J I T A A
Journal of the Indonesian Tropical Animal Agriculture
Accredited by Ditjen Riset, Teknologi dan Pengabdian
kepada Masyarakat No. 164/E/KPT/2021

J. Indonesian Trop. Anim. Agric.
pISSN 2087-8273 eISSN 2460-6278
http://ejournal.undip.ac.id/index.php/jitaa
51(1):60-71, March 2026
DOI: 10.14710/jitaa.51.1. 60-71

Effect of supplementation of *Typha domingensis* Pers. fruit powder and aqueous extract on productive performance and some physiological characteristics of broiler chickens

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Received November 06, 2025; Accepted February 02, 2026

ABSTRACT

This study evaluated the effects of dietary supplementation with *Typha domingensis* Pers. fruit flour (TDF) and its aqueous extract (TDE) on growth performance, physiological responses, and gut microbial balance in broiler chickens. A total of 216 one-day-old chicks were allocated at seven days of age into six treatment groups. Birds received either a basal diet (T1, control), TDE supplementation in drinking water at 5 or 15 mL/L (T2 and T3), TDF inclusion in feed at 5 or 15 g/kg (T4 and T5), or a combined supplementation of TDF and TDE at 7.5 units each (T6). Supplemented groups exhibited significant improvements ($p \leq 0.05$) in final body weight, body weight gain, feed conversion ratio, production index, performance index, and economic efficiency compared with the control group. Additionally, the relative weight of the bursa of Fabricius increased, whereas abdominal fat deposition decreased. Blood biochemical analysis revealed significant reductions in serum cholesterol, triglycerides, low-density lipoprotein (LDL), aspartate aminotransferase (AST), and alanine aminotransferase (ALT), accompanied by increased high-density lipoprotein (HDL) levels. Antioxidant status was enhanced, as indicated by elevated superoxide dismutase (SOD) and glutathione peroxidase (GSH-PX) activities. Microbiological assessment demonstrated reduced total bacterial counts and *Escherichia coli*, alongside increased populations of beneficial *Lactobacillus spp*. In conclusion, supplementation with TDF and TDE positively influenced growth performance, metabolic health, antioxidant capacity, and intestinal microbial balance in broiler chickens, suggesting their potential as natural feed additives to improve poultry productivity and health.
Keywords: Broilers, Ileal microbiota, Productive performance, Typha domingensis Pers. Fruit.

INTRODUCTION

Typha domingensis Pers. (cattail) is a globally widespread aquatic plant, also known as Bardy (papyrus). It is a perennial plant with lance-shaped leaves, fast growing, belonging to the Typhaceae family. There are over 500 species of Typha plants worldwide, along with approximately 104 genera, which can grow excessively in tropical wetlands, reaching lengths of up to 2-3 meters (Sorourian *et al.* 2020; Pandey *et al.,* 2022). In southern Iraq, particularly in various regions, particularly in various regions of Basrah province, *Typha domingensis* (Pers.) is widely distributed in marsh areas (Maki *et al.,* 2024). Its pollen is yellow and rich in nutrients, including vitamins, minerals, and flavonoids.The flavonoids present in the pollen are responsible for its yellow color Aljazy *et al.,* 2021), and have antioxidant properties that help protect against oxidative damage (Avcı *et al.,* 2023), and offer antimicrobial benefits (Al-Mazirah *et al.,* 2021). Pollen extracts from various plant species contain bioactive compounds (gamma-sitosterol, catechol, propionic acid, phenols, and palmitoleic acid), these compounds, along with flavonoids and essential minerals, can benefit the human body (Aljazy *et al.,* 2021).

The bioactive polyphenolic compounds in the Typha domingensis plant have been shown to lower blood pressure associated with hyperlipidemia (Akram and Jabeen, 2022). Dilshad *et al.* (2024) found that the n-butanol fraction of *Typha domingensis* Pers. exhibits significant antioxidant activity, contains a wide range of bioactive metabolites, and shows strong antidiabetic effects. Furthermore, *in vitro* and *in vivo* experiments have demonstrated significant analgesic and anti-inflammatory properties of *T. domingensis* Pers. This research therefore supports the plant's efficacy in pain relief and the treatment of inflammatory diseases (Dilshad *et al.*, 2024). Additionally, alkaloids isolated from the fruit have been shown to act as hepatoprotective agents, suggesting the potential for developing natural hypoglycemic agents with antioxidant effects (Bukhibkh *et al.,* 2022). The pollen of *Typha domingensis* has also demonstrated inhibitory effects against bacterial and fungal isolates, including those that can cause diseases in humans (Al-Mazirah *et al.,* 2021). The vegetative part of *Typha domingensis* has been found to have several bioactive properties.

