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Effects of *Sida hermaphrodita* leaf meal on growth performance, carcass quality and gastrointestinal tract development in broiler chickens

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ABSTRACT. The aim of this study was to determine the effects of dietary supplementation with *Sida hermaphrodita* leaf meal (SH meal) on growth performance, carcass quality, breast muscle chemical composition, and gastrointestinal function in broiler chickens. The experimental material consisted of 100 one-day-old Ross 308 broiler chickens (male), divided into five groups (10 replicates, 2 birds per replicate). The control group received a standard diet without SH meal, while the experimental groups were fed diets containing 1, 2, 3, and 4% SH meal. The parameters assessed included growth performance, breast muscle chemical composition, carcass quality, gastrointestinal tract morphology, digesta pH, and short-chain fatty acid (SCFA) concentration. Dietary inclusion of SH meal at levels up to 4% had no negative effects on final growth performance, carcass quality traits, or gastrointestinal tract structure. Total SCFA levels were not affected by SH meal addition, but caecal isobutyric acid concentration was significantly reduced ($P < 0.05$) in birds fed SH-supplemented diets. Moreover, broilers fed diets supplemented with 3% and 4% SH meal were characterised by increased digesta viscosity ($P < 0.05$). These findings indicate that SH meal can be included in broiler diets at levels up to 4% over the entire rearing period without detrimental effects. Further research is needed to expand knowledge on the functional efficacy of SH meal in poultry nutrition.

Introduction

Sida L. is a genus of plants in the mallow family (*Malvaceae*), comprising over 200 species used in traditional medicine due to their antibacterial, anti-inflammatory, hepatoprotective, and antioxidant properties (Dinda et al., 2015). Virginia fanpetals (*Sida hermaphrodita* (L.) Rusby) is a representative of this family and is native to North America. Interest in Virginia fanpetals and its potential applications increased in Europe in the mid-20th century, following its introduction from the United States (Borkowska and Styk, 2006).

Virginia fanpetals is a perennial crop with low soil requirements and high resistance to adverse climatic conditions such as drought and frost. Its resilience to extreme environmental conditions, combined with a high yield potential (reaching up to 20 t/ha dry matter (DM) or 90 t/ha fresh herbage), make it an attractive substrate for biogas and biofuel production (Borsuk et al., 2021). *Sida* also contributes to soil health by enhancing structure and fertility while reducing erosion. In addition, it can store carbon dioxide in its extensive root system, thereby providing ecological benefits by sequestering carbon in the soil. *Sida* is also a source of nectar

for pollinating insects, yielding up to 120 kg honey per ha (Nahm and Morhart, 2018).

Sida, in both fresh and preserved forms, can be utilised as feed for ruminants (Nogalski et al., 2020; Purwin et al., 2022) and, after appropriate processing, also for pigs (Tarkowski et al., 2002) and rabbits (Purwin et al., 2019). The plant demonstrates significant nutritional value, with whole plants and leaves reaching protein contents exceeding 20 and 30%, respectively, under optimal nitrogen fertilisation. *Sida* herbage contains approximately 4% lysine, 0.88% methionine, and 2.17% threonine (Tarkowski and Truchliński, 2012), while the average crude fat and crude fibre content is around 1.8% and 29%, respectively. *Sida* also contains biologically active compounds, including carotenoids, tocopherols, and vitamin C (Borkowska and Molas, 2012). While Virginia fanpetals micronutrient and macronutrient herbage concentrations are lower than those found in alfalfa, it provides 3.33 g calcium/kg DM and 0.58 g phosphorus/kg DM, resulting in a calcium: to-phosphorus ratio of 5.7:1 (Borsuk et al. 2021).

The beneficial effects of grass, alfalfa, and red clover meals on growth performance, carcass quality, and yolk pigmentation in birds have been reported by many authors (Arif et al., 2000; AL-Haweizy and AL-Sardary, 2007; Jiang et al., 2012; Kwiatkowska et al., 2017). However, the potential application of *Sida hermaphrodita* leaf meal (SH meal) as a feed component in poultry nutrition has not yet been investigated.

This study was designed to determine the effects of SH meal supplementation on growth performance, carcass quality, chemical composition of breast muscle, and gastrointestinal function in broiler chickens. The proposed research hypothesis assumed that dietary inclusion of SH meal would not adversely affect these parameters.

