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The Effects Of Adding Ferula Asafoetida Gum to The Diet Of Broiler Chickens On Their Intestinal Growth, Morphology, and Digestive Enzyme Activity

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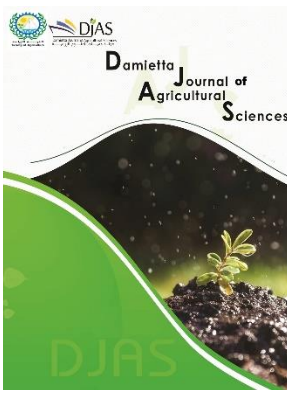

ABSTRACT

As natural substitutes for antibiotics in poultry production, phytogenic feed additives (PFAs) have garnered significant interest because to their potential to regulate intestinal health. This trial was performed to determine the effect of Ferula asafoetida gum powder (FAGP) inclusion in diets of broiler chickens on digestive enzymes and intestinal morphology. The 192 one-day-old Ross 308 broiler chicks were divided into four treatment groups, each consisting of three replicates, for the 35-day feeding trial. FAGP was examined at different inclusion levels per kg diet, 0% (control, T0), 4 g (T1), 8 g (T2), and 12 g (T3) in a completely randomized design. The results showed that at the end of the trial (35 days) the FAGP addition had positive effects ($p < 0.001$) on the serum lipase, chymotrypsin and trypsin in compared to control group. Dietary addition of FAGP had no effect on the small intestine's weight and relative length between days 1 and 18. But FAGP addition significantly reduced the relative weight of duodenum. From day 1 to day 35, the addition of FAGP to the diet was linked to higher ($p<0.05$) villus height in the ileal and jejunal mucosa compared to same regions in the control. When compared to the control group, the addition of FAGP did not significantly ($p>0.05$) affect the crypt depth in the ileal and jejunal mucosa. In conclusion, dietary addition of FAGP enhanced intestinal morphology, increased intestinal weight and length, and enhanced digesting enzyme activity.

Keywords: Broiler, Digestive Enzyme, Ferula asafoetida, Histology, Intestine

INTRODUCTION

In the poultry industry, intestinal health is one of the main elements affecting a bird's performance and, in turn, its financial yield. The use of natural dietary supplements to improve intestinal health has been the subject of numerous studies (Moharreri et al., 2022; Rafeeq et al., 2023; El-Kholy et al., 2025). A common practice in chicken nutrition is the use of natural feed additives to improve physiological indices, productivity, health, and product quality (Arif et al., 2022; El-Kholy et al., 2022 & 2024; Taghizadeh et al., 2024). Because the internal oxidative equilibrium is disrupted, poultry are vulnerable to stressors such food, physiology, pathology, or both, and the environment (Shi et al. 2022; Peng et al. 2023). Functional additives can be added to the feed to help broilers cope with oxidative stress-related poorer performance, higher mortality, and financial losses (Yan et al. 2024). Among these, Phyto-biotics can boost host welfare and health by acting as antioxidants in a variety of ways (Strugala et al. 2016; Yao et al. 2023). The use of phytobiotics—biologically active compounds produced in plants—as an antibiotic substitute has drawn the attention of numerous researchers working in farm animal feed in recent years (Abreu et al., 2012). The effects of phytobiotics' secondary bioactive chemicals are similar to those of synthetic antibiotics (Murugesan et al., 2015), and they can help farm animals develop better and maintain gut health (Stevanović et al., 2018). According to recent research, phytobiotics can completely replace antibiotics in the chicken business (Carrasco et al., 2018). Because phytobiotics can alter the dynamics of the beneficial microbiota (Yadav and Jha, 2019), which enhances feed efficiency (Suresh et al., 2018) and growth rates (Mashayekhi et al., 2018; Saleh et al., 2018), adding them to the diet of broiler chickens has a positive impact on intestinal health (Basit et al., 2020).

One of the plants that has been tested and used in poultry diets is *Ferula asafoetida*, which has many active compounds with medical effects that directly affect human health. According to Mahboubi (2021), the gum of the Umbelliferae family plant *Ferula asafoetida* is traditionally used to cure gastrointestinal diseases, including cancer, bloating, parasites, and digestion. The plant extract contains significant amounts of antioxidants, antibiotics, and antimicrobial compounds, which lower blood pressure and improve the functions of the digestive and respiratory systems (Fatehi, 2004). According to Kareparamban et al. (2013), ferulic acid, a phenolic acid with strong pharmacological activity, is present in the oleo gum resin derived from Ferula asafoetida, generally known as "HING." Additionally, one of Ferula asafoetida's active components is ferulic acid, which is linked to the plant's antioxidant and anticancer properties (Baskaran et al., 2010). Phytobiotics are known to affect the growth performance and nutrient absorption of poultry. The most crucial aspects of intestinal mucosal physiology are enterocyte enzymatic activity, shape, and development. The small intestine is the place where feed nutrients are both digested and absorbed (Yang et al., 2013). In addition, the intestinal epithelium serves as a natural defense against poisons and harmful germs (Xiaofei and Yuming, 2008). The impact of including FAGP into broiler diets on intestinal morphology, however, remains unknown. Based on this theory, the study's objective is to evaluate the effects of dietary addition of FAGP and determine whether this has a positive overall effect on the gut development, morphology, and digestive enzyme activity of the broiler chickens.

MATERIALS AND METHODS

Ethical Approval

The experimental procedures were approved and carried out in accordance with the ethical guidelines of the experimental animal care committee at Damietta University in Egypt. During the trial, the European Union Council's Directives 2010/63/EU and 98/58/EC on the protection of animals used for studies and for scientific reasons were also adhered to.

