Effects of Supplementation of Brassica juncea Seed Extract in Drinking Water on Intestinal Histomorphometry, Bacteriology and Serum Biochemistry Parameters of Broiler Chicken

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Abstract

Brassica juncea (B. juncea) is an erect, often unbranched plant belongs to family Brassicaceae. Its seeds have been used in many countries to treat considerable common and chronic diseases as a folk remedy. The current study designed to investigate the possible effects of Brassica juncea seed extract supplementation in the drinking water as an antibiotic alternative growth promoter for poultry production. Unsexed Ross broilers 308, were allocated into 4 treatments of 4 replicates, in a completely randomized design, each replicate getting 10 birds. Aqueous extract of Brassica juncea Seeds (MSE) was administered in drinking water at levels 0, 3, 5, 7 ml / litre to T1, T2, T3 and T4 respectively from day one to day 35. No significant effects (P≥0.05) were reported for jejunum villi height and villi thickness, but the birds which were given Brassica juncea Seed extract levels increased the ratio of villus height to crypt depth (P < 0.05) and reduced the crypt depth (P < 0.05) compared to control treatment (T1) at 35 day. The MSE at levels 7 ml (T4) yielded the highest serum total protein, phosphorus and calcium. The T2, T 3 and T4 had the lowest values of cholesterol (160, 180mg /L) and the highest value (P < 0.05) of alkaline phosphatase. On day 35 the birds receiving different levels of Brassica juncea seed extract had a lower total aerobic bacteria counts in the ileum than the control treatment. Administering Brassica juncea Seed extract water at levels 3, 5, 7 ml can be included in
drinking water to improve, gut morphology, blood biochemical traits, and intestinal bacterial load.

**Keywords:** Brassica juncea Seed, broilers, intestinal health

1. Introduction

In the poultry production industry has antibiotic growth promoters (AGP) been used to reduce morbidity, mortality, and intestinal problems (Mehdi, et al. 2018). In recent years, the growing concern about the spread of bacterial resistance to antibiotics has severely restricted the use of antibiotics in animal feeds (Suresh 2018; Liliana, 2020). Restriction of the use of antibiotic growth promoters had a negative effect on the growth performance and intestinal health (Gaucheretal 2020). For these reasons, producers will increasingly attend to take the manipulation of the balance between beneficial bacteria (*Lactobacillus, Enterococcus*, and *Bifido bacteria*) and pathogenic bacteria (preferences *Clostridium, Escherichia coli, Salmonella, Spp*), which should be of 90 and 10% of the intestinal bacteria respectively into consideration in order to overcome the effect of banning AGP (Nuriaetal. 2021). Using locally available natural resources may have some beneficial effects to alleviate this problem. This is why various investigations have been conducted recently to examine the use of bioactive agents that have shown a positive effect on gut health (Abdulameeretal. 2018; Lillehojetal. 2018). There is evidence to suggest that some of these components have appetite stimulating properties (menthol); antibacterial effect (chaminoil) or may provide antioxidant function (Torrecillas eta. 2018). Mustard seeds (Brassica) are a very good source of organo-Sulphur compound known as glucosinolates and phosphorus, manganese, dietary fiber, magnesium, selenium, iron, calcium, protein, niacin, zinc and omega-3 fatty acids (Kumar et al. 2011). Sinigrin, sinalbin and glucobrassicin, are the most prevalent glucosinate found in mustard (Anisha et al. 2016). Sinigrin metabolism activation is thought to lead to the synthesis of isothiocyanates, which contribute antibacterial choices in animal production (Moyosoreetal. 2020). A number of studies have revealed that sinigrin acts as an anti-cancer, anti-inflammatory, anti-bacterial, anti-fungal, antioxidant and wound-healing agent, Moreover, mustard seeds have been shown to have growth stimuli, antioxidants, and play a
role in improving metabolic activity, intestinal structure, and intestinal bacterial load (Anisha et al. 2016). Although natural growth stimulants (NGPs) are commonly included in feed as alternative products, but not much is known about their possible impression on the health and productivity of the broiler chickens. Therefore, new compounds will appear as an alternative to the antibiotic in poultry feed, and other nutaceuticals may be tested.

