Research Article

Effect of *Acacia karroo* Leaf Meal Inclusion Levels on Performance and Gut Morphology of Broiler Chickens

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Abstract | The study was conducted to determine the effect of *Acacia karroo* leaf meal (*AKLM*) inclusion in diets on growth performance and gut morphology of Ross 308 chickens from day-old to 6 weeks of age. 320-day-old Ross 308 broiler chicks were assigned to a 2 (sex) × 4 (dietary treatment levels) factorial arrangement in a CRD, having 8 treatments, replicated x4 with 10 chicks/replicate. *AKLM* inclusion levels were at 0, 0.5, 1.0 or 1.5g/kg dry matter (DM). Weekly feed intake (FI), live weight (LW), and growth rate (GR) were measured to obtain the feed conversion ratio (FCR). Gut characteristics were measured on days 21st and 42nd of age. Data were analysed using the General Linear Model (GLM) procedures of the Statistical Analysis System. FI, FCR, GR, and LW of both sexes were the same (P>0.05) across all treatments for the first 2 weeks. During the 3rd week, *AKLM* inclusion levels significantly (P<0.05) affected DM intake, FCR, GR, and LWs of both sexes. In the last 3 weeks of the trial, FI, FCR, GR, and LW for both male and female broilers were similar (P>0.05) across all treatments. *AKLM* did not affect (P>0.05) gut organ digesta pH, lengths, and weight values of male and female broilers aged 21 days. At day 42 of age, *AKLM* inclusion levels in the diets affected (P<0.05) gastrointestinal tract (GIT), ileum, and large intestine lengths of male broilers. Female broiler chickens on a diet having 1.0g of *AKLM* had longer (P<0.05) GIT than those without *AKLM* inclusion. Female broiler chickens on a diet having 1.0g of *AKLM* per kg DM had higher (P<0.05) gizzard weights than those diets with no *AKLM* inclusion at 6 weeks old. It is concluded that *AKLM* up to 1.5g/kg DM could be included in broiler chicken diets without any adverse effects on the performance and gut morphology.

Keywords | *Acacia karroo,* Broilers, Gut morphology, Leaf meals, Tannins.

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INTRODUCTION

The poultry industry continues to grow worldwide due to an increase in demand for poultry meat by consumers (Truong et al., 2019). This is due to its high nutritional value and the fact that it is cheap, fast, and easy to prepare, thus, making it the leading supplier of protein meat in the world (Hafiz et al., 2015; Gravel and Doyen, 2020). South Africa is leading in terms of poultry-producing countries in Africa followed by Egypt, Morocco, Nigeria, and Algeria respectively (Nkukwana, 2018). Furthermore, broiler production in South Africa generates more income than other livestock production (Nkukwana, 2018). Moreover, it plays a huge role in providing food, income, and employment for communities (Kumar et al., 2021). According to Alahakoon and Jayasena. (2016), poultry meat is the most preferred meat by consumers and is considered healthier than meat from other livestock. However, FAO (2013) reported that the cost of feeds constitutes about 70% of the total cost of producing broiler chickens. This is a huge challenge for poultry farmers, especially smallholders, as they struggle to cope with the continuous rise in feed costs. There is therefore a need to explore nutritionally beneficial alternative feed sources that can be used in broiler chicken diets to improve production and subsequently reduce feed costs.

Tanniniferous plants such as *Acacia karroo* have been reported to contain high levels of natural antioxidants which can improve meat quality and animal performance (Jiang et al., 2016; Huang et al., 2018; Atiba et al., 2021). Hassan et al. (2020) reported that *Acacia karroo* leaves have a high content of condensed tannins. However, it has been reported that dietary inclusion of tanniniferous leaf meals at low levels can improve the growth parameters and gut morphology of broiler chickens (Huang et al., 2018; Miya et al., 2019). Unfortunately, information on the use of dietary tanniniferous leaf meals to improve growth performance and gut morphology of broiler chickens is limited. Therefore, there is a need to determine the response in performance and gut morphology from Ross 308 broiler chickens fed incremental levels of *AKLM*. The study aimed to evaluate the effect of *AKLM* incremental levels in diets on growth performance and meat quality of Ross 308 broiler chickens

MATERIALS AND METHODS

Study site

The study was conducted at the University of Limpopo Animal Unit (1282m altitude 23°53′24″S latitude and 29°45′25″E longitude), Limpopo Province, South Africa. The ambient temperature around the study area ranges between 16 and 27 in summer while in winter it ranges between 8and 22. The mean annual rainfall ranges between 446.8 and 468.4 mm (Kutu and Asiwe, 2010).

Harvesting and preparations of *Acacia karoo* leaf meal

The *Acacia karroo* plant tree leaves were hand-harvested in August 2019 at the University of Limpopo experimental farm. The small branches were cut using a pair of scissors, and leaves from the branches were then shade-dried and stored indoors for 14 days before chopping. The leaves were then chopped and ground into a fine meal to go through a 2mm screen, and then stored in air-tight bags until needed for analysis and subjected to diet formulation (Table 1).

