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Research article

Effects of replacing soybean meal with Giant Mimosa (*Mimosa pigra* L.) leaf meal in diet on productive performance, carcass characteristics, and apparent digestibility of native chickens (Leung Hang Kao)

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Abstract

Importance of the work: Giant Mimosa leaf meal (GLM) in poultry diets is a promising approach to improving nutrition and production efficiency.
Objectives: To investigate the productive performance and digestibility for Leung Hang Kao chickens fed a diet containing GLM.
Materials & Methods: There were 5 groups with varying GLM levels (0%, 5%, 10%, 15% or 20%), each with 4 replicates of 10 chickens. In total, 200 chickens were assessed for growth rate and production costs, while 20 chickens were studied for apparent digestibility. At age 16 wk, 40 chickens were examined for carcass characteristics.
Results: The diet with 5% GLM (GLM5) resulted in increased body weight, average daily gain and feed conversion ratios in the chickens. The GLM5 chickens had lower feed cost per gain and a higher net profit per bird ($p < 0.05$). Chickens in the GLM20 group had higher feed intake and total feed cost ($p < 0.01$). The GLM5 group had highly significantly ($p < 0.01$) lower total rearing costs and higher net profit return per bird and a significantly ($p < 0.05$) greater return on investment compared with the GLM10, GLM15 and GLM20 groups. There were no significant differences in carcass characteristics. At age 16 wk, with increased content of GLM in the diet, the digestibility of dry matter, organic matter and crude protein decreased ($p < 0.01$).
Main finding: Compared with the other GLM levels, the GLM5 group showed improved growth and feed efficiency, lower rearing costs and higher net profit and return on investment. The higher GLM content did not affect carcass characteristics, despite changes in digestibility.

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Introduction

The Leung Hang Kao chicken is a pure breed of Thai native chicken developed by the Department of Livestock Development since 2002, with the achieved aim of better growth performance than other native chickens (Intharachote et al., 2008). This breed propagates in rural farm environments primarily to provide local farmers with an additional source of income. In addition, Leung Hang Kao chickens have been selected for conservation breeding and sustainable use among Thai native chickens because of their remarkable fighting ability and productivity. In chicken production, feed is an essential component as it makes up about 60–70% of production costs (Chomchai, 1999). Any attempt to increase chicken production should concentrate on using inexpensive, locally available ingredients because the substantial recent increases in feed prices (Office of Agricultural Economics, 2020). Agro-industrial wastes and local plants may be cheap sources of ingredients for this purpose. There have been reports on the replacement of expensive feed ingredients, particularly protein sources, with agro-industrial wastes and local plants. For example, many plants are often used as alternative protein sources in diets, such as cassava leaves (Saparattananan et al., 2005), mulberry leaves (Soipeth, 2020) and Leucaena leaves. Another noteworthy plant is Giant Mimosa (GM; *Mimosa pigra* L.), is frequently abundant in watersheds as a serious weed and highly invasive plant, For example, GM is pervasive throughout Thailand harming the genetic diversity and ecology of local plant species (Kosalanan, 2017). However, GM is a leguminous nutritious plant that could be used as a feed additive to reduce its spread and feed costs. GM has a high average protein content in dry weight for both seeds (28%) and leaves (24–27%), with no mimosine, in contrast to Leucaena, which has mimosine in every part of the trunk (Bunnag, 1983). Several studies suggested that GM leaves could be used to replace protein sources in animal feed. For example, Maomoonha (2018) found that including 20% Giant Mimosa leaves in tilapia feed did not affect growth performance, nor the hematological and histopathological values of liver and spleen tissues. In addition, including GM leaves in the goat diet at 1.5% of body weight resulted in the highest average growth rate and final body weight, as well as the lowest feed cost (Natewichai et al., 2009). GM leaf meal (GLM) replaced soybean meal at 14–33% in Japanese quail diets with no negative effects on growth performance and digestibility (Kaewwongsa, 2016; Kaewwongsa et al., 2017). However, to data, there has been no published thorough investigation of the use of GM leaves in Thai native chicken diets.

Therefore, the purpose of this study was to determine the effect of GLM in the diet on the productive performance, carcass characteristics, and digestibility of Thai native Leung Hang Kao chickens.

