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The Effect of Adding Soybean Bioactive Peptides on Productive Performance, Some Digestive and Visceral Traits, and Blood Biochemical Parameters of Japanese Laying Quail

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Abstract | The aim of the study is to identify safe and promising natural food additives and supplements including Soybean Bioactive Peptides (SBP) that can improve the health, growth and productivity of birds. Among these additives are. For this purpose, a total of 72 Japanese laying quail were used in the study, distributed into four treatments with three replicates for each treatment with three levels of SBP (1, 2, 3 g/kg of feed). The results showed a significant superiority of the T4 (3g/kg feed) in egg production, average egg weight, and a significant improvement in feed conversion ratio (FCR) for the third and fourth treatments (2g/kg feed and 3g/kg feed, respectively). The relative weight of intestine and heart for the supplementation treatments, the relative weight of liver and gizzard for the third treatment, and a significant increase in total protein, globulin, and high-density lipoprotein (HDL) for the third and fourth treatments, and LDL for the supplementation treatments. Albumin and albumin-to-globulin ratios decreased significantly. There were no significant differences in feed consumption, relative weight of ovary and oviduct, glucose, triglycerides, cholesterol, very low-density lipoprotein (VLDL), and liver enzymes ALT and AST among the experimental treatments. We conclude from the study that the addition of (SBP) may have nutritional functions that enhance production and improve the nutritional value of feed and some blood serum biomarkers, which support the health and productivity of birds.

Keywords | Soybean bioactive peptides, Productive performance, Serum, Oviduct, Ovary, Japanese laying quail

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INTRODUCTION

Antibiotics have been used in poultry feed in recent decades to improve feed efficiency and the health of poultry flocks. Currently, the use of antibiotics has been banned in many countries around the world due to the serious biological threats they pose to human and animal health, and their use has led to the development of new generations of antibiotic-resistant bacteria. Hence, the need to search for alternatives such as safe, non-toxic food supplements and additives that can support the functions of the digestive and immune systems and increase productivity in birds (Nosrati *et al*., 2017; Toghyani *et al*., 2010; Muhammad *et al*., 2020; Al-Doori and Allaw, 2021; Al-Doori *et al*., 2024).

Soybeans are an important source of high-quality vegetable protein and have numerous health benefits. Major (SBP) can be produced by in vitro enzymatic hydrolysis or microbial fermentation of soybeans (Wei *et al*., 2024). These peptides have superior properties to soybeans, being more stable, digestible, and absorbable, and possessing multifunctional activities, such as antioxidants (Chatterjee *et al*., 2018). Soybean peptides have been added to poultry diets in several previous studies, and their positive effects have been found.

They can improve intestinal morphological development, regenerate dead cells caused by pathogenic bacterial infections, enhance immunity, and stimulate beneficial bacteria in the gut (Abdollahi *et al*., 2017, 2018; Wei *et al*., 2024). Adding peptides to feed increases its nutritional value and enhances antimicrobial resistance due to their resistance to bacteria. They also do not produce any toxic residues that could harm the environment or human health (Silveira *et al*., 2021). When added to poultry feed, SBP has shown positive results by improving intestinal morphology, immunity, and intestinal microflora, as well as enhancing metabolic function (Peng *et al*., 2025).

This study aimed to evaluate the addition of (SBP) to the diet on productive performance, visceral function, and serum biochemical parameters of Japanese laying quail.

