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Evaluation of Canistel (*Pouteria campechiana*) Fruit Meal as a Feed Ingredient for Poultry

Research Article

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ABSTRACT

Canistel (*Pouteria campechiana*) is an underutilized fruit tree species found in many parts of the world. The objective of this study was to evaluate suitability of canistel fruit meal (CFM) as a feed ingredient for broiler chickens. Giving completely randomize design, ninety broiler chickens in 30 floor pens received one of five diets *ad libitum* from day 21 to 42. The nutritionally balanced control diet contained 40% maize meal. In the other four test diets, CFM quantitatively replaced 25, 50, 75 and 100% of maize meal from the control diet. One randomly selected bird from each cage was killed on day 42 to determine the visceral organ weights and tibia ash contents. Breast meat samples were subjected to sensory evaluation by ten panelists. No mortality or visible health problems were observed throughout the experiment. Except between day 21 and 28, CFM had no significant effect on feed and water intake. Increasing levels of dietary CFM linearly reduced the live weight on day 42 and weight gain while increasing the feed conversion ratio (FCR). However, above parameters of the birds fed diet with 10% CFM (25% substitution of maize meal) was not significantly different from those of the birds fed control diet (40% maize meal). The transit times of digesta, relative weights of gizzard, pancreas, heart and abdominal fat pad, tibia ash contents and organoleptic properties of the meat in the birds were not significantly different among treatments. Birds fed 40% CFM had higher relative gut length and liver weight compared to those fed 40% maize meal. It was concluded that canistel fruit meal could be included up to 10%, substituting 25% of the maize fraction of the broiler diet without any delirious effects on growth performance. Further research is needed to determine the important nutritional indices of CFM.

KEY WORDS broiler, canistel fruit, feed ingredient, maize, poultry.

INTRODUCTION

Cereals, the principle energy feed ingredient of the poultry rations are competitively demanded by human food industry as well. Meanwhile, maize, the most widely used cereal in poultry feeds is increasingly used for bio-fuel production. Due mainly to the above two reasons, the world poultry industry is under intense pressure from the rising cost of feed ingredients. The best strategy to reduce the feed cost of the poultry industry is to increase the use of novel or alternative cheap feed ingredients which are less competitively demanded by other industries. Preston (1992) suggested evaluating the feasibility of cereal-free poultry diets based on materials such as sugarcane, cassava roots, sweet potato tubers, banana and plantain fruits for intensive poultry feeding.

A range of materials such as distillers dried grain with soluble (Lumpkins *et al.* 2004; Martínez-Amezcúa *et al.* 2007), dried tomato seeds (Persia *et al.* 2003), sugar syrup (John, 2008), finger millet (Rama Rao *et al.* 2004; Rama Rao *et al.* 2005; Reddy *et al.* 2008), yam peel meal (Akinmutimi and Onen, 2008), mango kennel meal (Diarra and Usman, 2008) and sorghum (Reddy *et al*. 2008) have been studied as alternative energy feed ingredients for poultry, at a varying levels of success.

Canistel (*Pouteria campechiana*) (Saponacea) is a fruit tree species native to Central South America. It is grown in many Central and South American, African and Asian countries and some states of the USA (Morton, 1992). In Sri Lanka and other South Asian countries, canistel is found in home gardens and agro-forestry systems. Canistel (In Sinhala: Lawulu) has been identified as an under-utilized multi-purpose fruit tree species in Sri Lanka (Pushpakumara, 2007).

The ripped canistel is consumed as a dessert fruit. A fruit is weighing about 175 g and it has a waxy outer peel and a seed. The fruit generally matures from September to February. Some trees produce fruits more or less continuously throughout the year (Pushpakumara, 2007). One tree produces 136-250 kg of fruits/year. The immature mesocarp contains a high level of sticky latex. The dark yellow colour ripen mesocarp is starchy and sweet. Canistel fruit is high in energy, niacin and carotene and contains a fair level of ascorbic acid (Morton, 1987).

Even though the fruit is nutritious, canistel is hardly used for human consumption in Sri Lanka but is wasted. The available nutritional information suggest that canistel could be used an alternative energy source for poultry feed formulations.

We were unable to find any literature where canistel has been used as an ingredient in poultry feed formulations. The objectives of this study were: 1) to investigate the suitability of CFM as a feed ingredient for broilers and 2) to determine to what level CFM can replace the maize meal fraction of a broiler a diet.

