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Research article

The Effect of *Acacia mangium* Leaf Feed on Apparent Metabolizable Energy, Growth Performance, and Carcass Composition of Broiler Chickens

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Abstract: The experiments were conducted to determine the apparent metabolizable energy of *Acacia mangium* leaf meal (AMLM) and the effect on growth performance and carcass composition of broiler chickens (*Arbor acres*). Twenty-four broiler chickens at the age of 24 days were divided into 2 groups with four replications of two chickens raised individually in a cage. The apparent metabolizable energy of AMLM-feeding chicken was 2,359.90 kcal/kg. Experimental diets consisted of AMLM 0%, 2.5%, 5%, 7.5%, and 10% feeding for 161 one-day-old unsexed broiler chickens and were randomly assigned to five groups with four replications of eight chickens in a completely randomized design. Feed and water were offered *ad-libitum* throughout the experimental period. At the age of 45 days, 2 broilers per replicate were slaughtered, and the carcass was determined. The results indicated that broiler chickens fed AMLM diets were not significantly different in weight gain, average daily gain and feed intake compared to the control diet (P>0.05). But chickens fed AMLM had decreased feed conversion ratio than the control (P<0.05). In addition, broiler chickens fed AMLM diets were not significantly different in all carcass composition parameters compared to the control diet (P>0.05). It is concluded that the AMLM contained 10% in diets does not affect broiler chickens' growth performance and carcass composition.

Keywords: *Acacia mangium* leaf meal, Metabolizable energy, Growth performance, Carcass composition, Broiler chicken.

1. Introduction

The global poultry sector is characterized by faster growth in consumption and trade than any other major agricultural sector. In 2020 poultry meat production was 132 million tonnes, growing from 2020 to about 3 million tonnes [1].

Poultry feedstuffs are expensive, limiting the growth of poultry production in tropical areas. The cost of feeding has been put at 60-80% of poultry production. There is a constant need to look for locally available and cheaper feed ingredients that do not attract competition between humans and livestock.

The largest area of plantation of *Acacia mangium* (AM) is in South East Asia, where planting covers about 2 Mha [2]. In the 2000s, Malaysia and Indonesia had nearly 850,000 ha of commercial plantations of AM [3]. In Thailand, commercial plantations of AM had about 1,000,000 Rai [4]. As an exotic and fast-growing tree, AM can be used in a wide range, such as furniture, sawn wood, pulp, and paper [5]. Logging operations in plantation forests usually generate abundant waste, such as residual wood, branches/twigs, leaves, and bark. The waste accounts for more than 60% of the total biomass [6]. The AMLM contained 14% crude protein, 2.15% crude fat, 39.81% NFE, and 26.4% crude fiber [7], which could be used as feed alternatives in commercial livestock. The fresh *Acacia mangium* leaf can be used for ruminant animals [8-9]. However, there is a lack of direct information on the usefulness of AMLM in poultry diets. Other results were obtained the *Leucaena leucocephala* leaf meal (25% crude fiber) could be an acceptable use of resources up to 10% in laying hen diets [10]. Therefore, the objective of this study was to determine the effect of *AMLM* on metabolizable energy, growth performance, and carcass quality of broiler chickens.

2. Materials and Methods

2.1 Study chemical composition and metabolizable energy

2.1.1. Chemical composition

Fresh acacia mangium leaves (AML) were harvested from 2-4-year-old *acacia mangium* tree stands in the KMITL PCC forest in Chumphon province, Thailand. The leaves were cut and spread out on a clean concrete floor of a well-ventilated room for 3-4 days until they became crispy [11]. Dried AML were grinding through a 3-horse-power locally built hammermill (Thais, Thailand) equipped with a 2 mm screen. Sample AMLM were taken and analyzed for proximate analysis [12], tannin [13], and gross energy [12] according to analytical methods for oxygen bombs.