Material and methods

Animals and diets

In compliance with Polish law and European Union regulations (Directive 2010/63/EU), the experiments conducted in this study did not require approval from the Local Ethics Committee for Animal Experiments in Olsztyn. All animal procedures strictly adhered to the requirements of the Polish Act of 15 January 2015 on the Protection of Animals Used for Scientific or Educational Purposes.

The experimental material consisted of 100 one-day-old Ross 308 broiler chickens (male), randomly assigned to five groups (10 replicates per group, and 2 broilers per replicate). The experiment lasted 42 days. The birds were housed in cages without litter, under standard environmental conditions. The temperature in the facility was maintained at 32–33°C on day 1 and gradually reduced by 2–3 °C per week, reaching 18.5–20 °C in the final week. The lighting schedule was as follows: 24 h of light (L) on day 1, 23L:1 h of dark (D) from days 2 to 7, 20L:4D from days 8 to 11, and 18L:6D from days 12 to 42. The birds had unrestricted access to water and feed throughout the study period.

Broilers were fed according to a four-phase feeding system, using friable diets: starter (days 1–10), grower 1 (days 11–21), grower 2 (days 22–35), and finisher diet from day 35 until the end of the finishing period. All diets were formulated according to the Nutrient Requirements of Poultry (2018) guidelines, with their complete composition and nutritional values detailed in Tables 1–5.

The experimental feeds varied in their inclusion rate of SH meal, with the control group receiving no SH meal (0%) and the treatment groups receiving 1, 2, 3, and 4% SH meal supplementation. SH meal

Table 1. Ingredients and chemical composition of broiler chicken diets in the control (Group 1), %

Ingredient	Starter	Grower 1	Grower 2	Finisher
Wheat	68.38	71.95	73.82	76.07
Soybean meal	27.51	23.29	20.62	17.9
Soybean oil	0.82	1.69	2.67	3.33
Limestone	1.04	1.04	1.01	0.96
Calcium phosphate	0.71	0.49	0.31	0.19
SH meal	0	0	0	0
Premix*	0.5	0.5	0.5	0.5
Nutritional value				
dry matter	89.32	89.17	89.19	89.48
crude ash	7.74	6.75	4.74	5.3
crude protein	22.79	22.15	21.16	20.11
ether extract	2.06	2.88	4.79	4.69
crude fibre	3.55	3.20	3.02	2.88
AME, kcal/kg	2960	3060	3150	3220

* Starter/Grower 1/Grower 2 diets contained: IU: vit. A 400 000, vit. D_3 150 000; mg: vit. E 2 000, vit. K_3 120, vit. B_1 120, vit. B_2 320, vit. B_6 180, vit. PP 2 000, D-calcium pantothenate 350, folic acid 60, choline chloride 18 000, betaine 5 000, Zn 3 000, Mn 3 800, Fe 2 500, Cu 600, I 60, Se 10; mcg: vit. B_{12} 2 400, betaine 4 000; 6-phytase; enzymatic preparation; coccidiostat; antioxidant; Finisher diet contained: IU: vit. A 500 000, vit. D_3 137 500, vit. E 1 800, vit. K_3 125, vit. B_1 100, vit. B_2 300, vit. B_6 200, vit. PP 2 000, D-calcium pantothenate 600, folic acid 75, choline chloride 15 000, betaine 5 000, Zn 3 000, Mn 4 300, Fe 3 000, Cu 75, I 75, Se 12.5; mcg: vit. B_{12} 2 250, biotin 5 000; 6-phytase; enzymatic preparation; antioxidant; AME – apparent metabolizable energy

Table 2. Ingredients and chemical composition of broiler chicken diets supplemented with 1% *Sida hermaphrodita* leaf meal (Group 2), %

Ingredient	Starter	Grower 1	Grower 2	Finisher
Wheat	67.42	70.99	72.87	75.12
Soybean meal	27.26	23.05	20.37	17.65
Soybean oil	1.03	1.9	2.88	3.54
Calcium phosphate	0.71	0.5	0.32	0.19
Limestone	1.03	1.03	1	0.9
SH meal	1	1	1	1
Premix*	0.5	0.5	0.5	0.5
Nutritional value				
dry matter	89.34	88.94	89.27	89.8
crude ash	7.74	6.51	5.17	5.14
crude protein	22.59	21.26	20.6	19.06
ether extract	2.02	2.83	4.19	4.35
crude fibre	3.46	3.13	2.92	3.28
AME, kcal/kg	2960	3060	3150	3220

