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Effects of ginger and purslane supplemented diets on the production and physiology of Japanese quail

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Abstract The Japanese quail is considered one of the most significant species in the poultry industry. Various dietary strategies aim to improve the quality of quails and reduce or eliminate the use of antibiotics. Therefore, depending on the use of herbal plants, a new trend exists to provide high-quality feed. This study aims to provide insight into the possible improvement effects of ginger and purslane powder concentrations (1% and 2%) on the growth performance and reproductive aspects of quail and to implement a completely randomized design (CRD) in triplicate. The results revealed that 1% ginger powder significantly influenced the final week of feed intake, resulting in minimum cholesterol and blood sugar levels in the blood. The data indicated that 1% purslane powder affected body weight and weight gain. It also has a positive effect on blood attributes, including PCV, Hb, amylase, and HDL, while the lowest LDL level is recorded. The application of 2% purslane resulted in the highest feed conversion ratio (FCR) and lipase blood parameters. The male quail presented the highest levels of PCV, Hb, and HDL but the lowest levels of blood sugar and TG. However, the female quail presented the lowest levels of cholesterol and LDL and the highest total protein. The findings of this study suggest that incorporating herbal plants like ginger and purslane into Japanese quail diets can enhance poultry quality. Such dietary supplements may offer natural, cost-effective alternatives for improving the health and productivity of quails, benefiting breeders and farmers in the poultry industry.

Keywords: *Coturnix japonica*, herbal diet, quality, reproductive, blood attributes

1. Introduction

The demands from consumers, wholesalers, and chains of restaurants for antibiotic-free meat, coupled with the risk of antibiotic resistance and rigorous controls on antibiotic usage, strongly motivate poultry producers to adopt antibiotic-free production practices (Safavipour et al., 2022). Notably, the efficient manufacturing of poultry meat from antibiotic-free poultry necessitates a paradigm shift (Lu et al., 2019). Nonetheless, this presents a substantial challenge for the poultry breeding industry. Without antibiotics as tools to sustain optimal gut function, even minor intestinal disorders can swiftly transition into chronic impairments, detrimentally impacting the efficiency of breeders (Kiarie and Mills, 2019). The removal of antibiotics from livestock feed has a negative effect on feed efficiency, growth enhancement, and feed conversion ratio (Sheiha et al., 2020). Global society, particularly researchers, is increasingly prioritizing safety trends, with a focus on natural components such as probiotics (El-Saadony et al., 2022), prebiotics (Yaqoob et al., 2021), plant extracts (Abou-Kassem et al., 2021), and bioactive medicinal herbs (Nahed et al., 2022). Today, numerous medicinal herbs rich in phytochemicals are being explored as potential substitutes for antibiotics and growth promoters because of the prevention of antibiotic use in livestock in many regions (Nemati et al., 2021). Ginger (*Zingiber officinale Roscoe*), a medicinal herb, belongs to the Zingiberaceae family (Policegoudra and Aradhya, 2007). The ginger rhizome is rich in and contains vitamins, fatty acids, amino acids, and minerals. Additionally, it contains several compounds, such as gingerol, gingerdione, gingerdiol, and shagaol. These substances are powerful stimulants of the mucous membranes in the intestines and enhance the process of digestion. (Dieumou et al., 2009; Nahed et al., 2022). Ginger contains various phenolic components, each of which has numerous bioactivities (Ma et al., 2021). Annually, the production of powder, ginger drinks, flakes, and ginger extracts results in a substantial quantity of waste and byproducts. These compounds could be used as cost-effective feed additives in the animal industry (Gao et al., 2021). These findings underscore the promising role of ginger as a natural additive in poultry feed formulations, potentially improving both production efficiency and bird health (Al-Shuwaili et al., 2015). Other medicinal herbs can serve as natural additives in poultry

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feed formulations, such as purslane plants. Purslane (*Portulaca oleracea*) has garnered significant attention since the discovery of its notable nutritional advantages because it is rich in antioxidant qualities, omega-3 fatty acids, and phenolic components (Montoya-García et al., 2023). The high nutrient content of purslane can potentially enhance the nutritional profile of broiler feed, leading to better feed utilization by poultry (Wang et al., 2021). In addition, Japanese quail (*Coturnix coturnix japonica*) belongs to Asia, northern Africa, Asia, and Europe. Raising Japanese quail has been described as both economically sustainable and highly productive (Batool et al., 2023). Quail production is a developing sector within the poultry industry that introduces diversity among poultry meats. Multiple strains have been chosen for both egg and meat yield (Sabow, 2020). According to the insights mentioned above, there is a growing global demand for quail meat consumption. To increase quail quality the objective of this study was to increase the growth performance and meat quality of Japanese quail by incorporating active herbal powders such as ginger and purslane into their feed formulation.