2.1.2 Metabolizable energy

Twenty-four broiler chickens (*Arbor acres*), 24 days of age, were used to test the metabolizable energy value of AMLM. The chickens (1 female and one male) were assigned to 45 x 30 x 35 cm individual cages and allotted to 2 groups with 6 replicates. Dextrose and soybean meal was used as a basal diet to calculate the metabolizable energy, which was determined using the substitution method according to Hill and Anderson [14]. Dextrose in the basal diet was replaced by 30% AMLM to make up experimental diets (Table 1). After 7 days adaptation period, 7 day collection period was started by adding 1% chromium oxide to the experimental diet as an initial marker. As a finishing marker, 1% chromium oxide was added to each experimental diet on the 8th day of collection. A collection of excreta (mixed fecal and urine) was started when the chromium oxide appeared in the excreta and kept until the appearance of chromium oxide in the excreta. Every day, the excreta samples were dried in a drying oven at 60 ^{o}C for 72 h. Finally, the total excreta was grounded to 1 mm in the blender mill grinder. Diet and excreta samples were analyzed for chemical analysis, protein [12], and gross energy (Oxygen bomb calorimeter, Parr model 6050) to determine the metabolizable energy (ME). The ME content of AMLM was calculated according to the equation developed by Hill and Anderson [14] as follows:
ME per gm diet = Energy per gm diet – (excreta energy per gm diet + 8.22 x gm N retained per gm diet)
To compute the ME of material substituted for glucose, the following equation applies:

$$\text{ME per gm substitute} = 3.64 - \left[\frac{\text{ME per gm referent diet} - \text{ME per gm diet with substitute}}{\text{Proportion of substitute}}\right]$$

(3.64 = experimentally established ME per gm of glucose dry matter)

Table 1. Ingredient composition of experimental diets

Ingredients (%) as fed basis	Reference diet	Test diet
Dextrose	45.81	15.81
Soybean meal (48% CP)	53.00	53.00
AMLM	-	30.00
DCP (P 18)	0.50	0.50
Salt	0.19	0.19
Vitamins & trace minerals [1/]	0.50	0.50
total	100.00	100.00

[1/] This premix provided the following microelements (µg/kg): vitamin A, 4,500,000 IU; vitamin D, 750,000 IU; vitamin E, 10,000; vitamin K3, 750; vitamin B1, 1,100; vitamin B2, 3,000; vitamin B3, 10,000; vitamin B6, 2,000; vitamin B12, 12.5; pantothenic acid, 7,000; folic acid, 425; biotin, 100; Cu, 5,000; Fe, 4,800; I, 500; Mn, 30,000; Se,100; Zn, 50,000.

2.2 Study growth performance and carcass quality

2.2.1. Growth performance

A total of 160 one-day-old broiler chicks (CP 707) were allocated to 5 dietary treatments and 4 replicates of 8 chickens (4 male and 4 female) in a completely randomized design for 1 to 45 days. The chickens were housed in a 1.35 x 1.50 m. pen in an open-air facility. Feed and water were provided *ad libitum* throughout the trial. Dietary treatments were 1) control group (0% AMLM), 2) to 5) equipped with a diet containing 2.5%, 5.0%, 7.5%, and 10.0% AMLM. All diets were fed in mash form, using the ME for formulating dietary treatments. The birds were fed a common corn-cassava-soybean-based diet formulated as-fed to meet [15] requirement for a starter diet (3,100 kcal of ME/kg; 23% CP) from 1 to 17 d of age, a grower diet (3,150 kcal of ME/kg; 20% CP) from 18 to 31 d of age and a finisher diet (3,200 kcal of ME/kg; 18% CP) from 32 to 45 d of age (Table 2). The chickens weight and feed consumption were measured on days 1 and 45.

2.2.2. Carcass composition

At the end of the experiment (45 d), 2 chickens per replicate (1 male and 1 Female) were individually weighed and slaughtered. The chickens were defeathered and weighed. Abdominal fat, neck, head, shanks, and edible offal (gizzard, liver, and heart) were excised and finally calculated as a percentage of live body weight. Cold carcass (pre-chilling in water at 20 ^{0}C for 20 min, chilling at 4 ^{0}C for 25 min, and dripping for 3 min) was cut into wings, thighs, drumsticks, breasts, and backbone. The yields of the various cuts are calculated as a percentage of cold carcass weight. Moreover, to evaluate the digestive organs (with digesta), proportions of the crop, spleen, small intestine (duodenum, jejunum, and ileum), cecum, and large intestine to live body weight were calculated. The length of intestinal segments, including the duodenum, jejunum, ileum, cecum, and large intestine, was measured according to Mossami [16]. In addition, the thickness of the muscular layer of the gizzard wall was measured at the maximum width by vernier calipers [17].