Table 1: Ingredients and nutrient composition of diets used in Experiments 1 and 2.

	Treatment levels			
Feed Ingredient	0	0.5	1.0	1.5
Maize	51.00	50.5	50.5	50
Wheat offal	12.00	12	11.5	11.5
Full fat soya	28.00	28	28	28
Fish meal	4.00	4	4	4
Limestone	1.00	1	1	1
Bone meal	2.95	2.95	2.95	2.95
Salt (NaCl)	0.25	0.25	0.25	0.25
Vit TM Premix	0.25	0.25	0.25	0.25
Dl-Methionine	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25
Acacia	0.00	0.5	1.00	1.500
Coccidiostat	0.05	0.05	0.05	0.05
TOTAL	100.00	100.00	100.00	100.00
Analysed nutrient composition				
DM (g/kg)	989	985	986	983
CP (g/kg DM)	199.0	198.6	197.8	197.4
Energy (MJ/kg DM)	17.10	17.11	17.10	17.10
EE (g/kg)	62.58	62.97	63.11	63.02
ADF (g/kg)	22.0	25.32	28.12	30.24
NDF (g/kg)	83.33	87.02	90.44	99.13
Ash (g/kg)	42.05	40.92	39.97	39.82
CT (mg/kg)	0.11	0.19	0.26	0.31

† The active ingredients contained in the vitamin–mineral premix were as follows (per kg of diet): vitamin A 12000 IU, vitamin D3 3500 IU, vitamin E 30.0 mg, vitamin K3 2.0 mg, thiamine 2 mg, riboflavin 6 mg, pyridoxine 5 mg, vitamin B12 0.02 mg, niacin 50 mg, pantothenate 12 mg, biotin 0Æ01 mg, folic acid 2 mg, Fe 60 mg, Zn 60 mg, Mn 80 mg, Cu 8 mg, Se 0Æ1 mg, Mo 1 mg, Co 0Æ3 mg, I 1 mg.

-CP- Crude protein; ADF – acid detergent fibre; NDF – neutral detergent fibre; CT - condensed tannins (mg/kg DM)

Experimental design, procedure, and ethics statement

The experiment determined FI, FCR, GR, LW, and gut morphology of male and female Ross 308 broiler chickens from one to 6 weeks to dietary *AKLM* levels. 320-day-old Ross 308 broiler chicks were assigned to a 2 (sex) × 4 (dietary treatment levels) factorial arrangement in a CRD, having 8 treatments, replicated x4 with 10 chicks/replicate. *AKLM* inclusion levels were at 0, 0.5, 1.0 or 1.5g/kg DM. The chickens were fed formulated diets (Table 2). Feeds and water were offered *ad libitum*. . Lighting was provided 24 hours daily utilizing natural lighting and artificial lighting using 175watt infrared ruby lamps. The experimental procedures were conducted following the University of Limpopo (UL) Animal Research Ethics committee, reference number: AREC/08/2020: PG.

Table 2: Dietary treatments in the experiment

Diet code	Diet description
AKM_0	Male Ross 308 broiler chickens fed a diet without *AKLM* inclusion.
$AKM_{0.5}$	Male Ross 308 broiler chickens were fed a diet having 0.5g of *AKLM* per kg DM.
$AKM_{1.0}$	Male Ross 308 broiler chickens were fed a diet having 1.0g of *AKLM* per kg DM.
$AKM_{1.5}$	Male Ross 308 broiler chickens were fed a diet having 1.5g of *AKLM* per kg DM.
AKF_0	Female Ross 308 broiler chickens were fed a diet without *AKLM* inclusion.
$AKF_{0.5}$	Female Ross 308 broiler chickens were fed a diet having 0.5g of *AKLM* per kg DM.
$AKF_{1.0}$	Female Ross 308 broiler chickens were fed a diet having 1.0g of *AKLM* per kg DM.
$AKF_{1.5}$	Female Ross 308 broiler chickens were fed a diet having 1.5g of *AKLM* per kg DM,

Data collection

Live weights were determined at the start of the experiment and then weekly. FI per chicken was determined by calculating the difference between the weight of feed offered and the weight of feed leftover, the difference was divided by the total number of chickens in the pen. FI and weight gain were used to calculate FCR (McDonald et al., 2010). At the ages of 3 and 6 weeks, 3 chickens per replicate were slaughtered using the cervical dislocation method to determine gut organ weights and lengths and gut organ digesta pH. Before the slaughtering, each chicken was weighed using an electronic weighing balance. The gastrointestinal tract, small intestine, caeca, and large intestine lengths were determined using a tape measure. The pH of gut (crop, proventriculus, gizzard, ileum, caecum, and colon) contents were measured using a digital pH meter (Crison, Basic 20 pH meter). Breast, drumstick, thigh, crop, proventriculus, gizzard, small intestine, caeca, and large intestine weights were measured using an electronic weighing balance.