MATERIALS AND METHODS

Preparation of canistel fruit meal

Well matured, but un-ripened fruits (dark yellow color, but hard) were collected from local home gardens. Fruits were peeled and flesh and seed were separated. Flesh was cut into small pieces and cooked in boiling water (15 min) to remove the latex. Hot water treated canistel fruit pieces were dried at 80 ˚C for 3 days in a forced draught electric oven. Dried pieces were ground to small particles (1-2 mm). Dried fruit materials were stored in plastic containers until used for rations.

Broiler assay

Day-old broiler chicks (Cobb strain), purchased from a local commercial hatchery were brooded in an electric brooder for two weeks. Chicks were fed with a commercial broiler starter diet until they were 20 days old.

On day 20, chicks (n=90) were individually weighed and allocated into 30 floor pens so that between pen weight variation was minimum. Pens were randomly allocated into five dietary regimens. The control diet contained 40% maize meal and met or exceeded nutrient requirements as set out by NRC (1994). In the four other test diets, CFM quantitatively replaced 25% (10% CFM in the diet), 50% (20% CFM in the diet), 75% (30% CFM in the diet) and 100% (40% CFM in the diet) of maize meal in the control diet as described by Oryschak *et al.* (2010). The ingredients and calculated nutrient compositions of the diets are given in Table 1.

Table 1 Ingredients composition of the control (0% substitution) and test diets and the calculated nutrient composition of the control diet

Ingredients (%)	Level of maize meal substitution (%) by CFM				
	0	**25**	**50**	**75**	**100**
Rice bran	20	20	20	20	20
Canistel fruit meal	0	10	20	30	40
Maize meal	40	30	20	10	0
Fish meal	1.60	1.60	1.60	1.60	1.60
Coconut oil	6.3	6.3	6.3	6.3	6.3
Soybean meal	22.5	22.5	22.5	22.5	22.5
Sesame oil meal	6.65	6.65	6.65	6.65	6.65
Shell powder	0.94	0.94	0.94	0.94	0.94
Dicalcium phosphate	1.29	1.29	1.29	1.29	1.29
L-lysine	0.021	0.021	0.021	0.021	0.021
Common salt	0.25	0.25	0.25	0.25	0.25
Vitamin mineral mixture	0.25	0.25	0.25	0.25	0.25
Nutrient composition			**%**		
CP			20.0		
Energy (ME kcal/kg)			3200		
Lysine			1.0		
Methionine			0.38		
Methionine + Cystine			0.71		
Calcium			0.9		
Non phytate phosphorus			0.35		
Crude fiber			5.2		

Each pen had a feeder and a bell-shaped drinker. Paddy husk was the litter material. Feeds and water were given *ad libitum* from day 21 to 42. From day 21 to 28 chicks were given 743 cm^2 of floor space per chick and 1208 cm^2 thereafter. Birds were provided 20 L: 4 D light schedule. Daily feed and water intakes were recorded. Birds were weighed on day 28, 35 and 42.

One bird was randomly selected from each pen on day 35 and the rate of passage was determined as described by Washburn (1991). On day 42, one randomly selected bird from each pen was killed by cervical dislocation and dissected to determine the carcass parameters. Left tibias were analyzed for fat free tibia content (Kim *et al*. 2004). Meat sensory properties were evaluated as described by Kim *et al*. (2009).

Breast meat samples taken from each bird were boiled for 20 minutes and a sensory evaluation was done with ten untrained panel. Although untrained, the panelists were familiar with sensory testing from previous studies. Panelists were asked to give scores of a Likert scale (1 for unsatisfactory, 2 for satisfactory and 3 for good) for meat color, taste, texture and overall acceptability.

Statistical design and analysis

The experiment followed a completely randomized design with five treatments and six replicates pens, each pen housed three birds. Data were analyzed using GLM procedure of SAS (1996). Pen means served as replicates in growth performance, feed intake and water intake data analysis while randomly selected individual bird was considered as replicates in carcass data analysis. Linear, cubic and quadratic relationships of different substitution levels were also determined using MINITAB. Significant means were compared using Tukey's Studentized Range Test. Sensory evaluation scores were analyzed using Kruskal Wollis test by MINITAB.