2. Materials and Methods

2.1. Animals and rearing

The experimental procedure was approved by the Animal care unit of the University of Alqasim Green University, during the April to June 2020. 160 unsexed Ross 308 broiler chicks (45 ± 5 g mean body weight), were sourced from a local hatchery and randomly divided into four equal groups according to randomized complete design. Each group consisted of four duplicates, each with ten birds, housed in floor pens of 1.2x1 meters in length and subjected to conventional management methods and environmental conditions for 35 days. The condition of 23 lighting and 1 of darkness and temperature was 33°C in the first week and minimized gradually by 3°C every week until it reached 21°C in the third week. Each pen was supplied with aspirate feeding trough and one bell water and bedded with wood shavings (7 cm deep). A free supply of food and water was made available to the animals, and a constant lighting schedule remained in place during the whole trial.

2.2. Experimental diets

Broiler chickens were supplied with starter diet (21.7 g/ Kg CP, 11.87 MJ ME/Kg from day 1 to 21 and with finisher diet (18.5 g/ Kg CP, 12.16 MJ ME/ Kg) from day 22 to 35, respectively (Table 1, Calculated as-fed basis). Using the UFFDA feed formulation program, the components of diets were created (iso-caloric and iso-nitrogenous were managed for meeting the nutritional requirements of the birds in accordance with the Ross 308 criteria for all nutrients). UFFDA feed formulation program was created by J. Hargrave of the University of Georgia in Athens, Georgia, United States (Aviagen, 2007). The experimental groups were as follows: T1: Basal diet with water free from any addition, T2: Basal diet with Water contained 3 ml Aqueous extract of Brassica juncea Seeds (MS) per 1 litter
drinking water, T3: Aqueous extract of Brassica juncea Seeds (MS) 5ml per 1 litter drinking water. T4: Aqueous extract of Brassica juncea Seeds (MS) 7 ml per 1 litter drinking water.

Table 1. Items containing ingredients and nutritional levels in baseline diets% (as fed basis) 

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Starter(1-21 d)</th>
<th>Finisher(22-35d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>58.50</td>
<td>63.10</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>35.99</td>
<td>31.39</td>
</tr>
<tr>
<td>Vegetable fat</td>
<td>1.25</td>
<td>2.21</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1.75</td>
<td>1.25</td>
</tr>
<tr>
<td>CaCo3</td>
<td>1.57</td>
<td>1.39</td>
</tr>
<tr>
<td>Lysine-Hcl</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td>0.37</td>
<td>0.23</td>
</tr>
<tr>
<td>Salt</td>
<td>0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>Mineral-vitamin premix</td>
<td>0.30</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Nutrients composition

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Starter(1-21 d)</th>
<th>Finisher(22-35d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (metabolic) (kcal/kg)</td>
<td>2,960</td>
<td>3,085</td>
</tr>
<tr>
<td>Protein (Crude)</td>
<td>22.00</td>
<td>20.2</td>
</tr>
<tr>
<td>Calcium%</td>
<td>1.00</td>
<td>0.94</td>
</tr>
<tr>
<td>Available phosphorus%</td>
<td>0.71</td>
<td>0.63</td>
</tr>
<tr>
<td>Methionine + cysteine%</td>
<td>0.92</td>
<td>0.77</td>
</tr>
<tr>
<td>Lysin %</td>
<td>1.13</td>
<td>1.05</td>
</tr>
</tbody>
</table>

\[^{\text{y}}\text{Per kilogram of food, mineral-vitamin premix supplied the following: 9,000 IU vitamin A; 2,100 IU vitamin D3; vitamin E, 30 magnisum (mg) ; nicotinic acid vitamin , 30 mg; vitamin B12, 0.12 mg; calcium pantothenate, 10 mg; vitamin K3, 5 mg; thiamine (B1), 1.1 mg; riboflavin, 4.5 mg; vitamin B6, 2.0 mg; folic acid, 0.5 mg; Biotin, 0.5 mg; Fe, 50 mg; copper (Cu), 10 mg; Mn, 70 mg;}

\[^{\text{1}}\text{Estimated from NRC (1994) composition table.}\]
2.3. Blood parameters and bacteriological test