Statistical analysis

The GLM from SAS version 9.4 software program, was used to analyse the effect of *Acacia karroo* inclusion level growth performance and gut morphology. Where there were significant differences (P0.05), the treatment means were separated using the Least Significant Difference (LSD) test at a 5% level of probability (SAS, 2013). The responses in optimal FI, digestibility, FCR, GR and LW, and gut morphology to *AKLM* inclusion level were modeled using the following quadratic equation: . The quadratic model was preferred because it gave the best fit. The linear relationships between the *Acacia karroo* inclusion levels and the responses in FI, digestibility, FCR, GR, LW, and gut morphology were modeled using the following linear regression equation: .

RESULTS

Feed intake (FI)

AKLM inclusion levels in the diets did not affect (P>0.05) FI of both male and female Ross 308 broiler chickens across all the treatments for the first 2 weeks and the last 4 weeks of the trial period (Table 3). However, *AKLM* inclusion levels affected (P<0.05) FI of both sexes during the 3rd week. Male Ross 308 broiler chickens on a diet having 1g of *AKLM* per kg DM had higher (P<0.05) FI than those on diets having 0, 0.5, or 1.5g. However, males on diets having 0, 0.5, or 1.5g of *AKLM* had similar (P>0.05) FI. Female broilers on a diet having 1.5g of *AKLM* per kg DM had higher (P<0.05) FI than those on diets having 0, 0.5, or 1.0g. In addition, FI of females was optimized at 1.03g per kg DM of *AKLM* inclusion level on the 3rd week.

Feed conversion ratio

AKLM inclusion levels had no effect (P>0.05) on the FCR of female broilers throughout the trial period (Table 4). Whereas the inclusion levels did not affect (P>0.05) on the FCR of males in the first 2 weeks and from week 4 until the end of the trial. However, *AKLM* inclusion levels affected (P<0.05) FCR male broilers during the 3rd week. Males on a diet without *AKLM* had better (P<0.05) FCR values than those on diets having 0.5, 1.0, or 1.5g. However, those on diets having 1.0 or 1.5g of *AKLM* had similar (P>0.05) FCR values.

Growth rate

AKLM inclusion levels had no effect (P>0.05) on the GR of both male and female broilers for the first 2 weeks and the last 3 weeks of the trial period (Table 5). *AKLM* inclusion levels had an effect (P<0.05) on GR of both gender during week 3 of the trial period. Male chickens on a diet without *AKLM* had slightly higher (P<0.05) GRs than those on diets having 1.0 or 1.5g of *AKLM*. However, males on diets having 0 or 0.5g of *AKLM* per kg DM had similar (P>0.05) GRs. Female broiler chickens on a diet without *AKLM* had slightly higher (P<0.05) GRs than those on diets having 0.5, 1.0, or 1.5g of *AKLM* during the 3rd week. However, female broilers on diets having 0.5, 1.0, or 1.5g of *AKLM* had similar (P>0.05) GRs.

Weekly live weights

AKLM inclusion levels had no effect (P>0.05) on LW of male and female broilers for the first 2 weeks and from week 4 until the end of the trial (Table 6). However, *AKLM* inclusion levels affected (P<0.05) LWs of both sexes on the

Table 3: Results of FIs of Ross 308 broiler chickens (g/week)

	Week#/age					
Treatment*	1	2	3	4	5	6
Male Ross 308 broiler chickens						
AKM_0	22.5±0.71	60.1±2.15	92.8^b±1.75	113.2±2.86	157.1±2.82	131±5.78
$AKM_{0.5}$	23.8±1.23	61.5±3.38	90.4^b±3.91	114.3±4.85	165.8±5.06	126±7.72
$AKM_{1.0}$	23.2±0.82	62.0±1.61	97.5^a±2.85	116.7±3.21	161.6±4.02	127±7.60
$AKM_{1.5}$	23.9±0.48	62.3±1.60	91.3^b±1.58	110.2±2.97	159.4±3.45	136±6.78
Female Ross 308 broiler chickens						
AKF_0	22.2±0.52	53.3±2.36	85.6^b±3.10	103.2±3.55	149.6±3.80	126±6.50
$AKF_{0.5}$	23.7±0.38	54.23±0.58	84.7^b±0.49	102.6±2.09	153.1±4.99	127±9.22
$AKF_{1.0}$	23.09±0.15	50.7±0.82	75.2^b±5.77	103.0±3.33	149.6±3.80	122±6.15
$AKF_{1.5}$	22.8±0.71	51.6±0.16	86.6^a±1.61	101.4±5.21	150.1±3.94	118±6.66

[a, b, c, d,]: Means with different superscripts in the same column indicate significant differences

: Means with no superscripts in the same column indicate non-significant differences

[*]: Treatments were Acacia karroo inclusion level at 0 (AKM_0), 0.5 ($AKM_{0.5}$), 1.0 ($AKM_{1.0}$) or 1.5 ($AKM_{1.5}$) g/kg DM (Table 2).