RESULTS AND DISCUSSION

Preparation of CFM

Un-ripened, but well matured (yellow color) fruits were used to prepare CFM. The main problem of using unripened fruits to prepare CFM was the presence of sticky latex. Cutting of canistel fruits into thin slices, subsequent wiping with papers and hot water treatment removed the latex to a great extent. Dark brown colour grits produced by drying and subsequent grinding of well-matured, but unripened fruits having deep yellow colour flesh were defined as canistel fruit meal. CFM stored for 6 weeks or diets containing CFM stored for four weeks did not show any visible signs of rancidity, fungal growth or discoloration.

Growth performance

Many non conventional or alternative feed ingredients such as banana meal (Velasco *et al*. 1983), ground mango kernels (Teguia, 1995), Jack bean (D'Mello and Walker, 1991; León *et al*. 1991), maize-sorghum brewers' dried grain (Fasuyi, 2005), cassava cane mollases (Rodríguez and Salazar, 1991) and leaves or forages (Teguia *et al.* 1993; Teguia *et al.* 2002) have been found to reduce feed intake and growth performance of poultry when included at levels higher than 10-15%.

Preston (1992) concluded that a non conventional feed resource does not optimally sustain broiler production. Low nutrient density and digestibility/availability, presence of some anti-nutrients such as non starchy polysaccharides, fibre, phytate, tannins and low palatability are the contributory factors for suboptimal performance of the birds fed diets with those alternative feed resources. The results of this experiment suggest that CFM contains little or no such anti-nutritive substances and thus can be used as an energy and beta carotene rich alternative feed resource for poultry.

The crude fiber content of CFM found to be as low as 3.9% (Sanjeewani and Atapattu, 2008). Morton (1992) reported that phosphorus level of canistel was 0.05% and thus the level of phytate could also be low. No literature was available on tannin content of canistel. However, the taste and high starchy nature of canistel fruit suggests low tannin content as well.

Daily feed intake values of the birds given experimental diets were within the normal range as reported by NRC (1994). The texture of the diet with 40% CFM was grittier and courser than that of the commercial diet that fed the birds until being used for the experiment. Probably due to that reason, the complete replacement of maize meal by CFM (40% CFM) significantly reduced feed intake compared to other substitution levels at early stages of the growth (from day 21 to 28) (Table 2). Jia and Slominski (2010) have also reported that broiler chickens fed diet with coarser flux meal from day 1 to 18 tended to eat (P=0.07) lesser amount of feed compared to a diet with finer flux meal particles. Water intake and water: feed ratio were not affected by the substitution of maize meal by CFM. The water intake and water: feed ratios reported in this experiment were similar to values reported in other studies (Atapattu and Wickramasighe, 2007; Atapattu and Lal, 2009; Wickramasinghe *et al*. 2009) conducted under similar environmental conditions. Results of this experiment clearly suggest that CFM could be included into broiler diets up to 30% between day 21 and 28 and up to 40% thereafter, without any adverse effects on feed and water intake. However, as discussed later, utilization efficiency of feed was low when high levels of CFM were fed.

Available nutrient information suggests that CFM could be an alternative energy rich feed ingredient for poultry. The flesh of canistel is very sweet and it has as high as 25 Brix value. Morton (1992) reported that canistel contain 38 g carbohydrate/100 g of fresh weight. Suggesting that CFM contains insignificant amounts of non starchy polysaccharides, the gastric transit times of digesta in birds given 0 (121±13.4 min), 10 (133±15 min), 20 (125±15 min), 30 (127±12 min) and 40% (118±8 min) of CFM were not significantly different. Sanjeewani and Atapattu (2008) found that CFM contains as high as 4187 kcal of GE/kg. The metabolizable energy content of CFM has not been studied and it could not be calculated due to the non availability of required nutrient information. Further research is needed to determine the metabolizable energy (ME) values of CFM.

Despite the fact that feed intake of the birds was not affected by the CFM, increasing levels of CFM in diets linearly reduced the live weight (g) on day 42 (y=2178-6.95%; R^2=0.78) and weight gain (g) from day 21 to 42 (1544-6.9%; R^2=0.77) while increasing feed conversion ratio (FCR) (y=1305+0.0069%; R^2=0.79).

