effect of different levels of Labazyme (a multi-enzyme with probiotics) on production and biochemical traits in quail. A total of 180 quail were housed in 12 pens; each group was randomly allocated to four replicates (15 hens/replication); Group 1 was designated as the control, Groups 2 and 3 were supplemented with Labazyme at 1000 and 2000 mg/kg, respectively. The addition of Labazyme to the diet substantially increased quail production compared to the control group, and there was a substantial difference in feed intake and improved feed conversion efficiency, with the Labazyme groups generally superior to the control group. The groups did not differ substantially in egg quality parameters. The economic analysis indicated that Labazyme groups were substantially different to the control group. Globulin, total protein, and alkaline phosphatase were substantially reduced, whereas lipid profiles were reduced in Labazyme groups compared to the control. The glutathione level was increased and a decrease in malondialdehyde levels was observed in all groups. In addition, there were no substantial differences in aspartate aminotransferase and alanine aminotransferase in either group. Labazyme can be used in quail feed as a feed additive to improve egg production and reduce lipid profiles.

Keywords: economic evaluation, exogenous enzymes, liver function, productive performance
[#]**Corresponding author:** dr.arkanmohammed@tu.edu.iq

Introduction
Breeding strategies aside, poultry nutritionists have focused on increasing poultry feed efficiency through the use of alternative feed ingredients or feed additives (Carter *et al*., 2013). Improving nutrient utilisation in poultry can reduce feed intake, resulting in cheaper production, less environmental impact on crop or grain production, less environmental impact, and a reduction in undigested/unabsorbed nutrient waste (Carter *et al*., 2013; Mohammed *et al*., 2021). Poultry produce a variety of digestive enzymes. However, due to the presence of anti-nutritive factors that endogenous enzymes cannot combat, endogenous enzyme digestion alone leaves up to 25% of feed undigested (Celi *et al*., 2017; Madigan-Stretton *et al*., 2021). As a result, the significance of gut health in animal production highlights the need to improve food processing and nutrient utilization, as well as product performance and vitality (Burden, 2020). Dong *et al.* (2019) showed that the gastrointestinal tract plays a role in health in a variety of ways, facilitating efficient digestion and absorption, balanced intestinal microbiota, and a healthy immune system. Exogenous enzymes are enzymes active in various feedstuffs. Amylase, lucanase, arabinoxylanase, cellulose, protease and phytase were found to be effective in poultry feed (Kiarie *et al*., 2014; Lee *et al*., 2014). Khattak *et al*. (2006) and Burden (2020) reported that the use of exogenous enzymes in bird feed improves nutrient utilization and growth performance, lowers feed costs, and reduces pollution. Bedford (2018) showed that the successful use of enzyme promoters increases profits in the poultry industry by improving feed efficiency. These additives are used in animal nutrition to improve performance, immunity, and nutrient absorption in the gut. Overall, the poultry industry is

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focused on improving nutrient utilization and disease resistance to reduce indirect costs, improve animal welfare, and reduce the environmental impact of poultry production. Improving poultry production through health and nutrient utilization requires a better understanding of the role of exogenous enzymes (Bischoff, 2011; Mbukwane *et al*., 2022). Thus, this study aimed to assess the impact of using Labazyme in quail feed on egg production, physiological parameters, and economics.

Materials and Methods

The animal experiment was conducted according to the guidelines approved by the Institutional Animal Ethics Committee in the Department of Animal Production, Tikrit University. The product was purchased from a local business in Baghdad, Iraq. The contents of the multi-enzyme and microbiotic supplement, Labazyme, are stated on the company label. Each kilogram contains *Lactobacillus acidophilus* (>2.75×10 CFU), *Streptococcus faecium* (>8.25×10 CFU), *Bacillus subtilis* (>1.1×10 CFU), protease (>2.750 CSU), amylase (>5.500 SLU), and cellulase (>275 FPUI) (Register No. 151-801, Seoul, Korea).