SH meal – *Sida hermaphrodita* leaf meal; * Starter/Grower 1/ Grower 2 diets contained: IU: vit. A 400 000, vit. D_3 150 000; mg: vit. E 2 000, vit. K_3 120, vit. B_1 120, vit. B_2 320, vit. B_6 180, vit. PP 2 000, D-calcium pantothenate 350, folic acid 60, choline chloride 18 000, betaine 5 000, Zn 3 000, Mn 3 800, Fe 2 500, Cu 600, I 60, Se 10; mcg: vit. B_{12} 2 400, betaine 4 000; 6-phytase; enzymatic preparation; coccidiostat; antioxidant; Finisher diet contained: IU: vit. A 500 000, vit. D_3 137 500, vit. E 1 800, vit. K_3 125, vit. B_1 100, vit. B_2 300, vit. B_6 200, vit. PP 2 000, D-calcium pantothenate 600, folic acid 75, choline chloride 15 000, betaine 5 000, Zn 3 000, Mn 4 300, Fe 3 000, Cu 75, I 75, Se 12.5; mcg: vit. B_{12} 2 250, biotin 5 000; 6-phytase; enzymatic preparation; antioxidant; AME – apparent metabolizable energy

Table 3. Ingredients and chemical composition of broiler chicken diets supplemented with 2% *Sida hermaphrodita* leaf meal (Group 3), %

Ingredient	Starter	Grower 1	Grower 2	Finisher
Wheat	66.46	70.04	71.91	74.16
Soybean meal	27.01	22.8	20.12	17.40
Soybean oil	1.24	2.11	3.09	3.75
Limestone	1.02	1.02	0.98	0.93
SH meal	2	2	2	2
Calcium phosphate	0.72	0.5	0.33	0.2
Premix*	0.5	0.5	0.5	0.5
Nutritional value				
dry matter	88.98	89.25	90.01	89.12
crude ash	7.03	6.3	5.69	5.78
crude protein	23.41	22.11	21.64	19.48
ether extract	2.25	3.24	5.47	4.74
crude fibre	3.24	2.9	3.69	2.6
AME, kcal/kg	2962	3056	3148	3217

SH meal – *Sida hermaphrodita* leaf meal; * Starter/Grower 1/ Grower 2 diets contained: IU: vit. A 400 000, vit. D_3 150 000; mg: vit. E 2 000, vit. K_3 120, vit. B_1 120, vit. B_2 320, vit. B_6 180, vit. PP 2 000, D-calcium pantothenate 350, folic acid 60, choline chloride 18 000, betaine 5 000, Zn 3 000, Mn 3 800, Fe 2 500, Cu 600, I 60, Se 10; mcg: vit. B_{12} 2 400, betaine 4 000; 6-phytase; enzymatic preparation; coccidiostat; antioxidant; Finisher diet contained: IU: vit. A 500 000, vit. D_3 137 500, vit. E 1 800, vit. K_3 125, vit. B_1 100, vit. B_2 300, vit. B_6 200, vit. PP 2 000, D-calcium pantothenate 600, folic acid 75, choline chloride 15 000, betaine 5 000, Zn 3 000, Mn 4 300, Fe 3 000, Cu 75, I 75, Se 12.5; mcg: vit. B_{12} 2 250, biotin 5 000; 6-phytase; enzymatic preparation; antioxidant; AME – apparent metabolizable energy

Table 4. Ingredients and chemical composition of broiler chicken diets supplemented with 3% *Sida hermaphrodita* leaf meal (Group 4), %

Ingredient	Starter	Grower 1	Grower 2	Finisher
Wheat	65.51	69.08	70.95	73.21
Soybean meal	26.77	22.55	19.88	17.14
Soybean oil	1.45	2.32	3.3	3.96
Limestone	1	1	0.97	0.92
SH meal	3	3	3	3
Calcium phosphate	0.73	0.51	0.33	0.21
Premix*	0.5	0.5	0.5	0.5
L-lysine 98	0.34	0.38	0.4	0.43
Nutritional value				
dry matter	89.97	89.08	90.03	88.73
crude ash	6.5	6.58	5.07	6.53
crude protein	23.16	22.46	21.47	19.25
ether extract	2.32	3.55	5,61	4.82
crude fibre	3.19	3.26	4.3	3.67
AME, kcal/kg	2955	3054	3144	3217

