The effects of goji berry (Lycium barbarum L.) leaves on performance, meat lipid oxidation, digestive tract parts, and some blood parameters of broiler chickens

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The effects of goji berry (*Lycium barbarum* L.) leaves on performance, meat lipid oxidation, digestive tract parts, and some blood parameters of broiler chickens

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ABSTRACT: This study aimed to investigate the effects of supplementing diets with goji berry (*Lycium barbarum* L.) leaves (GBL) on performance, meat lipid oxidation, meat chemical composition, carcass traits, some internal organs, digestive tract parts, and some blood parameters in broiler chickens. A total of 144 d-old mixed-sex chicks (Ross-308) were weighed and randomly allocated to four experimental groups with three replicates of 12 chickens each. Treatments were as follows: (i) basal diet (control), (ii) basal diet+1 g/kg GBL, (iii) basal diet + 5 g/kg GBL, and (iv) basal diet+ 10 g/kg GBL. After analysis by one-way ANOVA, the results revealed that 10 g/kg GBL improved body weight (0-6 weeks) (*p*<0.01), body weight gain (4-6 weeks), and feed intake (4-6 and 0-6 weeks) (*p*<0.05). The feed conversion ratio did not significantly improve with GBL treatment (*p*>0.05). In addition, 10 g/kg GBL of the diet increased heart weight and proventriculus length (*p*<0.05), however, it decreased breast meat lipid oxidation on d 21 (*p*<0.05). Experimental treatments did not affect the total cholesterol, HDL, glucose, and triglycerides (*p*<0.05) but decreased LDL (*p*<0.05). In conclusion, supplementing 10 g/kg GBL to a broiler chicken diet may improve performance and decrease breast meat lipid oxidation and blood serum LDL.

Keywords: Goji berry leaves, broiler, performance, lipid oxidation, blood parameters.
INTRODUCTION

Chicken meat production is a necessary animal activity for fulfilling essential amino acids of people’s health (Hanusová et al., 2015). The immune system needs a variety of amino acids to function actively and continuously in people (Alam et al., 2019). It becomes even more important to feed with functional foods to increase body immunity against Covid-19, which is on the agenda all over the world, and other infectious diseases. Food safety and functional foods have become progressively important matters for the poultry and livestock industry worldwide.

Goji berry (or wolfberry) is a perennial plant and a common name for Lycium barbarum L., Lycium chinense L., and Lycium ruthenicum L. species of the Lycium species, belongs to the family of Solanaceae (eggplants), is commonly found in the arid and semi-arid regions of China, Tibet, Himalayas, Mongolia, Southeast Europe, and the Mediterranean countries (Levin and Miller, 2005; Potterat, 2010; Bucheli et al., 2011; Wang et al., 2015). Goji berry has been used in conventional Chinese medicine since the first century A.D. and in other Asian countries for centuries (Potterat, 2010; Anonymous, 2021). Goji berries have been cultivated and largely grown in Northwest China for more than six hundred years (Chen et al., 2013). Goji berry has the highest oxygen radical absorbance capacity values than other vegetables and fruits consumed as food (Chen et al., 2013; USDA, 2010). Foods with high oxygen radical absorbance capacity levels protect cells and cell components from oxidative damage (Prior et al., 1999). Goji berry fruit contains vitamins, mineral elements, monosaccharides, polysaccharides, essential oils, amino acids, carotenoids, betaine, and flavonoids (Zhang et al., 2012; Endes et al., 2015; Shen et al., 2016). Flavonoids are antioxidant compounds that deactivate harmful impacts of formerly consumed substances in the body (Kanti Dey et al., 2012; Khalili et al., 2016). In folk medicine, goji berry has been used for life-enhancing effects and many benefits in China for years (Gündüz et al., 2015). In addition, goji berry has been reported in studies that strengthen the immune system, increase muscle mass, balance blood sugar, prevent chronic diseases such as hypercholesterolemia, prevention of diabetic retinopathy, lowering cholesterol, antimicrobial activity, effective in Alzheimer’s disease, anti-tumor effect, aphrodisiac effect, spatial learning behavior, anti-anxiety, preventing loss of vision, anti-cancer, anti-bacterial and memory enhancer (Chao et al., 2006; Thomson, 2010; Amagase and Fransworth, 2011; Hu et al., 2012; Tang et al., 2012; Kulczynski and Gramza-Michalowska, 2016; Pehlivan Karakaş et al., 2016; Soares de Sousa et al. 2016; Hempel et al. 2017; Protti et al. 2017; Sun et al. 2019; Meng et al. 2020; Shahrajabian, et al., 2020). In recent years, positive results have been obtained in studies on broiler nutrition with medicinal plants. All the features of the goji berry are generally related to the fruit, and no study has been found in the search on the use of the leaves in broilers. However, there are many studies conducted with leaves of herbal sources rich in bioactive compounds in broilers (Ebrahim et al., 2015; Alnidawi et al., 2016; Oloruntola et al., 2019).