On day 35 of age after 6 h of feed starvation, 8 female birds were chosen randomly and weighed. Blood samples were taken from the brachial vein and placed in identified tubes and centrifuged at 2700 rpm for 15 minutes at 25°C to separate the serum, which was then stored in eppendorf tubes at -15°C. Total protein (Tp), total cholesterol, calcium (Ca), phosphorus (P), and alkaline phosphatase (ALP) were all measured using the Reflotrone plus analyzer (Roche, USA). Following blood tests, these chosen broiler chickens were killed using a halal procedure to assess gastrointestinal tract morphological and bacteriological characteristics. Bacterial Population in the small intestinal contents were used for a determination of some selected micro-organisms. The contents of the ileum (10 cm middle part) was separately collected, cooled and used for microbial methods. The populations of *Escherichia coli*, *Salmonella* spp. and *Staphylococcus aureus* were diagnosed then measured as cfu g-1. Sterilized PBS (99ml) was added (1:100) to 1 g of fresh material, and then subsequent dilutions prepared. These bacteria were cultivated in pure cultures, sub cultured was done on nutrient agar, MacConkey agar, blood agar, eosin methylene blue, (EMB) and triple sugar iron. All the isolates were stored in brain heart infusion broth with 15% glycerol at 4°C in the refrigerator to maintain the stock culture. Cultures identified by using conventional biochemical tests. Samples were diluted using sterile saline or phosphate buffer when the serial dilution was reached to count properly is the conventional plate count procedure. That example, the last plates in the series should have 30 to 300 colonies. More than the 300 colonies on a plate are likely to generate colonies that are too close together to be recognized as different colony-forming units (they may not be representative of the sample), and the lesser than 30 colonies on a plate are not acceptable statistically (they may not be representative of the sample) (CFUs). The idea is that each viable bacterial cell is different from the others and will aggregate to form a single separate colony when multiplied many times (CFU). Thus, the count of colonies should be equal to the number of bacteria
that may develop under the incubation conditions that were employed. In order to calculate the number of bacteria (CFU) per milliliter or gram of sample, divide the number of colonies by the dilution factor multiplied by the amount of specimen supplied to liquefied agar (Figure 1).

\[
\text{number of colonies (CFUs)} = \text{number of bacteria/ml} \times \text{invert dilution factor.}
\]

2.4. Histological test

The middle third of the jejunum was excised approximately two cm. Immediately, the pieces were washed in distilled water, identified and fixed 10% buffered formalin for a period of one week and dehydrated by immersion through a series of alcohols with increasing concentration (from 70% to absolute100%), infiltrated with xylene, and embedded in paraffin. The rotary type microtome was used for cutting the paraffin sections (7µm). After, the samples were prepared and stained by haematoxylin and eosin at the histological lab in Alqasim green University to estimate villus height (VH), the junction of villus crypt, villus width (VW) (at half height), crypt depth (CD) (crypt depth as the depth of the invagination between adjacent villi), VH to CD ratio (VH/CD). All specimens were studied using multiple magnifications (100 and 400X) (Teunveent etal.2017). Measurements of VH and CD were made using Sigma scan Pro 5 software (Olympus AMERICA Inc., Melville, NY.).

2.5. Plant Extract

Mustard seeds were purchased at a local market in Hilla, Iraq’s central south. The procedure described for preparing the extract by (Tolulopetal. 2017)). A blender was used to break the mustard seeds (Brassica nigra) into powder. Three hundred grams of crushed seeds were immersed in 1000 ml of deionized water, mixed, and stored in a refrigerator at 4°C for 36 hours. Whatman No. 1 filter paper was used to filter the mixture. For the concentrate, the filtrated fluide was dried for 96 hours at 40°C in a water bath to get a product that was then diluted to make stock. The extract was administered orally to the participants.