2.2.3. Statistical analysis

All data growth performance and carcass composition were subjected to analysis of variance procedures suitable for a completely randomized design using the GLM procedure [18]. Means were compared using Duncan. Statements of statistical significance were based on P<0.05.

Table 2. Ingredient composition and nutrient content of experiment diets (as fed basis)

Ingredients (%)	Starter Diets					Grower Diet					Finisher Diet				
	Acacia mangium leaf meal level (%)					*Acacia mangium* leaf meal level (%)					*Acacia mangium* leaf meal level (%)				
	0	**2.5**	**5.0**	**75**	**10**	**0**	**2.5**	**5.0**	**75**	**10**	**0**	**2.5**	**5.0**	**75**	**10**
Corn meal	30.00	30.00	28.00	27.45	23.50	34.00	32.00	30.00	30.00	30.00	36.56	33.61	30.76	27.80	25.00
Cassava chip	24.00	21.47	20.52	18.40	19.37	27.21	26.58	25.68	23.08	20.48	30.00	30.00	30.00	30.00	30.00
Soybean meal (45%CP)	30.28	29.85	29.60	29.23	29.18	25.00	24.68	24.45	24.02	23.58	20.15	20.00	19.80	19.70	19.44
Fish meal (60% CP)	9.50	9.50	9.50	9.50	9.50	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
A. Mangium leaf meal	0.00	2.50	5.00	7.50	10.00	0.00	2.50	5.00	7.50	10.00	0.00	2.50	5.00	7.50	10.00
DCP (18%P) [1]	2.30	2.30	2.40	2.40	2.40	2.40	2.40	2.45	2.45	2.45	2.20	2.20	2.25	2.27	2.27
Salt	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Vitamin-mineral premix[2]	0.33	0.33	0.33	0.33	0.33	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Palm oil	3.40	3.85	4.46	5.00	5.53	3.00	3.45	4.03	4.56	5.10	2.70	3.30	3.80	4.34	4.90
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Chemical composition, analysis (% DM basis)															
Dry matter (%)	90.62	90.53	90.62	91.22	90.54	90.36	90.37	90.55	90.33	90.33	90.30	90.34	90.09	90.34	90.65
Ash (%)	7.92	7.76	8.03	8.18	8.35	7.49	7.81	8.24	8.50	8.04	8.09	7.93	8.25	8.41	8.01
Crude protein (%)	21.18	22.32	22.44	21.77	22.93	18.31	18.32	18.74	18.91	18.97	16.37	17.04	16.58	16.91	17.33
Crude fat (%)	4.13	4.34	4.92	5.58	5.48	3.49	4.43	4.84	5.14	3.71	4.50	4.81	4.40	4.78	3.62
Crude fiber (%)	3.73	3.91	4.42	4.70	4.81	2.80	3.02	3.78	4.62	5.25	2.84	3.36	4.19	4.89	5.05
Gross energy (Kcal/ kg)	4,735	4,595	4,646	4,558	4,603	4,294	4,393	4,509	4,845	4,525	4,670	4,430	4,305	4,600	4,571

[1] DCP = Dicalcium phosphate. , [2] Vitamin-mineral premix provides per kg of diet: vitamin A 15,000 IU; vitamin D_3 3,000 IU; vitamin E 25 IU; vitamin K_3 0.5 g; vitamin B_1 2.5 mg; vitamin B_2 7 mg; vitamin B_6 4.5 mg; vitamin B_{12} 0.025 mg; pantothenic acid 35 mg; nicotinic acid 35 mg; chorine chloride 0.25 g; biotin 0.025 mg; Cu 1.6 mg; folic acid 0.5 mg; Mn 0.06 g; Se 0.15 mg; Fe 0.08 g; I 0.4 mg; Zn 0.045 g

3. Results and Discussion

3.1. Study chemical composition and metabolizable energy

Results of the proximate analysis of AMLM are presented in Table 3. It reveals that it is high in crude fiber (25.92%), tannin (13.28%), and gross energy (5,200.29 Kcal/kg). The crude protein content was lower than those (15.2% and 15.6 %) obtained respectfully by Van et al. and Keir et al. [19-20]. The composition of leaves is generally affected by various factors such as plant age, soil fertility, and preparation method [10]. The metabolizable energy content for broiler chicken of AMLM was analyzed to be 2,359.90 Kcal/kg. This value was similar to the ME of *the L. leeucocephala* leaf meal (2,377 Kcal/kg) obtained by Hien et al. [21].