This study was conducted to determine the effects of goji berry (Lycium barbarum L.) leaves (GBL) on growth performance, carcass yield, thiobarbituric acid value (TBARS) in breast meat, meat composition, and some blood parameters of broilers. Moreover, it is aimed to provide functional food production by using goji berry leaves in broiler nutrition.

MATERIALS AND METHODS

This experimental protocol was approved by the local ethical commission (No: 2019/01-03).

Broiler management and experimental design:

A total of 144-day-old mixed-sex chickens (Ross-308) were weighed and randomly divided into four experimental groups with three replicates of 12 chickens each. According to us, there is no GBL study in broilers in the literature. Considering both the high cost of feed and the previous studies with other leaves, doses of 1, 5, and 10 g/kg were used in the experiment. Treatments were as follows: (i) basal diet (control), (ii) basal diet+1 g/kg GBL, (iii) basal diet + 5 g/kg GBL and (iv) basal diet+ 10 g/kg GBL. Control and treatment diets did not include any additives. Birds fed on a starter diet for three weeks (0-21 days) and a finisher diet for three weeks (22-41 days). The starter and finisher diets were formulated to meet the requirements of the broiler chicks are in line with NRC (1994). The chemical composition and ingredients of the starter and finisher diet were presented in Table 1.

Water and experimental diets were provided ad-libitum throughout the six weeks. Chicks were reared in-group cages with continuous 1/23 hours dark/light and were exposed to standard temperature regimes which by stages decreased from 33 to 25 °C. Body weight and feed intake of broilers were monitored...
weekly. Feed conversion ratio (FCR) and body weight gain (BWG) was calculated at the end of wk 0-3, 4-6, and 0-6 for each replication.

\[
\text{BWG} = \text{Body weight - Initial weight}
\]

\[
\text{FCR} = \frac{\text{Total feed intake}}{\text{Total body weight gain}}
\]

**Goji berry leaves preparation and analyses**

Goji berry leaves (in air-dried form) were obtained from a goji berry producer in Denizli, Turkey. The goji berry leaves were ground in a 1 mm sieve and their chemical composition was analyzed according to AOAC (1990). GBL was added to the starter and finisher diets at different levels homogeneously and no other additives were added. Total phenolic compounds, total flavonoid contents, and antioxidant activity of GBL used as an additive in the study were determined. The antioxidant activity was assayed according to the method reported by Villano et al. (2007). The total phenolic compounds of the goji berry leaves were analyzed using the method stated by Elzaawely and Tawata (2012) and the total flavonoid contents were tested by the aluminum chloride colorimetric method (Chang et al., 2002).

**Body components and digestive tract parts**

On the 42nd day, four birds from each sub-group were weighed and slaughtered for determination of body organs (thigh, wing, breast, liver, heart, pancreas, abdominal fat, proventriculus, gizzard weight, gizzard length, gizzard width, crop weight, crop length) and digestive tract parts (duodenum weight, duodenum length, ileum+jejunum weight, ileum+jejunum length, colon weight, colon length, caecum weight, and caecum length).