[#]: Values presented as mean ± standard error (SE)

Table 4: Results of feed conversion ratio of Ross 308 broiler chickens (g/week)

	Week#/age					
Treatment*	1	2	3	4	5	6
Male Ross 308 broiler chickens						
AKM_0	1.5±0.04	1.5±0.08	1.4^c±0.04	1.6±0.06	1.5±0.07	1.6±0.04
$AKM_{0.5}$	1.5±0.07	1.7±0.10	1.5^b±0.04	1.6±0.11	1.5±0.04	1.6±0.05
$AKM_{1.0}$	1.6±0.03	1.7±0.04	1.6^a±0.03	1.6±0.06	1.5±0.06	1.6±0.03
$AKM_{1.5}$	1.7±0.07	1.8±0.07	1.6^a±0.05	1.6±0.06	1.6±0.06	1.6±0.03
Female Ross 308 broiler chickens						
AKF_0	1.4±0.03	1.5±0.07	1.5±0.03	1.6±0.09	1.5±0.05	1.6±0.06
$AKF_{0.5}$	1.5±0.04	1.6±0.05	1.5±0.02	1.5±0.06	1.5±0.05	1.6±0.04
$AKF_{1.0}$	1.6±0.06	1.5±0.02	1.5±0.06	1.6±0.06	1.5±0.07	1.5±0.05
$AKF_{1.5}$	1.6±0.04	1.5±0.01	1.5±0.04	1.5±0.07	1.5±0.08	1.5±0.06

[a, b, c, d,]: Means with different superscripts in the same column indicate significant differences

: Means with no superscripts in the same column indicate non-significant differences

[*]: Treatments were Acacia karroo inclusion level at 0 ($AKMM_0$), 0.5 ($AKMM_{0.5}$), 1.0 ($AKMM_{1.0}$) or 1.5 ($AKMM_{1.5}$) g/kg DM (Table 2).

[#]: Values presented as mean ± standard error (SE).

Table 5: Results of growth rates of Ross 308 broiler chickens (g/week)

	Week#/age					
Treatment*	1	2	3	4	5	6
Male Ross 308 broiler chickens						
AKM_0	21.1±0.43	31.1±0.53	42.7^a±0.96	51.1±0.34	62.0±1.10	64.6±1.44
$AKM_{0.5}$	22.0±0.37	29.1±0.34	41.6^{ab}±0.67	49.1±1.63	64.1±2.17	64.8±1.84
$AKM_{1.0}$	20.5±0.31	28.9±0.31	41.2^b±0.33	49.6±0.95	60.1±1.66	62.5±2.05
$AKM_{1.5}$	19.9±0.73	27.4±0.33	40.2^b±0.94	49.7±1.52	61.1±1.62	61.9±3.63
Female Ross 308 broiler chickens						
AKF_0	21.9±0.22	28.8±0.90	38.7^a±0.87	48.1±0.34	58.1±1.10	60.2±1.44
$AKF_{0.5}$	21.7±0.33	28.2±0.33	37.2^b±0.51	49.3±1.63	60.0±2.17	60.2±1.84
$AKF_{1.0}$	20.7±0.56	27.3±0.60	35.8^b±0.99	47.9±0.95	58.7±1.66	59.8±2.05

$AKF_{1.5}$	19.9±0.13	27.1±0.13	36.8[b]±0.71	47.4±1.52	58.2±1.62	60.5±3.63

[a, b, c, d,]: Means with different superscripts in the same column indicate significant differences

: Means with no superscripts in the same column indicate non-significant differences

*: Treatments were Acacia karroo inclusion level at 0 (AK_0), 0.5 ($AK_{0.5}$), 1.0 ($AK_{1.0}$) or 1.5 ($AK_{1.5}$) g/kg DM (Table 2).

#: Values presented as mean ± standard error (SE).

Table 6: Results of live weights of Ross 308 broiler chickens (g/week)

	Week#/age					
Treatment*	1	2	3	4	5	6
Male Ross 308 broiler chickens						
AKM_0	148±2.99	436±7.42	897[a]±20.17	1399±19.43	62.0±1.10	2712±60.53
$AKM_{0.5}$	154±2.62	406±4.73	873[ab]±13.98	1374±45.63	64.1±2.17	2722±35.08
$AKM_{1.0}$	144±2.09	404±4.14	865[b]±6.95	1344±26.49	60.1±1.66	2625±44.02
$AKM_{1.5}$	139±5.11	383±4.57	845[b]±19.73	1335±42.67	61.1±1.62	2599±62.12
Female Ross 308 broiler chickens						
AKF_0	153±1.56	403±12.63	813[a]±18.21	1311±22.22	2048±70.06	2337±28.85
$AKF_{0.5}$	152±2.34	395±4.65	781[bc]±10.46	1284±14.99	1996±62.14	2501±46.02
$AKF_{1.0}$	145±3.90	382±8.42	751[c]±20.83	1321±35.10	2003±44.08	2319±35.45
$AKF_{1.5}$	139±0.93	378±.1.79	772[b]±14.84	1316±29.31	2039±65.65	2482±38.88

[a, b, c, d,]: Means with different superscripts in the same column indicate significant differences

: Means with no superscripts in the same column indicate non-significant differences

*: Treatments were Acacia karroo inclusion level at 0 (AK_0), 0.5 ($AK_{0.5}$), 1.0 ($AK_{1.0}$) or 1.5 ($AK_{1.5}$) g/kg DM (Table 2).