2.6. Statistical analysis
The data was designed with a randomized complete design with a $1 \times 4$ factorial arrangement (analysis of variance, ANOVA), statistical package (SPSS/PC + (2001)). The comparison between values was tested by LDS tests at $P < 0.05$. The mathematical model was as follow:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where $Y_{ij}$ = Responded variables (intestinal histology, biochemical and bacteriology);

$\mu$ = Overall mean

$T_i$ = Treatment effect

$e_{ij}$ = Random error. The statement of significant levels was based on $P \leq 0.05$.

3. Results

3.1. Blood biochemical parameters

The effect of MSE and water on blood biochemistry showed in table 2. The groups that received MSE at level 5 and 7 ml (T3 and T3) had numerically the higher total protein values as compared to the control group T1. Elevated levels of ALP, Ca and P (Table 3) were observed in all MSE treated groups when compared with the controls ($p<0.05$). The increase level of the MSE was associated with the numerically decrease in serum total cholesterol.
Table 2. The effect of incorporating MSE into drinking water on the blood parameters of broilers at 35 days was investigated.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Hb (mg/dl)</th>
<th>Total Protein (g/dl)</th>
<th>Alkaline Phostase (μ/L)</th>
<th>Calcium (mg/dL)</th>
<th>Phosphor (mg/dL)</th>
<th>Cholesterol (mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>3.4b</td>
<td>5</td>
<td>16.7c</td>
<td>9 ab</td>
<td>6.1 b</td>
<td>191.2</td>
</tr>
<tr>
<td>T2</td>
<td>3.9b</td>
<td>4</td>
<td>20.7 ab</td>
<td>7b</td>
<td>5.5 b</td>
<td>200</td>
</tr>
<tr>
<td>T3</td>
<td>3.4b</td>
<td>5</td>
<td>21.7 ab</td>
<td>9a</td>
<td>5.4 b</td>
<td>186</td>
</tr>
<tr>
<td>T4</td>
<td>3.5b</td>
<td>6</td>
<td>25.7 ab</td>
<td>10a</td>
<td>7.7 a</td>
<td>165</td>
</tr>
<tr>
<td>Pooled SEM</td>
<td>0.29</td>
<td>0.42</td>
<td>1.2</td>
<td>0.39</td>
<td>0.31</td>
<td>9.1</td>
</tr>
<tr>
<td>P-value</td>
<td>0.06</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.07</td>
</tr>
</tbody>
</table>

1Values are the averages of four replicated pens with 10 chicks each; SEM stands for standard error of the mean. 2 T1: control; T2: 3 percent MSE in drinking water; T3: 5 percent MSE in drinking water; T4: 7 percent MSE in drinking water. SEM stands for standard error of the mean. A-b. At P < 0.05, the means within a column in each parameter with the same superscripts do not differ substantially.

3.2. Histomorphometery parameters

The effects MSE on the morphological development of small intestine in the jejunum of broiler chickens are presented in table 3 (Figure 2). Adding MSE levels in the drinking water significantly improved VH:CD compared to the control group (P < 0.05). Mustard seed extract levels did not affect VH and V thickness significantly compared to the controlled birds. The CD was reduced with all the levels of MSE compared with control (217, 208, 242 vs. 343) (P < 0.05), while VH/CD was increased significantly (P < 0.05) by addition of MSE at levels 3 and 5 ml per litter.
Table 3. Effects of MSE on histomorphometry of intestine in Broilers

<table>
<thead>
<tr>
<th>Intestinal histological</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>Pooled SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Villi height(µm)</td>
<td>1277.7</td>
<td>1244</td>
<td>1118</td>
<td>1090</td>
<td>38.7</td>
</tr>
<tr>
<td>Villi thickness(µm)</td>
<td>150.4</td>
<td>146</td>
<td>178</td>
<td>155</td>
<td>10</td>
</tr>
<tr>
<td>Crypt depth(µm)</td>
<td>343&lt;sup&gt;a&lt;/sup&gt;</td>
<td>216&lt;sup&gt;b&lt;/sup&gt;</td>
<td>208&lt;sup&gt;b&lt;/sup&gt;</td>
<td>242&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.4</td>
</tr>
<tr>
<td>VH/CD</td>
<td>3.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Values represent the means of 4 replicated pens of ten chicks each, SEM: standard error of mean. T1: control; T2: drinking water + 3% MSE; T3: drinking water + 5% MSE; T4: drinking water + 7% MSE.