---

**Table 1. Chemical composition and ingredients of basal diets**

<table>
<thead>
<tr>
<th>Feed Ingredients, %</th>
<th>Starter Diets (0-3 weeks)</th>
<th>Finisher Diets (4-6 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn (CP 8%)</td>
<td>39.2</td>
<td>50.7</td>
</tr>
<tr>
<td>Full fat soya (CP 36 %)</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Soybean meal (CP 42 %)</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Corn gluten meal (CP 42 %)</td>
<td>6.9</td>
<td>3.8</td>
</tr>
<tr>
<td>Boncalite (CP 15 %)</td>
<td>-</td>
<td>3.0</td>
</tr>
<tr>
<td>Fish meal (CP 53 %)</td>
<td>4.5</td>
<td>-</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>DCP</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>NaCl</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>NaHCO₃</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Vitamin premix*</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Mineral premix**</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Calculated Composition**

- ME (kcal kg⁻¹): 3108, 3224
- Lysine, %: 1.67, 1.07
- Methionine + cystine, %: 1.19, 0.92
- Ca, %: 1.10, 0.89
- P (available), %: 0.55, 0.44

**Analyzed Values, %**

- Dry matter: 90.60, 89.54
- Crude protein: 23.91, 22.89
- Ether extract: 8.59, 11.73
- Crude fiber: 1.18, 1.70
- Crude ash: 5.45, 4.16

* Provides per kg of diet: Vitamin A 8000 IU, Vitamin D₃ 800 IU, Vitamin E 15 mg, Vitamin K₂ 2 mg, Vitamin B₁ 2 mg, Vitamin B₂ 4 mg, Vitamin B₁₂ 10 mg.

** Provides per kg of diet: Mn 80 mg, Zn 60 mg, Fe 25 mg, Cu 15 mg, Co 0.25 mg, I 1 mg, Se 0.2 mg, Mo 1 mg, Mg 50 mg.
Meat lipid oxidation and chemical composition
Breast and thigh meat samples collected from slaughtered birds were analyzed for TBARS (lipid oxidation in meat) on the 3rd day (after keeping at +4 °C) and on the 21st day (after being kept at -18 °C in the deep freezer) (Tarladgis et al., 1960).

Crude protein, crude ash, and dry matter contents of breast and thigh meat of birds and feeds used during the experiment (starter and finisher) were determined as reported by AOAC (1990).

Blood parameters
Blood samples were collected from the brachial vein of eight birds from each treatment on 42-d of the experiment using heparinized syringes. The serum was separated by centrifugation for 5 min. at 10,000 rpm and were kept at -18 °C. The total cholesterol, total triglycerides, total glucose, high-density lipoprotein cholesterol (HDL), and low-density lipoprotein cholesterol (LDL) concentration of these serum samples were analyzed using commercial kits.

Statistical analyses
The one-way Analyses of Variance (ANOVA) procedure was used to determine the statistical differences in the parameters to evaluate the effect of different doses of GBL supplementation on broiler chickens. Duncan’s Multiple Comparison Test was used to determine significant differences between experimental groups means using SPSS Version 16.01 (SPSS, 2007). Statistical significance was considered at p<0.05.

RESULTS

Chemical evaluation of experimental GBL
Dry matter, crude protein, and crude ash of GBL are given in Table 2. Total phenolic contents, total flavonoid compounds, and antioxidant capacity of GBL are shown in Table 3 and Table 4, respectively.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>GBL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter, %</td>
<td>96.21</td>
</tr>
<tr>
<td>Crude protein, % DM</td>
<td>16.06</td>
</tr>
<tr>
<td>Crude Ash, % DM</td>
<td>14.49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters</th>
<th>GBL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phenolic (mg GA EQ / 1 g)</td>
<td>7.756</td>
</tr>
<tr>
<td>Total Flavonoid (TFC mg CATECEQ/1 g)</td>
<td>3.468</td>
</tr>
</tbody>
</table>

Results from chemical analysis stated that GBL contains 7.756 mg GA EQ / 1 g total phenolic and 3.468 TFC mg CATECEQ/1 g total flavonoid. 96.21 % dry matter, % 16.06 crude protein, and 14.49 % crude ash. Also, inhibition of it is 93.209 %.