A flock of 180 laying, Japanese quail, aged 13 weeks, were used in the trial conducted from 11 to 20 weeks of age at the poultry facilities of the Department of Animal Production, Tikrit University. Quail were housed in 12 pens, with three groups of four replicates each and 15 quail per pen. The pens measured approximately 80 × 40 × 50 cm^3. The photoperiod consisted of 16L:8D hours/day. Each pen was randomly assigned to three diets, with four replicates per group, using a fully randomized design. The independent variable of this experiment was diet and consisted of three groups: Group 1, the control maize–soybean basal diet; Groups 2 and 3 consisted of 1000 and 2000 gm/kg of Labazyme (Table 1).

Table 1 Feed ingredients of the basal diet used during the eight-week quail feeding trial

Ingredients (% as fed)	(%)
Yellow maize (8.5% crude protein)	55.7
Soybean (44% crude protein)	27
Wheat	5
Vegetable oil	2.5
Primix[1]	5.2
Salt	0.3
Di-calcium phosphate	4
Limestone	0.3
Chemical Composition[2]	
Metabolisable energy, Kcal/kg	2940.5
Crude Protein, %	19.26
Phosphorous, %	0.57
Lysine, %	1.09
Methionine, %	0.46
Methionine+cysteine, %	0.77
Calcium, %	2.28
Crude fibre, %	3.42

[1] Premix (1 kg of Premix): vit. E, 500 IU; vit. B_{12}, 0.06 mg; vit. B_1, 67 mg; vit. A, 334000 IU; vit. D_3, 67000 IU; vit. B_2, 1000 mg; vit. B6, 0.66 mg; folic acid, 17 mg; choline, 17000 mg; N, 1000 mg; Mg, 3.334 mg; Zinc, 334 mg; Iron, 1.667 mg; Cu, 10 mg; I, 17 mg; Met, 27000 mg; P, 10.6%, and Se, 0.20 mg
[2] according to the NRC (1994)

Egg production was recorded daily; weekly egg weight, feed intake, and feed conversion efficiency were recorded. Feed intake was calculated by subtracting the total amount of feed weighed over a specified period from the amount weighed back at the end of the specified period. Feed consumption was then calculated to average consumption per hen per day by dividing the calculated consumption by the number of quail in each pen and the total number of days in the predetermined time period. Feed conversion was calculated by dividing feed intake by egg mass. The eggshell was weighed after all components had been scraped out. Egg mass was calculated by multiplying percentage egg production by egg weight. Eggshell percentage was calculated using the formula:

Egg shell (%) = (shell weight × 100/ egg weight)

Haugh units were calculate as per the equation provided by (Haugh, 1937). An economic score (average feed intake, average egg production (%), feed cost/kg, income from eggs sold, and total return) for this trial was calculated according to (Al-Harbawi, 2019). Egg sales were based on wholesale prices.
Blood samples were taken from four quails in each group. At the end of the experiment, the quails were sacrificed, and bled individually into a siliconized tube containing anticoagulant to obtain serum. Sterile vials containing anticoagulant (heparin) were centrifuged at 3000 rpm for 10 min. The serum was separated and stored in a deep freezer at -80 ^{o}C until lipid, biochemical, and oxidative analysis. The concentrations of glutathione (GSH) and malondialdehyde (MDA) in the serum were determined according to (Guidet *et al*., 1989). Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) concentrations were determined in the serum using spectrophotometric methods (Biolabo/Franch). Glucose, total protein, albumin, uric acid, cholesterol, triglyceride, and high-density lipoprotein were determined spectrophotometrically (Apel Type) using a kit (Apinreact, Spain), as per the manufacturer's instructions. Globulin was calculated as:

Globulin = serum total protein - serum albumin

Very low density-lipoprotein (VLDL) and low density-lipoprotein (LDL) were calculated as:
VLDL = 5/triglyceride;
LDL= (Cholesterol – HDL - VLDL)

Quail egg laying performance was analysed using SAS (V.9., SAS Institute Inc. Cary, North Carolina, USA), and significant differences between the means were determined using Duncan's multiple range test (Duncan, 1953). The effect of Labazyme dietary supplements on interperiod egg production and lipid profiles was determined using analysis of variance and was charted using GraphPad Prism (version 8.0.1).