#: Values presented as mean ± standard error (SE).

Table 7: Results of gut digesta pH of male Ross 308 broiler chickens

	Parameters#												
	21 Days of age								42 Days of age				
Treat-ment*	Crop	Proven-triculus	Gizzard	Duo-denum	Ileum	Jeju-num	Caeca	Large intes-tine	Duo-denum	Ileum	Jejunum	Caeca	Large intes-tine
Male Ross 308 broiler chickens													
AK_0	6.6± 0.28	5.5± 0.14	3.7± 0.15	6.4± 0.04	6.4± 0.17	6.5± 0.11	6.9± 0.15	6.7± 0.13	6.0[ab]± 0.11	6.3[a]± 0.21	6.1[a]± 0.10	6.7± 0.11	6.8[a]± 0.13
$AK_{0.5}$	6.1± 0.29	5.6± 0.13	3.4± 0.18	5.6± 0.76	6.4± 0.11	6.6± 0.18	6.7± 0.11	6.4± 0.23	6.1[a]± 0.07	5.9[ab]± 0.35	5.8[ab]± 0.30	6.9± 0.03	6.2[b]± 0.23
$AK_{1.0}$	6.4± 0.25	5.5± 0.11	3.5± 0.16	6.3± 0.02	6.5± 0.18	6.6± 0.13	6.8± 0.21	6.7± 0.11	5.8[b]± 0.12	6.1[ab]± 0.16	5.7[b]± 0.13	6.8± 0.25	6.1[b]± 0.19
$AK_{1.5}$	6.5± 0.15	5.5± 0.11	3.4± 0.18	6.4± 0.09	6.2± 0.26	6.3± 0.32	7.1± 0.31	6.5± 0.19	6.0[ab]± 0.09	5.8[b]± 0.23	5.7[ab]± 0.35	6.9± 0.11	5.8[b]± 0.41
Female Ross 308 broiler chickens													
AK_0	6.4± 0.29	5.0± 0.05	3.8± 0.08	6.2± 0.09	6.5± 0.15	6.2± 0.18	6.8± 0.21	6.4± 0.19	6.1± 0.16	6.5± 0.27	6.2± 0.34	6.5± 0.24	6.1± 0.30
$AK_{0.5}$	6.1± 0.29	5.2± 0.19	3.9± 0.07	6.2± 0.11	6.4± 0.05	6.4± 0.17	6.9± 0.23	6.6± 0.18	5.9± 0.10	6.0± 0.26	6.0± 0.15	6.3± 0.17	5.8± 0.09
$AK_{1.0}$	5.8± 0.35	5.0± 0.11	3.8± 0.09	6.2± 0.07	6.4± 0.06	6.4± 0.16	6.8± 0.31	6.6± 0.11	6.0± 0.05	6.1± 0.30	5.9± 0.20	6.7± 0.26	5.9± 0.11
$AK_{1.5}$	5.9± 0.34	5.2± 0.17	3.8± 0.08	6.3± 0.05	6.5± 0.09	6.4± 0.18	6.9± 0.25	6.5± 0.16	5.9± 0.08	6.4± 0.13	6.0± 0.17	6.6± 0.12	5.8± 0.25

[a, b,]: Means with different superscripts in the same column indicate significant differences

: Means with no superscripts in the same column indicate non-significant differences

*: Treatments were Acacia karroo inclusion level at 0 (AK_0), 0.5 ($AK_{0.5}$), 1.0 ($AK_{1.0}$) or 1.5 ($AK_{1.5}$) g/kg DM (Table 2).

#: Values presented as mean ± standard error (SE).