Growth performance
The effects of goji berry leave on body weight, body weight gain, feed intake, and feed conversion ratio (FCR) of broiler chicks are presented in Table 5.

At 0-3 and 4-6 weeks, it was observed that the body weight of birds increased numerically, especially with 5 and 10 g/kg GBL treatment (p>0.05). But, when the experiment was evaluated overall, a significant increase in body weight was detected with 10 g/kg GBL supplementation compared to the control and 1 g/kg GBL (p<0.05). GBL had no significant effect on body weight gains of broilers at 0-3 and 0-6 weeks (p>0.05).

It was concluded that the effect of GBL on the FCR throughout the experiment was not significant (p>0.05). Also, mortality was not observed during the experiment.

Body components and digestive tract parts
The data regarding body components and digestive tract parts of birds are summarized in Table 6.

When the effect of GBL on body components was evaluated, it was concluded that heart weight and proventriculus length increased with 10 g/kg GBL supplementation (p<0.01). Differences in other body parameters were not found to be significant (p>0.05). According to Table 5, duodenum, ileum + jejunum weights and duodenum, ileum + jejunum and colon lengths were not affected by GBL treatment, but, it was determined that 5 and 10 g/kg GBL treatment increased the colon weight of broiler chickens comp-
Table 5. The effects of GBL on the performance of broiler chickens

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Goji Berry Leaves, g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>BW, g/bird</td>
<td>788.00±16.18</td>
</tr>
<tr>
<td>0-3. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1436.86±66.21</td>
</tr>
<tr>
<td>4-6. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2224.86±67.01</td>
</tr>
<tr>
<td>0-6. weeks</td>
<td></td>
</tr>
<tr>
<td>BWG, g/bird</td>
<td>743.00±16.11</td>
</tr>
<tr>
<td>0-3. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1436.86±66.21</td>
</tr>
<tr>
<td>4-6. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2179.86±66.60</td>
</tr>
<tr>
<td>0-6. weeks</td>
<td></td>
</tr>
<tr>
<td>FI, g/bird</td>
<td>1133.61±34.50</td>
</tr>
<tr>
<td>0-3. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2476.67±34.09</td>
</tr>
<tr>
<td>4-6. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3580.29±53.63</td>
</tr>
<tr>
<td>0-6. weeks</td>
<td></td>
</tr>
<tr>
<td>FCR</td>
<td>1.52±0.03</td>
</tr>
<tr>
<td>0-3. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.73±0.06</td>
</tr>
<tr>
<td>4-6. weeks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.66±0.03</td>
</tr>
</tbody>
</table>

Mortality %

a-b: The differences between the means indicated by different letters on the same line are statistically significant (p<0.05).
X̅ ±S.E.: Mean±Standard Error

Table 6. The effects of GBL on body components and digestive tract parts of broiler chickens