Results and Discussion

Quail egg production performance (%), egg weight (g), egg mass (g/hen/d), and cumulative egg numbers are shown in Table 2. The interaction between the groups was not significant in the first two weeks of age for egg production (%); but Labazyme supplementation produced different results (P <0.05) from 15 weeks of age in groups 1 and 2, compared to the control. The egg weight (g) of the hens was different (P <0.05) between groups 1 and 2 and the control group, and the effect of the feed additives (Labazyme) on egg mass and cumulative number was significant between the groups (Table 2). Our results showed that the addition of 1000 and 2000 mg/kg of a multi-enzyme with probiotics (Labazyme) to the feed resulted in significant differences between groups. There were differences in feed intake and feed conversion efficiency, with the hens in the additive groups having the lowest and best feed intake and feed conversion efficiency values compared to the control (Table 3). Similarly, Labazyme dietary supplements improved (P <0.05) feed intake and feed conversion efficiency in groups 1 and 2 when compared to the non-supplemented control group (Table 3).
The bioactivity of Labazyme (multi-enzyme with probiotics) in quail hen feed was shown to improve egg production. According to the findings, Labazyme has a synergistic effect as it contains probiotics and a group of digestive enzymes capable of forming complexes with essential nutrients. The release of these nutrients helps improve nutrient utilization and had a beneficial effect on the quail egg production and decreased the feed intake with better feed conversion efficiency. We believe there are a number of mechanisms through which enzymes can help remove antibiotic growth promoters and reduce the risks associated with their use. These mechanisms include shifting digestion to other gut segments, using the posterior gut microbiome, the production of fermentable oligosaccharides, and enhancing enterocyte proliferation (Bedford *et al*., 2012). According to Yörük *et al*. (2004) and Mikulski *et al*. (2012), probiotic supplementation not only increases egg production, but also improves feed conversion efficiency, hen performance, and eggshell quality. Some probiotic strains work by stimulating appetite, improving gut balance, stimulating digestive enzymes, reducing colonization by pathogenic microorganism, and improving nutrient absorption in poultry (Yasar *et al*., 2018). Enzymes play a role in all digestive and metabolic pathways, anabolic and catabolic, leading to increased performance (Chimote *et al*., 2009). Markowiak and Ślizewska (2017) showed that microorganisms such as *Lactobacillus*, *Bifidobacterium,* and *Streptococcus* had beneficial effects on gut function and improved nutrient digestibility.