The ethanolic extract from this part showed antibacterial activity against Staphylococcus *aureus*, *Streptococcus faecalis*, and *Klebsiella pneumonia* (Khalid *et al*., 2022). Several phytochemicals in the plant extract also exhibit antibacterial activity (Al-Mazirah *et al*., 2021; Elfar *et al*., 2025). Moreover, the water extract of *Typha domingensis* has found to have anti-tumor properties (Aziz and Alhammer, 2021). The edible parts of the Typha plant, including rhizome, shoots, and pollen, have been consumed as food in various countries such as Southern Iraq, India, South America, China, and New Zealand (Zhang *et al.,* 2020). These parts can be eaten fresh or cooked, and they can also be used to make desserts sweet treats like "Khurrait" (Aljazy *et al*., 2021). The potential use of Typha domingensis for animal feed has been reported by Mosa and Garba (2022). Research has shown that incorporating Typha silage into beef cattle diets has no adverse effects on feed intake, blood profile, production costs, or growth performance (John *et al.,* 2022).

To our knowledge, this is the first study to incorporate papyrus fruit flour into broiler feed; therefore, this study was designed to investigate the positive effects of *Typha domingensis* Pers. fruit flour and its aqueous extract on the performance of broiler chickens. We hypothesized that these natural feed additives would enhance the productivity of broilers without adversely affecting their health.

MATERIALS AND METHODS

Plant Material and Preparation of Plant Extract

The flour of *Typha domingensis* Pers. fruit was purchased from a local market in Basrah City, Iraq. Aquatic extract of *Typha domingensis* Pers. fruit flour was prepared as described by Almeida et al., (2017) by taking 10 g of flour and adding it to 100 milliliters of distilled water. The mixture was placed in a shaking incubator at 40°C. The extract was filtered through Whatman no.1 filter paper. The filtrate was then evaporated in a rotary evaporator below 40°C. Finally, the resulting filtrate was kept as the extract and stored at a temperature of 4°C until use.

Birds and Experimental Diets

This study was conducted at the Poultry farm, Faculty of Agriculture, University of Basrah for a period of 35 days from 14thApril 2024 to 18 May 2024. A total of 216 day-old chicks were randomly divided into six treatment groups, each containing three replicates of twelve birds. All chicks were given a basic corn and soybean meal diet for 35 days throughout all growth stages, including the starter stage (1–21 days) and the grower stage until the end of the experiment.The dietary experimental treatments were as follows: - T1 (control): Basal diet without supplements - T2 and T3: TDE at 5 and 15 ml/l in drinking water - T4 and T5: TDF at 5 and 15 g/kg in the basal diet respectively- T6: TDE at 7.5 ml/l in drinking water plus TDF at 7.5 g/kg in the basal diet. *Typha domingensis* was added from the 7th days of age until slaughter at 35 d. The basic diet was formulated to meet broiler chicks' nutrient needs according to their age (as illustrated in Table 1). Throughout the experiment, the chicks had unlimited access to both feed and water, and all groups received consistent hygienic and managerial conditions.

Bird's Performance

Live body weight (LBW) of the chicks was recorded at 7 and 35 days of age after two hours of not feeding. Body weight gain (BWG) was calculated as the change in body weight from 7-35 days of age, and feed intake (FI) was recorded for the corresponding periods. The feed conversion ratio (FCR) was then calculated. The birds' mortality was recorded on the day when it occurred. Production index was calculated using the formula described by Naji (2006):
Production index =
Where:
Livability percentage = 100 – mortality percentage.

$$\frac{\text{Average of live weight} \times \text{liveability percentage}}{\text{Age in days} \times \text{FCR} \times 10}$$

Feed conversion ratio (FCR) = (Total feed given/ Total live weight).

The performance index was calculated using the formula presented by North (1981):
Performance index (PI) = (LBW kg/FCR) ×100

After recording the total weight of marketed birds (kg) and calculated FCR, the economic efficiency (EE) was calculated according to the following formula:
Economic efficiency (EE) = Feed cost (ID feed intake/kg live weight) × FCR

Evaluation of Carcass Traits

After the trial period, three birds from each treatment were randomly taken and then fasted for six hrs. After fasting, the birds were weighed and then slaughtered by bleeding and evisceration. The liver, gizzard, heart, bursa, spleen, and abdominal fat pad weights were recorded and expressed as a percentage of the live weights. Dressing percentage was determined using the formula: Dressed weight/live weight × 100.