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Goji Berry Leaves, g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>Carcass, g</td>
<td>1655.83±25.06</td>
</tr>
<tr>
<td>Thigh, g</td>
<td>477.08±7.03</td>
</tr>
<tr>
<td>Wing, g</td>
<td>169.58±3.23</td>
</tr>
<tr>
<td>Breast, g</td>
<td>544.17±18.11</td>
</tr>
<tr>
<td>Liver, g</td>
<td>42.19±4.46</td>
</tr>
<tr>
<td>Heart, g</td>
<td>8.75±0.49</td>
</tr>
<tr>
<td>Pancreas, g</td>
<td>4.20±0.45</td>
</tr>
<tr>
<td>Abdominal fat, g</td>
<td>44.77±1.95</td>
</tr>
<tr>
<td>Proventriculus, cm</td>
<td>5.08±0.27</td>
</tr>
<tr>
<td>Gizzard, g</td>
<td>20.80±1.01</td>
</tr>
<tr>
<td>Gizzard length, cm</td>
<td>5.83±0.28</td>
</tr>
<tr>
<td>Gizzard width cm</td>
<td>4.08±0.08</td>
</tr>
<tr>
<td>Crop, g</td>
<td>9.53±0.49</td>
</tr>
<tr>
<td>Crop, cm</td>
<td>17.33±0.60</td>
</tr>
<tr>
<td>Duodenum, g</td>
<td>6.25±0.34</td>
</tr>
<tr>
<td>Duodenum, cm</td>
<td>29.25±0.48</td>
</tr>
<tr>
<td>Ileum + Jejunum, g</td>
<td>28.84±2.10</td>
</tr>
<tr>
<td>Ileum + Jejunum, cm</td>
<td>144.20±2.97</td>
</tr>
<tr>
<td>Colon, g</td>
<td>1.57±0.09</td>
</tr>
<tr>
<td>Colon, cm</td>
<td>9.92±0.58</td>
</tr>
<tr>
<td>Caecum, g</td>
<td>5.38±0.42</td>
</tr>
<tr>
<td>Caecum, cm</td>
<td>16.91±0.55</td>
</tr>
</tbody>
</table>

Mortality %

a-c: The differences between the means indicated by different letters on the same line are statistically significant (p<0.05).
X̅ ±S.E.: Mean±Standard Error
pared to the control group \((p<0.05)\) and the caecum length and weight of broilers increased statistically with GBL compared to the control group \((p<0.05)\).

**Meat lipid oxidation and chemical composition**

Data on the chemical composition of the thigh and breast meat of broilers are given in Table 7.

GBL treatment on breast crude ash and crude protein did not affect \((p>0.05)\), but birds fed 10 g/kg GBL had lower breast dry matter than compared to the control group \((p<0.05)\). The thigh dry matter and crude protein were not affected by supplementing the basal diet with GBL \((p>0.05)\). In addition, supplementing the diet with 10 g/kg GBL increased thigh crude ash \((p<0.01)\).

The effects of GBL on d 3 and d 21 TBARS values of the thigh and breast meat of birds were presented in Table 8.

TBARS values obtained showed that the addition of GBL to the basal diets had no effect on breast meat lipid oxidation on d 3 \((p>0.05)\), but significantly decreased meat lipid oxidation on d 21 \((p<0.05)\). It was found that GBL had no statistically significant effect on thigh meat lipid oxidation \((p>0.05)\). Thigh meat TBARS values at 10 g/kg GBL were numerically lower compared to the control group on the d 3 and d 21. The data stated that there is no significant effect of GBL on thigh TBARS.

**Some blood serum parameters**

The effects of GBL on cholesterol, triglycerides, glucose, high-density lipoprotein cholesterol (HDL), and low-density lipoprotein cholesterol (LDL) of broiler chicks were presented in Table 9.

According to Table 9, the total cholesterol, triglycerides, glucose, and high-density lipoprotein cholesterol (HDL) were not affected by the GBL treatment \((p>0.05)\). Supplementing of 10 g/kg GBL decreased low-density lipoprotein cholesterol (LDL) compared to other all treatments.

**DISCUSSION**

Goji berry leaves have many health benefits, such as immune system, kidney, liver, longevity-related functions, and activities but studies on GBL are very limited. According to our knowledge, there is no study on chemical composition and the possible effects of goji berry leaves on broilers. But, there are many previous studies conducted with different dietary leaf meals similar to the current study. In the present study, it was hypothesized that the beneficial contents of goji berry leaves may enhance the health status of broilers reflecting performance, meat lipid oxidation and chemical composition.