Table 2 Effect of Labazyme supplementation on Japanese quail production

Trait			Group 1 (Control)	Labazyme Group 2 1000 mg/kg	Labazyme Group 3 2000 mg/kg
Egg Production (%)	Period (1)	Week 13	85.71 ± 1.94	82.14 ± 1.19	84.52 ± 2.28
		Week 14	79.76 ± 4.50	88.09 ± 2.38	89.28 ± 2.26
		Week 15	78.56 ± 5.66[b]	92.85 ± 3.07[a]	90.48 ± 4.08[a]
		Week 16	76.19 ± 7.01[b]	88.09 ± 1.27[a]	89.28 ± 2.09[a]
	Period (2)	Week 17	76.19 ± 3.88[b]	88.09 ± 3.07[a]	86.90 ± 1.19[a]
		Week 18	77.38 ± 3.57[b]	83.33 ± 2.38[a]	91.66 ± 2.99[a]
		Week 19	69.04 ± 7.40[b]	84.52 ± 2.28[a]	88.09 ± 3.07[a]
		Week 20	71.42 ± 6.73[b]	90.47 ± 4.34[a]	89.28 ± 3.57
Egg weight (g)	Period (1)	Week 13	11.53 ± 0.08	11.05 ± 0.05	11.48 ± 0.23
		Week 14	11.45 ± 0.14[a]	11.15 ± 0.04[b]	11.80 ± 0.10[b]
		Week 15	11.73 ± 0.16[ab]	11.53 ± 0.09[b]	11.92 ± 0.04[a]
		Week 16	11.31 ± 0.32[b]	11.68 ± 0.18[ab]	12.09 ± 0.03[a]
	Period (2)	Week 17	11.68 ± 0.09[b]	11.97 ± 0.12[ab]	12.41 ± 0.19[a]
		Week 18	11.66 ± 0.12[b]	12.33 ± 0.10[a]	12.42 ± 0.10[a]
		Week 19	11.50 ± 0.33[b]	12.31 ± 0.04[a]	12.47 ± 0.07[a]
		Week 20	11.73 ± 0.17[b]	12.46 ± 0.06[a]	12.48 ± 0.10[a]
Egg mass (g/h/d)	Period (1)	Week 13	9.88 ± 0.20[a]	9.07 ± 0.12[b]	9.71 ± 0.33[ab]
		Week 14	9.14 ± 0.59[b]	9.78 ± 0.23[ab]	10.54 ± 0.22[a]
		Week 15	9.20 ± 0.59[b]	10.70 ± 0.31[a]	10.79 ± 0.04[a]
		Week 16	8.61 ± 0.83[b]	10.29 ± 0.22[a]	10.79 ± 0.27[a]
	Period (2)	Week 17	8.91 ± 0.49[b]	10.54 ± 0.28[a]	10.78 ± 0.13[a]
		Week 18	9.01 ± 0.35[b]	10.27 ± 0.27[a]	11.39 ± 0.46[a]
		Week 19	7.92 ± 0.83[b]	10.41 ± 0.31[a]	10.98 ± 0.38[a]
		Week 20	8.37 ± 0.76[b]	11.27 ± 0.49[a]	11.15 ± 0.50[a]
Cumulative egg number	Period (1)	Week 13	6.00 ± 0.13	5.75 ± 0.08	5.91 ± 0.15
		Week 14	5.58 ± 0.31[a]	6.16 ± 0.16[a]	6.25 ± 0.16[a]
		Week 15	5.50 ± 0.39[b]	6.50 ± 0.21[a]	6.33 ± 0.18[ab]
		Week 16	5.33 ± 0.49	6.16 ± 0.09	6.25 ± 0.16
	Period (2)	Week 17	5.33 ± 0.27[b]	6.17 ± 0.21[a]	6.08 ± 0.08[a]
		Week 18	5.41 ± 0.25[b]	5.83 ± 0.16[ab]	6.41 ± 0.20[a]
		Week 19	4.83 ± 0.51[b]	5.91 ± 0.15[a]	6.16 ± 0.21[a]
		Week 20	5.00 ± 0.47[b]	6.33 ± 0.30[a]	6.25 ± 0.25[a]

[a,b].Means with different superscripts within each column are significantly different (P <0.05)

Other studies show that multi-enzyme and probiotic supplementation can improve egg production (Chimote *et al*., 2009; Markowiak & Ślizewska, 2017). In addition, Effiong *et al.* (2019) suggested that enzyme additions to monogastric animal feed could reduce digestive viscosity in the gut and improve the morphological effects of feed fibre materials in poultry. Furthermore, Sjofjan & Adli (2020) also report that probiotics or enzymes can increase laying hen production. Bedford (2018) showed that broilers fed either separately or a combination of enzyme supplements had improved growth performance, feed intake, and feed conversion rate, and enzyme supplementation improved egg production in white Leghorn laying hens. In another study, Chimote *et al*. (2009) found that probiotic supplementation increased egg production and feed efficiency. This could be because the small and large intestines are stronger, they have a suppressive effect on bad bacteria, and stimulant effects on the growth and activity of good bacteria in the gut, improving nutrient absorption.

Table 3 Effect of Labazyme supplementation on feed intake (g/bird) and feed conversion efficiency of Japanese quail