Table 8: Results of gut organ lengths (cm) of Ross 308 broiler chickens

	Parameters[#]											
	21 Days of age						42 days of age					
Treatment*	GIT	Ileum	Jejunum	Duodenum	Caecum	Large intestine	GIT	Ileum	Jejunum	Duodenum	Caecum	Large intestine
Male Ross 308 broiler chickens												
AK_0	161.0± 4.20	55.9± 2.53	59.2± 2.38	24.5± 1.19	13.8± 1.75	8.4± 0.87	246.0^{b}± 5.87	82.8^{b}± 2.96	87.5± 4.63	37.3± 1.89	21.5± 0.87	10.0^{b}± 1.08
$AK_{0.5}$	156.1± 2.16	51.4± 3.64	59.1± 3.33	24.5± 0.65	13.1± 1.28	7.4± 0.84	256.8^{ab}± 19.03	94.0^{a}± 6.00	90.3± 9.66	30.8± 1.46	22.3± 0.85	11.3^{a}± 0.48
$AK_{1.0}$	162.3± 4.77	51.8± 3.95	61.4± 2.98	24.8± 1.65	14.1± 1.32	8.3± 0.63	256.3^{ab}± 8.93	97.3^{a}± 3.71	92.0± 6.11	33.0± 1.96	22.5± 1.19	11.8^{a}± 0.25
$AK_{1.5}$	162.0± 4.11	55.5± 3.54	57.6± 3.60	23.5± 1.32	13.5± 1.25	8.7± 0.74	267.8^{a}± 10.26	95.5^{a}± 5.12	93.8± 5.79	35.8± 1.11	22.5± 1.19	11.0^{ab}± 0.71
Female Ross 308 broiler chickens												
AK_0	148.2± 6.44	51.2± 3.64	64.3± 6.69	23.7± 0.77	12.5± 1.71	7.0± 0.21	238.5^{b}± 5.11	80.1^{b}± 3.05	85.6± 5.01	32.0± 1.97	19.9± 1.62	9.4± 0.36
$AK_{0.5}$	142.2± 5.38	48.1± 2.07	54.8± 5.64	22.4± 1.14	11.5± 1.85	6.5± 0.11	248.9^{ab}± 9.38	84.2^{ab}± 3.66	83.9± 12.46	29.8± 0.97	18.5± 1.48	9.5± 1.26
$AK_{1.0}$	143.6± 5.85	45.8± 2.64	52.9± 7.93	21.0± 2.48	11.9± 1.23	6.3± 0.61	252.2^{a}± 5.60	87.8^{a}± 2.02	85.1± 4.44	31.2± 1.84	20.0± 0.89	9.3± 1.81
$AK_{1.5}$	154.1± 7.31	50.0± 2.47	60.6± 5.08	22.5± 1.19	13.9± 1.12	7.1± 0.56	246.3^{ab}± 13.60	80.5^{b}± 5.11	82.9± 5.45	29.7± 1.35	19.8± 1.11	9.4± 0.66

a, b,: Means with different superscripts in the same column indicate significant differences

: Means with no superscripts in the same column indicate non-significant differences

*: Treatments were Acacia karroo inclusion level at 0 (AK_0), 0.5 ($AK_{0.5}$), 1.0 ($AK_{1.0}$) or 1.5 ($AK_{1.5}$) g/kg DM (Table 2).

#: Values presented as mean ± standard error (SE).

Table 9: Results of gut organ weights (g) of Ross 308 broiler chickens

	Parameters[#]															
Treatment*	21 Days of age								42 Days of age							
	Crop	Proventriculus	Gizzard	Liver	Small intestine	Spleen	Caeca	Large intestine	Crop	Proventriculus	Gizzard	Liver	Small intestine	Spleen	Caeca	Large intestine
Male Ross 308 broiler chickens																
AK_0	3.5± 0.40	6.1± 0.62	28.6± 1.98	21.5± 1.21	38.8± 1.83	0.6± 0.13	4.5± 0.54	1.5± 0.30	9.8± 1.32	11.1± 1.25	60.6± 5.02	59.0± 3.18	116.9± 10.81	17.8± 1.25	9.4± 2.36	13.4± 3.11
$AK_{0.5}$	3.0± 0.60	5.8± 0.32	24.5± 2.68	20.3± 1.82	37.9± 1.85	0.5± 0.17	6.5± 1.46	2.1± 0.32	10.8± 1.49	11.1± 1.31	59.1± 3.33	57.3± 1.45	122.3± 11.62	16.9± 1.34	13.4± 4.04	10.5± 2.30
$AK_{1.0}$	3.3± 0.34	5.3± 0.52	26.0± 2.35	23.6± 1.75	42.6± 2.61	0.5± 0.16	5.5± 0.02	1.5± 0.32	9.9± 1.77	11.0± 0.91	59.9± 2.38	53.9± 7.41	118.8± 9.04	18.8± 0.83	11.5± 2.54	14.1± 4.64
$AK_{1.5}$	3.3± 0.43	5.6± 0.44	26.5± 1.17	20.8± 1.52	40.0± 1.90	0.8± 0.14	5.3± 0.43	1.9± 0.32	11.1± 2.33	11.1± 0.55	60.8± 0.43	55.1± 2.35	137.9± 20.19	18.1± 3.39	14.3± 7.05	11.6± 1.01
Female Ross 308 broiler chickens																
AK_0	2.4± 0.98	5.7± 0.65	23.0± 1.51	19.8± 1.61	36.1± 3.55	0.6± 0.33	5.1± 0.75	1.6± 0.23	9.5± 0.98	10.4± 0.37	50.5^{b}± 1.24	54.2± 2.47	109.3± 12.35	13.9± 1.15	8.1± 1.49	10.2± 1.39
$AK_{0.5}$	2.5± 0.97	4.8± 0.72	22.1± 1.21	18.6± 1.55	32.0± 1.99	0.8± 0.34	5.1± 0.43	1.4± 0.23	9.2± 1.35	10.2± 1.82	51.8^{ab}± 2.18	53.6 ± 1.06	102.7± 7.47	12.7± 0.89	7.8± 1.11	10.8± 1.03
$AK_{1.0}$	3.6± 0.97	4.5± 0.84	22.1± 1.66	17.3± 1.81	32.0± 1.95	0.5± 0.24	5.6± 0.75	1.5± 0.21	9.2± 1.81	10.9± 0.80	53.7^{a}± 1.01	54.1± 2.44	103.2± 14.15	12.3± 1.82	8.0± 0.97	9.8± 2.87
$AK_{1.5}$	3.0± 0.80	5.6± 0.54	24.5± 1.72	19.9± 1.84	35.6± 1.75	0.9± 0.23	6.1± 1.09	1.8± 0.34	8.9± 2.11	10.2± 1.95	52.1^{ab}± 2.22	50.1± 3.11	107.0± 18.88	11.1± 2.78	7.4± 2.25	9.2± 3.13

a, b,: Means with different superscripts in the same column indicate significant differences