Materials and Methods

Poultry

All poultry and experimental procedures performed in this study were conducted following the approved guidelines and regulations of the Institute of Animals for Scientific Purpose Development (IAD), Thailand and the Institutional Animal Care and Use Committee (IACUC Permit NO. 02/2565/IACUC) of Ubon Ratchathani University, Thailand. The Leung Hang Kao chicks aged 3 wk were obtained from the Ubon Ratchathani Livestock Research and Breeding Center, Thailand.

Preparation of Giant Mimosa leaf meal

GM leaves were collected from mature GM trees. All samples were sun-dried for 2–3 d with frequent turning. The branches and stems were removed so only the leaves were collected. Then, the dried leaves of GM were crushed into pieces of 0.5 mm using a 1.5 kg multipurpose mill. The GLM sample was stored in a zippered plastic bag to protect it from moisture and maintained at room temperature until mixed with the other feed ingredients according to the indicated amounts for each treatment group (Table 1). An examination of the nutrient composition of GLM was carried out in the laboratory (Table 2).

Experimental design

The assessment of the productive performance of Leung Hang Kao chickens fed a diet including GLM was conducted using a completely randomized design (CRD). In this experiment, 200 chickens were distributed across 5 treatments, with 4 replications and 10 birds per floor pen (5 males and 5 females). Data on initial body weight, final body weight and feed intake were collected and recorded throughout the experiment. For the assessment of apparent digestibility,

Table 1 Ingredients and nutrient composition in tested diets

Ingredient	Dietary treatment groups				
	Control	GLM5	GLM10	GLM15	GLM20
Soybean meal	22	20	18	16	14
Fish meal	3	3	3	3	3
Giant Mimosa leaf meal (GLM)	0	5	10	15	20
Broken rice	46	43	40	37	34
Rice bran	15	15	15	15	15
Salt	0.5	0.5	0.5	0.5	0.5
Di-calcium phosphate	5	5	5	5	5
Mineral/vitamin premix*	1.5	1.5	1.5	1.5	1.5
White limestone powder	7	7	7	7	7
Total (kg)	100	100	100	100	100
Price (THB/kg)	14.9	14.34	13.79	13.24	12.68
Calculated analysis (%)					
Crude protein	17.14	17.14	17.14	17.14	17.14
Crude fiber	3.0	3.83	4.65	5.46	6.28
Calcium	1.44	1.37	1.31	1.24	1.17
Available phosphorus	0.34	0.35	0.36	0.37	0.39
ME (Kcal/kg)	2802	2793	2783	2774	2764

ME = metalizable energy; GLM5 = 5% in diet; GLM10 = 10% in diet; GLM15 = 15% in diet; GLM20 = 20% in diet.
USD 1 = 34.60 THB
* = to provide 6,400,000 international units (IU) vitamin (Vit) A; 2,600,000 IU Vit D3; 11,000 IU Vit E; 880 mg Vit K; 870 mg Vit B1; 4,000 mg Vit B2; 2180 mg Vit B6; 18,000 mg nicotinic acid; 88 mg biotin; 4 mg Vit B12; 5,290 mg pantothenic acid; 660 mg folic acid; 38.13 g manganese; 30 g zinc; 40 g iron; 6 g copper; 0.2 g iodine; 0.12 g selenium; 5 g ethoxyquin; 4 g silicon dioxide.

Table 2 Nutrient composition of Giant Mimosa leaf meal based on laboratory analysis

Nutrient compositions	Giant Mimosa leaf meal content (%)
Dry matter	91.2
Crude protein (CP)	22.70
Ether extract (EE)	6
Crude fiber	15.71
Ash	6.43
Nitrogen free extract (NFE)	49.15
Acid detergent fiber	20.32
Neutral detergent fiber	28.41
Acid detergent lignin	3.38
ME (Kcal/kg)	3,070

ME = metalizable energy = 37 × %CP + 81 × %EE + 35 × %NFE (Pauzenga, 1985)

20 chickens (10 males and 10 females) were divided into 5 groups with 4 replications, with each chicken considered as an individual replication. At both age 10 wk and 16 wk, 20 chickens were individually housed in cages measuring 20 cm × 40 cm × 35 cm for 7 d. During this period, they were provided feed *ad libitum* and the amount of feed given and the amount of daily feed intake were meticulously recorded. Body weights were recorded both before and after isolation to observe any changes. All feces collected from the chickens were chemically analyzed in the laboratory to determine apparent digestibility.