Animals and experimental design

This experiment carried out in a private farm near of Kafr Saad, Damietta Governorate in collaboration with Faculty of Agriculture, Damietta University, Egypt, during the period of September to October 2024. One hundred and ninety-two (192) unsexed commercial broiler chicks (Ross 308), 1-day old "obtained from a local commercial hatchery" were weighed and divided into equal four experimental groups, each of three replicates (16 chicks/ replicate) in a completely randomized design (CRD). The commercial diets (starter, grower and finisher) were formulated approximately iso- energetic and iso- nitrogenous to meet the broiler requirements according to NRC (1994). Chicks fed a starter diet from hatch day up to 14 days, the grower diet from 15 day up 28 days, then the finisher diet from 29 day up to 35 days of age. The experimental groups arranged as, the first group fed a control diet (NC) that formulated without any addition (T_0= standard diet or control treatment), T_1= contained *Ferula asafoetida* gum powder (FAGP) 4 g / kg diet, T_2= contained 8g FAGP/kg diet; and T_4= contained 12g FAGP/kg diet. The composition and calculated analysis of commercial diets are shown in Table 1 for each growth period. Every broiler chick was housed under identical environmental, sanitary, and management circumstances. The broiler chicks in each replicate were kept at an ideal stocking density of 30 kg/m^2 in floor pens on wood shavings litter. Programs for lighting and temperature were in line with Ross's breeding guide's suggestions. For the first seven days, the light schedule in each trial pen was maintained at 23 L:1 D h, and then it was changed to 20 L:4 D h until the study was over. The original ambient temperature was around 32°C for the first seven days of life, and it then progressively dropped by 2°C per week until it reached 22°C. A range of 65 to 75% relative humidity was maintained. Over the course of the experiment, no mortality was reported. A veterinarian oversaw the immunization program's implementation.

Obtained data and estimating parameters:

At 35 days of age, blood samples were collected from five slaughtered birds per treatment in non-heparinized tubes, then centrifuged at 3000 rpm for 15 minutes, and serum obtained was stored at −20◦C. Serum amylase, lipase, trypsin and Chymotrypsin concentrations were measured using spectrophotometry (commercial kits from Biodiagnostic Company, Giza, Egypt). Relative length and weights of small intestine in broilers. Three broilers from each treatment were chosen at random, weighed after 12 hours of feed deprivation, and slaughtered at the conclusion of each experimental period (18 or 35 days). The intestinal portions were then removed. The small intestine was divided into three sections: duodenum (from gizzard outflow to the end of the pancreatic loop), jejunum (from the pancreatic loop to Meckel's diverticulum), and ileum (from

Meckel's diverticulum to the cecum junction). Each small intestinal segment was emptied by gentle pressure, and the length and weight were recorded to calculate the relative length and weight of each segment.

Table 1. The composition and calculated analysis of the commercial diets.

Ingredients., %	Starter diets	Grower diets	Finisher diets
Corn	55.90	61.40	66.50
Soybean (46%)	40.10	34.60	29.50
Di Cal phosphate	1.50	1.60	1.60
Limestone	1.50	1.40	1.40
Min. & Vit. Premix[1]	0.30	0.30	0.30
Salt	0.30	0.30	0.30
Bicarbonate sodium	0.10	0.10	0.10
Methionine	0.10	0.10	0.10
Lysine	0.20	0.20	0.20
Total	**100**	**100**	**100**
Calculated analysis[2]			
CP,%	22.99	20.89	18.94
ME kcal/kg	3064	3186	3200
C. fat, %	2.53	2.68	2.82
Ca, %	0.98	0.95	0.94
Av. Phos., %	0.42	0.43	0.42
C. fiber, %	2.89	2.80	2.71
Av. Methionine, %	0.42	0.40	0.37
Av. Lysin, %	1.32	1.20	1.06
Na., %	0.17	0.17	0.17

[1]Each 3 kg of the Vit and Min. premix contains: Vit. A 10 MIU, Vit. D 2 MIU, Vit E 10 g, Vit. K 2 g, Thiamin 1 g, Riboflavin 5 g, Pyridoxine 1.5 g, Niacin 30 g, Vit. B_{12} 10 mg, Pantothenic acid 10 g, Folic acid 1.5 g, Biotin 50 mg, Choline chloride 250 g, Manganese 60 g, Zinc 50 g, Iron 30 g, Copper 10 g, Iodine 1g, Selenium 0. 10 g, Cobalt 0.10 g. and carrier CaCO3 to 3000g.

[2]According to NRC (1994).

Morphological measurement of the jejunal and ileal mucosa

At 18 and 35 days of age, and from the same 3 birds previous randomly selected for morphology, one centimeter of the ileum, jejunum, and duodenum were removed, respectively, and preserved in a 10% formalin-buffered saline solution before being embedded in paraffin. According to Uni et al. (2001), three cross-sections of each intestinal segment (duodenum, jejunum, and ileum) were preserved with formalin solution and made using conventional paraffin embedding procedures by sectioning at 5 µm thickness and stained with hematoxylin and eosin. Every type of tissue from each broiler had thirteen intact, properly aligned crypt-villus units measured. Villus height (VH) and crypt depth (CD) were measured in micrometers (µm) using an image processing and analysis system (version 6.0, Image-Pro Plus). The VH to CD ratio was computed.