### Table 7. The effects of GBL on some chemical composition of breast and thigh meat of broiler chickens

<table>
<thead>
<tr>
<th>Parameters, %</th>
<th>Control</th>
<th>1</th>
<th>5</th>
<th>10</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X ±S.E.</td>
<td>X ±S.E.</td>
<td>X ±S.E.</td>
<td>X ±S.E.</td>
<td></td>
</tr>
<tr>
<td>Breast Dry Matter</td>
<td>30.88±1.91</td>
<td>29.30±0.39</td>
<td>28.15±0.49</td>
<td>25.92±0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Breast Crude Protein</td>
<td>32.45±1.82</td>
<td>33.82±4.91</td>
<td>32.09±2.05</td>
<td>25.33±0.25</td>
<td>0.13</td>
</tr>
<tr>
<td>Breast Crude Ash</td>
<td>1.31±0.03</td>
<td>1.42±0.12</td>
<td>1.58±0.10</td>
<td>1.54±0.09</td>
<td>0.23</td>
</tr>
<tr>
<td>Thigh Dry Matter</td>
<td>26.66±0.61</td>
<td>26.97±0.80</td>
<td>27.29±0.29</td>
<td>25.09±0.57</td>
<td>0.12</td>
</tr>
<tr>
<td>Thigh Crude Protein</td>
<td>23.75±0.47</td>
<td>23.98±0.89</td>
<td>21.95±0.73</td>
<td>21.36±0.56</td>
<td>0.06</td>
</tr>
<tr>
<td>Thigh Crude Ash</td>
<td>1.28±0.08</td>
<td>1.41±0.10</td>
<td>1.22±0.24</td>
<td>1.79±0.04</td>
<td>0.01</td>
</tr>
</tbody>
</table>

\(^{a-b}:\) The differences between the means indicated by different letters on the same line are statistically significant \((p<0.05)\). X ±S.E.: Mean±Standard Error

### Table 8. The effects of GBL on TBARS values of thigh and breast meat of broiler chickens

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control</th>
<th>1</th>
<th>5</th>
<th>10</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>X ±S.E.</td>
<td>X ±S.E.</td>
<td>X ±S.E.</td>
<td>X ±S.E.</td>
<td></td>
</tr>
<tr>
<td>Breast TBA, d 3</td>
<td>0.13±0.01</td>
<td>0.17±0.09</td>
<td>0.12±0.07</td>
<td>0.10±0.05</td>
<td>0.25</td>
</tr>
<tr>
<td>Breast TBA, d 21</td>
<td>0.15±0.02</td>
<td>0.09±0.09</td>
<td>0.03±0.01</td>
<td>0.05±0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>Thigh TBA, d 3</td>
<td>0.07±0.02</td>
<td>0.09±0.01</td>
<td>0.07±0.04</td>
<td>0.06±0.05</td>
<td>0.12</td>
</tr>
<tr>
<td>Thigh TBA, d 21</td>
<td>0.57±0.14</td>
<td>0.54±0.10</td>
<td>0.53±0.26</td>
<td>0.50±0.30</td>
<td>0.59</td>
</tr>
</tbody>
</table>

\(^{a-b}:\) The differences between the means indicated by different letters on the same line are statistically significant \((p<0.05)\). X ±S.E.: Mean±Standard Error
oxidation, some body components, some digestive tract, parts, and some blood parameters. A limited number of studies have been conducted on the chemical composition, antioxidant activity, total phenolic and total flavonoid contents of goji berry leaves. In the current study, it was found that GBL contained 96.21 % dry matter, 16.06 % crude protein, and 14.49 % crude ash. Potterat (2010) reported that GBL has 13 % crude protein. Systems that destroy the effects of free radicals are called antioxidants. It has demonstrated by studies that herbal sources are beneficial against reactive oxygen species due to natural compounds such as ascorbic acid (vitamin C), flavonoids, and phenolic acids (Halvorsen et al., 2002; Ogwuegbu et al., 2021; Seidavi et al., 2022). It is determined that GBL is opulent in phytochemicals (Table 3) and has a high antioxidant capacity (Table 4). By adding GBL to diets, the bioactive components it contains can be exploited to improve broiler growth performance, health, well-being, and meat quality. Due to these properties, it is considered to have the potential to be used in poultry nutrition.