Feeding and management procedures

All chickens were raised in open houses in litter and under uniform housing conditions. Chickens were given mash feed and clean drinking water *ad libitum* throughout the study period. All chickens were weighed weekly in the morning before feeding and watering. Feed intake was calculated by measuring the amount of feed offered and the amount of feed remaining after 24 hr. The feed conversion ratio (FCR) was calculated by dividing feed intake by weight gain. At age 7 d, the chickens were vaccinated against Newcastle disease and Infectious bronchitis. Mortality rates among the chickens were monitored and all routine poultry husbandry procedures were diligently carried out.

Carcass characteristics

At age 16 wk, 40 chickens from the floor pen were randomly chosen for further analysis, with an even split of 8 chickens from each experimental group. This selection constituted 20% of the total experimental animals. Subsequently, these chosen chickens were processed following the methods outlined by the National Bureau of Agricultural Commodity and Food Standards (2006). Good manufacturing practices for poultry abattoir were followed, including requiring the chickens fast for 12 hr, cutting the neck to allow complete bleeding, scalding, de-feathering and collecting carcasses and visceral organs (liver, gizzard, intestines). Carcass characteristics including live weight and carcass weight were recorded and the percentages were determined represented by the breast, drumsticks, thighs, wings and visceral organs.

Nutrient digestibility

The chickens were fed individually in cages for 7 d with fecal collection at ages 10 wk and 16 wk. The amounts of feed given daily and feed residue were recorded. All fecal collection was performed during the last 4 d of the experiment using plastic trays placed under the cages. Feces were collected once daily at 0900 hours and sprayed with 5% hydrochloric acid to prevent nitrogen loss. The collected feces were dried at 55°C for 48 hr, crushed and stored in zip-lock bags for chemical analysis of the dry matter (DM), organic matter (OM), ether extract, crude fiber and crude protein (CP) according to Association of Official Analytical Chemists (1990) to calculate the digestibility of nutrients according to Equations 1 and 2 (Kajarern, 2004; Okrathok, 2013):

$$\text{Dry matter digestibility} = \frac{(FI - FC) \times 100}{FI} \quad (1)$$

$$\text{Nutrient digestibility} = \frac{(FI \times \%FN) - (FC \times \%FC) \times 100}{FI \times \%FN} \quad (2)$$

where FI is the feed intake, FN is the feed nutrient and FC is the fecal nutrient, with all amounts measured in grams.

Statistical analysis

All data were subjected to analysis of variance using the CRD model procedure in the SAS Studio statistical package (SAS Institute, 2023). Duncan's new multiple range test was used to determine treatment effects and difference between different groups, with $p < 0.05$ considered significant and $p < 0.01$ considered highly significant. Additionally, trend analysis with the orthogonal polynomial was applied.

Results

Growth performance

The chickens were evaluated for growth performance (Table 3) after being fed diets that included GLM at 0% (GLM0), 5% (GLM5), 10% (GLM10), 15% (GLM15) or 20% (GLM20). Chickens in the GLM5 group had significantly higher final body weight and average daily gain than the control and GLM20 groups. There were no significant differences in body weight gain among treatment groups. However, including GLM at 5%, 10%, 15% and 20% in the diet highly significantly increased feed intake compared to the control group ($p < 0.01$). In addition, chickens fed the GLM5 diet had a highly significantly better FCR than all other treatment groups ($p < 0.01$).

Carcass characteristics

The carcass characteristics of the chickens were examined at age 16 wk (Table 4). There were no significant differences in live weight, carcass weight, carcass percentage, external organ percentage and internal organ percentage between the control and the treatment groups. It appeared that the diets with high GLM levels tended to have reduced carcass traits, particularly in thigh percentages ($p > 0.05$).