Trait			Group 1 (Control)	Labazyme	
				Group 2 1000 mg/kg	Group 3 2000 mg/kg
feed intake (g/bird)	Period (1)	Week 13	33.53 ± 1.11[a]	30.97 ± 3.02[ab]	26.34 ± 1.08[b]
		Week 14	35.21 ± 2.19[a]	33.41 ± 2.00[ab]	26.44 ± 3.08[b]
		Week 15	34.79 ± 1.45[a]	32.75 ± 2.30[ab]	26.94 ± 1.95[b]
		Week 16	33.28 ± 3.11	32.03 ± 1.49	27.18 ± 2.03
	Period (2)	Week 17	39.13 ± 1.98[a]	30.02 ± 0.31[b]	27.99 ± 0.29[b]
		Week 18	37.15 ± 0.93[a]	29.29 ± 0.84[b]	27.74 ± 0.29[b]
		Week 19	36.10 ± 1.39[a]	29.13 ± 0.64[b]	26.46 ± 0.81[b]
		Week 20	37.84 ± 0.91[a]	29.84 ± 0.74[b]	27.99 ± 0.82[b]
feed conversion efficiency	Period (1)	Week 13	3.39 ± 0.11	3.43 ± 0.34	2.77 ± 0.18
		Week 14	3.88 ± 0.28[a]	3.44 ± 0.24[a]	2.49 ± 0.24[b]
		Week 15	3.82 ± 0.26[a]	3.05 ± 0.18[b]	2.49 ± 0.17[b]
		Week 16	3.87 ± 0.10[a]	3.12 ± 0.19[b]	2.53 ± 0.24[b]
	Period (2)	Week 17	4.46 ± 0.43[a]	2.85 ± 0.08[b]	2.59 ± 0.04[b]
		Week 18	4.13 ± 0.13[a]	2.75 ± 0.05[b]	2.44 ± 0.11[b]
		Week 19	4.70 ± 0.47[a]	2.80 ± 0.08[b]	2.41 ± 0.05[b]
		Week 20	4.60 ± 0.42[a]	2.66 ± 0.08[b]	2.51 ± 0.07[b]

[a,b].Means with different superscripts within each column are significantly different (p < 0.05).

The effect of Labazyme on egg quality parameters is shown in Table 4. No significant interaction was observed between groups for Haugh units, yolk (%), albumin (%), eggshell (%), and eggshell thickness (mm). Our results confirmed the results of Haryati (2011) and Panda *et al.* (2003), who reported that dietary supplementation with probiotic or enzymes had no effect on egg quality parameters. According to Widiyanto and Indrawan (2018), probiotics have a substantial impact on eggshell thickness. Yalçin *et al*. (2008) suggested that probiotics and enzymes could improve egg quality in hens fed an enzyme-supplemented diet. Dipeolu *et al*. (2005) discovered that hens fed enzyme or enzyme/antibiotic diets produced the best egg quality.

Table 4 Effect of Labazyme supplementation on the egg quality parameters of Japanese laying quail

Trait	Group 1 (Control)	Labazyme	
		Group 2 1000 mg/kg	Group 3 2000 mg/kg
Haugh unit (%)	89.43 ± 0.84	89.88 ± 0.99	90.98 ± 1.56
Yolk (%)	31.82 ± 0.69	30.87 ± 0.70	31.13 ± 1.01
Albumin (%)	57.30 ± 0.57	58.57 ± 0.58	58.49 ± 1.17
Eggshell (%)	10.87 ± 0.40	10.55 ± 0.18	10.37 ± 0.23
Eggshell thinness (mm)	0.29 ± 0.00	0.30 ± 0.00	0.29 ± 0.00

The economic impact of using Labazyme as a feed additive for quail is presented in Table 5. The results showed a difference (P <0.05) between the groups. The average feed intake was different in groups 2 and 3 during period 1 and overall (56 days) compared to the control group, but similar in period 2. When compared to the control, the addition of Labazyme (1000 and 2000 mg/kg) substantially reduced feed costs compared to the control. When we compared the control to groups 2 and 3, it had the highest revenue from sales and total return. Labazyme groups reduced feed costs compared to the control group and achieved the highest total return and sales, with a substantial increase in total egg production (%). Our results are consistent with those of Percic *et al*. (2011), Shehata *et al*. (2018), and Abd El-Baky (2018).

