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Giant Taro (*Alocasia macrorrhiza*) Root Meal with or without Coconut Oil Slurry as Source of Dietary Energy for Laying Hens

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Abstract

The effect of feeding *Alocasia macrorrhiza* root meal (AMRM) with or without added coconut oil slurry (COS) on egg production and egg qualities was investigated in a 20-week experiment. A control diet based on maize and 4 other diets containing 10 and 20% AMRM with or without COS were fed each to 4 replicates of 10 birds in a completely randomized design. There were no significant dietary effects on feed intake (FI) and the intake of lysine, methionine and metabolizable energy (ME). Birds fed the 20% AMRM_COS added significantly less weight during the experimental period compared to the control fed group. Body weight change (BWC) did not differ among the AMRM fed birds. Per cent hen-day and feed conversion ratio were depressed on 20% AMRM and egg weight on 10% AMRM but these depressing effects were overcome by COS addition. Egg shape index, Haugh unit and per cent shell were not affected by the diet. It is concluded that AMRM can replace 10% dietary maize without adverse effect on laying performance but 20% replacement negatively impacts on hen-day and egg weight. These adverse effects are however, overcome by treating AMRM with COS at the ratio of 9: 1. More research into higher levels of COS treated AMRM in the diet is warranted.

Keywords: high feed cost, alternative ingredients, laying performance, egg quality.

Introduction

Traditional energy feed ingredients for poultry feeding such as maize and wheat are not grown in the South Pacific region and thus very expensive. Commercial poultry farming depends largely on feed importation. High feed cost is a major impediment to the growth of the poultry industry in the region. Ayalew (2011) reported a 56 to 100% increase in retail prices of commercial pig and poultry feeds in Papua New Guinea (PNG) from 2003 to 2011, representing an annual increase of about 7-13%. There are however, many locally available raw materials in the region but their use in poultry diets is not documented. The need to increase research into such locally available, cheap materials in the region is eminent.

Giant taro (*Alocasia macrorrhiza*) is a root crop which grows wild in many countries of the region including Samoa where it is locally known as “tamuu”. Two cultivars of tamuu are found in Samoa; the purple (tamuu New Guinea) and the white (tamuu Tonga). Tamuu Tonga grows well in Samoa but hardly eaten by Samoans except during periods of famine. This makes it readily available for stock feeding. Proximate analysis of tamuu Tonga at the USP Alafua Central Laboratory revealed about 11.3MJ ME/kg and 130 g crude protein/kg (Diarra and Perera, 2015 unpublished). Calcium oxalate has been identified in *Alocasia macrorrhiza* root (Bui, 2001) but adequate supplementation of diet with inorganic calcium sources has been reported to overcome the adverse effect of oxalate (Göhl, 1981). Although there are reports on the feeding of *Alocasia macrorrhiza* root (AMR) meal to pigs (Pham *et al.*, 2005; 2006) its feeding to poultry is not documented at the moment. Fat is a highly concentrated source of energy which may be used to boost the energy content of AMR. Coconut oil slurry (COS) is a fat-rich residue of cold-press coconut oil extraction which may be of environmental concern in Samoa as it is disposed in the landfill at the moment. This study investigated the utilization of TRM with or without COS as a source of dietary energy by laying hens.

Materials and Methods

Experimental Site, Source and Processing of AMR

The study was conducted at the Poultry Unit of the University of the South Pacific's School of Agriculture and Food Technology, Alafua Campus, Samoa. Fresh tamuu root purchased from farmers around the Campus were chopped and sun-dried for 72 h. The sun-dried root was then ground in a hammer mill to pass through a 2-mm sieve and labelled *Alocasia macrorrhiza* root meal (AMRM). Half of the meal obtained was left as AMRM (untreated) and the other half treated with coconut oil slurry (COS) in liquid form at the ratio of 9: 1 and labelled AMRM-COS. Coconut oil slurry was collected from a small scale cold-press coconut oil mill where this by-product is of major disposal problem at the moment. Maize, AMRM and AMRM-COS were analysed for proximate composition and AMRM for oxalic acid content (Table 1).