Table 3 Effects of Giant Mimosa leaf meal on growth performance and viability of Leung Hang Kao chickens

Parameter	Dietary treatment group					SEM	Trend analysis		
	Control	GLM5	GLM10	GLM15	GLM20		L	Q2	C
IBW (g/b)	152.80	151.48	149.33	151.48	147.90	3.58	0.7044	0.9948	0.8493
FBW (g/b)	1006.75^{c}	1130.60^{a}	1099.13^{ab}	1079.82^{abc}	1022.35^{bc}	12.01	0.8207	0.0033	0.1878
BWG (g/b)	853.95	979.12	922.85	920.32	852.11	13.85	0.5331	0.0116	0.2557
FI (g/b/d)	40.32^{C}	45.81^{B}	54.42^{A}	55.79^{A}	57.16^{A}	0.72	<.0001	0.0349	0.3863
ADG (g/b/d)	9.44^{c}	10.74^{a}	10.44^{ab}	10.20^{abc}	9.61^{bc}	0.13	0.8491	0.0054	0.2121
FCR	4.32^{B}	4.28^{B}	5.43^{A}	5.69^{A}	6.15^{A}	0.12	<.0001	0.9170	0.2696
Viability (%)	98.00	98.00	88.00	95.00	98.00	1.82	0.8490	0.1614	0.7040

GLM5 = 5% in diet; GLM10 = 10% in diet; GLM15 = 15% in diet; GLM20 = 20% in diet; IBW = initial body weight; FBW = final body weight; BWG = body weight gain; FI = feed intake; ADG = average daily gain; FCR = feed conversion ratio; SEM = standard error of the mean; L = linear; Q2 = quadratic; C = cubic.

a-c Lowercase superscripts indicate significant differences in means within a row ($p < 0.05$).

A-C Uppercase superscripts indicate highly significant differences in means within a row ($p < 0.01$).

Mean values in a row without superscripts are non-significant ($p > 0.05$) difference.

Table 4 Effects of Giant Mimosa leaf meal on Carcass characteristics of Leung Hang Kao chickens

Parameters	Dietary treatment groups					SEM	Trend analysis		
	Control	GLM5	GLM10	GLM15	GLM20		L	Q2	C
Live weight (g)	1184.0	1292.1	1258.8	1201.8	1165.8	19.36	0.3700	0.0732	0.2540
Hot carcass weight (g)	938.8	1035.8	1009.3	963.3	941.1	14.36	0.5132	0.0485	0.1675
Dressing percentage (%)	79.32	80.17	80.20	80.21	80.76	0.22	0.0795	0.7364	0.4010
Breasts (%HCW)	12.61	13.15	13.22	13.45	13.54	0.21	0.1611	0.6755	0.8248
Wings (%HCW)	12.64	12.73	12.41	12.87	12.35	0.09	0.5197	0.5813	0.3966
Drumstick (%HCW)	14.02	13.87	13.63	13.35	13.92	0.14	0.4827	0.2521	0.3515
Thighs (%HCW)	14.80	14.74	14.20	14.02	14.11	0.10	0.0118	0.4564	0.3255
Heart (%HCW)	0.73	0.79	0.62	0.79	0.64	0.03	0.5076	0.8467	0.7390
Liver (%HCW)	3.36	3.27	2.91	3.24	2.99	0.08	0.2333	0.6211	0.6232
Gizzard (%HCW)	4.83	4.90	5.25	5.31	5.22	0.09	0.1029	0.4681	0.5479
Gastrointestinal tract (%HCW)	11.47	11.60	12.01	12.33	12.13	0.17	0.1140	0.6138	0.5226

GLM5 = 5% in diet; GLM10 = 10% in diet; GLM15 = 15% in diet; GLM20 = 20% in diet; HCW = hot carcass weight; SEM = standard error of the mean; L = linear; Q2 = quadratic; C = cubic.
External and visceral organs expressed as a percentage of hot carcass weight.
Mean values in a row without superscripts are non-significant ($p > 0.05$) difference.

Nutrient digestibility

The nutrient digestibility of Leung Hang Kao chickens was measured at age 10 wk and 16 wk. At age 10 wk, the digestibility levels of DM, OM, CF and CP were not significantly different among the treatment groups. However, the digestibility of OM and CP tended to decrease in a manner dependent on the levels of GLM inclusion ($p > 0.05$). The digestibility of EE had the highest increase in the GLM20 group, which was significantly different compared to the control and GLM5 groups (Table 5).