MATERIALS AND METHODS

Our study was carried out in the animal field designated for animal experiments and equipped with all the requirements for animal and bird breeding affiliated to the College of Agriculture - Tikrit University for the period from 9/10/2024 to 11/10/2024, to evaluate and study the effect of adding several levels of (SBP) (commercially manufactured) to the diets of Japanese laying quails on productive performance and some characteristics of the viscera, digestive and reproductive systems and blood serum biochemical values. A total of 72 Japanese quail laying, brown, 8-week-old birds were used in the field experiment. The experiment was designed with four treatments, with 18 birds in each group and each treatment with three replicates, with (6) birds per replicate, as follows: Treatment 1: Control treatment without any additives; Treatment 2: Adding (SBP) at 1 g/kg feed; Treatment 3: Adding (SBP) at 2 g/kg feed; Treatment 4: Adding (SBP) at 3 g/kg feed. The birds were housed in a quail rearing hall with an area of 5*4 square meters, equipped with iron floor cages divided into two compartments, each compartment (replicated) measuring 70*50*40 cm length*width*height, equipped with a hanging feeder, a 2-liter water trough, and LED lighting for 16 hours a day. The floor was covered with 8 cm thick rice husks. An electric heater was used to provide a temperature of 22-25°C, and a medium-sized air extractor was used to expel stale air from the hall to the outside. The experiment was divided into four production periods: (8-10) weeks, (11-12) weeks, (13-14) weeks, and (15-16) weeks. The egg production rate, cumulative number of eggs, average egg weight, average egg mass, feed consumption, and (FCR) were studied. Eggs were collected daily according to the production for each period, and according to the (FCR) for egg production (g feed/g egg). After the end of the experiment, 3 birds from each replicate were taken and dissected after carcass removal. The weight and length of the oviduct and ovary were measured using a metric tape measure. The relative weight of the eaten internal organs (heart, liver, gizzard) was measured. Blood samples were collected during carcass removal using 6 ml tubes and separated in the physiology laboratory using a centrifuge at 3000 rpm for 10 minutes to obtain serum, which was collected in small tubes and stored in a refrigerator at -18°C. Serum tests included (total protein, albumin, glucose, triglycerides, cholesterol, HDL, LDL, VLDL, AST, ALT).

$$\text{H.D\%} = \left(\frac{\text{Number hen days in the period}}{\text{Number of eggs produced during the period}}\right)\text{days}$$

$$\text{Average egg mass (g)} = \frac{\text{Average egg weight (g)} \times \text{Average egg production (H.D) \%}}{100}$$

$$\text{Food conversion ratio (kg feed/kg egg} = \frac{\text{Amount of feed consumed during a given period (g)/bird}}{\text{Egg mass during the same period (g)/bird}}$$

Soybean peptides and feed formulation

SBP produced by Vanavaran Novin Joestar Biotechnology Co., Tehran, Iran, were used. The peptides were in the form of yellow powder. The feed was prepared in the animal feed factory using a 1-ton vertical electric feed mixer connected to an electric grain crusher. The feed was divided into 50 kg and mixed using a 50 kg horizontal electric mixer to mix the BAPs with the supplementary feeds. Table 1 shows the proportions of feed materials and additives included in the feed composition.

Statistical analysis

The statistical analysis of the experimental data was conducted using a completely randomized design (CRD) within the ready-made statistical program (SAS, 2012) to study the influence of factors. Duncan's test (1955) was conducted to determine the significance of differences between the means of the coefficients at a probability level of (p<0.05).

RESULTS

The effect of adding three different levels of SBP to the diet of Japanese laying quail on egg production, egg weight, egg mass, feed consumption, and feed conversion efficiency (Table 2). Regarding egg production, we observed no significant differences between all experimental treatments over the 8–10-week period. During the second, third, and fourth periods, we observed a significant

Table 1: The proportions of feed materials and additives included in the composition of the feed with the calculated chemical composition.

Ingredient	%
Yellow corn	55
Soybean meal (48%) CP	33
Sunflower oil	2
Lysine	0.25
Methionine	0.25
Limestone	6.25
Dicalcium	3
Salt (NaCl)	0.25
Total	100
***Calculated Nutrients**	
Metabolizable energy (Kcal/kg)	2827
Crude protein (%)	21
Crude fiber (%)	3.67
Calcium (%)	3.07
Available phosphorus (%)	0.18
Lysine (%)	1.28
Methionine+ Cysteine (%)	0.62

* The NRC (1994) guide was used to calculate the chemical analysis of the feed.

superiority ($P<0.05$) for the fourth treatment compared to the remaining treatments of the first, second, and third experiments, respectively. Regarding egg weight, the results of the first and second periods indicated no significant differences between all experimental treatments. During the third and fourth periods, we observed a significant superiority ($p < 0.05$) in favor of the fourth treatment compared to the control treatment. The results for egg mass indicated no significant differences between the experimental treatments during the first rearing period. During the second, third, and fourth periods, we observed a significant superiority ($p < 0.05$) in favor of the fourth treatment compared to the remaining experimental treatments. Regarding feed consumption, we did not find significant differences between the experimental treatments. Regarding feed conversion efficiency, there were no significant differences between all experimental treatments during the first rearing period. During subsequent rearing periods, we observed a significant improvement ($p < 0.05$) in favor of the fourth treatment (adding 3 g/kg of (SBP)) compared to the remaining experimental treatments.