Estimation of Biochemical Parameters

On the 35th day, 5 ml of blood samples were drawn from three birds per treatment through the wing vein into anticoagulant-free bottles and were used to determine blood biochemical components. The serum was separated by centrifugation and stored at −20 ^{0}C for further analysis. The requisite stored samples were evaluated for liver function test (total protein, albumin, globulin, glucose), lipid profile (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triglycerides using commercially available kits supplied by BIOLABO-SAS Company, and the assay was done according to the manufacturer's instructions. The liver enzymes test (Aspartate aminotransferase, Alanine aminotransferase), were measured by using diagnostic kits (QCA, Amposata, Spain). The ELISA (Enzyme-Linked Immune Sorbent Assay) was

Table 1. Ingredients and nutrient composition of broiler basal diet (%)

Ingredients	Starter (21d–1)	Grower (35d–22)	Calculated composition[3]	Starter (21d–1)	Grower (35d–22)
Maize	53.80	54.80	ME (kcal/kg)	3012.76	3149.43
Wheat	6.00	9.00	Crude protein	23.13	21.62
Soybean meal (48%)	32.30	29.0	Crude fiber	3.85	3.72
Broiler concentrates (40%)[1]	5.00	4.00	Calcium	0.90	0.61
Soya oil	1.45	1.75	Available phosphorus	0.45	0.41
.Dicalcium phosphate (18	0.50	0.50	Lysine	1.12	1.03
Limestone	0.50	0.50	Methionine + Cystine	0.78	0.73
Premix[2] (Vit. & Min)	0.20	0.20	Energy: protein	130.28	145.66
Salt	0.25	0.25			

[1]Broiler concentrate contains the following: 40% CP, 3.8% CF, 10% calcium, 4.5% available phosphorus, 1.8% lysine, 0.55% methionine, 2.89% methionine + cysteine, Metabolizable energy 2800 0kcal/kg, 0.14% Sodium. [2]Premix provides the following nutrients (per kilogram of diet): Vitamin A, 6 mg; vitamin D3, 0.15 mg; vitamin E, 40 mg; vitamin K3, 4 mg; B1, 3 mg; B2, 12 mg; B6, 10mg; vitamin B12, 0.04 mg; niacin, 60mg; choline chloride, 700 mg; calcium D-pantothenate, 20 mg; folic acid, 2 mg; Biotin, 0.2 mg; Iron, 90 mg; Copper, 30 mg; Manganese, 120 mg; Zinc, 140 mg; Iodine, 4 mg; Selenium, 0.8 mg; Calcium, 30.8%. [3]Calculated composition: NRC (1994) feed ingredient tables were used for calculation

used to estimate the activity of antioxidant enzymes in serum (superoxide dismutase, glutathione peroxidase) using the standard ready-made kit from IBM International GMBH, Germany. The activity of catalase in serum was assayed using a standard ready-made kit produced by ABO Swiss Company. Sample readings were performed using a spectrophotometer with a light wavelength adequate for each parameter.

Ileal microbial count

Three birds from each dietary group were randomly chosen for microbial sampling. On day 35 of the trial, these birds were sacrificed, and fresh intestinal contents from the ileum were collected from each bird. The collected digesta samples were diluted using a normal saline solution. Different selective media, such as nutrient agar, MRS agar, and MacConkey agar, were used to assess the microbial populations, including total bacterial count, Lactic acid bacteria, and *Escherichia coli*. After incubation, the microbial colonies grown on each type of selective agar medium would be counted and identified.

Statistical Analysis

Results were analyzed by one-way ANOVA using the SPSS software package program (2018). The differences were tested using Duncan's multiple-range test (Duncan, 1955). Significance value was set at $P \leq 0.05$. Results were presented as mean and pooled standard error of the mean (SEM).