At age 16 wk, the digestibility levels of EE and CF were not significantly different among the treatment groups. In addition, the digestibility of DM in the GLM5 and GLM15 groups did not differ compared to the control group ($p > 0.05$). The inclusion of GLM at 5% and 10% in the diet had no effect on the digestibility of OM and CP ($p > 0.05$). However, chickens in the GLM20 diet group had decreased results for the digestibility levels of DM, OM and CP compared to the control, GLM5 and GLM10 groups (Table 5).

Production costs

The total costs of the GLM15 and GLM20 groups (Table 6) were highly significantly greater than those of the control and GLM5 groups. In addition, the GLM10 and GLM15 groups had highly significantly greater total costs per bird compared to the control and GLM5 groups ($p < 0.01$). Feed costs in the control and GLM5 groups were highly significantly lower than those in the GLM15 and GLM20 groups. Furthermore, the GLM5 group had a significantly lower feed cost per gain compared to the other treatment groups. However, there were

Table 5 Nutrient digestibility of Leung Hang Kao chickens fed Giant Mimosa leaf meal

Parameter	Dietary treatment group					SEM	Trend analysis		
	Control	GLM5	GLM10	GLM15	GLM20		L	Q2	C
Nutrient digestibility at age 10 wk									
Dry matter	81.56	79.32	81.40	75.52	75.35	1.50	0.1474	0.7653	0.8979
Organic matter	85.99	84.51	85.41	79.52	77.20	1.10	0.0111	0.3729	0.8798
Ether extract	87.03^{b}	86.63^{b}	91.44^{ab}	89.15^{ab}	93.10^{a}	0.69	0.0094	0.7877	0.8356
Crude fiber	52.97	61.99	67.89	55.25	51.36	2.26	0.5433	0.0334	0.4700
Crude protein	83.99	78.84	78.40	71.32	70.14	1.64	0.0084	0.9256	0.9196
Nutrient digestibility at age 16 wk									
Dry matter	88.65^{a}	87.23^{a}	89.54^{a}	82.91^{ab}	77.33^{b}	1.09	0.0034	0.0800	0.7336
Organic matter	93.91^{A}	91.56^{AB}	92.20^{A}	87.40^{B}	82.10^{C}	0.63	<.0001	0.0477	0.4463
Ether extract	91.39	93.04	96.25	93.32	95.21	1.02	0.2879	0.5151	0.6573
Crude fiber	70.16	75.79	81.62	71.96	61.33	2.12	0.1725	0.0163	0.9386
Crude protein	90.32^{A}	86.42^{AB}	87.79^{A}	79.16^{BC}	73.85^{C}	1.21	0.0003	0.2268	0.8237

GLM5 = 5% in diet; GLM10 = 10% in diet; GLM15 = 15% in diet; GLM20 = 20% in diet; SEM = standard error of the mean; L = linear; Q2 = quadratic; C = cubic.
[a-b] Lowercase superscripts indicate significant differences in means within a row ($p < 0.05$).
[A-C] Uppercase superscripts indicate highly significant differences in means within a row ($p < 0.01$).
Mean values in a row without superscripts are non-significant ($p > 0.05$) difference.

Table 6 Effects of Giant Mimosa leaf meal on production cost of Leung Hang Kao chickens

Parameters	Dietary treatment groups					SEM	Trend analysis		
	Control	GLM5	GLM10	GLM15	GLM20		L	Q2	C
TC (THB)	726.34^{B}	775.63^{B}	786.57^{AB}	847.86^{A}	853.29^{A}	9.93	0.0003	0.6594	0.8067
TCB (THB/bird)	74.58^{C}	79.69^{BC}	90.95^{A}	89.43^{A}	87.64^{AB}	1.26	0.0011	0.0235	0.4826
TFC (THB)	532.64^{A}	581.93^{A}	592.87^{AB}	654.16^{B}	659.59^{B}	9.94	0.0003	0.6594	0.8067
FCG (THB/kg)	64.41^{bc}	61.37^{c}	74.85^{ab}	75.37^{ab}	80.56^{a}	1.68	0.0014	0.8064	0.3346
TSR (THB)	983.00	1103.00	964.13	1028.00	997.50	25.97	0.8057	0.6577	0.3847
NPR (THB)	256.66	327.37	177.55	180.14	144.21	19.71	0.0175	0.7174	0.2115
NPRB (THB)	26.10^{ab}	33.40^{a}	18.98^{b}	18.57^{b}	14.64^{b}	1.86	0.0117	0.5952	0.1868
TFC NP GLM (THB)	532.64	572.19	571.38	617.1	608.09	9.69	0.0120	0.5421	0.8368
FCG NP GLM(THB/kg)	64.33	60.32	72.14	71.10	74.27	1.62	0.0174	0.9128	0.3273
NPRB NP GLM (THB)	26.10	34.40	21.46	22.48	19.93	1.84	0.0823	0.6231	0.1949
Return on investment (%)	35.51^{ab}	42.35^{a}	21.78^{bc}	21.10^{bc}	16.81^{c}	2.45	0.0041	0.9090	0.1902