Table 5 Economic evaluation of the effect of Labazyme supplementation in Japanese quail

Trait	Group 1 (Control)	Labazyme	
		Group 2 1000 mg/kg	Group 3 2000 mg/kg
Period 1 (week 13–16)			
Average feed intake (g/hens)	34.20 ± 1.56[a]	32.60 ± 2.01[a]	26.73 ± 1.08[b]
Average egg production (%)	22.42 ± 1.08	24.58 ± 0.29	24.74 ± 0.31
Feed cost/kg	0.47 ± 0.02[a]	0.46 ± 0.02[a]	0.38 ± 0.01[b]
Income from egg sold	1.24 ± 0.05[b]	1.36 ± 0.01[a]	1.37 ± 0.01[a]
Total return	0.77 ± 0.04[b]	0.90 ± 0.02[a]	0.99 ± 0.03[a]
Period 2 (week 17–20)			
Average feed intake (g/hens)	37.50 ± 1.12	36.20 ± 1.80	33.20 ± 0.98
Average egg production (%)	20.58 ± 1.29	24.26 ± 0.31	24.91 ± 0.41
Feed cost/bird	0.52 ± 0.01	0.51 ± 0.02	0.47 ± 0.01
Income from egg sold	1.14 ± 0.07[b]	1.35 ± 0.01[a]	1.38 ± 0.02[a]
Total return	0.62 ± 0.07[b]	0.83 ± 0.02[a]	0.91 ± 0.03[a]
Total (56 days)			
Average feed intake (g/hens)	35.86 ± 1.26[a]	34.40 ± 1.80[a]	29.97 ± 0.76[b]
Average egg production (%)	43.00 ± 2.23[b]	48.84 ± 0.52[a]	49.66 ± 0.70[a]
Feed cost/bird	1.00 ± 0.03[a]	0.97 ± 0.05[ab]	0.85 ± 0.02[b]
Income from egg sold	2.39 ± 0.12[b]	2.72 ± 0.02[a]	2.76 ± 0.04[a]
Total return	1.39 ± 0.03[b]	1.75 ± 0.03[a]	1.91 ± 0.05[a]

[a,b].Means with different superscripts within each column are significantly different (P <0.05)

The lipid profiles are shown in Figure 2. The Labazyme supplement had an effect on cholesterol, triglycerides, high-density lipoprotein, low-density lipoprotein, and very low-density lipoprotein between groups during the experimental period (P <0.05). Our data show increased (P <0.05) serum levels of high-density lipoprotein in groups 2 and 3 in quail serum, compared to the control. The mechanism of action of Labazyme's cholesterol reduction may involve probiotic strains and groups of digestive enzymes that inhibit the expression of Niemann–Pick C1-Like 1a protein and thereby decrease cholesterol absorption (Perić *et al*., 2011; Shehata *et al*., 2018). Hydroxymethylglutaryl coenzyme (A) may be reduced, which is a fatty acid biosynthetic enzyme and can convert cholesterol in the gut to coprostanol, which can be excreted in faeces; the supplementation may inhibit cholesterol biosynthesis (Yao *et al*., 2017; Widiyanto *et al*., 2018).
The results of this study are consistent with Mohan *et al.* (1995), Panda *et al.* (2006), and Aluwong *et al.* (2013), and demonstrate that the probiotics cause a reduction in serum lipid profiles. According to Cho and Kim (2015), the *Lactobacillus* strain causes a substantial decrease in lipid profiles. Our results agree with Siadati *et al.* (2017) and Yazhini *et al*. (2018), who reported that probiotic supplementation lowered the serum cholesterol level in poultry. However, this disagrees with Shirisha *et al.* (2017), who observed no significant difference between the treatments in cholesterol levels.

The effects of Labazyme supplementation on biochemical parameters are presented in Table 6. Plasma glucose levels in quail were different (P <0.05) between the groups. Group 3 (2000 mg/kg Labazyme) had the lowest serum glucose compared to group 2 (1000 mg/kg Labazyme) and the control (no-supplementation). However, Labazyme had an impact on the total protein and immune response (globulin) in Japanese quail serum at 20 w of age. Total protein, globulin, and alkaline phosphatase levels were increased in hen serum in group 3 (2000 mg/kg), compared to group 2 and the control. To our knowledge, administration of 1000 and 2000 mg/kg of Labazyme had no effect on plasma albumin and uric acid levels in hen's serum (Table 6). The serum glucose results in our study could be due to the mode of action of the probiotic bacteria on glucagon, which lowers serum glucose (Panda *et al*., 2006; Shirisha *et al*., 2017; Yazhini *et al*., 2018). Our data show that Labazyme supplementation also increases alkaline phosphatase, concurring with Pourakbari *et al.* (2016), who reported that alkaline phosphatase activity increased with probiotic supplementation. In contrast, other studies report no effects on serum alkaline phosphatase activities (Pourakbari *et al*., 2016; Long *et al*., 2017).