SH meal – *Sida hermaphrodita* leaf meal; * Starter/Grower 1/ Grower 2 diets contained: IU: vit. A 400 000, vit. D_3 150 000; mg: vit. E 2 000, vit. K_3 120, vit. B_1 120, vit. B_2 320, vit. B_6 180, vit. PP 2 000, D-calcium pantothenate 350, folic acid 60, choline chloride 18 000, betaine 5 000, Zn 3 000, Mn 3 800, Fe 2 500, Cu 600, I 60, Se 10; mcg: vit. B_{12} 2 400, betaine 4 000; 6-phytase; enzymatic preparation; coccidiostat; antioxidant; Finisher diet contained: IU: vit. A 500 000, vit. D_3 137 500, vit. E 1 800, vit. K_3 125, vit. B_1 100, vit. B_2 300, vit. B_6 200, vit. PP 2 000, D-calcium pantothenate 600, folic acid 75, choline chloride 15 000, betaine 5 000, Zn 3 000, Mn 4 300, Fe 3 000, Cu 75, I 75, Se 12.5; mcg: vit. B_{12} 2 250, biotin 5 000; 6-phytase; enzymatic preparation; antioxidant; AME – apparent metabolizable energy

Table 5. Ingredients and chemical composition of broiler chicken diets supplemented with 4% *Sida hermaphrodita* leaf meal (Group 5), %

Ingredient	Starter	Grower 1	Grower 2	Finisher
Wheat	64.55	68.12	69.92	72.26
Soybean meal	26.52	22.3	19.7	16.89
Soybean oil	1.66	2.53	3.52	4.16
Limestone	0.99	0.99	0.96	0.9
SH meal	4	4	4	4
Calcium phosphate	0.73	0.52	0.34	0.21
Premix*	0.5	0.5	0.5	0.5
Nutritional value				
dry matter	89.15	89.3	90.25	88.43
crude ash	6.78	6.21	5.06	8.07
crude protein	22.72	22.18	21.96	19.19
ether extract	2.72	3.73	5.78	5.15
crude fibre	3.67	3.2	4.09	3.03
AME, kcal/kg	2950	3061	3142	3215

SH meal – *Sida hermaphrodita* leaf meal; * Starter/Grower 1/ Grower 2 diets contained: IU: vit. A 400 000, vit. D_3 150 000; mg: vit. E 2 000, vit. K_3 120, vit. B_1 120, vit. B_2 320, vit. B_6 180, vit. PP 2 000, D-calcium pantothenate 350, folic acid 60, choline chloride 18 000, betaine 5 000, Zn 3 000, Mn 3 800, Fe 2 500, Cu 600, I 60, Se 10; mcg: vit. B_{12} 2 400, betaine 4 000; 6-phytase; enzymatic preparation; coccidiostat; antioxidant; Finisher diet contained: IU: vit. A 500 000, vit. D_3 137 500, vit. E 1 800, vit. K_3 125, vit. B_1 100, vit. B_2 300, vit. B_6 200, vit. PP 2 000, D-calcium pantothenate 600, folic acid 75, choline chloride 15 000, betaine 5 000, Zn 3 000, Mn 4 300, Fe 3 000, Cu 75, I 75, Se 12.5; mcg: vit. B_{12} 2 250, biotin 5 000; 6-phytase; enzymatic preparation; antioxidant; AME – apparent metabolizable energy

was prepared in the laboratory of the Department of Animal Nutrition, Feed Science, and Cattle Breeding at the University of Warmia and Mazury in Olsztyn. *Sida* biomass was harvested from a field in northern Poland. The plants were cut during the early bud stage, at a height of 30 cm. Leaves were separated from stems, chopped using an electric chaff cutter, and dried at 60 °C in a forced-air BINDER dryer for 24 h. The dried material was then ground to a 2 mm particle size using a Retsch ZM 200 mill (Haan, Germany). Chemical analysis of SH meal revealed the following composition (on a dry matter (DM) basis): DM – 93.05%, crude protein (CP) – 22.32%, crude fat – 1.96%, crude fibre (CF) – 7.31%, crude ash – 7.80%, neutral detergent fibre (NDF) – 15.80%, acid detergent fibre (ADF) – 9.56%, and acid detergent lignin (ADL) – 1.44%. The calculated apparent metabolizable energy (AME) value was 1347 kcal/kg AME.