Table 2 Effects (mean±sd) of the substitution of maize meal by CFM on feed and water intakes and growth performance of broiler chickens

Parameter	Level of maize meal substitution by CFM					ANOVA
	0	**25**	**50**	**75**	**100**	
Feed intake (g/b/d)						
21-28 d	75±3^{a}	73±5^{a}	72±7^{a}	64±7^{ba}	55±13^{b}	**
28-35 d	118±10	117±12	124±17	110±11	111±41	NS
35-42 d	102±20	89±9	91±13	78±9	90±29	NS
21-42 d	98±10	93±8	95±12	84±7	85±27	NS
Water intake (mL/b/d)						
21-28 d	199±26	187±29	195±33	193±50	165±36	NS
28-35 d	397±57	345±68	398±71	367±67	321±79	NS
35-42 d	397±33	366±90	372±31	317±52	353±75	NS
21-42 d	331±32	299±54	322±37	292±49	280±56	NS
Water:Feed						
21-42 d	3.36±0.2	3.2±0.5	3.38±0.3	3.44±0.3	3.5±0.9	NS
Live weight						
21 d	633±2	632±5	628±6	627±7	629±5	NS
28 d	1091±23^{a}	1033±20^{ba}	980±39^{b}	906±36^{c}	843±46^{d}	***
35 d	1603±61^{a}	1502±36^{a}	1437±101^{ba}	1278±36^{bc}	1162±186^{c}	***
42 d	2197±116^{a}	1987±64^{ba}	1833±81^{bc}	1626±93^{dc}	1508±260^{d}	***
Weight gain (g)						
21-28	457±22^{a}	400±18^{b}	351±34^{b}	278±31^{c}	213±49^{d}	***
28-35	512±54^{a}	468b±30^{a}	457±66^{ba}	372±32b^{c}	319±142^{c}	**
35-42	593±79^{a}	485±42^{ba}	395±58^{bc}	348±77^{c}	345±94^{c}	***
21-42	1563±117^{a}	1354±63^{ba}	1204±77^{bc}	998±94^{dc}	878±264^{d}	***
Feed conversion ration						
21-28	1.15±0.02^{d}	1.28±0.07^{dc}	1.43±0.1^{bc}	1.64±0.17^{ba}	1.80±0.16^{a}	***
28-35	1.61±0.06^{c}	1.75±0.11^{cb}	1.89±0.03^{cb}	2.08±0.19^{b}	2.56±0.38^{a}	***
35-42	1.21±0.2^{b}	1.29±0.1^{ba}	1.66±0.4^{ba}	1.62±0.2^{ba}	1.80±0.3^{a}	*
21-42	1.32±0.08^{d}	1.45±0.1^{cd}	1.66±0.13^{cb}	1.78±0.16^{b}	2.02±0.15^{a}	***

Each value represent mean±sd of six replicate pens, each housed three birds.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
NS: non significant; * P<0.05; ** P<0.01; *** P<0.001.

However, growth performance parameters such as live weight on day 42, weight gain from day 21 to 42 and the FCR of the birds fed diet with 10% CFM (25% substitution of maize meal) was not significantly different from those of the birds fed the control diet (40% maize meal) (Table 2). As discussed earlier, reduced energy intake could not be the reason for inferior performance indicators of the birds fed diets containing higher than 10% CFM.

Since the ME value of CFM was not available, the ME values of the diets with CFM were not known. No attempt was made to balance the rations containing CFM for crude protein (CP) as well. Sanjeewani and Atapattu (2008) found that CFM contains 3.3% CP. which is lower than that of maize meal (8.4%) according to NRC (1994). The calculated CP values of diets containing 10, 20, 30 and 40% CFM were 19.5, 18.0, 18.5 and 17.0%, respectively. Canistel is a poor source of lysine (0.08%), methyonine (0.01%) and tryptophan (0.028%) (Morton, 1987). Therefore, higher levels of substitution of maize meal by CFM might have reduced the protein value of the feeds and consequently the growth performance.

Since feed intake was not affected by the dietary CFM, it is suggested that higher levels of CFM could be included into broiler diets without being growth performance negatively affected, if rations are nutritionally balanced considering the CP, important amino acids and mineral levels of CFM in ration formulation. Therefore, further research is needed in this direction. The control diet was formulated to meet the Ca and non phytate phosphorus (NPP) requirement as set by NRC (1994). The levels of both Ca and P in canistel (Morton, 1992) and maize meal (NRC, 1994) have found to be low. Therefore, lower tibia ash contents were expected for the birds fed higher levels of CFM. However, replacement of maize meal by CFM had no effect on tibia ash content (Table 3). Several studies (Angel *et al*. 2000a; Angel *et al*. 2000b; Dhandu and Angel, 2003; Powell *et al*. 2008) have shown that NPP requirements of broilers were substantially lower than the standards set out in NRC (1994). Since both CFM and maize meal contains trace amounts of Ca and P, substitution of maize meal by canistel might have had a little effect on the Ca and P contents of the diets and in turn on the bone status of the birds.