Labazyme improved the antioxidant measurements in quail (Table 6). Serum GSH content was increased in groups 2 and 3, compared with the control. Furthermore, serum MDA levels were substantially reduced in the Labazyme groups compared to the control group. Serum ALT and AST activity were similar between the groups (Table 6). In addition to serum antioxidant parameters, the antioxidative capacity is also an important indicator for characterizing the extent of oxidative stress in the body, due to the key role of the liver in metabolism in animal studies. It is normally exposed to high concentrations of reactive oxygen species and is sensitive to oxidative stress (Li *et al*., 2019). According to Vieco-Sazi *et al.* (2019) and Ebeid *et al*. (2021) probiotics are involved in stimulating endogenous enzymes and reduce toxic substances generated by metabolic reactions. Yao *et al*. (2017) noted that probiotic antioxidant mechanisms have been reviewed in terms of their ability to enhance the antioxidant system and their ability to reduce radical generation. Similarly, Świątkiewicz *et al*. (2016) found no difference in blood parameters such as creatinine, GOT, GPT, and glucose between the dietary treatments.

Table 6 Effect of Labazyme supplementation on the biochemical parameters of Japanese laying quail

Trait	Group 1 (Control)	Labazyme	
		Group 2 1000 mg/kg	Group 3 2000 mg/kg
Glucose (mg/dL)	240.72 ± 12.75[a]	229.72 ± 2.12[b]	185.79 ± 9.43[b]
Total protein (g/dL)	2.50 ± 0.15[b]	3.04 ± 0.31[a]	3.87 ± 0.14[a]
Albumin (g/dL)	1.47 ± 0.07	1.33 ± 0.10	1.53 ± 0.16
Globulin (g/dL)	1.03 ± 0.15[b]	1.71 ± 0.38[a]	2.34 ± 0.16[a]
Uric acid (mg/dL)	3.78 ± 0.47	4.94 ± 0.29	3.74 ± 0.44
Alkaline phosphatase	30.73 ± 0.66[b]	31.36 ± 1.39[b]	36.44 ± 1.81[a]
GSH (nmol/mL)	7.85 ± 0.44[b]	9.47 ± 1.04[b]	10.50 ± 0.97[a]
MDA (nmol/mL)	0.63 ± 0.04[a]	0.59 ± 0.04[a]	0.42 ± 0.03[b]
ALT (U/L)	64.25 ± 1.31	59.75 ± 2.39	57.00 ± 1.58
AST (U/L)	62.25 ± 3.81	58.75 ± 3.81	56.75 ± 2.28

[a,b] Means with different superscripts within each column are significantly different ($p < 0.05$).

Conclusions

In conclusion, Labazyme (1000 and 2000 mg/kg) had a significant impact on quail performance, lipid profiles, anti-oxidants, and the economic evaluation. Labazyme has a different mode of action as it contains different strains of probiotics and multi-enzymes that contribute to improving feed conversion efficiency and reduce feed intake. The results indicate that the use of exogenous enzymes improves feed efficiency with effects on feed intake and reduced feed costs. A relationship was established between Labazyme and various response variables (egg production, feed intake, feed conversion efficiency, and economics). Our results indicate that Labazyme (1000 and 2000 mg/kg) can be used as a feed additive in quail diets.

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Author`s contributions

AA, AM, AA, and TA contributed to the planning and research work in study design and writing. AA, AM, and TA contributed to the nutritional aspects of the work. AM and AR contributed to writing. AA, AR, and AA were involved in the data collecting, statistical analysis, and drafting of the manuscript. All authors read and approved the final manuscript.

Conflict of Interests Declaration

The authors declare that they have no conflict of interest.

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