The results of Table 3 indicate the effect of adding three different levels of (SBP) to the diet of Japanese laying quail on the percentages of intestine weight, ovary weight, oviduct weight, liver, heart, and gizzard. Regarding relative intestine weight, we observed a significant superiority ($p < 0.05$) for the second, third, and fourth treatments compared to the control treatment. As for the ovary and oviduct weight traits, there were no significant differences between all experimental treatments. Regarding the relative weight of the liver, we found a significant superiority ($p < 0.05$) for the third treatment compared to all experimental treatments, and the second and fourth treatments outperformed the first treatment. Regarding the relative weight of the heart, we found a significant superiority ($p < 0.05$) for the three (SBP) added treatments compared to the control treatment. Regarding the relative weight of the gizzard, we found a significant superiority ($p < 0.05$) for the third treatment compared to the control treatment, while there was no significant difference between the second and fourth treatments.

Table 2: Effect of adding soybean bioactive peptides on egg production, weight and mass of eggs produced, feed consumption and feed conversion ratio (mean ± standard error.

Treat-ments	Period (week)			
	First period	Second period	Third period	Fourth period
	8-10	10-12	12-14	14-16
Hen day production (H.D)				
T1	61.11±5.55a	61.11±5.55b	61.11±5.55 b	72.22±5.55 b
T2	50.00±9.62a	55.55±5.55b	72.22±5.55 b	77.77±5.55ab
T3	50.00±9.62a	66.66±9.62b	72.22±5.55 b	88.88±5.55ab
T4	66.66±9.62a	88.88±5.55a	94.44±5.55 a	94.44±5.55 a
Egg weight rate				
T1	9.90±0.20a	10.36±0.18a	10.33±0.33 b	11.06±0.29 c
T2	9.66±0.08a	10.40±0.40a	11.16±0.44ab	11.83±0.44bc
T3	9.33±0.44a	11.00±0.57a	11.26±0.14ab	12.33±0.33ab
T4	9.43±0.31a	11.20±0.41a	11.63±0.46 a	13.16±0.16 a
Egg mass				
T1	6.07±0.66 a	6.32±0.52 b	6.33±0.69 b	7.96±0.39 c
T2	4.84±0.95 a	5.82±0.82b	8.05±0.62 b	9.25±0.96 bc
T3	4.72±1.02 a	7.27±0.89b	8.14±0.64 b	10.94±0.58ab
T4	6.25±0.83 a	9.94±0.62a	10.94±0.31 a	12.44±0.81 a
Feed intake				
T1	31.33±0.66a	29.33±2.60a	29.33±0.88 a	30.66±0.88 a
T2	27.66±2.40a	32.33±0.88a	30.00±2.64 a	30.33±0.33 a
T3	29.66±0.33a	31.33±0.33a	28.33±0.88 a	29.33±0.33 a
T4	28.66±0.33a	30.33±0.88a	30.66±0.88 a	30.66±0.33 a
Feed conversion ratio (FCR)				
T1	5.27±0.52 a	4.65±0.27ab	4.73±0.47 a	4.86±0.14 a
T2	6.35±1.61 a	5.78±0.82a	3.75±0.37 ab	3.35±0.37 ab
T3	6.99±1.66 a	4.45±0.59ab	3.51±0.18 b	2.70±0.16 bc
T4	4.74±0.60 a	3.08±0.28b	2.81±0.15 b	2.48±0.19 c

*Different letters within one column indicate the presence of significant differences at the probability level ($p \le 0.05$). T1= control (without any addition), T2= 1 gm/kg of (SBP), T3= 2 gm/kg of (SBP), T4= 3 gm/kg of (SBP).

Table 3: Effect of adding soybean bioactive peptides on reproductive and digestive system traits (mean ± standard error).

