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Short communication

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GROWTH, CARCASS AND MEAT CHARACTERISTICS OF LOCAL BREED OF RABBITS FED DIETS CONTAINING SOAKED AND DRIED MANGO (*Mangifera indica*) SEED KERNEL MEAL

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ABSTRACT

This study was conducted to find substitutes for dietary maize in rabbit rations, to minimize competition between humans and livestock over the commodity. Mango seed kernel meal (MSKM) was used to substitute up to 20% of maize in rabbit rations, to assess its effects on growth, carcass and meat characteristics. Fresh mango seeds were obtained, husks were removed and seeds soaked in fresh potable water for 48 hours. The seeds were then dried to a moisture content of about 15 %, and then milled for use. Three experimental diets were formulated, where T1 (control, had no MSKM), T2 (10% of maize was replaced with MSKM) and T3 (20% of maize was replaced with MSKM). A total of 48 six-week old rabbits of indeterminate breeds (24 males and 24 females) were assigned to the three dietary treatments (16 rabbits per treatment), and were fed *ad-libitum* for 6 weeks, to determine feed intake and growth rates of the rabbits. Water was however provided *ad-libitum*. At the end of the feeding trial, 24 rabbits were randomly selected (8 from each treatment, equal number of males and females) and were slaughtered humanely after a 12-hour feed withdrawal, for carcass and proximate analyses of the meat. Results from the study indicate that, feed intake and growth rates of the animals reduced significantly ($p<0.05$) when dietary maize replacement with MSKM increased beyond 10% inclusions. However, crude protein, phosphorus, potassium and zinc contents of the meat increased significantly ($p<0.05$) as MSKM inclusions increased. That notwithstanding, carcass parameters and organ weights were not affected by substituting up to 20% of maize with MSKM ($p>0.05$). It can be concluded that MSKM can efficiently be used to substitute up to 20% of maize in rabbit rations, for reduced feed cost, improved crude protein, phosphorus, potassium, and zinc contents of the meat.

Key words: mango seed kernel meal, maize meal, rabbit meat, substitution

INTRODUCTION

The rabbit (*Oryctolagus cuniculus*), has been identified as a livestock species which provides alternative source of good quality meat to many consumers worldwide. Currently, patronage of rabbit meat is increasing due to its high quality protein, low fat and low cholesterol contents [1]. The meat is also highly palatable and it easily substitutes for chicken in Ghana and in other West African countries like Nigeria [1]. Rabbit meat is reported to produce less uric acid during metabolism; therefore, its consumption is being encouraged for good health, especially among diabetic and hypertensive patients [2]. Rabbits have relatively higher litter size with short gestation period (30 days), so multiply within a short period of time [3]. Consequently, commercial rabbit production is gradually becoming a specialized operation that is gaining popularity in many tropical countries, especially in West Africa [4]. The use of rabbits as a source of meat and income, continues to increase, with expanding interest, particularly across Eastern Europe, Africa, Asia and Latin America [1].

A major challenge associated with commercial rabbit rearing, however, is dry season feeding. This is due to the seasonal fluctuation in forage availability and quality, as a result of the bi-modal rainfall pattern in Ghana and in other tropical countries [5]. In order to ensure consistency in the growth and reproductive performance of rabbits all year round, there is often a need to supplement forage fed, with formulated feed. However, the use of formulated feed as supplement in rabbit production is not popular in the tropics, as the practice results in higher production costs, making rabbit meat quite expensive, especially to low income earners [2]. This is mainly due to competition between humans and animals over some staples such as maize and fish that increase their costs. This has necessitated investigations into the potential of non-conventional, less expensive, safe and readily available ingredients for use in formulating rabbit rations. One of such ingredients is mango (*Mangifera indica*) seed kernel meal [6, 7].