RESULTS AND DISCUSSION

Productive Performance Parameters

The effects of dietary supplementation with *Typha domingensis* Pers fruit powder or its aqueous extract on the productive performance of broiler chicks are presented in Table 2. The live body weight at 7 days, feed intake from 7 to 35 days, and livability did not differ significantly ($p \geq 0.05$) among the treatment groups. However, the final body weight of the broilers fed the supplemented diet significantly increased (p=0.04) compared to those fed the control diet. Additionally, total weight gain was positively influenced by the treatments. Feed conversion ratio (FCR) values were better in the supplementary groups than in the control group. Furthermore, broilers fed diets with T. domingensis supplements had significantly (p=0.033) better production index, performance index (p= 0.036), and economic efficiency (p=0.050) than the control group. The highest value of the production index was achieved in the third treatment (15 ml/l TDE), which reached 468.03. In contrast, the fifth treat-

Table 2. Productive performance of broiler chicks as influenced by *T. domingensis* supplementation (7-35 days)

Parameters	Dietary treatments[1]						SEM[2]	*P-value*
	T1	T2	T3	T4	T5	T6		
LBW 7 d (g)	207.75	211.14	211.58	208.86	209.06	207.31	0.632	0.283
LBW 35 d (g)	1963.67c	2070.70[ab]	2096.43[ab]	2038.50[b]	2119.22[a]	2098.47[ab]	14.692	0.004
BWG 7-35 (g)	1755.92[c]	1859.56[ab]	1884.85[ab]	1829.64[b]	1910.16[a]	1891.16[ab]	14.715	0.005
FI 7-35 (g/bird)	2560.59	2340.85	2413.52	2390.32	2413.45	2408.13	35.039	0.658
FCR 7-35 (feed/gain)	1.46[a] 1.30	1.26[b]	1.28[b]	1.31[b]	1.26[b]	1.27[b]	0.024	0.050
Production index	363.69[b]	458.14[a]	468.03[a]	19[a] .447	452.23[a]	457.86[a]	11.063	0.033
Performance index	134.82[b]	165.01[a]	163.81[a]	157.10[a]	168.00[a]	165.17[a]	3.568	0.036
Economical efficiency	1275.4[a]	962.04[b]	996.45[b]	1038.02[b]	974.23[b]	990.35[b]	36.269	0.050
Livability(%)	94.45	100	100	99.67	94.45	97.22	1.123	0.497

[a-c] .Means followed by different letters in each row as significantly different at $p \leq 0.05$

[1]Treatments: T1, control (Basal diet); T2, and T3 - *Typha domingensis* extract at 5, and 15 (ml/l) in drinking water; T4, and T5- *T. domingensis* flour at 5, and 15 (g/kg) in basal diet; T6- *T. domingensis* extract at 7.5 (ml/l) in drinking water + *T. domingensis* flour at 7.5 (g/kg) in basal diet respectively. [2]SEM: Standard error of the means. LBW: Live body weight; BWG: Body weight gain; FI: Feed intake; FCR: Feed conversion ratio

Table 3. Effect of experimental diets on carcass characteristics of broiler chickens at 35 days of age

Parameters	Dietary treatments[1]						SEM[2]	*P*<
	T1	T2	T3	T4	T5	T6		
Carcass yield, %	72.62	73.93	73.95	73.87	75.24	74.41	1.785	1.000
[3]Total giblets, %	3.87	4.27	4.16	4.55	4.55	4.31	0.155	0.841
Liver yield, %	2.22	2.58	2.68	2.92	2.69	2.51	0.018	0.816
Heart yield, %	0.38	0.38	0.37	0.43	0.40	0.43	0.012	0.722
Gizzard yield, %	1.27	1.38	1.09	1.20	1.46	1.37	0.535	0.429
Spleen yield, %	0.118	0.136	0.104	0.120	0.124	0.105	0.008	0.910
Bursa of Fabricius,%	0.042^{b}	0.117^{a}	0.119^{a}	0.078^{ab}	0.121^{a}	0.126^{a}	0.011	0.043
Abdominal fat, %	1.53^{a}	1.04^{b}	0.89^{b}	1.02^{b}	0.97^{b}	0.83^{b}	0.065	0.049

$^{a-b}$ means within a row for each parameter with different superscripts are significantly different ($p \leq 0.05$).

[1]Treatments: T1, control (Basal diet); T2, and T3 - *Typha domingensis* extract at 5, and 15 (ml/l) in drinking water; T4, and T5- *T. domingensis* flour at 5, and 15 (g/kg) in basal diet; T6- *T. domingensis* extract at 7.5 (ml/l) in drinking water + *T. domingensis* flour at 7.5 (g/kg) in basal diet respectively. [2]SEM: Standard error of mean. [3]Total giblets: (gizzard+ liver+ heart).

ment (15 g/kg TDF) achieved the best performance index at 168.00. The control (T1) had the lowest values, with a production index of 363.69 and a performance index of 134.82. Regarding economic efficiency (EE), the study revealed a significant decrease (p=0.050) in EE values for the supplementary treatments compared to the control, which had the highest EE value. T2 exhibited the best economic efficiency at 962.04, while the control group had the lowest value at 1275.44. Additionally, *Typha domingensis* supplementation did not affect livability (%) across all experimental groups (Table 2).