2. Materials and Methods

2.1. Experimental birds

This study was conducted at the College of Agricultural Engineering Sciences, University of Raparin, Kurdistan Region, Iraq. The total duration of this experiment was 42 days. In this study, 225 one-day-old unsexed Japanese quail chicks were collected from a local hatchery. The quails were randomly divided into five treatment groups of three replicates, with 15 birds per replicate. Housing conditions remained consistent for all chicks throughout the experiment. The temperature was initially maintained at 35°C during the first week and then gradually decreased by 3°C per week until it stabilized at 25°C for the remainder of the trial. The relative humidity was 55% - 65%.

2.2. Housing and management

Each replicate was housed in a cage (90 cm, 45 cm, and 25 cm). It was thoroughly washed and disinfected before the chicks arrived. The washing process involved the use of fresh tap water, followed by drying at the conclusion. Uniform environmental conditions were maintained for all the quails throughout the experiment. The lighting program consisted of 23 hours of light and 1 hour of darkness for the first week of age, with subsequent weekly reductions of one hour of light until the conclusion of the 42-day trial period. Both water and experimental diets were provided *ad libitum*.

2.3. Experimental diets

The responses of quail to different dietary levels of ginger and purslane powder were evaluated from 1--42 days. Owing to the specific environmental conditions of breeding, a commercial diet with 22% CP and 2900 kcal/kg was implemented. The birds were provided with the initial meal for the entire duration of the experimental trial, which lasted 42 days. The five treatments were designed in the following approach: Treatment (T) T1: A control group receiving a basal diet; T2: The basal diet was enriched with ginger powder at a concentration of 1% of the total feed supplied. T3: The basal diet was supplemented with ginger powder at a concentration of 2% of the total feed offered. T4: The basal diet was supplied with purslane powder at a concentration of 1% of the total feed offered. T5: The basal diet was enriched with purslane powder at a concentration of 2% of the total feed offered. All the treatments were organized according to a completely randomized design (CRD).

2.4. Preparation of ginger and purslane powder

Ginger and purslane were purchased from a local market. The samples were subsequently cleansed and washed with tap water, chopped into small pieces, and air-dried under shade at 25°C. After drying, they were ground to produce a homogeneous powder and stored at room temperature until feeding. Table 1 summarizes the ingredients of ginger and purslane powder.

Table 1 Constituents of the basal feed alongside ginger and purslane poder.

Diet properties (%)	Basal feed value	Ginger value	Purslane value
Ash	2.96	0.0	4.15
Fat	2.27	2.86	2.87
Moisture	11.15	11.0	12.11
Protein	20.8	16.34	27.27
Fiber	4.26	7.11	13.33

2.5. Growth performance and blood serum parameters

Body weight (BW), weight gain (WG), and feed intake (FI) were measured on day one; this process was repeated each week in a cage. These parameters were calculated for each replicate and growth period via the following equations:

WG (g) = BW at the end of the week − BW at the beginning of the week

The feed conversion ratio (FCR) was computed via the following formula:

$$FCR = \frac{FI\ during\ a\ feeding\ period}{WG\ during\ the\ same\ period}$$

On day 42, blood samples were collected from four birds per treatment, two males and two females, via the wing vein. Blood samples (1 mL/bird) were collected into EDTA tubes and centrifuged (3000 rpm for 10 min) at room temperature. The resulting plasma was stored at -20°C until analysis. The plasma samples were analyzed for PCV, Hb, cholesterol, blood sugar, amylase, lipase, total protein, HDL, LDL, and TG.

2.6. Statistical data analysis

The data were analyzed via one-way ANOVA-CRD via XLSTAT statistical analysis software version 2019.2.2. The differences between means were compared via Duncan's new multiple range test at $p \leq 0.05$. Additionally, principal component analysis (PCA) was implemented to observe the relationships between the observations and blood variables.