In Ghana, mango seed kernel is regarded as a waste product which contributes to environmental pollution, as it is discarded after extracting juice from the mango fruit [7]. Meanwhile, several studies reported that mango seed kernel is a promising source of carbohydrate and other nutrients for both farm animals and humans [8, 9]. In India, mango kernel is reportedly used to prepare porridge for human consumption [6, 10]. Mango seed kernels could, therefore, be a useful source of energy, and would probably be a good substitute for maize in rabbit rations to minimize cost of formulating rabbit feed. There is currently minimal information on the use of mango seed kernel meal as feed ingredient for broiler chicken, but levels of inclusion have been very minimal due to presence of tannins in the kennel, which have been reported to impede growth of chicks [11, 12].

The current study was, therefore, aimed at soaking mango seed kernels in fresh water, as a means of reducing concentration of the tannins [13, 14], and the kernels were used to substitute up to 20 % of maize in rabbit rations; and its effects on growth and carcass characteristics of the rabbits were assessed.

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MATERIALS AND METHODS

Study area

The study was conducted at the Teaching and Research Farm of the School of Agriculture, University of Cape Coast, Ghana. The area experiences a bimodal rainfall regime with a mean annual rainfall of 920mm. The temperature of the area is relatively high with annual mean of 23 ^{0}C. The relative humidity is about 90 % in the night and decreases gradually to 70 % in the afternoon. This study had prior ethical approval from the Department of Animal Science's Animal Welfare Committee of the University of Cape Coast, Ghana.

Experimental Rabbits and Feed

A total of 48 (6 weeks old) indeterminate breed of rabbits (24 males and 24 females) were obtained from the Rabbitry of the Department of Animal Science, University of Cape Coast, for the study.

Fresh mango seeds were collected from a fruit processing factory, and the kernels were removed by breaking the hard endocarp with sharp knives, and were soaked in fresh potable water for 48 hours (water was changed every 6 hours) to reduce the levels of tannins/anti-nutritional factors from the kernels [13]. After soaking, the kernels were washed with clean fresh water, and sundried until they became crispy dried (to about 15% moisture content) following the method prescribed by El-Boushy [14]. The dried kernels were then milled with a conventional hammer mill and stored in an air-tight container for use.

Three experimental diets were compounded, coded T1 (control, no MSKM), T2 (10% of maize was replaced with MSKM) and T3 (20% of maize was replaced with MSKM).
The composition of the experimental feed was as presented in Table 1:

The animals were each weighed, and later put into 3 groups of 16 rabbits; housed individually in cages with dimensions 20" x 22" and 32" high. The animals were randomly assigned to the three experimental diets in a Completely Randomized Design. Feed and water were provided *ad-libitum*. The feeding trial lasted for 6 weeks, after which 24 of the rabbits (8 per treatment) were randomly selected and slaughtered for carcass evaluation.

Data collection and Analyses

Data collected include:
Feed Intake – The experimental diets were weighed using a digital electronic scale (Sartorius, CP 224S, USA) for each animal on daily basis, and leftover/spilled feed were weighed out the following morning to determine the quantity consumed per day. Feed intake was determined as the difference between feed served and the left over/spilled feed after 24 hours.
Weight gain – Differences between weights in the previous week, and those in the present week were computed to get the weekly weight gain.
Feed Conversion Ratio (FCR): The feed conversion ratio was calculated as the ratio of feed taken, to the weight gained over the same period.

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Slaughtering, and carcass analysis - At the end of the feeding trial, eight (8) rabbits from each treatment (4 males and 4 females), were randomly selected and weighed with a digital electronic scale (Sartorius, CP 224S, USA). Prior to their slaughter, the rabbits were stunned with a captive bolt pistol, Matador SS3000 (Termet, France) to minimize pain at slaughter, followed by a ventral neck incision with a sharp knife (GIESSER, Germany), and carcasses were allowed to bleed for about 90 seconds. The carcasses were then scalded in warm water, at a temperature of about 80 ^{0}C for about 60 seconds, and the furs were scraped off with sharp knives. The de-furred carcasses were washed and eviscerated, after which they were again washed with potable water. The dressed carcasses were weighed and stored in a refrigerator at 4 ^{0}C, and re-weighed after 24 hours of chilling, to determine the chilling losses. The heart, kidney, lungs and liver were all weighed separately.