GLM5 = 5% in diet; GLM10 = 10% in diet; GLM15 = 15% in diet; GLM20 = 20% in diet; SEM = standard error of the mean; L = linear; Q2 = quadratic; C = cubic; TC = total cost; TCB = total cost per bird; TFC = total feed cost; FCG = feed cost per gain; TSR = total salable return; NPR = net profit return; NPRB = net profit return per bird; TFC NP GLM = total feed cost not including price of Giant Mimosa leaf meal; FCG NP GLM = feed cost per gain not including price of Giant Mimosa leaf meal; NPRB NP GLM = net profit return per bird not including price of Giant Mimosa leaf meal.
USD 1 = 34.60 THB.
$^{a-c}$ Lowercase superscripts indicate significant differences in means within a row ($p < 0.05$).
$^{A-C}$ Uppercase superscripts indicate highly significant differences in means within a row ($p < 0.01$).
Mean values in a row without superscripts are non-significant ($p > 0.05$) difference.

no significant differences in total salable return and net profit return among the control and treatment groups. The net profit return per bird in the GLM5 group was comparable to the control group ($p > 0.05$) and significantly higher than in the other groups. Furthermore, the return-on-investment percentages in both the control and GLM5 groups were significantly higher than in the GLM20 group. No significant difference was observed in the viability rates among the control and treatment groups.

Discussion

GLM, a legume with a high protein content (21–24%; Vearasilp, 1988; Buranawit and Punyatong, 2016), when used as a feed ingredient at an appropriate level, resulted in a better growth rate in chickens. In addition, Mateos et al. (2012) reported that a moderate fiber diet improved the development of the gastrointestinal tract, enzyme production and digestibility. Likewise, cellulose and lignin at 3–5% in the diet improved nutrient metabolism (Svihus, 2011; Sacranie et al., 2012). In quail diets, Kaewwongsa et al. (2017) reported that replacing soybean meal with a low level of GLM (14.34%) increased the body weight, growth rate and protein efficiency compared to high inclusion levels of GLM (28% and 43%). This was consistent with the current results that showed the final body weight and average daily gain were greater in the GLM5 and GLM10 groups compared to the control group. However, the current results showed that the inclusion of GLM significantly increased the feed intake of chickens. GLM contains high fiber; consequently, when it is used at high levels in the diet, it contributes to a spongier and higher dietary fiber content, resulting in a more rapid passage through the gastrointestinal tract, leading to more frequent emptying of the gastrointestinal tract. Thus, to obtain sufficient nutrients, chickens need to consume more feed, resulting in a higher feed intake (Kaewwongsa et al., 2017). Furthermore, a high-fiber diet may not be fully digested and utilized, which can affect productive performance (Kantho, 1986; Rangilal et al., 1995). The current findings supported these other studies, because the groups fed diets with high levels of GLM (10%, 15% and 20%) had poor FCR values. Furthermore, the inclusion of a high level of GLM in diets resulted in reduced dietary energy levels, as shown in Table 1. This observation aligned with the findings of Kaewwongsa et al. (2017), who noted a decrease in total dietary energy following supplementation with GLM and an associated increase in quail feed intake. Similarly, Tangtaweewipat et al. (2001) reported that chickens consuming diets with lower energy levels exhibited higher feed intake, as they attempted to satisfy their energy requirements. When chickens do not receive adequate energy, their feed consumption increases until their energy needs are satisfied. Low dietary energy levels can adversely affect the FCR. Typically, native chickens aged 4–16 wk require an energy content in the range 2,700–2,800 kcal metalizable energy/kg (Panja, 1999; Polsiri, 2001).