Treatments				Items
T4	**T3**	**T2**	**T1**	
5.44±0.50 a	6.18±0.19 a	5.95±0.24 a	4.42±0.18 b	Intestinal weight%
4.21±0.18 a	3.49±0.23 a	3.48±0.73 a	3.66±0.7 a	Ovarian weight%
3.08±0.02 a	2.94±0.07 a	3.11±0.30 a	2.75±0.19 a	oviduct weight%
2.59±0.14 b	3.15±0.6 a	2.81±0.10 b	2.19±0.07 c	Liver%
0.81±0.03 a	0.84±0.01 a	0.77±0.01 a	0.62±0.3 b	Heart%
2.11±0.17 ab	2.35±0.26 a	2.12±0.13 ab	1.60±0.02 b	Gizzard%

*Different letters within one column indicate the presence of significant differences at the probability level ($p \leq 0.05$). T1= control (without any addition), T2= 1 gm/kg of (SBP), T3= 2 gm/kg of (SBP), T4= 3 gm/kg of (SBP).

Table 4: Effect of adding soybean bioactive peptides on the biochemical characteristics of blood serum of female laying quails (mean ± standard error).

Treatments				
T4	**T3**	**T2**	**T1**	**Items**
4.45±0.06 b	4.46±0.15 b	4.77±0.03 a	4.07±0.04 c	TP
2.15±0.07 b	2.10±0.01 b	2.18±0.05 b	2.64±2.64 a	Albumin
2.30±0.07 a	2.36±0.16 a	2.59±0.02 a	1.43±0.05 b	globulin
0.93±0.05 b	0.90±0.07 b	0.84±0.02 b	1.85±0.09 a	A/G ratio
368.58±2.30 a	354.92±5.30 a	380.84±0.16.97 a	366.92±0.77 a	Glucose
459.04±8.84 a	416.82±9.65 a	412.70±17.25 a	438.73±19.13 a	TC
811.33±8.22 a	816.22±12.67 a	830.22±15.32 a	826.89±23.66 a	TG
50.97±0.81 a	40.42±1.04 c	53.21±0.74 a	46.30±0.69 b	HDL
245.81±8.98 a	213.15±22.53ab	193.44±13.94 b	227.05±18.41ab	LDL
162.26±1.64 a	163.24±2.53 a	166.04±3.06 a	165.37±4.72 a	VLDL
15.82±0.31 a	14.30±0.72 a	14.52±0.53 a	14.46±0.46 a	AST (U/L)
285±8.32 a	276.66±16.14 a	277.00±10.53 a	252.66±15.33 a	ALT (U/L)
5.81±0.04 ab	4.90±0.31 b	5.53±0.50 ab	6.37±0.21 a	Uric acid (mg/100 Ml)

*Different letters within one column indicate the presence of significant differences at the probability level ($p \leq 0.05$). T1= control (without any addition), T2= 1 gm/kg of (SBP), T3= 2 gm/kg of (SBP), T4= 3 gm/kg of (SBP). TP: Total protein, A/G ratio: Albumin/globulin, TC:, Cholesterol TG: Triglycerides, HDL: high-density fats, LDL: low-density fats, VLDL: Very low density fats.

The effect of adding different levels of (SBP) on the biochemical properties of the blood serum of Japanese white quail (Table 4). We note a significant increase ($p < 0.05$) for the second treatment in the total protein of the blood serum compared to the rest of the experimental treatments. As for albumin, we note a significant increase ($p < 0.05$) for the control treatment compared to the addition treatments. We find a significant superiority ($p < 0.05$) for globulin in the addition treatments compared to the control treatment. We find a significant superiority ($p < 0.05$) for the albumin/globulin ratio in the control treatment compared to the addition treatments. We find no significant difference in glucose between the control treatment and the rest of the addition treatments. Regarding lipid profiles, there was no significant difference in blood cholesterol, triglycerides, and very low-density lipoprotein (VLDL) values between all experimental treatments. For high-density lipoprotein (HDL), we found a significant ($p < 0.05$) superiority for the second and fourth addition treatments compared to the control and third treatments. For low-density lipoprotein (LDL), we found a significant ($p < 0.05$) superiority for the fourth treatment compared to the second treatment. Regarding liver function enzymes, there were no significant differences in AST and ALT values between all experimental treatments. However, there was a significant ($p < 0.05$) superiority for the control treatment in uric acid compared to the second treatment.