The dressing percentage was calculated = carcass weight/live weight x 100

Laboratory analyses of feed and meat samples – Feed samples from all treatments were taken to the laboratory to determine the proximate composition. In addition, leg muscles of the rabbits - *Semitendinosus*, *Semimembranosus*, and *Biceps femoris* were homogenized using a domestic blender, to determine their proximate and mineral compositions. The crude protein contents were determined using the Kjeldahl method, ether extract using the Soxhlet method, moisture and ash contents according to the methods described by the AOAC [15].

Chilling losses: The warm carcasses were chilled in a cold room (4 °C) for 24 hours, after which they were weighed with a digital electronic scale (Sartorius, CP 224S, USA). The difference between the warm and chilled carcass weights gave the chilling losses, determined as: weight of warm carcass – weight of chilled carcass/weight of warm carcass x 100

pH of the muscles - The pre-rigor pH of the carcasses (taken 45 minutes after slaughter), and the ultimate pH (pHu, taken after 24 hours of chilling), were assessed by making incisions along the loin muscles of the carcasses, and a digital pH meter (PCS Testr 35, Singapore) was inserted into the incised muscle. The readings were taken at approximately 60 seconds after insertion of the pH meter.

Data Analysis

To determine the effect of levels of inclusion on the growth and carcass characteristics, the one-way analysis of variance (ANOVA) of the Minitab Statistical Package (version 15) was used. Where significant differences in means were observed, the means were separated using Tukey's pair-wise comparison at 5 % level of significance.

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RESULTS AND DISCUSSION

Proximate composition of the experimental diets

The proximate composition of the experimental diets is presented in Table 2. There were no differences in the dry matter, ether extract, ash, NFE and metabolizable energy contents of the diets ($p > 0.05$).

The crude protein contents, however, increased significantly ($p < 0.05$) with increasing levels of MSKM inclusions. The crude protein content of the T3 diet was higher than the T1 and T2 diets ($p < 0.01$). This observation contradicts findings of Diarra [16], who reported decreasing crude protein contents in broiler chicken ration, as inclusions of boiled mango seed kernel increased. The authors associated the decrease to denaturation of proteins as the mango seed kernel was boiled. The increasing crude protein levels observed in the current study could imply that the soaking and drying method applied, conserved proteins in the seed kernel meal, unlike the boiling method in previous studies (though boiling improves safety of food products). It was realized that the protein content of feed in the current study was higher (Table 2) than the recommended crude protein levels of 16 – 18 % for growing rabbits [17], implying that the experimental diets met the protein needs of rabbits in the present study.

The initial weights (Table 3) and feed conversion ratio of the rabbits, were not different among animals in the various treatments ($p > 0.05$). However, feed intake and daily weight gain significantly ($p < 0.05$) varied among animals on the various treatments. The replacement of 10 % maize with MSKM in the rabbit feed significantly increased the growth rates, but weight gain reduced as maize substitution increased to 20 %. In addition, feed intake of rabbits on the T2 diets was significantly higher than those on the T3 diets (Table 3). These findings are similar to those of Diarra [16], who observed lower feed intake and growth rates in broiler chicken fed on diets containing raw mango seed kernel meal as substitute for maize. Teguia [12] also reported reduced feed intake and growth rates of broiler chicken fed diets containing up to 20% MSKM. The reduced feed intake with increasing levels of MSKM was associated with the presence of tannins or anti-nutritional factors in MSKM [11], which probably reduced palatability of the feed, and also nutrient absorption from the feed, thus reducing growth rates of the animals. The observation from this study could imply that the soaking and drying method applied to the mango seed kernel was probably not efficient at reducing the tannin/anti-nutritional levels of the kernels, thus reduced palatability of the feed. This contradicts findings of El-Boushy [14], who indicated that soaking and drying of feed materials reduce tannin/anti-nutrient levels of the feed. From these results, it can be said that MSKM could be used to replace maize to levels lower than, but not up to 20% inclusions in rabbit rations, confirming earlier findings of Teguia [12].