: Means with no superscripts in the same column indicate non-significant differences

*: Treatments were Acacia karroo inclusion level at 0 (AK_0), 0.5 ($AK_{0.5}$), 1.0 ($AK_{1.0}$) or 1.5 ($AK_{1.5}$) g/kg DM (Table 2).

#: Values presented as mean ± standard error (SE).

3rd week. Male Ross 308 broiler chickens on the control diet had slightly higher (P<0.05) LWs than those on diets having 1.0 or 1.5g of *AKLM*. Male chickens on diets having 0 or 0.5g had similar (P>0.05) LWs. Similarly, those on diets having 0.5, 1.0, or 1.5g of *AKLM* had the same (P>0.05) LW values. Female broilers on a diet without *AKLM* had a higher (P<0.05) LWs than those on diets having 0.5, 1.0, or 1.5g of *AKLM* during week 3. Similarly, female chickens on a diet having 1.5g of *AKLM* had a slightly higher (P<0.05) LWs than those on a diet having 1.0g of *AKLM*. However, chickens on diets having 0.5 or 1.5g had similar (P>0.05) LWs.

Gut organ digesta pH

Effects of *AKLM* inclusion levels in the diets on gut organ digesta pH values of male and female Ross 308 broiler chickens aged 21 and 42 days are presented in Table 7. *AKLM* inclusion levels in the diets did not affect (P>0.05 all digesta pH values of both sexes at day 21. Similarly, the inclusion levels had no effect (P>0.05) on all digesta pH values of female broilers chickens aged 42 days. Whereas only caecum digesta pH values in males were not affected (P>0.05) by *AKLM* inclusion levels at day 42. However, *AKLM* inclusion levels in the diets of male broilers affected (P<0.05) duodenum, ileum, and large intestine pH values. Male chickens on a diet having 0.5g of *AKLM* had higher (P<0.05) duodenum digesta pH than those on a diet having 0,1 or 1.5g of *AKLM*. However, males on diets having 0 or 1.5g of *AKLM* had similar (P<0.05) duodenum digesta pH values. Male broilers on a diet having 0g of *AKLM* had slightly higher (P<0.05) ileum digesta pH values than those on a diet with *AKLM*. However, males on diets having 0, 0.5, or, 1g of *AKLM* had similar (P>0.05) ileum digesta pH. Male chickens on a diet without *AKLM* inclusion had slightly higher (P<0.05) jejunum digesta pH values than those on diet having incremental levels of *AKLM*. However, male Ross 308 broiler chickens on diets having 0, 0.5, or, 1.5g of *AKLM* had similar (P<0.05) jejunum digesta pH values. Similarly, chickens on diets having 0.5, 1.0, or 1.5g of *AKLM* had the same jejunum digesta pH values. Males on a diet having no *AKLM* had higher (P<0.05) large intestine digesta pH values than those on diets having 0.5, 1.0, or, 1.5g of *AKLM*. However, male broilers on diets having 0.5, 1.0, or 1.5g of *AKLM* had similar (P<0.05) large intestine digesta pH values.

Gut organ lengths

Results of the effects of *AKLM* inclusion levels in the diets on lengths of both male and female Ross 308 broiler chickens aged 21 and 42 days are presented in Table 8. *AKLM* inclusion levels in the diets did not affect (P>0.05) the whole gut organ lengths of broilers aged 21 days. Similarly, *AKLM* inclusion levels in the diets did not affect (P>0.05) jejunum, duodenum, and caecum lengths of males and duodenum, jejunum, caecum, and LI lengths of female broilers aged 42 days. However, the inclusion levels affected (P<0.05) GIT, ileum, and large intestine lengths of males, and GIT and ileum lengths of female chickens at day 42.

Male broilers on a diet having 1.5g of *AKLM* had longer (P<0.05) GIT than those on a control diet. However, male Ross 308 broiler chickens on diets having 0.5, 1.0, or 1.5g of *AKLM* had similar (P>0.05) GIT lengths. Females on a diet having 1.0g of *AKLM* had longer GIT than those on a diet having no *AKLM* inclusion. However, female chickens on diets having 0, 0.5, or 1.5g of *AKLM* had similar (P>0.05) GIT lengths. Male chickens on diets having 0.5, 1.0, or 1.5g of *AKLM* had longer (P<0.05) ileum than on a diet without *AKLM*. However, males on diets having 0.5, 1.0, or 1.5g of *AKLM* had similar (P>0.05) ileum lengths. Females on diets having 0.5 or 1.0g of *AKLM* had longer (P<0.05) ileum than those from chickens on a diet having 0 or 1.5g *AKLM* inclusion. Males on diets having 0.5 or 1g of *AKLM* had longer (P<0.05) LI than those on the control diet. However, male chickens on diets having 0.5, 1.0, or 1.5g of *AKLM* had similar (P>0.05) LI. Male broilers on diets having 0 or 1.5g of *AKLM* also had similar (P>0.05) LI at day 42.