Table 3 Effects (mean±sd) of the substitution of maize meal by CFM on relative visceral organ and abdominal fat pad weight, gut length and tibia ash contents of broiler chickens

Carcass parameter	Level of maize meal replacement (%) by CFM					ANOVA
	0	25	50	75	100	
[1] Liver	2.6±0.2[b]	3.3±0.1[a]	2.9±0.3b[a]	2.9±0.1b[a]	3.1±0.4[a]	*
[1] Gizzard	1.7±0.2	2.0±0.1	2.0±0.3	2.0±0.2	2.1±0.3	NS
[1] Heart	0.6±0.07	0.6±0.19	0.7±0.16	0.6±0.12	0.7±0.13	NS
[1] Pancreas	0.2±0.06	0.3±0.05	0.3±0.14	0.4±0.11	0.3±0.05	NS
[1] Fat	2.9±0.5	3.3±0.8	3.0±0.8	3.0±1.0	2.7±0.7	NS
[1] Gut length	12±1.3[d]	14±0.9[cd]	15±1.3[cb]	16±1.0[b]	20±1.9[a]	***
Dressing percentage	76.8±0.9	76.3±1.4	75.6±2.6	75.3±2.0	74.0±2.5	NS
Tibia ash (%)	40.99±3.9	39.78±1.9	39.39±4.6	38.18±5.1	33.90±3.5	NS

[1] Relative to the empty carcass weight.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
NS: non significant; * P<0.05; ** P<0.01; *** P<0.001.

Table 4 Effects of the substitution of maize meal by CFM on the sensory properties of the breast meat of broiler chickens

Parameter[1]	Level of maize meal replacement (%) by CFM					ANOVA
	0	25	50	75	100	
Color	3	2	2	2	2	NS
Flavor / Taste	2	2	2	3	2	NS
Texture	2	3	2	3	2	NS
Overall acceptability	2	3	2	2	2	NS

[1] Median values of ten panelists.
NS: non significant.
1: for unsatisfactory; 2: for satisfactory and 3: for good.

The typical corn and soybean-based commercial poultry diets requires natural or synthetic carotenoid pigments (Pérez-Vendrell *et al.* 2001) to get suitable skin and egg yolk color. It has been shown that partial or complete replacement of maize meal with guar meal (Gutiérrez *et al.* 2007), Pearl millet (Collins, 1997) and fava bean (Laudadio and Tufarelli, 2010) in layer diets requires beta carotein sources.

The carotenoid content of canistel is as high as 23 mg/g dry weight (Lanerolle *et al.* 2008). Therefore, CFM potentially provides an additional benefit as a good source of natural carotenoid source.

Substitution of maize by CFM had no significant effect on the relative weights of gizzard, heart, pancreas and abdominal fat pad (Table 3).

Due to the hard gritty nature of the CFM, higher gizzard weights were expected for the birds given CFM diets. There was a trend (p=0.08) to have higher gizzard weight from broilers fed 40% CFM compared to those fed 40% maize meal. Birds fed 40% CFM also had higher relative gut length and liver weight compared to those fed 40% maize meal.

As discussed earlier, diets with CFM contained lower CP and lysine and methionine contents than the control diet and thus were nutritionally unbalanced. The excess energy may have stimulated the hepatic lipodogenesis giving heavier livers.

Presence of some anti-proteolytic substances has been found to be the cause of pancreatic hypertrophy (Deolanker *et al.* 1979). The non significant effect of CFM on pancreas weight indirectly suggests that CFM contains no or little anti-proteolytic substances. Confirming the suitability of CFM as an alternative feed ingredient for poultry the organoleptic properties of the meat in the broilers fed diets containing CFM were not significantly different from those of the birds fed control diet (Table 4).

CONCLUSION

It was concluded that canistel fruit meal could be included up to 10% of the diet substituting 25% of the maize fraction in broiler finisher diets without any delirious effects on growth performance. Up to 40% of the dietary canistel fruit meal had no adverse effects on feed intake, health and mortality of the birds and meat organoleptic properties of broiler meat. Further research is needed to determine the important nutrient indices of canistel fruit meal.

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