Statistical analysis

This study analyzed by using a general linear model approach (one-way analysis of variance; SAS, 2012). Differences between treatment groups were determined using Duncan's new multiple range post-hoc test, and $p < 0.05$ was deemed significant. All data were expressed as least square means ± pooled standard error of the mean (SEM).

RESULTS:

Blood digestive enzymes:

Effect of different dose of *Ferula asafoetida* gum powder added to broiler diets on serum digestive enzymes is found in Table 2. From the results, it is noted there is a significant alteration in activities values of amylase, lipase, trypsin and chymotrypsin among treatments. Serum lipase, chymotrypsin and trypsin were significantly ($P<0.01$) higher in treated groups in compared to control one. Trypsin and lipase levels were found to be highest in T_3 broilers in compared to other experimental groups. In contrast to other treatments, T_4 broilers had the greatest value of chymotrypsin activity, followed by T_3.

The small intestine's weight and relative length in broilers

Table 3 displays the impact of adding varying amounts of *Ferula asafoetida* gum powder to broiler diets on the small intestine's weight and relative length. There was no nutritional influence ($p>0.05$) on the relative length and weight of the duodenum, jejunum, and ileum during the period of 1 to 18 days when broilers were pretreated with varying concentrations of *Ferula asafoetida* gum powder. Furthermore, during the period of 19 to 35, there was no significant ($p>0.05$) impact on the relative weights of the ileum or the relative lengths of the duodenum and ileum. The weight and relative length of the jejunum significantly ($p<0.05$) increased in broilers treated with FAGP. Nonetheless, compared to the control group, the treated groups' relative duodenal weight was considerably ($p<0.05$) lower.

Broiler intestinal mucosa morphology (µm)

Table 4 displays the morphological measures of the ileal and jejunal mucosae. Over the course of the experiment, the treatment group's villus height in the jejunal mucosa was considerably ($p<0.05$) greater than that of the control group. Although there were minor ($p>0.05$) differences between the T_0 and T_1 groups, the villus heights in the jejunal mucosa in the treated groups were considerably ($p<0.05$) higher than those in the control group. The villus height in the ileal mucosae of chicks receiving the *Ferula asafoetida* gum powder in the feed was significantly ($p<0.05$) greater than in the control group but there were no significant ($p>0.05$) differences between the T_0 and T_1 groups during the overall experimental period. Dietary addition with *Ferula asafoetida* gum powder had significant ($p<0.05$) influence on the CD in the jejunal and ileal mucosa in compared to the control during the overall experimental period. Table 4 also shows that high-dose of *Ferula asafoetida* gum powder (T_4) recorded the lowest crypt depth in the jejunal and ileal mucosa in compared to those belonging to other experimental groups. During the overall experimental period, the *Ferula asafoetida* gum powder -addition groups differed significantly ($p<0.05$) from the control group in terms of the VH to CD ratio in the jejunal and ileal mucosa. The VH to CD ratio was not significantly ($p>0.05$) different from either the control (T_0) group or the T_1 group.

DISCUSSION

In current study, the improvement of digestive enzymes in treated groups especially in high dose are consistent with Wang and Gu (2010) and Abd El Latif and Omar (2023) findings that adding probiotics, prebiotics, or antibiotics raised blood digestion enzymes like lipase, protease, and amylase. Also, Jin et al. (1997) found that significantly increased intestinal amylase activity when probiotic has been added to the control diet of broiler chicks. Wang et al., (2021) and Sun et al. (2022) described that amylase, lipase and chymotrypsin activity were significant increased with basal diet supplemented with probiotic.

Table 2: Effect of dietary addition of *Ferula asafoetida* gum powder on the digestive enzymes of broiler chicks.

Items	**Treatments[1]**				**SEM[2]**	**P-value**
	T_0 (Control)	**T_1**	**T_2**	**T_3**		
Amylase (U/L)	51.27^{a}	47.78^{b}	46.48^{b}	40.21^{c}	0.44	0.001
Lipase (U/L)	24.30^{d}	27.16^{c}	43.27^{a}	31.84^{b}	0.65	0.001
Chymotrypsin (U/L)	25.59^{d}	37.26^{c}	46.22^{b}	57.96^{a}	0.35	0.001
Trypsin (U/L)	41.26^{c}	46.21^{b}	62.19^{a}	58.18^{a}	1.51	0.001

$^{a,b,c,\ d}$: indicates there are major differences between each item with different superscripts in the same row ($P\leq0.05$).
[1]T_0= standard diet or control treatment, T_1= contained 4 g *Ferula asafoetida* gum powder (FAGP)/kg diet, T_2= contained 8g FAGP/kg diet; and T_3= contained 12 g FAGP/kg diet. [2]SEM: standard errors mean.

Table 3: Effect of dietary addition of *Ferula asafoetida* gum powder on the relative weights (%) of some carcass parameters of broiler chicks.