Table 1. Proximate composition, calculated ME and price (WST$) of maize, *Alocasia macrorrhiza* tamuu root meal (AMRM) and AMRM with coconut oil slurry (AMRM-COS) on dry matter basis

Constituents (%)	Maize	AMRM	AMRM-COS
Dry matter	94.70	93.88	93.51
Crude protein	8.96	12.70	11.75
Ether extract	3.10	1.37	3.14
Crude fibre	3.74	7.13	7.09
Total ash	4.07	6.40	6.64
Nitrogen-free extract	74.83	66.28	64.89
ME* (MJ/kg)	13.54	12. 26	12.51
Calcium oxalate (mg/kg)	-	48.30	-
Price/kg (WST$)	4.00	0.30	0.32

*Metabolizable energy (calculated).
WST$ (Western Samoan Tala) ≈ US$ 0.4 at the time of the experiment.

Experimental Diets and Birds

A control layer diet based on maize as energy source and 4 other diets containing 2 levels (10 and 20%) each of AMRM and AMRM-COS as replacement for maize weight for weight were formulated (Table 2). Nutrient specification of the diets: 11.9MJ ME/kg, 16.5% CP, 4% Ca, 1.1% available P, 0.9% Lysine and 0.5% Methionine. A total of 75 Shaver brown pullets aged 126 d (1,621.53 g ± 2.72 g SD) were randomly allotted to 15 floor pens. Each diet was fed as mash to birds in 3 pens in a completely randomized design for a period of 10 wk. Birds received 16 light (12 h daylight and 4 h artificial light). Diets and clean drinking water were supplied *ad-libitum* throughout the experimental period.

Data Collection

Data were collected on feed intake, egg production, and body weight change. A weighed quantity of feed was given daily and the left-over weighed the next day to account for the quantity consumed by difference. Egg number and mean weight were recorded per pen daily. Per cent hen-day production was calculated as:

$$\% \text{ hen} - \text{day} = \frac{\text{number of eggs collected}}{\text{number of hens in the pen}} \times 100$$

Egg mass (g) was calculated per pen as a product of the mean egg weight and the number of eggs collected. Feed conversion ratio (FCR) was calculated as g feed consumed: g egg in each pen. The birds were weighed at the beginning and end of the study (days 126 and 196) and weight change recorded per pen.

Table 2. Ingredients and calculated composition of the experimental layer diets (g/kg, as fed-basis)

Ingredients	Control	AMRM		AMRM-COS	
		10	20	10	20
Maize	482.90	434.61	386.32	434.61	386.32
Wheat middling	241.4	257.3	273.20	241.40	249.30
AMRM	0	48.29	96.58	48.29	96.58
Fish meal	31.20	28.6	25.90	30.80	29.90
Meat & bone meal	62.40	57.1	51.80	61.5	59.80
Soya bean meal	93.60	85.70	77.70	92.3	89.70
Coral sand	50	50	50	50	50
Snail shell	30	30	30	30	30
Lysine HCL	2	2	2	2	2
DL-methionine	1	1	1	1	1
Vitamin/mineral premix*	2.50	2.50	2.50	2.50	2.50
NaCl	3	3	3	3	3
Analysed composition (%)					
Dry matter	90.88	89.93	89.85	88.74	88.58
Crude protein	15.98	16.10	16.30	16	16.20
Crude fibre	5.30	6.15	5.87	6.10	6.40
Calculated composition (%)					
Lysine	0.90	0.89	0.88	0.89	0.88
Methionine	0.50	0.48	0.48	0.50	0.49
Calcium	4.1	3.97	4.13	4.14	4.14
Phosphorus (available)	1.10	1.09	1.11	1.13	1.10
ME** (MJ/kg)	11.92	11.83	11.85	11.87	11.90