Gut organ weights

Results of the effects of *AKLM* inclusion levels in the diets on gut organ weights of male and female Ross 308 broiler chickens aged 21 and 42 days are presented in Table 9. *AKLM* inclusion levels in the diets did not affect (P>0.05) all the gut organ weights (crop, proventriculus, gizzard, liver, small intestine (SI), spleen, caeca, and LI weights) of both male and female broilers aged 21 days. Similarly, *AKLM* inclusion levels in the diets did not affect (P>0.05) all the gut organ weights of male broilers aged 42 days. However, *AKLM* affected (P< 0.05) gizzard weights of females aged 42 days. Female chickens on a diet having 1.0g of *AKLM* had higher gizzard weights than those fed a control diet after 42 days. However, female chickens on diets having 0.5, 1.0, or 1.5g of *AKLM* had similar (P>0.05) gizzard weights.

DISCUSSION

In the current study, *AKLM* inclusion levels did not affect FI, FCR, GR, and LW of both male and female broilers during the first two weeks of the trial. This is in agreement with Olugbemi et al. (2010) and Madzimure et al. (2018) who reported similar results. *AKLM* inclusion levels did not affect the FCR of female chickens during week 3. However, the FI of female broilers was optimized at 1.03g of *AKLM* inclusion level in the 3rd week. *AKLM* inclusion levels did not affect FI, FCR, GR, and LW of both male and female broilers during the last 3 weeks of the trial period. Similar observations were made by Lerdsuwan and Nalinanon (2017) and El-Galil et al. (2019).

At day 21 of age, *AKLM* inclusion levels did not affect all the gut organ digesta pH values, lengths, and weights of male and female broiler chickens. This is supported by Hafeni (2013) who observed that *AKLM* inclusion levels below 5g/kg of the diet did not affect gizzard weights of broiler chickens. On day 42, *AKLM* inclusion levels in the diets did not affect gut organ digesta pH, jejunum, duodenum and caecum lengths, and organ weights of both sexes. However, *AKLM* inclusion levels in the diets affected GIT, ileum, and large intestine lengths of males and GIT and ileum lengths, and gizzard weight of females. This is in agreement with Madzimure et al. (2018). Male broilers on a diet with1.5g of *AKLM* had longer GIT and ileum than those fed on a diet without *AKLM*. Similarly, female chickens on a diet having 1.0g of *Acacia karoo* leaf meal had longer GIT than the control diet. Similar observations were detected by Madzimure et al. (2018) who found that *Acacia anguistissima* leaf meal inclusion in the diet increased intestinal lengths. Huang et al. (2018) also, reported similar findings. Female broilers on a diet having 1.0g of *AKLM* had higher gizzard weights than those from the control diet after 6 weeks. This is in agreement with Ncube et al. (2017) and Miya et al. (2019) who observed similar results.

CONCLUSION

It is concluded that *AKLM* inclusion levels of up to 1.5g per kg DM could be included in the diets of broiler chickens without any adverse effects on their performance and gut morphology. However, it is suggested that further studies be carried out to ascertain these findings.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

NOVELTY STATEMENT

The Acacia karroo leaves are rich in protein (11 to 15% CP) and condensed tannins. The tannins are considered as one of natural antioxidants that could help improve meat quality, stability and shelf-life of animal meat products by reducing lipid oxidation and degradation of meat. Although high dietary tannins Acacia leaf meal reduce protein utilization by animals, poultry species such as chickens has been reported to cope with low inclusion levels of tannineferous leaf meals in their diets. The inclusion various tanniniferous leaf meals such as moringa and other Acacia species in chicken diets on performance and meatquality has been widely documented. However, there is limited information about the inclusion of the most cost effective and readily available Acacia karroo leaves on broiler chicken performance, gut morphology and meat quality. It is therefore crucial to determine the response in growth performance and gut morphology parameters of Ross 308 broiler chickens fed low incremental levels of Acacia karroo leaf meal prior to checking its effect on meat quality, stability and shelf life. The Acacia karroo leaves could further be processed through various method to improve protein utilization such that the leaves could be used as an alternative protein source. The information from this study will be useful to poultry farmers, feed companies and government departments which aim at improving performance and quality of broiler chicken meat and meat products for consumers.

AUTHORS CONTRIBUTION

SDK: executed the experimental work, interpretation results and writing of the manuscript from first to final draft. TGM: designed the research plan, organized the study, coordinated the data analysis, and took the lead in writing of the manuscript. JWN: participated in the experimental design, proof reading and diet formulation. SDK and TGM, EM, and MFDN: contributed to data collection and statistical analysis. SDK, TGM, JWN, EM and MFDN: Substantial contribution to translation of the manuscript, revisions and approval of the final version.

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