Items	**Treatments[1]**				**SEM[2]**	**P-value**
	T_0 (Control)	**T_1**	**T_2**	**T_3**		
1 to 18 days						
Relative length, cm/kg						
Duodenum	33.03	32.81	32.08	32.00	0.70	0.668
Jejunum	73.26	73.18	73.41	73.94	0.32	0.385
Ileum	70.78	69.06	68.24	69.39	1.64	0.744
Relative weights, g/kg						
Duodenum	9.35	9.06	9.09	8.81	0.26	0.586
Jejunum	14.71	15.00	14.78	15.00	0.31	0.860
Ileum	10.61	10.64	10.72	10.37	0.18	0.592
19 to 35 days						
Relative length, cm/kg						
Duodenum	10.97	10.88	10.95	10.94	0.17	0.981
Jejunum	24.99^{b}	25.00^{b}	26.13^{b}	28.09^{a}	0.41	0.002
Ileum	28.12^{c}	28.64^{bc}	29.15^{b}	31.92^{a}	0.28	0.001
Relative weights, g/kg						
Duodenum	7.61^{a}	6.30^{a}	5.62^{b}	5.63^{b}	0.56	0.013
Jejunum	8.07^{b}	8.09^{b}	8.27^{b}	10.81^{a}	0.13	0.001
Ileum	8.00^{bc}	7.69^{c}	8.39^{b}	9.11^{a}	0.13	0.003

$^{a,b,c,\ d}$: indicates there are major differences between each item with different superscripts in the same row ($P\leq0.05$).
[1]T_0= standard diet or control treatment, T_1= contained 4 g *Ferula asafoetida* gum powder (FAGP)/kg diet, T_2= contained 8g FAGP/kg diet; and T_3= contained 12 g FAGP/kg diet. [2]SEM: standard errors mean

Table 4: Effect of dietary addition of *Ferula asafoetida* gum powder on the morphology (µm) of the intestinal mucosa in broiler chicks.

Items	Treatments[1]				SEM[2]	P-value
	T0 (Control)	T2	T3	T4		
1 to 18 days						
Jejunum						
Villus height, µm	815.63^{c}	818.00^{c}	905.00^{b}	965.33^{a}	2.68	0.001
Crypt depth, µm	123.00^{a}	122.00^{a}	114.33^{b}	107.33^{c}	1.03	0.001
Villus height/crypt depth	6.63^{c}	6.70^{c}	7.92^{b}	8.99^{a}	0.07	0.001
Ileum						
Villus height, µm	517.00^{c}	516.67^{c}	550.00^{b}	576.00^{a}	2.07	0.001
Crypt depth, µm	129.67^{a}	129.33^{a}	118.00^{b}	105.33^{c}	0.91	0.001
Villus height/crypt depth	3.99^{c}	3.10^{c}	4.66^{b}	5.47^{a}	0.03	0.001
19 to 35 days						
Jejunum						
Villus height, µm	1060.33^{c}	1059.33^{c}	1192.00^{b}	1344.00^{a}	3.59	0.001
Crypt depth, µm	146.33^{a}	143.67^{b}	135.00^{c}	123.33^{d}	0.82	0.001
Villus height/crypt depth	7.25^{c}	7.37^{c}	8.83^{b}	10.90^{a}	0.04	0.001
Ileum						
Villus height, µm	786.00^{c}	788.00^{c}	847.33^{b}	902.33^{a}	2.67	0.001
Crypt depth, µm	148.00^{a}	147.33^{a}	128.00^{b}	124.00^{c}	0.67	0.001
Villus height/crypt depth	5.31^{c}	5.34^{c}	6.61^{b}	7.28^{a}	0.02	0.001

[a,b,c, d]: indicates there are major differences between each item with different superscripts in the same row ($P \leq 0.05$).

[1]T_0= standard diet or control treatment, T_1= contained 4 g *Ferula asafoetida* gum powder (FAGP)/kg diet, T_2= contained 8g FAGP/kg diet; and T_3= contained 12 g FAGP/kg diet.

[2]SEM: standard errors mean.

While, Thenmozhi et al., (2020) concluded that probiotic group in broiler chickens was recorded significant increase in digestive enzymes of serum like amylase and protease, nevertheless activity of lipase was not enhanced in probiotic supplemented group compared to control group. The improvement of digestive enzymes because of declining pathogenic load in gut thereby the perfection in intestinal health morphology and integrity (Lei et al., 2015) and the great effect of antimicrobial activity of probiotic (Jin et al., 1997). Additionally, because of the secretion of probiotic and the stimulation of endogenous enzymes synthesis and improve enzymes levels (Hu et al., 2018; Cao et al., 2020). The current findings were corroborated by Garcia et al. (2007), who emphasized the significance of *Ferula asafoetida* in stimulating the excretions of the digestive system, and Roy (2014), who found that adding *Ferula asafoetida* to poultry diets increased the production of digestive enzymes. In addition, Ferula generally has strong antibacterial and antioxidant qualities since it includes active substances and minerals such flavonoids, alkaloids, and glucosides. These characteristics can be used to fight against bacteria and other dangerous microbes (Fisher and Phillips, 2008). So, these findings may be related to current improvement of digestive enzymes for treated chicks.

The present study showed significant ($p<0.05$) change in the relative weight of the jejunum in birds who received high dose of dietary addition of *Ferula asafoetida* gum powder. These could be linked to a slower rate of ingestion through the digestive tract, and the jejunum utilized the limited nutrients for its growth with higher priority over body weight increase. Increased intestinal villi function is shown by higher villus heights in the jejunal and ileal mucosa (Ruttanavut and Yamauchi, 2010).

In the current study, the small intestine mucosa of the broiler chicks treated with *Ferula asafoetida* gum powder showed increases in villus height and the villus height to crypt depth ratio. These results are in agreement with the findings of Tu et al. (2024), who suggest that Phytobiotics can stimulate villi of the small intestine. Furthermore, increased villus size was also associated with activated cell proliferation in the crypt (Lauronen et al., 1998).