AMRM: *Alocasia macrorrhiza* root meal
COS: Coconut oils slurry
*Bio-mix Layer supplied/kg: Vit A = 3,400,000.00 IU; Vit D_3 = 600,000.00 IU; Vit E = 4,000.00mg; Niacin = 6,000.00mg; B_1 = 600.00mg; B_2 = 1,800.00mg; B_6 = 1,200.00mg; B_{12} = 6.00mg; K_3 = 400.00mg; Pantothenic acid = 1,600.00mg; Biotin = 200.00mg; Folic acid = 240.00mg; Choline Chloride = 70,000.00mg; Cobalt = 80.00mg; Copper = 1,200.00mg; Iodine = 400.00mg; Iron = 8,000.00mg; Manganese = 16,000.00mg; Selenium = 80.00mg; Zinc = 12,000.00mg; Anti-oxidant = 500.00mg.
**ME: Metabolizable energy.

On weekly basis 5 eggs were randomly selected per pen for egg quality assessment (weight, shape index, Haugh unit and per cent shell). Eggs were weighed using a digital scale sensitive at 0.1g. The length and width of each egg were taken using a digital vernier caliper and shape index calculated as the ratio of the width to the length times 100 (Reddy *et al.*, 1979). The eggs were then broken on a glass table and albumen height taken immediately at 3 different locations using a spherometer. Haugh unit (HU) was calculated using the formula $HU=100 \log (h-1.7w^{0.37}+7.6)$ (Eisen *et al.*, 1962) where, h is albumen height (mean of 3 measurements) in mm and w the weight of the egg in g. Eggshells were oven-dried at 60°C overnight and weighed and per cent shell calculated according to Chowdhury and Smith (2001).

Chemical Analysis

Maize, AMRM, AMRM-COS and the diets were analysed for proximate composition according to AOAC (1990). Dry matter was determined for 24 h in a forced air oven (103°C). Nitrogen was analysed by Kjeldahl method (AOAC, 1990 ID 954.01) and crude protein calculated as nitrogen × 6.25. Total fat, ash and fibre were analysed according to AOAC (1990, ID 942.05, 920.39, 962.09, respectively).

Statistical Analysis

Data collected were subjected to ANOVA (Steel and Torrie, 1980) of the GLM of SPSS (2013, version 22). Pen was used as the experimental unit for feed intake, hen-day production and egg qualities. Body weight change was measured on individual hen. Means were compared using the Least Significant Difference (LSD) and considered significant at 5% level of probability.

Results and Discussion

The crude protein content of AMRM in this experiment was higher than the value (8.6%) reported in the root meal by Pham *et al.* (2006) but the ME content was lower than the 13.18 MJ/kg reported by these authors. The root used in the present study contained 48.3 mg calcium oxalate/ kg against 113 mg/kg reported in the root by Pham *et al.* (2005). Several factors including cultivars, stage of growth and edaphic factors which have been reported to affect the composition of cassava products (Rogers and Milner, 1963, Eggum, 1970; Ravindran, 1988) might also be implicated in these differences. The improved ME content of COS treated AMRM was on account of the higher ME concentration in the oil. The level of COS treatment in this experiment (9: 1 AMRM and COS ratio) did not however, improve the ME content of the product to a level comparable to maize.

From the results of hens performance (Table 3) there were no significant dietary effects (P = 0.05) on feed intake (FI) and the intake of individual nutrients (lysine, methionine and ME). Body weight change (BWC) during the period of the experiment was minimal in birds fed the 20% AMRM-COS compared to the control (P = 0.05). BWC did not differ between the control and the other AMRM groups as well as among the AMRM fed birds. Per cent hen-day and feed conversion ratio were depressed on 20% AMRM and egg weight on 10% AMRM (P = 0.05) but these depressing effects were overcome with COS treatment. Egg shape index, Haugh unit and per cent shell were not also affected by the diet.