SEM: standard error of mean

a-b Means in same row with no superscript or with common superscripts are not significantly different (P < 0.05).

VH = Villus height, VW = Villus wide, CD = Crypt depth, VH/CD = Villus height to Crypt depth, Pooled SEM = Pooled Standard error of means.
3.3. Bacteriological

3.3.1. Isolation of bacteria

On day 35 the control group, which received no supplement in water, was heavily colonized with in 23(52.27%) E.coli, 15(34.09%) Salmonella spp. while 6 (13.64%) staphylococcus aureus in the illeum contents (44 total samples) (Figure 1). As shown in table 4, treating
broiler diets with MSE al levels 3 ml, 5 ml and 7 ml reduced \((P < 0.05)\) the bacterial total count in the gut in compression with that of the control group T1.

![Pie chart showing bacterial isolates](image)

**Figure 1.** Percentage the bacterial isolate
Table 4. Effect of inclusion of mustard seed extract MSE in drinking water days on intestinal microbial count of Ross 308 Broilers

<table>
<thead>
<tr>
<th>Items (log 10/c.f.u)</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>Total Sem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Bacteriacount ×10^5</td>
<td>6.1^d</td>
<td>4.6^c</td>
<td>1.5^b</td>
<td>0.5^a</td>
<td>0.40</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>0.3</td>
<td>0.27</td>
<td>0.5</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Values represent the means of 4 replicated pens of ten chicks each, SEM: standard error of mean.2 T1: control; T2: drinking water + 3% MSE; T3: drinking water + 5% MSE; T4: drinking water + 7% MSE
SEM: standard error of mean
a-b Means in same row with no superscript or with popular superscripts are not significantly different (P <0.05)

4. Discussion

4.1. Blood biochemical indices

Blood components are an indicator of the normal functions in animals and a diagnostic method of many organs dysfunction (Oloruntola et al. 2016). The function of phytogenic in the reduction of oxidative stress may explain through low cholesterol concentration observed in broiler chickens in this study. The lowered cholesterol concentrations in the blood resulted from alpha-linolenic acid in the MSE. The alpha-linolenic acid reduces the harmful effect caused by stress (Henderson et al., 2008; West et al., 2010). The ALP level in the plasma is good pointer of cellular metabolism and overall health (Sookoian & pirola, Etal. 2015). The elevated ALT concentration observed in the broiler chickens administrated with MSE levels compared to T1 may be due to the biogenic component (flavonoids and phenol). Consistent with our results West et al. (2010); Nkiruka et al. (2019); Adegbeye et al. (2020), observed enhanced blood ALP with supplemented of MSE at level 200 mg/kg BW. These authors
added that increasing the level of MSE up to 300MG\KG elevated the serum concentration of ALP. The higher serum TP concentration recorded in birds administrated high levels of MSE may be attributed to polyphenolic compounds that act as scavengers for free radicals then enhancing liver metabolic function (Pannala et al. 2001). The high concentration of Ca and P with MSE were attributed to the high mineral composition in the mustard seed meal (Daghir and Miana, 1976) who found that the mustard seed meal is richer in calcium, phosphorus, sodium and iron, but lower in potassium, manganese, zinc and copper. Ground mustard seed contains 26.6% of your daily calcium, 51.2% of your daily iron, 92.5% of your daily magnesium, 40.5% of your daily zinc, and 82.8% of your daily phosphorus, according to the USDA National Nutrient Database for Standard Reference (Divakaran&Babu, 2016). These findings were consistent with those of Abbasi et al. (2015) and Adgebeye et al. (2020), who found that a high dosage of MSE might alter serum calcium, phosphorus, and AKP levels. Also, these results were inconsistent with Adgebeye et al. (2019). They referred that MS as feed additives up to level of 15 g/kg did not affect the blood biochemical parameters (T.P, cholesterol and albumin).