The intestine's ability to digest and absorb food is linked to intestinal condition indicators (VH and CD) (Bellucci et al. 2022). While CD indicates the generative capability of the cells, with higher cellular maturity and lighter CDs indicating more absorption capacity (Yason et al. 1987), an increase in VH in the jejunum can enhance the surface area for nutrient absorption in broilers (Zhang et al., 2022). Conversely, a rise in the VH:CD ratio may suggest that *Ferula asafoetida* gum powder improves the intestinal morphology of broilers. The improvement of intestinal absorption by supplements may be closely associated with intestinal integrity. Intestinal morphology showed that the addition of *Ferula asafoetida* gum powder did not damage the intestine causing oxidative stress. Rather, it enhanced the jejunum's capacity to absorb nutrients, indicating that *Ferula asafoetida* gum powder had a positive effect on the intestine. The results showed that dietary addition of different levels of *Ferula asafoetida* gum powder improved intestinal morphology, significantly prolonged jejunal villi and increased with the increase of dose, significantly reduced crypt depth, and significantly increased VH/CD value. It indicated that the addition of *Ferula asafoetida* gum powder greatly increased the capacity for intestinal absorption.

Phytogenics have potent antioxidant qualities because they contain secondary metabolites including flavonoids and phenolic acids (Oni and Oke, 2025). By scavenging free radicals and lowering oxidative stress in intestinal epithelial cells, these compounds preserve the integrity of tight junctions and lessen inflammation (Oni et al., 2024). Immune modulation is another important mechanism. By triggering innate immune responses through Toll-like receptor signaling and altering the production of cytokines like interleukins and interferons, certain phytogenics improve mucosal immunity and regulate the activity of gut-associated lymphoid tissue (Obianwuna et al., 2024). Phytogenics also enhances intestinal barrier function by reducing intestinal permeability and preventing pathogen invasion by increasing the production of mucin and upregulating the expression of tight junction proteins including occludin and claudin-1 (Peng et al., 2023). Furthermore, they promote the production of digestive enzymes like protease and amylase, which improve the gut's capacity to absorb and process food (Obianwuna et al., 2024).

Conclusively**,** according to the current study's results, the dietary addition of FAGP to broiler chicks can exert beneficial effect in the gut digestive enzyme activity and intestinal morphology and development. However, research on the mechanism or mechanisms of FAGP on the gastrointestinal system is still lacking. Therefore, FAGP can be useful as a feed addition in the diet of broilers, but more research is required to fully comprehend and elucidate the process or mechanisms involved.

CONFLICTS OF INTEREST:

The authors of this work declare that they have no known conflicts of interest.

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DATA AVAILABILITY STATEMENT:

Upon reasonable request, the data supporting the study's conclusions can be provided by the corresponding author.

AUTHORS CONTRIBUTION

K.H.E., A.A.T.M.R., T.E.H.T., A.I.M. developed the concept of the manuscript. All authors checked and confirmed the final revised manuscript.

REFERENCES

Abd El Latif, M.A.; and Omar, M.O.A. (2023). Productive performance, digestibility, blood parameters and intestine microbiology of broiler chicks affected by prebiotic, probiotic and synbiotic addition. Egypt. Poult. Sci., 43, 217-237. https://doi.10.21608/epsj.2023.304305

Abreu, A.C.; McBain A.J. and Simoes, M. (2012). Plants as sources of new antimicrobials and resistance-modifying agents. Nat. Prod. Rep., 9,1007–1021. https://doi.org/10.1039/C2NP20035J

Arif, M.; Rehman, A.U.; Naseer, K.; Abdel-Hafez, S.H.; Alminderej, F.M.; El-Saadony, M.T.; Abd El-Hack, M.E.; Taha, A.E.; Elnesr, S.S.; Salem, H.M. and Alagawany, M. (2022). Effect of Aloe Vera and clove powder supplementation on growth performance, carcass and blood chemistry of Japanese quails. Poult. Sci., 101, 101702-10711. https://doi.org/10.1016/j.psj.2022.101702

Basit, M.A.; Arifah, A.K.; Loh, T.C.; Saleha, A.A.; Salleh, A.; Kaka, U. and Idris, S.B. (2020). Effects of graded dose dietary supplementation of Piper betle leaf meal and Persicaria odorata leaf meal on growth performance, apparent ileal digestibility, and gut morphology in broilers. Saudi J. Biol. Sci., 27, 1503–1513. https://doi.10.1016/j.sjbs.2020.04.017

Baskaran, N.; Manoharan, S. and Balakrishnan, S. (2010). Chemopreventive potential of ferulic acid in 7,12-dimethylbenz[a]anthracene-induced mammary carcinogenesisin Sprague-Dawley rats. Eur. J. Pharmacol., 637, 22–29. https://doi.org/10.1016/j.ejphar.2010.03.054

Bellucci, E. R. B.; Bis-Souza, C. V.; Dominguez, R.; Bermudez, R. and Barretto, A. (2022). Addition of natural extracts with antioxidant function to preserve the quality of meat products. Biomolecules, 12, 1506-1524. https://doi.org/10.3390/biom12101506

Biotechnology, *2*(1), 49-64..