Table 3. The chemical composition and metabolizable energy of AMLM (% dry matter)

Items	***Acacia mangium* leaf meal**
Moisture, %	13.58
Crude protein, %	11.62
Crude fat, %	2.99
Crude fiber, %	25.92
Crude ash, %	4.09
Nitrogen-free extract, %	41.80
Calcium, %	1.00
Phosphorus, %	0.04
Tannin, %	13.28
Gross energy, Kcal/kg	5,200.29
Metabolizable energy, Kcal/kg	2,359.90

3.2. Study growth performance and carcass composition

3.2.1. Growth performance

Broiler chicken performance from one to forty-five days of age is shown in Table 4. There were no significant differences in final body weight, weight gain, ADG, and DFI among dietary treatments. This result agreed with Eichie et al. [22], who reported that broilers fed with leucaena leaf meal lower than 12.16% in diets had feed intake and body weight gain different from the control diet. However, other studies have reported negative responses in growth performance to fed acacia leaf meal and leucaena leaf meal by broilers [11, 23-24].

However, broiler chickens fed the AMLM diet had a higher ($P<0.05$) FCR than those fed the control diet. The results in the negative response of FCR generally agreed with earlier reports [23-24]. The higher FCR due to feeding leaf meals compared to feeding the control diet may also be attributed to increased levels of dietary fibers and tannin, which could impair dietary nutrient utilization [10, 25]. The possible effect of the anti-nutritional compounds (fibers and tannin) has a limited capacity to digest high-fibrous ingredients efficiently, and the chickens lack the enzymes necessary for utilizing high-fibrous ingredients [26-27]. Therefore, using the highest dietary level of the AMLM could result in inadequate nutrient availability for the birds, which could negatively affect the FCR.

Table 4. Effect of AMLM on broiler chickens performance during ages of 1 to 45 days

Items	*Acacia mangium* leaf meal level (%)					*SEM*	*P-value*
	0	2.5	5	7.5	10		
Initial BW (g/chick)	42.19	41.88	42.19	42.19	42.19	0.131	0.941
Final BW (g/chick)	2095.00	1934.69	1989.00	1990.58	1913.44	25.238	0.177
WG (g/chick)	2052.81	1892.81	1946.82	1948.39	1871.25	25.246	0.178
ADG (g/day/chick)	45.62	42.06	43.26	43.30	41.58	0.561	0.178
DFI (g/day/chick)	102.33	103.87	103.87	108.86	104.63	0.796	0.083
FCR	2.25[b]	2.48[a]	2.41[a]	2.52[a]	2.52[a]	0.030	0.006

SEM, standard error of the mean.

[a,b] Mean in the same row with different superscripts differ significantly (P<0.05).

BW = Body weight; WG = Weight gain; ADG = Average daily gain;

DFI = Daily feed intake; FCR = Feed conversion ratio

3.2.2. Carcass composition

The carcass composition of forty-five days of age broiler chickens is shown in Table 5. Carcass parts were not significantly (P>0.05) affected by dietary AMLM. The relative weights of the carcass cut were similarities suggest that the control and the test diets (leaf meal-based diets) promoted similar carcass quality. This result was in agreement with Eichie et al. and Onibi et al. [22-23], who reported that broilers fed with a leucaena leaf meal in diets had carcass characteristics not different from the control diet.

The effect of diets supplemented with AMLM on digest organ size is shown in Tables 6 and 7. The visceral organ size was not significant (P>0.05) affected by dietary AMLM. No significant differences in the length of the duodenum, cecum, and large intestine were observed among the treatments. But chicken fed with AMLM diets had ilium longer (P<0.05) than those fed with a control diet (0% AMLM). Besides that, chicken fed with more than 5% AMLM diet tended to have a higher small intestine length (P=0.09), jejunum length (P=0.06), and gizzard wall thickness. The increase in the size of the intestinal segments is a physical adaptation to the presence of the AMLM. This represents an enhanced development of the intestinal segment [28-29]. An increase in the intestinal length could also result from an increase in gastro-duodenal refluxes as triggered by the high fiber content in the leaf meal feed base diet [29-31]. In this study, chicken fed with more than 5% AMLM diet tended to have higher gizzard wall thickness. One possible explanation for the higher relative gizzard wall thickness at a higher level of inclusion of leaf meals in the diet. The gizzard breaks down ingested feed by muscular action, and higher dietary fiber promotes more increased thickening of the muscles [23].