Sample collection and laboratory analyses

The content of DM, ether extract (EE), CF, CP, and crude ash in feed (n = 20) and meat samples (n = 10 per group) was determined according to AOAC methods (2016). DM content was determined by oven-drying the samples at 105 °C using a Binder ED 720 forced-air oven (Binder GmbH, Tuttlingen, Germany). CP content was measured using the Kjeldahl method with a FOSS 2200 Kjeltec system (FOSS, Hillerød, Denmark), while CF was determined by Soxhlet extraction using a FOSS SOXTEC System 2043 (FOSS, Hillerød, Denmark). CF content was analysed with both a FIBERTEC System M 2100 (FOSS, Hillerød, Denmark), and ANKOM 220 fibre analyser (ANKOM Technology, Macedon, NY, USA). Crude ash was determined by incineration at 600°C for 3 h in a CZYLOK FCF 2.5 muffle furnace (CZYLOK, Jastrzębie-Zdrój, Poland). The AME content of the diets was calculated based on the Nutrient Requirements of Poultry (2018). The proportions of NDF, ADF, and ADL in SH meal were determined using an ANKOM 2000 fibre analyser (ANKOM Technology Corp., Macedon, NY, USA), following the method described by van Soest (1991).

Body weight (BW), body weight gain (BWG), mortality rates, and feed intake were monitored throughout the experiment, and feed conversion ratio (FCR) subsequently calculated based on these values. On day 42, carcass dressing percentage was determined in 10 birds per group, selected to represent the average BW. After slaughter, carcasses were plucked, legs were cut off, and the gastrointestinal tract was removed. Each carcass was weighed, and the breast muscle, heart, liver, and gizzard were separated, weighed, and their proportions determined. Carcass dressing percentage was calculated as the ratio of carcass weight to live body weight. The segments of the gastrointestinal tract were examined, with the crop, gizzard, proventriculus, small intestine, and caeca isolated, measured (length measurements for small intestine and caeca), emptied of contents, and weighed. The pH of digesta samples from the crop, gizzard, proventriculus, small intestine, and caeca was measured using a model 301 Hanna Instruments pH-meter (Hanna Instruments, Vila do Conde, Portugal). The viscosity of small intestinal digesta was determined by diluting fresh digesta 1:1 with deionised water, centrifuging at 5 200 × g for 20 min (MPW-350 R laboratory centrifuge, rotor No. 12436), and measuring supernatant viscosity at 39 °C using a Fungilab rotational viscometer (ver. 1.2 Alpha Series 101 427, Barcelona, Spain). The concentrations of short-chain fatty acids (SCFA) in the caecal digesta were determined by gas chromatography (Shimadzu GC 14A, Shimadzu Co., Kyoto, Japan). Excreta DM content was determined during weeks 2, 4, and 6 by oven-drying the samples at 105 °C to constant weight in a forced-air BINDER ED 720 dryer (Binder GmbH, Tuttlingen, Germany).

Statistical analysis

The normality of the data distribution was assessed using the ShapiroWilk test. For normally distributed data, one-way analysis of variance (ANOVA) was conducted, followed by Tukey's post-hoc test when significant treatment effects were observed ($P < 0.05$). For non-normally distributed data, the KruskalWallis test was applied. All computations were carried out using Statistica 12.0 software (StatSoft, Kraków, Poland), with results expressed as arithmetic means ± standard error of the mean (SEM). Statistical significance was set at $P < 0.05$ for all analyses.

Results

The growth performance of broiler chickens fed diets supplemented with SH meal is presented in Table 6. During the initial phase (0–7 days), no significant differences in growth parameters were observed between groups. On day 35, broilers receiving 1% SH meal were characterised by lower BW and BWG than birds in the control group

Table 6. Growth performance of broiler chickens fed diets supplemented with *Sida hermaphrodita* leaf meal