There were no significant differences observed in carcass characteristics between the chickens fed GLM and the control diet group in the current study. Similar results have been reported for other poultry breeds, such as Japanese quail (Kaewwongsa, 2016). Studies on the addition of other plants similar to GLM in poultry diets reported that the addition of 15% cavalcade leaf meal in broiler chicken diets had no significant effect on carcass characteristics (Nopparatmaitree et al., 2019), the addition of 20% mulberry leaf meal in Serngwai black bone chicken diets had no negative effect on carcass percentages (Soipeth, 2020) and adding 5–10% Leucaena leaf meal to Cobb broiler chick diets did not affect carcass weight (Zanu et al., 2012). Esmail (2012) reported supporting results that 8–10% fiber content in broiler diets did not affect feed efficiency and growth performance.

The current study did not identify any differences in DM, OM, CF and CP digestibility among the chicken treatment groups at age 10 wk. Similarly, adding a high level of GLM in quail diets did not affect nutrient digestibility (Kaewwongsa et al., 2017). In the current study, the digestibility of EE in the GLM20 group increased compared to the control group. EE is an easily digestible nutrient, with its presence slowing the rate of feed passage in the gastrointestinal tract, giving a longer time for digestion (Tarachai, 2017). At age 16 wk in the current study, the GLM20 group had significantly decreased levels of DM, OM and CP digestibility compared to the control group. GLM contains 15.71% fiber and increasing the amount of GLM in the diet can elevate the fiber content (8–10%) of the feed (Esmail, 2012). It has been reported that higher dietary fiber levels reduce the digestibility of all nutrients, particularly protein, fat and energy (Jørgensen et al., 1996; Sklan et al., 2010). Furthermore, Kaewwongsa et al. (2017) found that increasing the amount of GLM in the diet reduced the digestibility of DM and CP. Krás et al. (2013) consistently found lower digestibility levels of DM, OM and neutral detergent fiber in chickens fed a high-fiber diet. Donadelli et al. (2019), found that chickens fed a diet supplemented with beet pulp (3% acid detergent fiber, ADF) digested their feed better than those fed a diet supplemented with miscanthus grass (4.2% ADF). In addition, high-fiber diets cause faster passage through the gastrointestinal tract, reducing the time for feed to mix with gastric juices, resulting in less efficient feed digestion by chickens (Kaewwongsa et al., 2017). Furthermore, GLM contains 0.76% tannins (Maomoonha, 2018), which can precipitate proteins in aqueous solutions (Butler, 1989) and reduce the digestibility of proteins, carbohydrates and some minerals by inhibiting the activity of digestive enzymes (Jansman et al., 1994).

The current study identified that returns decreased as the GLM level in the diet increased, particularly in the GLM20 group that had the lowest return on investment (16.81%). This was consistent with the findings of Zanu et al. (2012), who reported that increasing the amount of Leucaena leaf meal (LLM) in feed resulted in a decrease in net revenue per chicken. Furthermore, increasing the amount of LLM in the broiler chicken diet resulted in higher feed costs per gain (Lerdsuwan and Nalinanon, 2017). Presumably, chickens fed a high-fiber diet had a tendency to consume more feed compared to chickens on a low-fiber diet. This increased feed consumption, leading to higher feed costs and a slower growth rate. Consequently, this lower growth rate negatively impacted the potential profit earned from sales, resulting in a lower return on investment. Excluding GLM from the cost analysis resulted in no significant differences among the treatment groups in terms of feed cost, feed cost per gain and net profit return per bird. This could be attributed to the fact that GM is naturally abundant, widely distributed and easily accessible. Furthermore, it contains 22.70% crude protein, which is comparable to LLM (14–20%), which has a higher price and more restrictions on its use.

In conclusion, including 5% GLM in the diet of Leung Hang Kao chickens from age 3 wk to 16 wk resulted in improved body weight and average daily gain, while maintaining a favorable FCR and not negatively affecting carcass characteristics and nutrient digestibility. However, higher levels of GLM in the diet led to increased total costs and decreased nutrient digestibility.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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