Table 5. The effects of AMLM on carcass composition of broiler chickens

Items	*Acacia mangium* leaf meal level (%)					*SEM*	*p-value*
	0	2.5	5	7.5	10		
Live weight (kg)	2.11	2.01	2.11	2.05	2.07	0.018	0.328
Dressed weight (%)[1/]	69.06	70.63	70.84	70.53	69.83	0.253	0.149
Edible offal (%)[1/]							
Gizzard	1.84	1.68	1.79	1.85	1.97	0.041	0.253
Liver	2.15	2.13	2.07	2.22	2.27	0.056	0.835
Heart	0.52	0.52	0.52	0.55	0.55	0.012	0.922
Abdominal fat (%)[1/]	2.33	2.31	2.04	2.13	2.07	0.069	0.585
Blood and feather (%)[1/]	7.95	7.11	7.56	7.93	8.34	0.244	0.594
Neck and head (%)[1/]	7.05	7.47	6.66	7.10	7.43	0.134	0.296
Shanks (%)[1/]	3.26	3.43	3.35	3.72	3.75	0.084	0.254

Table 5. The effects of AMLM on carcass composition of broiler chickens (Continued)

Items	*Acacia mangium* leaf meal level (%)					*SEM*	*p-value*
	0	2.5	5	7.5	10		
Cold Carcass (kg)	1.46	1.42	1.50	1.45	1.44	0.013	0.486
Wings (%)2/	11.77	11.94	11.36	11.43	12.82	0.203	0.151
Thighs (%)2/	19.57	18.87	19.50	19.48	20.02	0.337	0.892
Drumsticks (%)2/	15.21	15.22	14.54	14.81	15.34	0.138	0.322
Breasts (%)2/	28.83	28.62	29.37	29.50	28.60	0.400	0.934
Backbone (%)2/	22.79	22.96	23.90	24.47	24.69	0.312	0.191

SEM, standard error of the mean.
1/percentage of live weight, 2/percentage of cold carcass weight.

Table 6. The effects of AMLM on the relative weight of visceral organs 3/ (Percentage of live weight).

Organ size (%)	*Acacia mangium* leaf meal level (%)					*SEM*	*p-value*
	0	2.5	5	7.5	10		
crop	0.34	0.40	0.36	0.32	0.30	0.017	0.360
Spleen	0.18	0.29	0.21	0.23	0.26	0.019	0.421
Small intestine	2.81	2.92	2.81	2.98	2.78	0.045	0.631
Duodenum	0.73	0.72	0.68	0.74	0.68	0.010	0.184
Jejunum	1.11	1.10	1.08	1.17	1.07	0.022	0.672
Ileum	0.97	1.10	1.05	1.07	1.03	0.024	0.580
Cecum	0.33	0.30	0.27	0.34	0.33	0.009	0.112
Large intestine	0.15	0.14	0.12	0.14	0.14	0.008	0.844

SEM, standard error of the mean.
3/ Visceral organs weight considered with digesta.

Table 7. The effects of AMLM on intestinal and gizzard length of broiler chickens.

Organ size (cm)	*Acacia mangium* leaf meal level (%)					*SEM*	*p-value*
	0	2.5	5	7.5	10		
Small intestine	197.13	195.56	206.44	211.88	210.63	2.512	0.115
Duodenum	30.50	29.13	29.81	33.19	28.88	1.056	0.727
Jejunum	69.49	68.44	71.44	72.94	75.13	0.802	0.052
Ileum	70.13^{c}	71.31^{bc}	77.44^{ab}	80.06^{a}	78.63^{a}	1.134	0.007
Cecum	17.56	16.81	18.00	17.06	18.63	0.236	0.100
Large intestine	9.50	9.88	9.75	8.63	9.38	0.319	0.777
Gizzard wall thickness (mm)	17.85	19.25	19.20	20.11	22.79	0.820	0.382

SEM, standard error of the mean.
^{a,b,c}Mean in the same row with different superscripts differ significantly (P<0.01).

4. Conclusions

Under the condition described in this study, We found that the apparent metabolizable energy in broiler-fed AMLM was 2,359.90 kcal/kg. Broiler chickens fed up to 10% AMLM in diets do not affect broiler chickens' growth performance and carcass composition.

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