The study showed that adding TDF or TDE to a broiler diet improved productive performance. This improvement may be attributed to bioactive compounds, such as phenols and flavonoids, present in the *T. domingensis* supplement. The presence of phenolic compounds, including polyphenols, flavonoids, hydroxycinnamic acids, and proanthocyanidins, is believed to be responsible for this improvement. These compounds have been reported to have antioxidant and anti-glucosidase activities (Chai *et al.,* 2014; 2015; Dilshad *et al.,* 2023; Avcı *et al.,* 2023), antimicrobial activities (Al-Kalifawi *et al.,* 2017; Al-Mazirah *et al.,* 2021; Khalid *et al.,* 2022), as well as anti-inflammatory and analgesic properties (Dilshad *et al*., 2023). All of these characteristics improve birds' health, which in turn positively impacts their performance. The improvements in animal health are seen as increased body weight, feed intake, and FCR. Additionally, there are physical benefits, such as enhanced carcass and meat quality, along with improved nutritional values (Valenzuela-Grijalva *et al.,* 2017). The increase in productivity, performance index, and EE in the supplementary treatments may be due to the rise in average body weight, vitality percentage, and improvement in FCR. These measures are directly linked to the birds' body weight rate, livability percentage, and FCR (Garner and Flint, 2009).

Carcass Traits

As shown in Table 3, the addition of T. domingensis fruit powder or extract had no significant effect on the carcass yield (%), total giblets, liver, heart, gizzard, and spleen relative to live weight ($p \geq 0.05$). However, *T. domingensis* supplementation in broiler diets significantly increased the bursa of Fabricius (%) (P= 0.043), whereas the abdominal fat (%) decreased significantly (P=0.049) in the supplemented groups compared to control. A previous study found that increasing the weights of the spleen and bursa of Fabricius can positively affect the body's immune function in chickens (Fan *et al.,* 2013)**.** In a study conducted by Talal and Haraib (2013), it was observed that the extracts of the aquatic plants *Typha domingensis* (Pers) and Lemna minor (Lamarck) may contain immunostimulants. These substances enable common carp fish, when raised in wastewater combined with *T. domingensis* extract or wastewater combined with L. minor extract, to survive and resist organic pollution. In comparison, fish raised in sewage alone could not survive well, with only 10% of them surviving.

The decrease in abdominal fat in broiler chickens treated with varying levels of TDF or

TDE may be attributed to the plant's anti-lipid effect, which inhibits the accumulation of fat droplets in fat cells. This effect is likely due to the high percentage of unsaturated fatty acids (such as linoleic acid and alpha-linolenic acid) and phenolic compounds (like caffeic acid) in T. domingensis aqueous extract (Gallardo-Williams *et al.,* 2002). these fatty acids can change the fats in the body, which helps reduce the layer of abdominal fat. A study on rats confirmed that T. domingensis may help treat diet-induced hyperlipidemia and its related problems, such as obesity, atherosclerosis, and hypertension (Akram and Jabeen, 2022).