Specification	Group						
	1 Control	2 SH meal 1%	3 SH meal 2%	4 SH meal 3%	5 SH meal 4%	SEM	*P*-value
Body weight, g							
day 7	149.67	143.00	146.30	140.00	145.11	2.863	0.871
day 35	2415.00^{a}	2083.44^{b}	2218.63^{ab}	2292.56^{ab}	2120.67^{ab}	237.49	0.021
day 42	3086.88	2879.89	3269.71	3186.88	2963.33	54.131	0.145
Body weight gain, g							
day 7	106.22	99.17	103.15	96.45	101.56	2.959	0.878
day 35	2370.75^{a}	2039.61^{b}	2175.19^{ab}	2249.06^{ab}	2077.11^{ab}	237.86	0.022
day 42	3042.63	2836.06	3225.50	3143.44	2919.79	54.258	0.144
Feed intake, g							
day 7	102.56	101.78	104.40	96.50	106.56	3.060	0.882
day 35	3647.25^{x}	3233.11^{y}	3416.81^{xy}	3441.61^{xy}	3251.78^{y}	329.13	0.057
day 42	5015.00	4900.12	5142.31	5167.12	4625.67	82.625	0.142
FCR, kg/kg							
day 7	0.97	1.03	1.01	1.02	1.06	0.016	0.489
day 35	1.54	1.59	1.57	1.53	1.57	0.071	0.497
day 42	1.71	1.72	1.64	1.66	1.70	0.017	0.556
Mortality rate, n	3	2	2	2	1	-	-

SH meal – *Sida hermaphrodita* leaf meal, FCR – feed conversion ratio; ^{ab} – $P < 0.05$; $^{x/y}$ – $0.05 > P \leq 0.10$

($P < 0.05$). Feed intake tended to be lower in broilers fed diets supplemented with 1% and 4% SH meal, compared with the control group. No significant differences were detected in FCR or mortality rates in any of the groups.

The carcass quality characteristics of broiler chickens (Table 7) were unaffected by SH meal supplementation, with no differences observed in carcass dressing percentage or proportions of breast muscle, heart, liver, and abdominal fat.

The chemical composition of breast muscle was similar in all groups (Table 8).

Gastrointestinal tract structure and digesta pH were not affected by dietary SH meal supplementation (Table 9). However, broilers fed diets supplemented with 3 and 4% SH meal showed increased digesta viscosity compared to control group and 1% SH meal groups ($P < 0.05$).

Table 7. Carcass quality characteristics of broiler chickens fed diets supplemented with *Sida hermaphrodita* leaf meal

Specification	Group						
	1 Control	2 SH meal 1%	3 SH meal 2%	4 SH meal 3%	5 SH meal 4%	SEM	*P*-value
Carcass dressing percentage, %	70.96	71.73	72.14	71.13	70.37	0.345	0.533
Content in carcass, %							
breast muscle	31.39	32.78	32.39	32.90	32.01	0.515	0.914
heart	0.97	0.92	0.89	0.87	0.92	0.022	0.754
liver	3.23	2.91	2.94	3.18	3.22	0.106	0.792
abdominal fat	0.70	0.30	0.27	0.27	0.17	0.113	0.360

SH meal – *Sida hermaphrodita* leaf meal; SEM – standard error of the mean; $P > 0.05$ (not statistically significant)

Table 8. Chemical composition of breast muscle in broiler chickens fed diets supplemented with *Sida hermaphrodita* leaf meal

Specification	Group						
	1 Control	2 SH meal 1%	3 SH meal 2%	4 SH meal 3%	5 SH meal 4%	SEM	*P*-value
Dry matter	25.90	26.35	26.06	25.93	25.84	0.148	0.849
Crude ash	1.19	1.18	1.17	1.15	1.16	0.008	0.604
Crude protein	23.68	24.12	23.38	22.98	23.61	0.149	0.174
Ether extract	1.13	0.90	0.93	1.25	0.74	0.076	0.235

SH meal – *Sida hermaphrodita* leaf meal; SEM – standard error of the mean; $P > 0.05$ (not statistically significant).

Table 9. Gastrointestinal parameters in six-week-old broiler chickens fed diets supplemented with *Sida hermaphrodita* leaf meal

Specification	Group					SEM	*P*-value
	1 Control	2 SH meal 1%	3 SH meal 2%	4 SH meal 3%	5 SH meal 4%		
Crop							
weight, g/kg of BW	3.37	2.82	3.21	3.52	3.64	0.147	0.409
digesta pH	4.53	4.30	4.44	4.55	4.51	0.086	0.889
Proventriculus							
weight, g/kg of BW	2.75	2.76	2.43	3.09	3.10	2.862	0.434
digesta pH	3.44	3.47	3.41	3.74	3.26	0.115	0.789
Gizzard							
weight, g/kg of BW	10.85	11.09	9.74	10.36	11.22	0.279	0.489
digesta pH	3.32	3.33	3.03	3.15	3.31	0.09	0.801
Small intestine							
length, cm/kg BW	60.88	66.13	57,39	57,47	65,69	1,393	0,102
weight, g/kg of BW	17.21	16.98	15.28	15.76	17.53	0.329	0.139
digesta pH	6.45	6.45	6.30	6.41	6.52	0.050	0.738
viscosity, mPas · s	1.68^{a}	1.69^{a}	1.87^{ab}	2.16^{b}	2.11^{b}	0.067	0.043
Caeca							
length, cm/kg BW	14.24	14.86	14.12	14.14	15.38	0.369	0.749
weight, g/kg of BW	2.80	2.89	2.74	2.78	2.92	0.071	0.935
digesta pH	6.06	6.39	6.33	6.41	6.49	0.078	0.549