4.2. Histomorphometry

Gross morphological characteristics of the intestinal epithelium, such as height and surface area, were used to assess intestinal integrity (Abdulameer et al. 2015). The role of herbal plant as feed additive on the intestinal morphology of the poultry was explained by (Giannenas et al 2019). The components of MSE, such as Sinigrin, are not usually antibacterial; nevertheless, when enzymatically degraded to produce allylisothiocyanate, it displayed strong antimicrobial action against food spoilage and pathogenic organisms. Also, the flavonoids and tannins may increase the number and width of the villi due to the complete maturation of the intestine with these plant components (Gamage et al 2009; Duy et al. 2016). The addition of 15% of mustard oil in vitro can reduce the methane formation that has as deleterious effect on intestinal structure (Adgebeye et al 2020). Mustard seed promotes intestinal growth and makes the villi stronger because of the presence of Vitamin A and E along with calcium, protein and Omega-fatty acids(Rachel etal.2019; Azubuike et al 2019). The effect of mustard oil has been attributed to alpha-linolenic acid (West et al 2010). This finding does not corroborate that of Azubuikeetal. (2019) who found that the
have adverse effect on heart. Also the findings of this study also did not corroborate those of Van Done (2012) who concluded that the intestinal length can have a profound effect on whole body energetic. The increase in VW could represent an attempt to increase the intestinal surface area to maximize absorption area. This result corroborates the findings of (Yahya et al. 2016). Zhang et al. (2015) who pointed out that enhancement in absorption function of the intestine is dependent on increasing WV rather than an increase in the total number of villi. Partially enhanced VH/CD ratio in the jejunum correlated with overall gut health. An enhanced VH / CD ratio and reduced CD might be associated with an increase in population of beneficial bacteria in gut lumen (Zhang et al. 2015; Wang et al. 2020).

4.3. Bacteriology

Results of the present study showed a reduced gut microbial count as a result of a MSE of up to 3%, 5% and 7% (Table 5). Similarly, Dufour et al. (2015); Bidaranamani et al. (2015) stated that MSE are a good source for reducing the pathogenic microbial population in the gastrointestinal tract. Maina et al. (2020) who claimed that the bioagen compound in the mustard seed, Antimicrobial action of isothiocyanates like allylisothiocyanate is mediated through induction of the intracellular cell cycle. The allylisothiocyanate disrupts bacteria's cell membrane by generating holes, allowing chemicals to seep into the cytoplasm, inactivating functioning enzymes, and altering cellular metabolic processes. It also produces homeostatic pressure and enhanced b-galactosidase activity (Maina et al. 2020). Alteration in intracellular structure, as seen in Listeria monocytogenes, is another mechanism of isothiocyanate action (Xue et al. 2014). The thioredoxin and acetate kinase of Escherichia coli are inhibited by allylisothiocyanate (Mazumder et al. 2016). Methane production was reduced in vitro by 15 percent when mustard oil was added, without altering fermentation processes or by-products, and the protozoa population was lowered as well (Adegbeye et al. 2020). Consistent with our findings, Abukhbta et al. 2021 who mentioned that mustard seeds were more effect on microbes. Mustard seeds contain the highest levels of glucosinolates, was thought to Myrosinase enzyme present in mustard seeds can contribute to its antimicrobial effect against Escherichia coli O157:H7 through the hydrolysis of glucosinolates (Abukhbta et al 2021). This result disagreed with Mhebali & Salarmonoini
Adegbeye et al. (2020); Adegbeye et al. (2021) who recorded that MSE at level 15g/kg feed did not affect total bacterial count in the cecum.

In conclusion, the health and morphological structure of the intestine as revealed in this study validated the notions that mustard seed extract up to 7 ml per litter drinking water can increase broiler gut integrity.

Declaration of Conflict of Interest. This text was authored by the aforementioned writers and has never been published before. We do not have any financial assistance.

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Competing Interests

The authors declare that they have no competing interests.

References