Serum Biochemical Parameters

The results in Table 4 show the effect of T. domingensis fruit powder and its aqueous extract on the serum biochemical parameters of broilers. The dietary groups did not have a significant effect ($p \geq 0.05$) on glucose, total protein, albumin, or globulin concentration. However, the serum lipid profile showed significant reductions ($p=0.005$) in total cholesterol (TC), triglycerides (TG) ($p<0.001$), and low-density lipoprotein cholesterol (LDL-c) ($p=0.008$) levels in all dietary groups compared to the control. This reduction was due to the inclusion of *T. domingensis* in the broiler feed or drinking water. Additionally, high -density lipoprotein cholesterol (HDL-c) increased ($p<0.001$) in the supplemented treatments compared to the control. The results of this study indicated that adding TDF or TDE to broiler diets improved serum concentrations of cholesterol, triglycerides, and LDL-c by lowering the levels of these substances in the blood. This suggests that *T. domingensis* supplementation may enhance liver lipid metabolism. In this regard, Akram and Jabeen (2022) found that treating animals with different concentrations of TDE reduced the levels of TC, TG, and LDL-c, and had anti-atherosclerotic effects when the animals were fed a high-fat diet. Additionally, specialists considered *T. domingensis* pollen, extracted from the papyrus plant, to be a complementary food that helps lower blood pressure and cholesterol levels in humans (Al-Mazirah *et al.,* 2021). The addition of TDF lowered serum cholesterol levels, demonstrating a hypocholesterolemic effect. The reduction in TC levels may be due to the presence of flavonoid compounds in *T. domingensis* (AL-Saeed 2012; Chai *et al.,* 2014; 2015). According to Tan *et al.,* (2022), flavonoids have health-promoting effects because of their antioxidant and anti-inflammatory properties. Numerous flavonoids can improve bird health and enhance the nutritional quality of poultry meat and eggs by changing the fatty acid profile and reducing cholesterol content. Several of these compounds have been found to inhibit

Table 4. Biochemical indices and enzyme activities of broiler chicks' fed experimental diets at 35 days old

Parameters	Dietary treatments[1]						SEM[2]	*>P*
	T1	T2	T3	T4	T5	T6		
Glucose (g/dl)	252.69	243.03	234.66	242.37	224.52	239.60	6.046	0.906
Total Protein (g/dl)	2.76	2.81	3.10	3.29	2.97	3.50	0.141	0.691
Albumins (g/dl)	1.47	1.33	1.50	1.50	1.40	1.50	0.035	0.737
Globulins (g/dl)	1.29	1.47	1.60	1.79	1.57	2.00	0.127	0.737
Total Cholesterol (mg/dl)	152.73[a]	138.55[b]	124.10[c]	138.86[b]	128.60[bc]	134.51[bc]	2.515	0.005
Triglyceride (mg/dl)	123.20a	107.96[c]	103.85[c]	112.94[b]	107.95[c]	116.64[b]	1.648	0.001>
HDL-c	35.75[d]	37.18[cd]	42.96[b]	38.51[bcd]	51.84[a]	40.72[bc]	1.408	0.001>
LDL-c	66.70[a]	52.99[b]	50.24[b]	[b] 57.97	51.03[b]	54.33[b]	1.779	0.008
AST (U/L)	453.67[a]	353.33[c]	334.00[d]	328.67[d]	363.67[b]	329.00[d]	10.622	0.001>
ALT(U/L)	14.67[a]	12.00[b]	11.67[bc]	10.33[cd]	9.67[d]	10.33[cd]	0.437	0.001>
SOD (U/mL)	19.315[b]	24.735[a]	24.210[a]	24.556[a]	24.790[a]	24.7500[a]	0.546	0.021
GSH-Px (U/ml)	639.067[b]	867.273[a]	881.564[a]	781.082[ab]	814.576[a]	887.593[a]	27.920	0.037
CAT (U/ml)	2.380	2.476	2.610	2.630	2.510	2.421	056 .0	0.813

[a, d]Values within a row with different superscripts differ significantly at $P \leq 0.05$. [1]Treatments: T1, control (Basal diet); T2, and T3 - *Typha domingensis* extract at 5, and 15 (ml/l) in drinking water; T4, and T5- *T. domingensis* flour at 5, and 15 (g/kg) in basal diet; T6- *T. domingensis* extract at 7.5 (ml/l) in drinking water + *T. domingensis* flour at 7.5 (g/kg) in basal diet respectively. [2]SEM, Standard error of mean's; HDL-c = high-density lipoprotein cholesterol; LDL-c = low-density lipoprotein cholesterol; AST= Aspartate aminotransferase; ALT= Alanine aminotransferase; SOD= Superoxide dismutase; GSH-Px= Glutathione peroxidase; CAT= Catalase

adipogenesis, increase fat breakdown, and promote fat cell death in adipose tissue, which could affect fat accumulation in poultry at different ages and production stages (Tan *et al.,* 2022). Aljazy *et al.,* (2021) and Khalid *et al.* (2022) reported that various compounds, such as terpenoids, fatty acids, esters, and steroids, are present in different parts and extracts of T. domingensis. These chemical compounds have shown diverse biological and medicinal activities, including antioxidant properties and the ability to inhibit cholesterol synthesis (Dilshad *et al.,* 2023). Additionally, Ji *et al.* (2019) reported that high cholesterol levels were reduced by modifying the body's cholesterol metabolism using bioactive compounds with anti-hypercholesterolemic properties. The reduction in fat levels may be attributed to the presence of a glycoside called naringenin in *Typha domingensis*.