3. Results

3.1. Effects of herbal supplementation on growth performance

The data in this study, which were analyzed via analysis of variance (ANOVA) for Japanese quail, revealed significant differences among the studied variables at a significance level of $p \leq 0.05$ across diverse diets of ginger and purslane applied at varying concentrations (Figure 1). In terms of body weight (Figure 1a), during the first week, supplementation did not significantly influence body weight. During the triple-week period (weeks 2--4), the purslane diet supplemented with basal feed at a concentration of 1% appeared to be the most influential treatment for body weight, resulting in the highest weight per quail (67.07 g, 119.70 g, and 168.50 g, respectively) among the other treatments. This herbal dose led to an average weight increase of 16.24% in the second week, 11.63% in the third week, and 9.25% in the fourth week compared with the 2% ginger herbal supplement, which presented the lowest values. For the final two weeks under basal conditions (control), a positive response was observed across various attributes during the feeding process, with the maximum weights recorded as 201.60 g and 220.40 g, respectively, for the fifth and sixth weeks. In contrast, the groups receiving 1% ginger in the fifth week (182.20 g) or 1% purslane in the sixth week (209.70 g) presented the lowest body weight. In terms of weight gain (Figure 1b), the quail fed a 2% purslane diet presented considerably better results than those in all the other treatment groups, with higher values recorded for the first (25.23 g) and fourth (52.20 g) weeks. In contrast, ginger in the 2% diet during the first week and basal feed (control) during the fourth week produced the lowest values (21.33 g and 46.09 g, respectively). When the quail were subjected to the feeding process in the second and fifth weeks, the basal feed (control) resulted in the greatest weight gain, reaching 35.51 g and 41.70 g, respectively. Moreover, ginger at 2% for the second week (28.47 g) and 1% for the fifth week (28.77 g) achieved the lowest gains. Additionally, among the treatments, the greatest increase in weight during the third (52.37 g) and sixth (46.30 g) weeks was observed with the application of a 1% purslane diet. Conversely, a decrease in weight gain (45.33 g) was noted in quails during the third week when the purslane dose was increased to 2%. Furthermore, during the sixth week, the basal group presented the lowest gain (28.40 g).

The findings shown in Figure 2 demonstrate the significant impacts of the herbal and basal diets on feed intake and FCR. The results revealed varying levels of feed intake across the different treatments (Figure 2a). Specifically, the utilization of the basal feed resulted in the highest feed intake during weeks 1-3 and 5, surpassing the recorded values of 46.63 g, 70.43 g, 127.77 g, and 141.83 g for the other treatments. Notably, during the fourth week, the purslane in the 1% diet led to increased feed efficiency, with the highest intake recorded at 154.13 g. Similarly, ginger at 1% in the final week had a maximum intake of 144.87 g. Conversely, the feed intake level was the lowest when the level of the purslane diet was increased to 2%, with values of 40.23 g, 137.67 g, and 134.57 g during the first, fourth, and sixth weeks, respectively. Additionally, treating quail with ginger at 1% mixed with the basal feed led to a decline in feed intake to the lowest levels during the second (63.10 g), third (100.30 g), and fifth (118.37 g) weeks. These results underscore the differential effects of herbal and basal diets on feed intake in quails. On the basis of the data in Figure 2b, significant variations were observed in FCR per quail. Increasing the percentage of ginger to 1% increased the FCR in the first week, and the highest value (2.10 g) was recorded, whereas the lowest value (1.70 g) was registered by increasing the percentage of purslane to 2%. In the second week, the FCR reached the maximum value (2.23 g) under purslane at 1%, but the sole basal diet resulted in the minimum ratio (1.98 g). During the third and sixth weeks, the maximum converse (2.60 g and 4.60 g, respectively) was observed when 2% purslane was applied. Conversely, 1% ginger for the third week (2.07 g) and 1% purslane for the sixth week (3.07 g) resulted in the most significant decrease in FCR. For the fourth week, the best ratio (3.13 g) was achieved under basal feed compared with the herbal diet treatments. Purslane at 1% had the lowest value compared with the highest value (13.00%). During the fifth-week growing period, the application of 1% ginger increased the food ratio to the highest value (4.30 g) among the other treatments. In contrast, purslane at the same level of diet decreased the ratio to the lowest value (3.50 g).