In the present study, it was concluded that GBL did not have a negative effect on the performance and mortality of broilers. With the GBL treatment, the feed intake increased and similar increases were observed in body weight and body weight gains. These similar increases were reflected in the FCR and therefore, no change was found. Also, it can be said that the muscle mass increasing effect of GBL may have increased the carcass weight and breast meat weights, and therefore it may have increased the body weight and body weight gain of broiler chickens. Arslan Duru (2019) stated that supplementation of laying hens fed with GBL did not change initial and final body weight, body weight gain, feed intake, and FCR in comparison with the control group. Alnidawi et al. (2016) suggested that supplementation of Moringa oleifera leaf meal enhances the growth performance of broilers; Kharde and Soujanya (2014) have reported that neem leaves treatment improved body weight gain and FCR of broilers and Tesfaye et al (2013) found that inclusion of 10-20 % of Moringa oleifera leaf meal in diets reduced growth performance of broilers. The differences observed in the performance of broilers in previous studies may be due to the types and their effectiveness of phytochemicals used as feed additives in diets. In addition, the concentration of active substances contained in different types of phytochemical herbs and their biological activities may be another reason for the variable findings.

In the current study, GBL had significantly no impact on the body components of broilers except for proventriculus and heart. It was noted that the proventriculus length and heart weight increased. In addition, GBL treatment was observed to increase in caecum length, colon, and caecum weight of birds. It can be said that the increase in feed intake reflected in the finishing phase is the reason for the prolongation of the proventriculus and large intestine parts (Table 2). Corduk et al. (2013) indicated that the relative weight of the proventriculus of broilers fed oregano and red pepper was significantly decreased by delaying access to diet and water for 24 h post-hatch. The increase in heart weights observed in experimental birds may be a result of the possible high concentration of anti-nutritional factors in the diet containing 10 g/kg GBL. Because the heart may be performing above-normal metabolic activities due to the relatively high concentration of anti-nutritional factors (Gemede and Ratta, 2014). Besides, GBL treatment, the rapid growth of birds may have made growth hormones work faster and may even have triggered heart enlargement by increasing blood pressure. As a result, it is understood that birds that consume GBL-supplemented diets do not have a negative effect on body components and

### Table 9. The effects of GBL on some blood serum parameters of broiler chickens

<table>
<thead>
<tr>
<th>Parameters (mg/dL)</th>
<th>Goji Berry Leaves, g/kg</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>1</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>(\bar{X} \pm S.E.)</td>
<td>133.0</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>42.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Glucose</td>
<td>249.25</td>
<td>239.25</td>
</tr>
<tr>
<td>HDL</td>
<td>35.75</td>
<td>40.0</td>
</tr>
<tr>
<td>LDL</td>
<td>40.0</td>
<td>40.0</td>
</tr>
</tbody>
</table>

\(a-b\): The differences between the means indicated by different letters on the same line are statistically significant. (P<0.05). \(\bar{X} \pm S.E.\): Mean±Standard Error

HDL: High-density lipoprotein cholesterol; LDL: Low-density lipoprotein cholesterol.
digestive tract parts. It has been reported that mistle- 
toe and *Moringa oleifera* leaf meal treatment in diets 
did not affect the carcass characteristics of broilers 
(Ologhobo et al., 2017; Rama Rao et al., 2019).