Akram and Jabeen (2022) stated, the aqueous methanolic extract of *T. domingensis* contains naringenin, which has various positive effects on human health (Salehi *et al.,* 2019). These effects include reducing biomarkers of lipid peroxidation and protein carbonylation, promoting carbohydrate metabolism, enhancing antioxidant defenses, scavenging reactive oxygen species, and modulating immune system activity (Wang *et al.,* 2015) by influencing genes involved in relevant pathways (Alam *et al.,* 2014). According to Zobeiri *et al.* (2018), naringenin has been reported to modulate signaling pathways related to fatty acids, which reduces their accumulation in the liver and helps prevent fatty liver. A study by Hager-Theodorides *et al.* (2021) found that supplementing broiler chickens with hesperidin and naringin positively impacted the fatty acid profiles in the breast meat and abdominal adipose tissue. This effect was attributed to an increase in fatty acid β-oxidation, as shown by the upregulation of related genes (PPARα and ACOX1) in the liver. Additionally, the antioxidant activity observed in broiler meat may be partly linked to the regulation of antioxidant defense genes, as indicated by the increased expression of glutathione reductase in response to naringin supplementation. Therefore, the health promoting effects on growth, as indicated by Starčević *et al.* (2015), can include a reduction in lipid oxidation, cholesterol levels, an increase in beneficial fatty acid content, and an enhancement of body weight of broiler chickens. The study results indicated that the concentration of hepatic enzymes (ALT and AST) in the blood significantly decreased ($P<0.001$) in the treated groups compared to the control. Additionally, there was a significant increase ($P=0.021$) in the activity of the antioxidant enzymes Superoxide dismutase (SOD) and Glutathione peroxidase (GSH-PX) ($p=0.037$) when TDF or TDE was added to the broiler diets. However, the activity of the catalase enzyme was not affected by the treatments (Table 3). The lower levels of liver enzymes (ALT and AST) in broilers indicate better health. The decrease in ALT and AST activities could be attributed to the presence of flavonoid compounds, which are known for their antioxidant properties, as mentioned by Chai *et al.* (2014) in the *T. domingensis* plant.

Additionally, a study involving rabbits confirmed that the methanolic extract of *T. domingensis* pers. fruit, when administered orally, resulted in decreased levels of serum glucose, AST, ALT, and ALP, suggesting that Typha has anti-diabetic and hepatoprotective effects (AL-Saeed, 2012). Furthermore, Bukhibkh *et al. (2022)* indicated that the alkaloids isolated from TDF reduced the increase in liver index, ALT, AST, ALP, and serum triglycerides, cholesterol, and LDL-c levels caused by CCl4, suggesting that alkaloids can act as hepatoprotective agents. Our results indicate that the supplementary groups of T. domingensis showed increased activity of SOD and GSH-Px compared to the control group. This suggests that *T. domingensis* enhances the antioxidant capacity of broilers. The increase in antioxidant activity may be due to the positive effects of phenolic compounds. These compounds help maintain the balance of oxidation in birds by scavenging free radicals, forming complexes with metal ions, and preventing the formation of singlet oxygen (Surai, 2014; Chia *et al.,* 2015). The antioxidant properties of polyphenols are also linked to the hydrogen atoms in their hydroxyl groups, which can prevent the oxidation of biomolecules by free radicals. Additionally, polyphenols inhibit oxidases, reduce tocopherol radicals, and activate antioxidant enzymes (Wang *et al.,* 2015). According to our findings, it is evident that the increase in catalase activity was insignificant when supplementing with *T. domingensis.* Along with SOD, CAT is a component of the antioxidant system that helps control the overabundance of

Table 5. Bacterial counts (Log cfu/g) in the ileal digesta of broilers supplemented with by *T. domingensis* on day 35

Bacteria types	Dietary treatments[1]						SEM[2]	*P-value*
	T1	T2	T3	T4	T5	T6		
Total bacterial count (× 10^5)	5.99[a]	5.12[d]	5.20[cd]	5.43[b]	5.35[bc]	5.24[bcd]	0.073	<0.001
lactic acid bacteria (×10^4)	3.17[b]	3.70[a]	3.77[a]	3.75[a]	3.86[a]	3.78[a]	0.058	0.002
Escherichia coli (×10^3)	6.52[a]	4.34[b]	4.63[b]	4.75[b]	4.66[b]	4.52[b]	0.174	<0.001

[a-d] Values within a row with different superscripts differ significantly at P≤0.05.