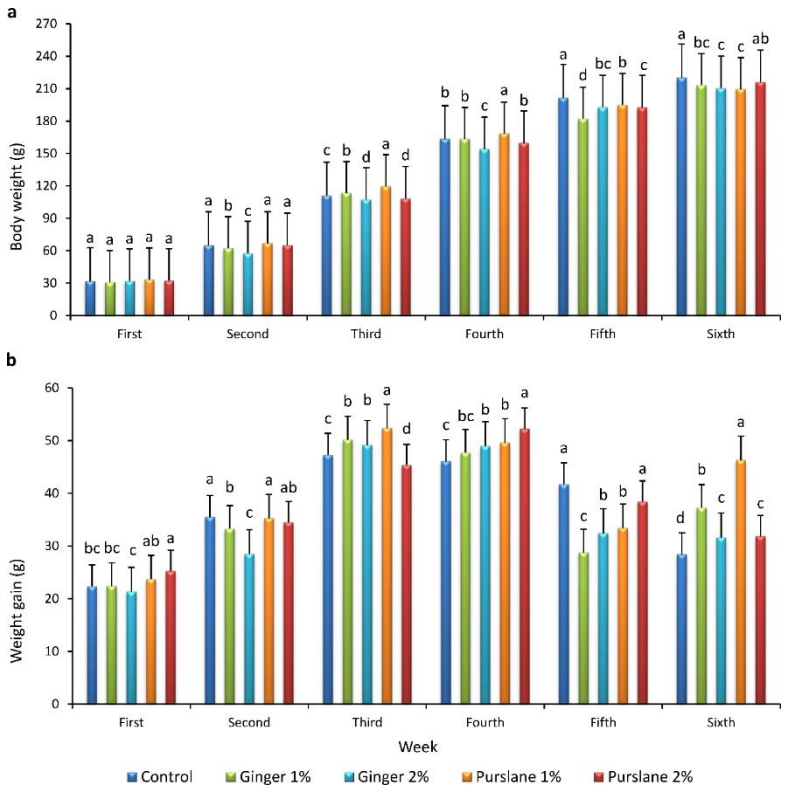

Figure 1 illustrates the effects of the basal and herbal diets on body weight and weight gain during the six-week feeding process. Column bars represent the means ± SDs (n=3) of the data, with distinct letters indicating significant differences between treatments at the 5% significance level, as determined by Duncan's test.

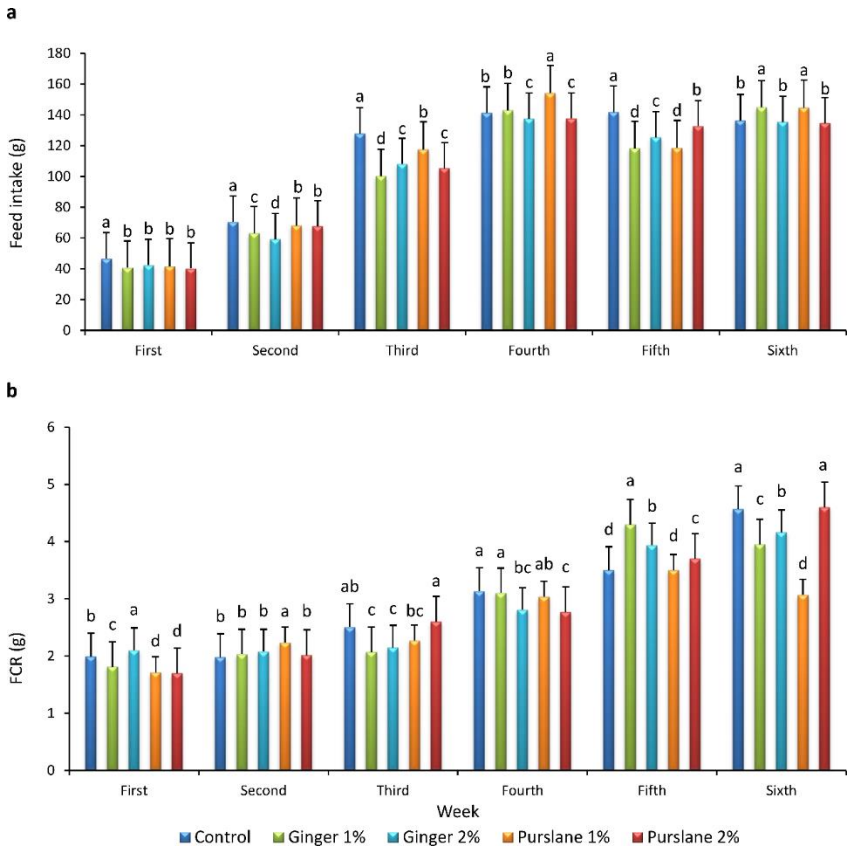

Figure 2 illustrates the effects of the basal and herbal diets on the feed intake and FCR during the six-week feeding process. Column bars represent the means ± SDs (n=3) of the data, with distinct letters indicating significant differences between treatments at the 5% significance level, as determined by Duncan's test.

3.2. Effects of herbal supplementation on blood characteristics

This study evaluated the blood characteristics of Japanese quail subjected to different concentrations of various herbal supplements, which play crucial roles in poultry quality. The results indicated that ginger and purslane significantly impacted the reported traits. The findings revealed that purslane at a 1% dose had significantly greater values for PCV (50.83 g/dL), Hb (15.17 g/dL), cholesterol (186.77 mg/dL), amylase (1192.0 U/L), and HDL (100.85 mg/dL) (Figure 3a, b, c, e, h). In contrast, quail fed solely a basal diet presented lower values for PCV (40.67 g/dL), Hb (12.28 g/dL), HDL (66.66 mg/dL), cholesterol (167.33 mg/dL), and amylase (320.67 U/L) when ginger was supplemented at a 1% level. The blood sugar and LDL contents (Figure 3d, i) in the basal diet (control) were significantly different from those in the other concentrations and were highest (238.17 mg/dL and 105.91 mg/dL, respectively), whereas the 1% ginger content for blood sugar (217.67 mg/dL) and the 1% purslane content for LDL (48.61 mg/dL) presented the lowest values. With respect to lipase (Figure 3f), the 2% purslane treatment increased the level of lipase (592.50 U/L), whereas it decreased with the basal diet (control) and was lowest (56.17 U/L). For the total protein content (Figure 3g), 1% ginger had the greatest effect on the total protein content (3.40 g/dL), but the effect of the 1% purslane diet also increased to 2.57 g/dL. The feed did not significantly affect the TG levels of quail (Figure 3j), as indicated by p values ≤ 0.05. Notably, decreasing cholesterol, blood sugar, LDL, and TG levels increased the quality of meat.