SH meal – *Sida hermaphrodita* leaf meal; BW – body weight; SEM – standard error of the mean; ^{ab} – means within a row with different superscripts are significantly different at $P < 0.05$

Total SCFA concentration in caecal digesta was unaffected by treatments, though isobutyric acid was not detected in SH meal-fed groups versus controls ($P < 0.05$). No significant differences were observed in the content of other SCFA between groups (Table 10).

The inclusion of SH meal in broiler diets did not affect the DM content of excreta (Table 11).

Table 10. Concentrations of short-chain fatty acids (µmol/g*) in the caecal digesta of six-week-old broiler chickens fed diets supplemented with *Sida hermaphrodita* leaf meal

Specification	Group					SEM	*P*-value
	1 Control	2 SH meal 1%	3 SH meal 2%	4 SH meal 3%	5 SH meal 4%		
Total SCFA	15.38	18.53	17.14	13.96	15.46	0.829	0.461
Lactic acid	0.12	0.41	0.23	0.32	0.09	0.063	0.439
Acetic acid	2.22	1.26	1.62	1.32	1.69	0.119	0.111
Propionic acid	2.53	7.98	5.94	3.36	5.70	0.710	0.121
Isobutyric acid	0.138^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.015	0.020
Butyric acid	9.48	8.05	8.76	8.31	7.33	0.394	0.531
Valeric acid	0.751	0.807	0.585	0.648	0.646	0.069	0.881

* fresh digesta; SH meal – *Sida hermaphrodita* leaf meal; SEM – standard error of the mean; ^{ab} – means within a row with different superscripts are significantly different at $P < 0.05$

Table 11. Dry matter content of excreta in broiler chickens fed diets supplemented with *Sida hermaphrodita* leaf meal

Specification	Group					SEM	*P*-value
	1 control	2 SH meal 1%	3 SH meal 2%	4 SH meal 3%	5 SH meal 4%		
Faecal dry matter content, %							
2 weeks	44.38	47.56	46.52	43.13	47.58	1.214	0.720
4 weeks	18.07	20.14	23.31	21.81	19.87	0.824	0.329
6 weeks	19.29	17.78	17.49	16.08	15.61	0.576	0.275

SH meal – *Sida hermaphrodita* leaf meal; SEM – standard error of the mean; $P > 0.05$ (not statistically significant)

Discussion

Grass and legume meals, including alfalfa, are used in poultry nutrition due to their relatively high content of protein (17–20%), secondary metabolites, and natural pigments. These dry forages in broiler and layer diets can reduce feed costs and provide health benefits through the bioactive compounds present in their leaves (Rama Rao et al. 2019). Alfalfa meal is particularly valued for its rich beta-carotene and xanthophyll contents, which enhances yolk and skin pigmentation (Yıldız et al., 2020). Similarly, *Sida hermaphrodita* herbage and silage are also rich in polyphenols, carotene, and tocopherols (Antoszkiewicz et al., 2019; Borsuk et al., 2021), suggesting that the dried form of this plant may similarly provide substantial amounts of these bioactive compounds. Additionally, it contains more than 20% protein.