A major problem affecting the utilization of AMRM as feed ingredient has been its itching characteristics mainly due to oxalic acid (Pham *et al.,* 2004) which reduces palatability. The similarity in feed intake among dietary treatments in the present study suggests that there were palatability problems with the meal. Variability in oxalate content among cultivars, the lower level of inclusion and the age of the birds may all be possible reasons for this. Dietary fat addition has been found to slow down digesta passage rate through the gastro-intestinal tract allowing better nutrient digestion, absorption and utilization (Mateos *et al.*, 1982; Latshaw, 2008) probably through increased contact with digestive enzymes. This could be a possible explanation for the improved performance of hens fed the 20% AMRM-COS based diet despite the similarities in FI and intake of individual nutrients (lysine methionine and ME) among the diets. Wignjosoesastro *et al.* (1972) also reported the beneficial effect of 10% dietary coconut oil on rate of lay and egg weight. Dietary unsaturated fat has also been reported to increase protein accretion in broilers (Sanz *et* *al.*, 2000). The presence of mono-unsaturated and poly-unsaturated fatty acids in coconut oil (Chowdhury *et al.*, 2007) might have increased the amount of protein available for egg production in the 20% AMRM-COS fed hens. Jeffri *et al.* (2010) observed that fat addition decreased feed intake and improved feed efficiency in broilers. In the present study, fat addition improved feed efficiency but not feed intake probably due to the similarity of the diets in ME content as birds feed to meet their energy requirement. Possible improvement in the absorption of fat-soluble vitamins on the COS supplemented diets may also be speculated. The higher nutrient demands for increased egg production on the 20% AMRM-COS group might be the main reason for the minimal BWC recorded in these birds during the period of the experiment.

Table 3. Laying performance and egg qualities of Shaver Brown hens fed *Alocasia macrorrhiza* tamuu root meal (AMRM) and AMRM with coconut oil slurry (AMRM-COS)

Performance indices	Control	AMRM		AMRM-COS		s.e.m.	P-value
		10	20	10	20		
Initial weight (g/bird)	1,621	1,627	1,620	1,621	1,619	19.926	0.475
Final weight (g/bird)	1,936	1,911	1,903	1,911	1,853	47.997	0.807
Weight change (g/bird)	315[a]	284[ab]	283[ab]	290[ab]	234[b]	25.434	0.037
Daily feed intake (g/bird)	108.60	116.80	109.20	115.20	107.70	6.682	0.809
Hen-day (%)	68.7[ab]	69.20[ab]	49.6[b]	68.7[ab]	75.6[a]	6.437	0.029
Mean egg weight (g)	60.4[a]	56.8[b]	60.5[a]	57.6[ab]	60.6[a]	1.000	0.049
FCR (feed: egg)	2.67[ab]	2.98[ab]	3.35[a]	2.99[ab]	2.36[b]	0.238	0.047
Egg shape index	74.5	75.67	77.00	75.68	76.17	1.478	0.859
Haugh unit	90.53	90.37	89.95	89.97	90.60	1.903	0.999
Per cent shell	11.85	12.43	12.08	11.81	11.96	0.428	0.844
Calculated daily intake							
Lysine (%)	0.98	1.04	0.96	1.03	0.95	0.059	0.760
Methionine (%)	0.54	0.56	0.52	0.58	0.53	0.033	0.771
ME (MJ/kg)	1.30	1.38	1.29	1.37	1.28	0.079	0.852

AMRM: *Alocasia macrorrhiza* root meal; COS: Coconut oil slurry; s.e.m.: standard error of the mean.

Conclusion

In conclusion *Alocasia macrorrhiza* root meal can replace 10% dietary maize without adverse effect on laying performance but 20% replacement may adversely affect egg production and egg weight. Treatment of the tamuu root with coconut oil slurry (9: 1 ratio) overcomes these adverse effects. More research into the processing method and higher levels of inclusion of the slurry treated root meal is warranted.

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