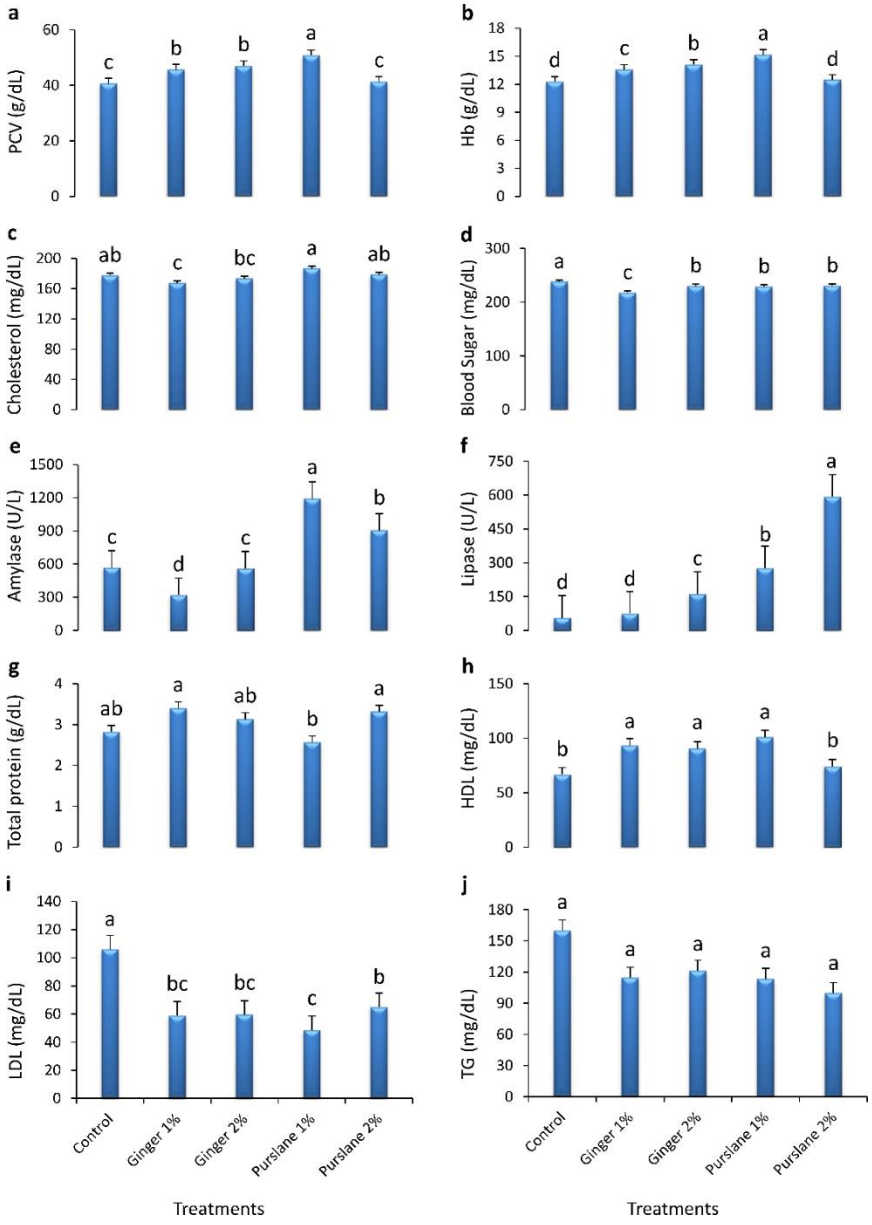

Figure 3 shows the effects of the basal and herbal diets on blood characteristics during the six-week feeding process. Column bars represent the means ± SDs (n=3) of the data, with distinct letters indicating significant differences between treatments at the 5% significance level, as determined by Duncan's test.