In the present study, broiler chickens receiving 1% SH meal were characterised by lower BW and BWG compared to controls until 35 days of age. Feed intake tended to be lower in broilers fed diets supplemented with 1 and 4% SH meal compared with the control group. At 42 days of age, the average final BW and feed intake of birds were consistent with breed standards (BW – 3.1 kg, feed intake – 5.0 kg) as established by Aviagen (2019). While all experimental diets were formulated to be isocaloric and isonitrogenous, the potential influence of SH meal palatability remains unknown due to lack of existing literature. Previous studies have shown that alfalfa meal inclusion at 4–10% levels did not affect final BW or BWG in broilers (Jiang et al., 2018, Zheng et al., 2019; Varzaru et al., 2020). Tkáčová et al. (2011). In contrast, He et al. (2021) observed an increase in final BW or BWG in broiler chickens fed diets supplemented with 2 and 8% alfalfa meal, while Pleger et al. (2020) found a negative effect of 5–20% alfalfa leaf meal on the fattening and slaughter performance of organic broilers. The discrepancies in bird growth performance may result from variation in plant material composition. In the current study, SH meal differed notably from typical alfalfa meal, containing comparable crude protein (22% CP) but substantially lower crude fibre content (7.31% CF versus 20–25% in alfalfa meal). Such compositional differences in plant materials – influenced by harvest timing, leaf:to:stem ratio, and processing methods – may account for the observed performance variations between studies.

In the present work, no differences were observed in the proportion of breast muscle in the carcass or carcass dressing percentage, which was consistent with findings reported by Jiang et al. (2018) and Varzaru et al. (2020). These carcass characteristics, known to correlate with final BW, remained unaffected by SH meal supplementation.

In the current experiment, the inclusion of SH meal in broiler chicken diets had no significant effect on gastrointestinal tract structure or digesta pH in individual intestinal segments. This contrasts with findings by He et al. (2021), who reported that alfalfa meal significantly affected caecal pH. High-CF feeds typically undergo prolonged microbial fermentation in the large intestine, generating SCFA such as acetic, propionic, butyric, and lactic acids (Sadeghi et al., 2015), which lower intestinal pH and exert bacteriostatic effects (Lin et al., 2017; He et al., 2021). In the present study, SH meal had a very low CF content (approx. 7%) and its inclusion level did not exceed 4%, which likely explains its lack of effect on digesta pH and total SCFA concentration. However, birds fed diets supplemented with SH meal showed a significant decrease in isobutyric acid concentration in the caecal digesta compared to the control group (0.138 vs 0.00 μmol/g). In the caecum, isobutyrate is derived from valine fermentation, and plays potential roles in improving intestinal morphology, maintaining gut homeostasis, and reducing diarrhoea risk in piglets (Fang et al., 2024). In this experiment, differences in isobutyrate levels between the groups indicate changes in the composition of caecal microbiota; however, the results are difficult to interpret due to the absence of microbiological analyses.

The inclusion of SH meal at 3 and 4% levels significantly increased digesta viscosity in broilers compared to the control group and birds fed 1% SH meal. Unlike alfalfa, Virginia fanpetals does not contain antinutritional compounds such as saponins, glycosides, or lectins (Michalski et al., 2020). However, both SH meal and alfalfa meal, contain soluble fibre (non-starch polysaccharides), which is known to interfere with fat digestion and nutrient absorption in poultry (Nguyen et al., 2021). Soluble polysaccharides may also interact with polyphenols in the gastrointestinal tract, potentially reducing their bioavailability and enzyme access, while contributing to increased digesta viscosity (Wojtunik-Kulesza et al., 2020). Additionally, plants from the family *Malvaceae* including SH, contain mucilaginous cells that store polysaccharides involved in water retention (Boual et al., 2012). Plant mucilage is a complex of polymeric polysaccharides, and it also contains glycoproteins and various bioactive

compounds, including tannins and steroids. Among its components, substances such as galactose and glucuronic acid can interact with water molecules (Alba et al., 2021, Munir et al., 2021), thereby increasing digesta viscosity. As a result, increased viscosity may slow the passage rate of nutrients through the small intestine, which in turn can reduce their digestibility and create favourable conditions for the proliferation of pathogenic bacteria, increasing the risk of diarrhoea (Tejeda and Kim, 2021). However, the current study found no differences in BWG, FCR, or excreta DM content between treatment groups, indicating that the inclusion of SH meal in broiler diets had no adverse effects. The use of SH meal in poultry nutrition requires further research to investigate the effects exerted by bioactive compounds in the gastrointestinal tract of birds.

Conclusions

The study demonstrates that *Sida hermaphrodita* leaf meal (SH meal) can be safely incorporated into broiler chicken diets at levels up to 4% throughout the rearing period, without a negative impact on growth performance, carcass quality, or gastrointestinal tract morphology. Further research is required to further evaluate its nutritional efficacy, long-term effects, and potential interactions with other dietary components to optimise its application in poultry nutrition.

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Conflict of interest

The Authors declare that there is no conflict of interest.

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