[1]Treatments: T1, control (Basal diet); T2, and T3 - *Typha domingensis* extract at 5, and 15 (ml/l) in drinking water; T4, and T5- *T. domingensis* flour at 5, and 15 (g/kg) in basal diet; T6- *T. domingensis* extract at 7.5 (ml/l) in drinking water + *T. doingness* flour at 7.5 (g/kg) in basal diet respectively. [2]SEM, Standard error of means

reactive oxygen species (ROS). According to Tang et al., (2022), catalase is a very important enzyme in the enzymatic antioxidant system, as it has anti-inflammatory, and antioxidant effects. Catalase catalyzes the decomposition of hydrogen peroxide (H_2O_2), preventing iron chelates from using H_2O_2 and oxygen (O_2) to generate more toxic hydroxyl radicals. This process effectively prevents lipid oxidation of cell membrane and reduces oxidative damage. The study also showed that inclusion catalase to the diet of yellow broilers can enhance their growth performance, antioxidant capacity, promoting the integrity of the intestinal construction, improving the composition of intestinal microbes, and increasing the mRNA expression of tight connection protein (Tang *et al.,* 2022).

Ileal Microbiota

The amounts of total bacteria and *Escherichia coli* in the ileum of broilers were decreased (P<0.001) by the addition of Typha domingensis, while the number of lactic acid bacteria (LAB) was significantly increased (P=0.002) compared to the control (Table 5). This indicates that *T. domingensis* supplementation can notably affect the gut microbiota of broiler chicks. The inactivation of total bacteria and *E. coli* counts by *T. domingensis* may be due to the presence of alkaloids, saponins, tannins, steroids, phenols, and flavonoid compounds, which are known to have antimicrobial activity (Alexeyena *et al.,* 2009). Various other studies have revealed the antibacterial activity of *T. domingensis* extracts (from pollen or vegetative parts) against several Gram-positive and Gram-negative bacterial strains (Al-Mazirah *et al.,* 2021; Khalid *et al.,* 2022). The TDE contains phytochemicals that exhibit antibacterial activity (Alexeyena *et al.,* 2009; Londonkar *et al.,* 2013; Al-Kalifawi *et al.* 2017), including flavonoids that can be used for antibacterial, antifungal, antithrombotic, antioxidant, anti-inflammatory, and anticancer activities (Panche *et al.,* 2016). On the other hand, tannins, as antibacterial agents, can decline the incidence of avian diseases and the transmission of zoonotic pathogens (Hassan *et al.,* 2020). According to Dakheel *et al.* (2020), tannins inhibit the growth of *E. coli* by acting as antibiofilm and antimotility agents.

The dietary inclusion of *T. domingensis* further affects ileal microbiota, reflecting increased populations of *Lactobacillus* in broiler chicks. *Lactobacillus* can generate lactic acid, contribute to weight gain, enhance antioxidant ability, and promote gut microbial diversity in broiler chickens (Wang *et al.,* 2023). Notably, the mechanism of action of LAB in the intestine involves removing or eliminating enteric pathogens by producing substances with antimicrobial activity, inhibiting the production of toxins by bacteria, and stimulating defense mechanisms and non-specific immunity (Krauze *et al.,* 2021; Martinez *et al.,* 2021). Phytochemicals used as additives in poultry feed can modify gut microbiota, and can act as prebiotics by promoting the growth of useful bacteria and suppressing the growth of pathogenic one (Cencic and Chingwaru, 2010), leading to improvements in gut microbes.

CONCLUSION

Based on the findings, it can be concluded that supplementary *Typha domingensis* extract (TDE) at concentrations of 5 and 15 ml/l, and *T. domingensis* flour (TDF) at 5 and 15 g/kg, along with their combination (7.5 TDE + 7.5 TDF), positively influence growth performance, economic indicators, bursa of Fabricius (%), lipid profile, and serum antioxidants (GSH-PX and SOD). These additives also reduce liver enzyme concentrations and abdominal fat in broiler carcasses, improve gut health by decreasing harmful *E. coli* and increasing beneficial Lactobacilli bacteria in the ileum.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

ACKNOWLEDGEMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

AUTHORS CONTRIBUTION

The authors contributed equally.

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