3.3. Effects of male and female sex on blood characteristics

Figure 4 depicts the effects of male and female quail on blood attributes. The maximum mean values of PCV (48.00 g/dL), Hb (14.34 g/dL), cholesterol (210.52 mg/dL), HDL (109.55 mg/dL), and LDL (87.83 mg/dL) were observed in male quail. A comparison of females and males revealed a significant decrease in descriptive data and average values of 13.74%, 12.82%, 47.36%, 81.12%, and 85.00%, respectively (Figure 4a, b, c, h, i). The blood sugar, total protein, and TG contents increased the most in the female quail, with the highest values recorded (232.87 mg/dL, 3.44 g/dL, and 152.67 mg/dL, respectively). Compared with males, females presented a 3.28% increase in blood sugar, 29.81% in total protein, and 68.29% in TG (Figure 4d, g, j). Moreover, the mean values for enzyme attributes such as amylase and lipase were not significantly affected by males or females at $p \leq 0.05$ (Figure 5e, f).

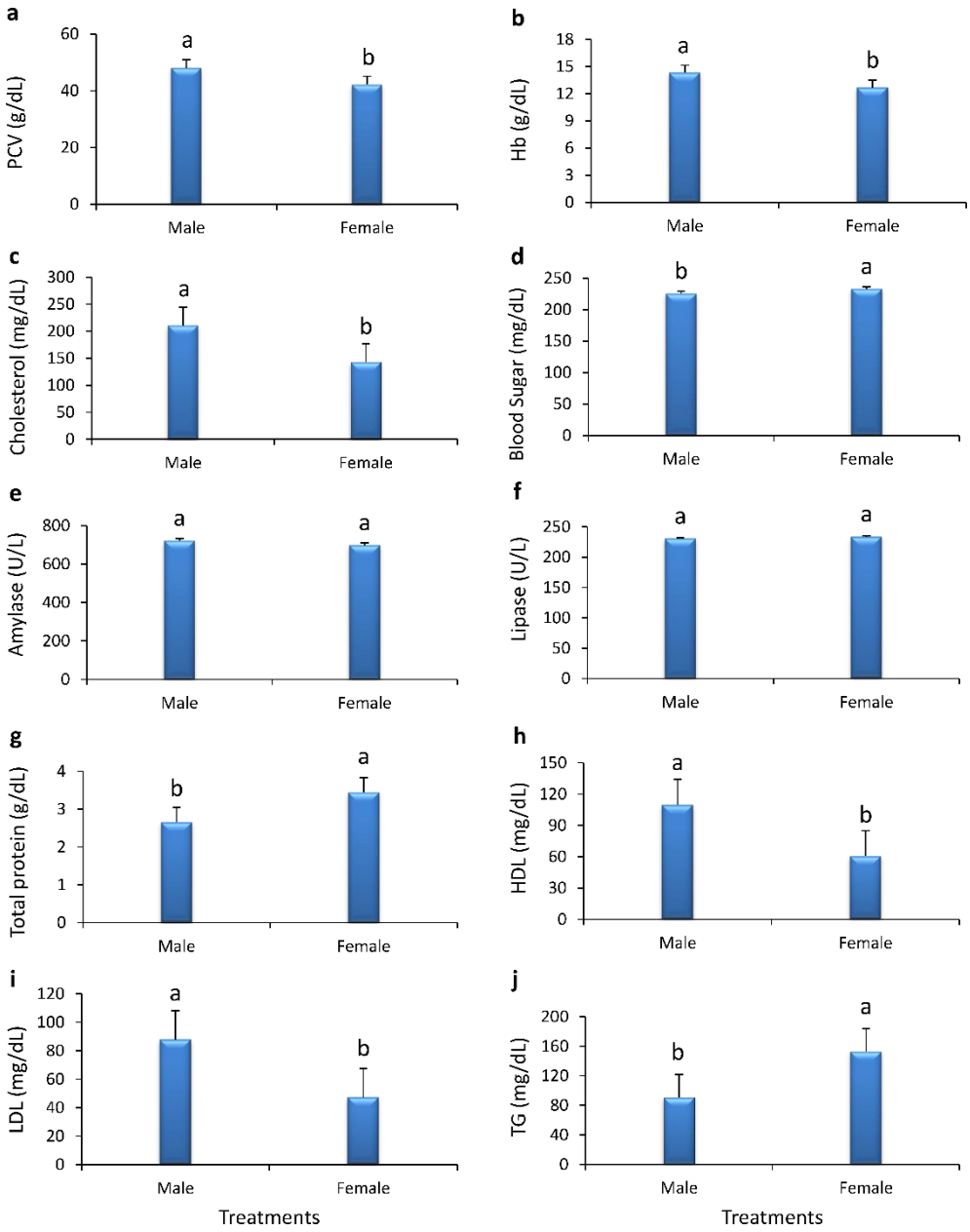

Figure 4 illustrates the effects of male and female sex on blood characteristics during the six-week feeding process. Column bars represent the means ± SDs (n=3) of the data, with distinct letters indicating significant differences between treatments at the 5% significance level, as determined by Duncan's test.