Cao, X.; Tang, L.; Zeng, Z.; Wang, B.; Zhou, Y.; Wang, Q.; Zou, P. and Li, W. (2020). Effects of probiotics Basc06 on intestinal digestion and absorption, antioxidant capacity, microbiota composition, and macrophage polarization in pigs for fattening. Front. Vet. Sci., 7, 570593- 570,608. https://doi.org/10.21203/rs.3.rs-25137/v1

Carrasco, J.M.D.; Redondo, E.A.; Viso, N.D.P.; Redondo, L.M.; Farber, M.D. and Miyakawa, M.E.F. (2018). Tannins and bacitracin differentially modulate gut microbiota of broiler chickens. BioMed. Res. Int., 4, 1879168. **https://doi.org/10.1155/2018/1879168**

El-Kholy, K.H.; Sokariaa, M.E. and El-Ratel, I.T. (2025). Gut microbiota and intestinal morphology of growing quails as affected by dietary addition of tryptophan or/and canthaxanthin. Damietta J. Agric. Sci., 4, 73-84. https://doi.org/10.21608/djas.2025.409421

El-Kholy, K.H.; Tag El-Din, H.; Tawfeek, F.A. and Hassab, S.H.M. (2022). Climate change mitigation by dietary phytogenic addition in layer hens: Some re-productive traits and endocrine hormones responses. Anim. Health Prod. J., 10, 81-87. http://dx.doi.org/10.17582/journal.jahp/2022/10.1.81.87

El-Kholy, K.H.; Tag El-Din, H.; Tawfeek, F.A.; Tufarelli, V.; Losacco, C.; Alhotan, R.A.; Shafi, M.E.; Attia, Y.A. and Hassab, S.H.M. (2024). Performance, blood and antioxidant status in dual-purpose laying hens supplemented with aqueous extract of Christ's thorn jujube (Ziziphus spina-christi L.) leaves as phytogenic agent in subtropical conditions. Anim. Sci. J., 37, 896-907. https://doi.org/10.5713/ab.23.0243

Fatehi, M.; Farifteh, F. and Fatehi-Hassanabad, Z. (2004). Antispasmodic and hypotensive effects of Ferula asafoetida gum extract. J. Ethnopharmacol., 91, 321-324. https://doi.org/10.1016/j.jep.2004.01.002

Fisher, K. and Phillips, C. (2008). Potential antimicrobial uses of essential oils in food: is citrus the answer?. Trends Food Sci. Technol., 19-156-164. https://doi.org/10.1016/j.tifs.2007.11.006

Garcia, V.; Catala-Gregori, P.; Hernandez, F.; Megias, M.D. and Madrid, J. (2007). Effect of formic acid and plant extracts on growth, nutrient digestibility, intestine mucosa morphology, and meat yield of broilers. *J. Appl. Poult. Res.*, 16, 555-562. https://doi.org/10.3382/japr.2006-00116

Hu, S.; Cao, X.; Wu, Y.; Mei, X.; Xu, H.; Wang, Y.; Zhang, X.; Gong, L. and Li, W. (2018). Effects of probiotic Bacillus as an alternative of antibiotics on digestive enzymes activity and intestinal integrity of piglets. Front. Microbiol., 9, 2427-2435. https://doi.org/10.3389/fmicb.2018.02427

Jin, L. Z.; Ho, Y. W.; Abdullah, N. and Jalaludin, S. (1997). Probiotics in poultry: Modes of action. Worlds Poult. Sci. J, 53, 351-368. https://doi.org/10.1079/WPS19970028

Kareparamban, J.; Nikam, P.; Jadhav, A. and Kadam, V. (2013). Determination and quantification of ferulic acid in *Ferula asafoetida* by a validated HPTLC method. Indian J. Pharm. Educ. Res., 47, 77-81. https://doi.org/10.5530/IJPER.47.3.12

Lauronen, J.; Pakarinen, M. P.; Kuusanmaki, P.; Savilahti, E.; Vento, P.; Paavonen, T. and Halttunen, J. (1998). Intestinal adaptation after massive proximal small-bowel resection in the pig. Scand. J. Gastroenterol., 33, 152-158. https://doi.org/10.1080/00365529850166879

Lei, X.; Piao, X.; Ru, Y.; Zhang, H. and Peron, A. (2015). Effect of Bacillus amyloliquefaciens-based direct-fed microbial on performance, nutrient utilization, intestinal morphology and cecal microflora in broiler chickens. Asian-Australas. j. anim. sci., 28, 239–246. http://dx.doi.org/10.5713/ajas.14.0330

Mahboubi, M. (2021). The beneficial effects of Ferula asafoetida oleo-gum resin in gastrointestinal disorders. Bull. Fac. Pharm. Cairo Unif., 59, 51-63. https://doi.org/10.54634/2090-9101.1025

Mashayekhi, H.; Mazhari, M. and Esmaeilipour, O. (2018). Eucalyptus leaves powder, antibiotic and probiotic addition to broiler diets: Effect on growth performance, immune response, blood components and carcass traits. Anim., 12, 2049–2055. https://doi.org/10.1017/S1751731117003731

Moharreri, M.; Vakili, R.; Oskoueian, E. and Rajabzadeh, G. (2022). Effects of microencapsulated essential oils on growth performance and biomarkers of inflammation in broiler chickens challenged with Salmonella enteritidis. J. Saudi Soc. Agric.

Sci., 21, 349–57. https://doi.org/10.1016/j.jssas.2021.10.012

Murugesan, G.R.; Syed, B.; Haldar, S. and Pender, C. (2015). Phytogenic feed additives as an alternative to antibiotic growth promoters in broiler chickens. Front. Vet. Sci., 2: 21. https://doi: 10.3389/fvets.2015.00021

NRC (1994). Nutrient Requirements of Poultry. 9th edition. Washington, DC., United States of America: National Academy Press. 1994.p 192.