The breast dry matter content was slightly lower 
while the thigh meat crude ash content was higher 
in the 10 g/kg GBL group compared to the control 
group. The content of breast crude protein, breast 
crude ash, thigh dry matter, and thigh crude protein 
did not change with GBL supplementation. Feeding 
with GBL has been found to improve the product 
quality of broilers. The addition of 10 g/kg GBL to 
the diet increased the breast meat juiciness of broiler 
chickens. However, the dry matter content of thigh 
meat increased statistically significantly with 10 g/ 
kg GBL supplementation compared to all other treat-
ments. Usually, meats are stored or frozen before 
consumption, so these processes observe negative 
changes in lipid fraction in meat. Lipid oxidation 
leads to the formation of potentially toxic compounds 
that negatively affect meat quality and reduce shelf 
life. Malondialdehyde (MDA) is accepted as the ox-
idative rancidity index. Therefore, the most common 
and sensitive method used to evaluate lipid oxidation 
in animal tissues is considered to be 2-thiobarbituric 
acid (TBA). As shown in Table 8, after 21 d of stor-
age, TBARS values of breast meat from broilers fed 
on the control diets, especially 5 and 10 g/kg GBL, 
significantly decreased whilst decreasing numerically 
in all other treatments. The phenolic compounds and 
antioxidant activity of GBL seem to be responsible 
for the reduces these phenomena. It has been found 
that GBL treatment does not have any adverse effects 
on the health of the chicks, as well as improving the 
product quality of broilers. The improvement in meat 
composition and TBARS values with the increase of 
GBL supplementation in diets supports these findings. 
As a result, lipid oxidation in meat can be delayed 
by the use of natural antioxidants in diets. Natural 
antioxidants are important both in protecting human 
and animal health and affecting meat quality. Musta-
fa (2019) observed that eucalyptus leaves improved 
the juiciness of the thigh and breast meats of broilers. 
Also, the feeding treatment with eucalyptus leaves 
also improved hardness and TBARS values in the thigh 
and breast meats of the broiler. Ebrahimi et al. (2015) 
stated that the inclusion of papaya leaves in the diet 
reduced lipid peroxidation and increased the antioxi-
dant activity of broiler breast meat.

In the present study, experimental treatments 
significantly did not affect the total cholesterol, tri-
glycerides, glucose, and high-density lipoprotein 
cholesterol (HDL) except the low-density lipoprotein 
cholesterol (LDL). GBL possesses multiple pharma-
cological effects, including hypocholesterolemic and 
anti-diabetic effects. Due to these effects of GBL, 
it can be said that there was no significant increase 
glucose, total cholesterol, triglycerides, and HDL 
compared to the control group. Feeding broiler on di-
ets added with GBL had a significant decrease in LDL. 
Mocan et al. (2017) and Gong et al. (2016) reported 
that GBL is a powerful antibacterial and antioxidant. 
Also, it has a cholesterol-lowering effect. Decreased 
LDL may reflect the hypocholesterolemic effects 
in the fiber-rich portion of GBL and may be due to 
blocking cholesterol absorption in the intestinal. Ar-
slan Duru (2019) declared that the cholesterol con-
centration of egg yolk decreased with the treatment 
of GBL in the laying hen’s diets. Khalaji et al. (2011) 
found that supplementation of *Artemisia* leaves in di-
ets had no effect on plasma triglyceride, cholesterol, 
HDL, and LDL while Oloruntola et al. (2019) stated 
that lower serum cholesterol, triglycerides, and cho-
lesterol in broilers fed a diet supplemented with neem 
leaves, pawpaw leaves, and bamboo leaves. Ghazalah 
and Ali (2008) had previously recorded lower LDL 
concentrations in broilers fed a diet added with rose-
mary leaves.

CONCLUSION

The current study discovered that GBL, a potent 
bioactive source, had a favorable impact on broiler 
feed. It was observed that with the addition of 5-10 g/
kg GBL, there was an improvement in many perfor-
ance parameters of birds, especially in body weight 
and lipid oxidation in meat, and a decrease in LDL 
value, further studies are needed. However, the effect 
of using different forms and/or higher doses of GBL 
or extracts obtained by different methods on the per-
formance of broilers can be seen more clearly.

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met Barit.
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