3.4. PCA for blood characteristics

PCA was utilized to reveal the associations between the blood parameters and the variables under investigation. PC1 and PC2 collectively explained 77.49% of the overall variability and are depicted as two axes of variation in Figure 5. PC1, which

represents the horizontal axis, accounted for the largest proportion of variance (46.40%), whereas PC2, which represents the vertical axis, contributed 31.08% to the total variance. Japanese quail fed the basal diet (control) had strong effects on blood sugar, LDL, and TG, resulting in a decrease in the quality of the quail. A strong correlation was observed between ginger at a 1% concentration and total protein. However, a weak correlation was recorded between the same treatment and cholesterol levels as well as blood sugar. Despite this, it led to an increase in the production quality of quail. A slight association was noted between 2% ginger and HDL. The use of 1% purslane significantly impacted PCV, Hb, and amylase, whereas the use of 2% purslane strongly influenced lipase.

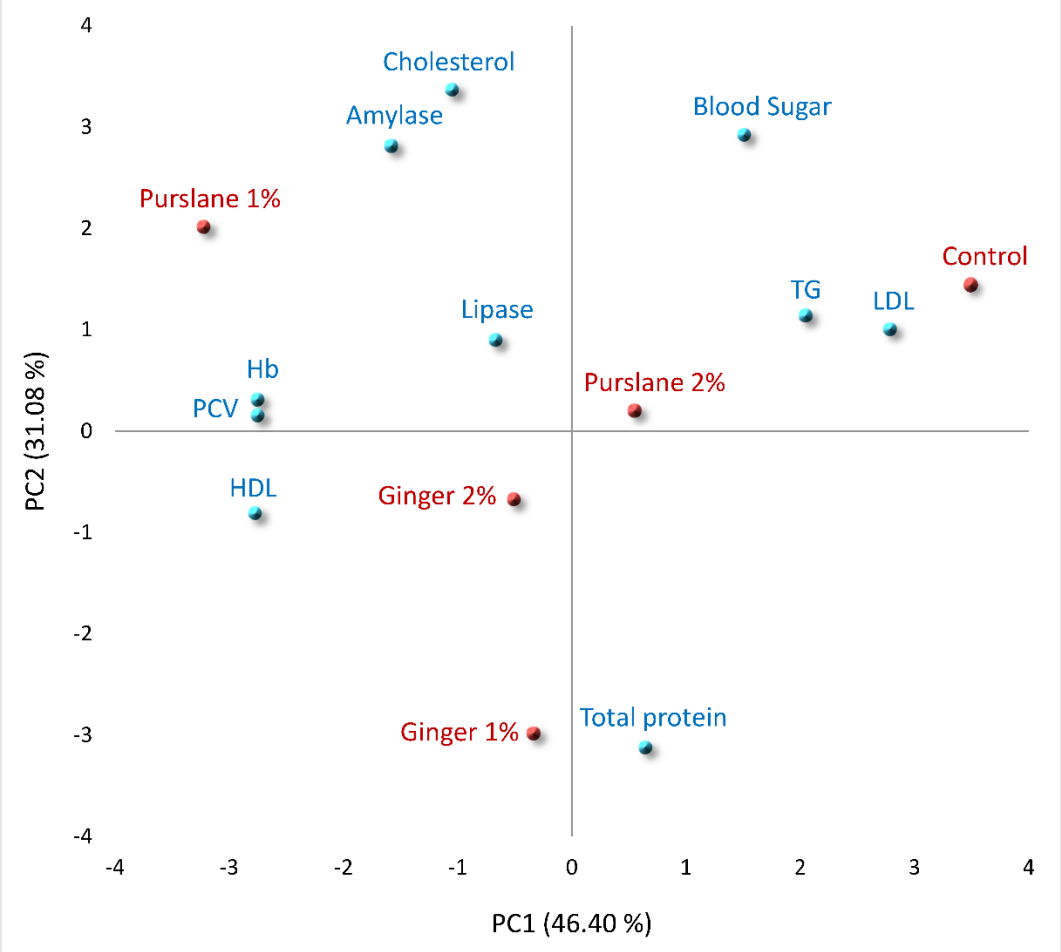

Figure 5 PCA biplot demonstrating the relationships between the blood parameters and the studied variables.