DISCUSSION

The significant superiority in egg production rates for treatments supplemented with SBP for quail females may be due to the role of the peptides in increasing the length of intestinal villi and increasing the surface area of the intestine (Abdollahi *et al*., 2017), regulating the balance of intestinal microflora, and increasing the availability and readiness of crude protein and fat in the feed, which improves the digestibility of nutrients, which may contribute to stabilizing egg production and maintaining weight (Pan *et al*., 2019).

The increase in egg production rates for treatments supplemented with (SBP) may be due to their containing multiple essential amino acids that meet the high nutritional needs of egg-producing quail females. The reason for the increase in egg weight rates may be due to the peptides containing nutritional factors that are easily digestible and absorbed, which work to quickly provide the bird with its nutritional needs to meet its high egg production. Therefore, productive performance is linked to the abundance of absorbed peptides present in the bloodstream, as found by (Hou *et al*., 2017). The microflora reduced the metabolism of small peptides compared to the same amount of free amino acids. The higher egg mass in the fourth treatment was due to its effect on egg production and weight, which is directly proportional to egg mass.

Because peptides are easily digestible, amino acids are prepared more quickly, protein metabolism increases, and feed conversion ratios and amino acid balance in feeds are improved (Alagawany *et al*., 2022). The higher relative weight of the intestine in the treatments supplemented with (SBP) may be due to the peptides' role in improving the growth and length of villi and increasing the surface area of the intestine. This morphological development increases the average weight of the intestine. The higher weight of viscera, such as the liver and heart, in the treatments supplemented with peptides may be due to their content of essential amino acids for quail, which prepare the body for tissue building and repairing and regenerating damaged cells. Additionally, the increased gizzard weight in the peptide treatments may be due to the fact that (SBP) are free of oxidizing agents. Anti-nutritional properties reduce gastrointestinal acidity, improve digestion and microflora, and stimulate the secretion of digestive enzymes.

The main end product of nitrogen metabolism is uric acid, which is excreted in feces. Serum uric acid concentration is an indicator of kidney function in chickens (Sturkie and Griminger, 1986). It has been used to detect kidney damage and disease, as a uric acid concentration above 13 mg/dL indicates impaired kidney function in birds (Thrall *et al*., 2012). The results of the study showed that all treatments were within the normal range for uric acid concentrations, despite a significant decrease in the serum of birds treated with (SBP).

The reason for the variation in the higher albumin levels in the control treatment and the higher globulin concentrations in the serum of the treatments supplemented with (SBP) between experimental treatments is due to variations in total protein concentrations. Serum total protein concentrations were higher in the birds treated with the supplementation treatments compared to the control treatment, as a result of the balance. Microbial and digestive function improved, which further enhanced nutrient absorption due to the contribution of lactic acid bacteria in secreting digestive enzymes that break down proteins and convert them into amino acids that are readily absorbed, thus increasing their concentration in the form of total protein in the blood serum. The improved biochemical indicators of birds fed diets containing soybean peptides are attributed to the nutrient availability of these protein fractions, and this may be linked to the lower molecular weight of these peptides (Sa'adoon and Abbas, 2024). Antioxidant peptides with a high content of essential amino acids, such as phenylalanine, tryptophan, and titanium, have the ability to donate electrons (Girgih *et al*., 2015).

CONCLUSION

Adding (SBP) to the diets of Japanese laying quail improves their production performance, intestinal health, and edible viscera, modifies blood lipid levels, and enhances immune function. We recommend adding (SBP) at a rate of 3g/kg to the diets of laying Japanese quail to improve production, feed conversion efficiency, and enhance bird and digestive health.

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NOVELTY STATEMENT

This study provides results supporting the positive effects of (SBP) on improving several productive traits, as well as some visceral traits and blood parameters in female Japanese quail. This study is significant for its ability to test the potential of (SBP) in the diet of Japanese quail.

AUTHOR'S CONTRIBUTION

ADSA-D: Conceived and planned the scientific research idea, supervised the formulation of bird diets, conducted statistical analysis of data, and interpreted the results. He also contributed to the final version of the manuscript.
SAJA-D: Contributed to scientific support for the research idea, contributed to data collection, and supervised the care and management of the birds.

AADA-D: Contributed to bird management and supervised the provision of field experiment supplies.
AAA: Reviewed the final version of the manuscript.

Generative AI and AI-assisted technology statement

The authors declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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