Obianwuna, U.E.; Chang, X.; Oleforuh-Okoleh, V.U.; Onu, P.N.; Zhang, H.; Qiu, K. and Wu, SH. (2024). Phytobiotics in poultry: revolutionizing broiler chicken nutrition with plant-derived gut health enhancers. J Anim Sci Biotechnol., 15, 169-202. http//doi: 10.1186/s40104-024-01101-9

Oni, A.I. and Oke, O.E. (2025). Gut health modulation through phytogenics in poultry: mechanisms, benefits, and applications. Front. Vet. Sci., 12, 1616734-1,616,747. https://doi.org/10.3389/fvets.2025.1616734

Oni, A.I.; Adeleye, O.O.; Adebowale, T.O. and Oke, O.E. (2024). The roles of phytogenic feed additives in stress mitigation in broiler chickens. J. Anim. Physiol. Anim. Nutr., 108, 81–98. http//doi: 10.1111/jpn.13869\

Peng, J.; Li, H.; Olaolu, O.A.; Ibrahim, S.; Ibrahim, S. and Wang, S. (2023). Natural products: a dependable source of therapeutic alternatives for inflammatory bowel disease through regulation of tight junctions. Molecules, 28, 6293-6318. https://doi.org/10.3390/molecules28176293

Rafeeq, M.; Bilal, R.M.; Batool, F.; Yameen, K.; Farag, M.R.; Madkour, M.; El-nesr, S.S.; El-Shall, N.A.; Dhama, K. and Alagawany, M. (2023). Application of herbs and their derivatives in broiler chickens: a review. World's Poult. Sci. J., 79, 95–117. https://doi.org/10.1080/00439339.2022.2108362

Roy, S.; Metya, S.K.; Rahaman, N.; Sannigrahi, S. and Ahmed, F. (2014). Ferulic acid in the treatment of post-diabetes testicular damage: Relevance to the down regulation of apoptosis correlates with antioxidant status via modulation of TGF-ß1, IL-1ß and Akt signaling. *Cell Biochem. Funct*., 32, 115-124. https://doi.org/10.1002/cbf.2983

Ruttanavut, J. and Yamauchi, K. (2010). Growth performance and histological alterations of intestinal villi in broilers fed dietary mixed minerals. Asian. J. Anim. Sci., 4, 96-106. DOI: 10.3923/ajas.2010.96.106

Saleh, A.A.; Ragab, M.M.; Ahmed, E.A.M.; Abudabos, A.M. and Ebeid, T.A. (2018). Effect of dietary zinc-methionine supplementation on growth performance, nutrient utilization, antioxidative properties and immune response in broiler chickens under high ambient temperature. J. Appl. Anim. Res., 46, 820–827. https://doi.org/10.1080/09712119.2017.1407768

SAS. (2012). Statistical Analysis Systems (SAS), User's Guide, 12.1 ed., pp. 108–110.

Shi, L.; Jin, X.; Xu, Y.; Xing, Y.; Yan, S.; Guo, Y.; Cheng, Y. and Shi, B. (2022). Effects of total flavonoids of artemisia ordosica on growth performance, oxidative stress, and antioxidant status of lipopolysaccharide-challenged broilers. Antioxidants, 11, 1985-2002. https://doi.org/10.3390/antiox11101985

Stevanović, Z.D.; Bošnjak-Neumüller, J.; Pajić-Lijaković, I.; Raj, J. and Vasiljević, M. (2018). Essential oils as feed additives-future perspectives. Molecules, 23, 1717-1736. https://doi.org/10.3390/molecules23071717

Strugala, P.; Cyboran-Mikolajczyk, S.; Dudra, A.; Mizgier, P.; Kucharska, A. Z.; Olejniczak, T. and Gabrielska, J. (2016). Biological activity of Japanese quince extract and its interactions with lipids, erythrocyte membrane, and human albumin. J. Membr. Biol., 249, 393-410. DOI 10.1007/s00232-016-9877-2

Sun, Y.; Zhang, Y.; Liu, M.; Li, J.; Lai, W.; Geng, SH.; Yuan, T.; Liu, Y.; Di, Y.; Zhang, W. and Zhang, L. (2022). Effects of dietary Bacillus amyloliquefaciens CECT 5940 supplementation on growth performance, antioxidant status, immunity, and digestive enzyme activity of broilers fed corn-wheat soybean meal diets. Poul. Sci., 101, 101585-101592. https://doi.org/10.1016/j.psj.2021.101585

Suresh, G.; Das, R.K.; Brar, S.K.; Rouissi, T.; Ramirez, A.A.; Chorfi, Y. and Godbout, S. (2018). Alternatives to antibiotics in poultry feed: Molecular perspectives. Crit. Rev.

Microbiol., 44, 318–335. https://doi.org/10.1080/1040841X.2017.1373062

Taghizadeh, M.; Esmaeili, H. and Vakili, R. (2024). Cholecalciferol combined with satureja Rechingeri essential oils improves growth performance and immune response of broiler chickens. Vet. Med. Sci., 10, e1587. https://doi.org/10.1002/vms3.1587

Thenmozhi, M.; Sinthiva, S.; Premalatha, M. and Dhasarathan, P. (2020). Effect of Probiotics on Digestive Enzymes and Immuno stimulation in Animal Model (Broilers). Singapore J. Sci. Res., 10, 266-273. https://scialert.net/abstract/?doi=sjsres.2020.266.273

Tu, J.; Kang, M.; Zhao, Q.; Xue, C.; Bi, C. and Dong, N. (2024). Oleanolic acid improves antioxidant capacity and the abundance of Faecalibacterium prausnitzii in the intestine of broilers. Poult. Sci., 103, 104340- 104352. https://doi.org/10.1016/j.psj.2024.104340

Uni, Z.; Gal-Garber, O.; Geyra, A., Sklan, D. and Yahav S. (2001). Change in growth and function of chick small intestine epithelium due to early thermal conditioning. Poult. Sci. 80: 438-445. https://doi.org/10.1093/ps/80.4.438