4. Discussion

Plants play important roles in animal feeding, enhancing diet quality, and influencing growth performance. They serve as primary food sources, providing essential nutrients and affecting overall dietary intake and health in various animal species (Ibrahim et al., 2024). Some plant powders, which are used as natural prebiotics, enhance animal health by improving biological parameters and meat quality indices (Talabani et al., 2023). Research indicates that herbal supplementation can impact the growth performance and blood parameters of poultry broilers (Khdr, 2017). Quail farming is gaining traction globally because of its economic viability and nutritional value. As with other poultry species, optimizing growth performance is crucial for quail production (Sigolo et al., 2019). Our findings revealed that incorporating ginger and purslane concentrations into basal feed significantly influences Japanese quail growth performance over a six-week feed processing period (Figures 1 and 2). The use of feed additives, such as antibiotics and natural supplements, to increase growth parameters and overall health in quail has been explored (Abd El-Hack et al., 2018). Overall, incorporating ginger powder into the birds' diet produced favorable outcomes in terms of multiple productive measures. Nevertheless, the consumption of food decreases as the quantity of ginger powder increases (Nemati et al., 2021). Supplementing the diet with ginger root increased the feed conversion ratio (FCR) in broiler poultry (Karangiya et al., 2016). Among these supplements, ginger powder has emerged as a promising candidate owing to its diverse pharmacological properties, including anti-inflammatory, antioxidant, and antimicrobial effects (Zhao et al., 2011). Ginger could increase feed digestion and increase the activity of digestive enzymes, thereby potentially improving the FCR (Mohamed et al., 2012). In addition, the purslane plant contains substantial amounts of phenolic compounds and

flavonoids, contributing to its nutritional richness and potential health benefits (Alu'datt et al., 2019). Purslane is a valuable source of omega-3 fatty acids, which significantly impact cardiovascular health, aiding in the prevention of various disorders. Additionally, it contributes to the maintenance of healthy immune organs (Uddin et al., 2014). Purslane supplementation promoted and improved the weight gain of quail (Abd El-Hack et al., 2022). The feed intake and FCR of broiler chickens supplied with a diet containing dried purslane powder decreased without affecting broiler chickens' weight gain during this period (Sadeghi et al., 2016).

Furthermore, in this study, the application of a diet containing ginger and purslane improved quail blood attributes and enhanced quail meat quality (Figure 3). There is evidence that ginger supplementation in the diet can lead to reductions in cholesterol, blood sugar, and LDL and TG levels without affecting serum protein levels. It was supported by (Mohamed et al., 2012). These findings collectively suggest that ginger may have potential as a dietary supplement for improving metabolic health, as it may exert its antilipidemic effects by suppressing cholesterol production (Alagawany et al., 2021; Jang et al., 2007). Specifically, ginger acts as a potent inhibitor of HMG-CoA reductase (HMGR), an enzyme involved in cholesterol synthesis. However, another study indicated that the inhibition of HMGR activity by ginger primarily occurs in the liver (Belachew et al., 2021). These findings suggest that ginger may exert its cholesterol-lowering effects by targeting liver-specific mechanisms of cholesterol synthesis. These findings provide valuable insights into the potential therapeutic applications of ginger in managing lipid metabolism and cardiovascular health (Figure 3). In quail, supplementation with ginger powder or probiotics resulted in at least total cholesterol levels in both the serum and yolk compared with those in the untreated (control) group. Additionally, there was a decrease in LDL cholesterol and an increase in HDL cholesterol levels (Herve et al., 2019; Khalifa and Noseer, 2019). Additionally, purslane supplementation reduces the harmful levels of total cholesterol (LDL) and TG. It is plausible that the synergistic interaction among purslane's active constituents or a straightforward combination of each component's effects is responsible for its lipid-lowering properties (Habibian et al., 2018). The omega-3 fatty acids present in purslane have been shown to possess blood-thinning properties, which may aid in the treatment of vascular diseases (Kartikasari et al., 2023). On the other hand, the analysis revealed consistent sex-based differences in several blood parameters among Japanese quails (Figure 4). The blood characteristics of quails can be attributed to various physiological factors, including hormonal influences, reproductive physiology, and metabolic demands (Abdul-Majeed and Abdul-Rahman, 2021). Androgens, such as testosterone, are known to exert profound effects on erythropoiesis and protein metabolism, potentially contributing to the elevated hematological and biochemical values observed in male quails. Furthermore, the reproductive activities associated with egg production in females may necessitate the allocation of resources toward egg formation, leading to alterations in blood parameters compared with those in males. This finding was in agreement with (Abou-Kassem et al., 2019; Tarhyel et al., 2012).

5. Conclusions

This study revealed the effects of the use of herbal plants such as ginger and purslane in the diet of quail, indicating promising potential for improving both the physiological characteristics and quality of the meat produced by these birds. Moreover, the introduction of these herbs may imbue the meat with unique flavors and aromas, potentially appealing to consumer preferences. However, determining the appropriate concentrations of these supplements is crucial for optimizing their effects on both meat quality and blood attributes. This study highlights the importance of incorporating herbal supplementation as a strategic method to increase the feed composition of quail. This study presents a promising opportunity to improve the quality of meat and nutritional characteristics in poultry farming.

Ethical considerations

The study received approval from the Ethics Committee of the Animal Resource Department, College of Agriculture Engineering Sciences, University of Raparin, Raparin, Kurdistan Region, Iraq.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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