Wang, Y. and Gu, Q. (2010). Effect of probiotic on growth performance and digestive enzyme activity of Arbor Acres broilers. Res. Vet. Sci., 89, 163-167. https://doi.org/10.1016/j.rvsc.2010.03.009

Wang, Y.; Heng, C.; Zhou, X.; Cao, G.; Jiang, L.; Wang, J.; Li, K.; Wang, D. and Zhan, X. (2021). Supplemental Bacillus subtilis DSM 29784 and enzymes, alone or in combination, as alternatives for antibiotics to improve growth performance, digestive enzyme activity, anti-oxidative status, immune response and the intestinal barrier of broiler chickens. Br. J. Nutr., 125, 494-507. http://doi:10.1017/S0007114520002755

Xiaofei, H. and Yuming, G. (2008). Corticosterone administration after small intestine morphology and function of broiler chickens. Asian-Aust. J. Anim. Sci., 21: 1773–1778.

Yadav, S. and Jha, R. (2019). Strategies to modulate the intestinal microbiota and their effects on nutrient utilization, performance, and health of poultry. J. Anim. Sci. Biotechnol., 10, 1-11. https://doi.org/10.1186/s40104-018-0310-9

Yan, D.; Wei, G.; Ai, Z.; Song, S.; Zhang, L.; Dong, N.; Dou, X. and Shan, A. (2024). CXCR2, as a key regulatory gene of HDP-PG-1, maintains intestinal mucosal homeostasis. Int. J. Biol. Macromol., 269, 132025. https://doi.org/10.1016/j.ijbiomac.2024.132025

Yang, H.M.; Wang, W.; Wang, Z.Y.; Wang, J.; Cao, Y.J.; and Chen Y.H. (2013). Comparative study of intestine length, weight and digestibility on different body weight chickens. Afr. J. Biotechnol., 12: 5097–5100. https://doi.org/10.5897/AJB11.4014

Yao, Y.; Liu, Y.; Li, C.; Huang, X.; Zhang, X.; Deng, P.; Jiang, G. and Dai, Q. (2023). Effects of rosemary extract supplementation in feed on growth performance, meat quality, serum biochemistry, antioxidant capacity, and immune function of meat ducks. Poult. Sci., 102, 102357-102364. https://doi.org/10.1016/j.psj.2022.102357

Yason, C.V.; Summers, B. and Schat, K. (1987). Pathogenesis of rotavirus infection in various age groups of chickens and turkeys: pathology. Am. J. Vet. Res., 48, 927–938.

Zhang, Y.; Mahmood, T.; Tang, Z.; Wu, Y. and Yuan, J. (2022). Effects of naturally oxidized corn oil on inflammatory reaction and intestinal health of broilers. Poult. Sci., 101, 101541- 101552. https://doi.org/10.1016/j.psj.2021.101541

الملخص العربى

تأثير إضافة صمغ الحلتيت إلى غذاء دجاج التسمين على نمو الأمعاء وشكلها ونشاط إنزيماتها الهضمية

أمل إسماعيل مكاوي – على أحمد تغيان محمد رشوان - تاج الدين حسن تاج الدين –- خالد حسان الخولي
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باعتبارها بدائل طبيعية للمضادات الحيوية في إنتاج الدواجن، حظيت إضافات الأعلاف النباتية (PFAs) باهتمام كبير نظراً لقدرتها على تنظيم صحة الأمعاء. أُجريت هذه التجربة لتحديد تأثير إضافة مسحوق صمغ الحلتيت (FAGP) في علائق دجاج التسمين على الإنزيمات الهضمية وشكل الأمعاء. قُسِّم 192 كتكوت تسمين من نوع روس 308، بعمر يوم واحد، إلى أربع مجموعات تجريبية، تتكون كل منها من ثلاث مكررات، لتجربة تغذية استمرت 35 يوماً. فُحصت إضافات الأعلاف النباتية بمستويات إضافة مختلفة لكل كيلوجرام من العلف: 0% (مجموعة التحكم، T_0)، 4 جرام (T_1)، 8 جرام (T_2)، و12 جرام (T_3)، بتصميم عشوائي كامل. أظهرت النتائج أنه في نهاية التجربة (35 يوماً) كان لإضافة FAGP تأثيرات إيجابية ($p < 0.001$) على انزيمات الليباز والكيموتربسين والتربسين مقارنةً بالمجموعة الضابطة. ولم يكن للإضافة الغذائية لـ FAGP أي تأثير على الطول النسبي ووزن الأمعاء الدقيقة في اليوم الأول إلى اليوم الثامن عشر. لكن إضافة FAGP قللت بشكل كبير من الوزن النسبي للإثني عشر. ارتبطت الإضافة الغذائية لـ FAGP بزيادة ($p < 0.05$) في ارتفاع الخملات في الغشاء المخاطي للصائم واللفائفي مقارنةً بتلك المناطق في المجموعة الضابطة من اليوم الأول إلى اليوم الخامس والثلاثين. ومع ذلك، لم يكن للإضافة مع FAGP أي تأثير كبير ($p > 0.05$) على عمق تجويف الخملة في الغشاء المخاطي للصائم واللفائفي مقارنةً بتلك الموجودة في المجموعة الضابطة. وفي الختام، أدت الإضافة الغذائية لـ FAGP إلى تحسين مورفولوجيا الأمعاء وزيادة وزن الأمعاء وطولها وتعزيز نشاط إنزيمات الهضم المعوي.