Costs of formulating the experimental feed

The costs of formulating 100 kg each of the feed is presented in Table 3. The costs ranged between 162.86 Ghana Cedis (GH₵) which is about $ 32.00 USD and GH₵ 130.31 (about $ 26.00). Feed costs reduced as MSKM inclusions increased in the rabbit rations. Replacing 10 % and 20 % of maize with MSKM in rabbit rations in every 100 kg formulation, reduced feed cost by about GH₵ 12.00 ($ 2.40 USD) and GH₵ 31.00 ($

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6.20 USD), respectively. This will go a long way to reduce financial burden on farmers in providing feed for their animals, and also make rabbit meat more affordable to consumers.

Proximate and mineral composition of meat of the experimental rabbits

Table 4 presents the proximate and mineral compositions of the meat of the experimental rabbits. The moisture content of the meat did not vary significantly, but was within the range of 70-75 % reported for fresh muscles [18]. The crude protein content of meat from rabbits on the T3 rations were significantly ($p < 0.01$) higher than those on the control and T2 diets. Proteins are necessary at higher levels for growth and productive functions such as pregnancy and lactation because of increased output of proteins in the products of conception and in milk [19]. Therefore, consumers need smaller quantities of meat with higher crude protein content to meet their nutrient requirements. This will reduce expenditure on meat and meat products, as well as satisfy health concerns over excessive meat intake.

The fat content was significantly ($p < 0.01$) higher in meat of animals on T2 diets, but was significantly ($p < 0.001$) lower in animals on the T3 diets. This observation could have resulted from the lower feed intake of animals on the T3 diets, and thus inadequate energy reserves to be stored in the muscles as fat, unlike animals in treatments 1 and 2. Fat in meat has been reported to play major roles in improving juiciness and flavour of meat products [20, 21], therefore, meat with higher fat contents is expected to possess better sensory characteristics than those with lower fat contents. However, excessive intake of dietary fats has been associated with development of hypertension, cardio-vascular diseases, obesity, cancers of the colon, breast and prostate [22]; thus, consumers must be mindful of excess dietary fat intake. A number of health organizations including the World Health Organization (WHO), have made recommendations to reduce daily fat intake for improved health [23].

There were no significant differences ($p > 0.05$) in the calcium and magnesium contents of the meat. However, potassium, phosphorus and zinc contents increased significantly ($p<0.01$) with increasing MSKM inclusions in the diets. This observation might be due to the higher mineral contents of mango seed kernel, as reported by Elegbede *et al.* [24]. Magnesium is a major component of bones, and also acts as a co-factor in many metabolism reactions. Phosphorus helps in bone formation as well as proper functioning of kidneys [25].

The Zinc content of the meat significantly ($p < 0.001$) increased as MSKM inclusions increased (Table 4). According to Lombardi-Boccia *et al.* [26], rabbit meat is a white meat and has low levels of Zinc. The increasing levels of Zinc in the meat of animals from this study, is good news to consumers, because Zinc is reported to play a significant role in improving the defensive system of the body [27]. It is also reported to contribute to cell division, act as an anti-oxidant and immune-boosting supplement, and is needed for the senses of smell and taste. It supports optimal levels of testosterone, thus improving fertility in males [28]. In addition, Zinc is needed in higher quantities during pregnancy and in lactation [29].

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Carcass characteristics of the experimental rabbits

The carcass characteristics of the experimental rabbits are presented in Table 5. There were no significant ($p > 0.05$) differences in the dressing percentage, warm and chilled carcass weights, as well as chilling losses among carcasses from the various treatments. The pH_{45} of the carcasses was expected to be higher than 6, but were lower than that [18]. This might be due to acute stress which the animals probably encountered prior to stunning, since rabbits easily get nervous when handled by humans.

The weights of the heart, liver, kidney, and lungs of the experimental animals were not significantly influenced by the inclusion of MSKM in the diets. Shittu *et al.* [30] in similar studies, also observed no significant differences in organs of rabbits fed diets containing mango seed kernel meal. According to Teye *et al.* [31] occurrence of diseases in animals, is evident in changes in weight, colour and general appearance of visceral organs of animals involved. The similarities in weights and in the general appearance of the organs of animals in the current studies indicate that there was probably no incidence of diseases among the animals as a result of adding mango seed kernel meal to their diets, hence its use would not compromise welfare or health of the animals.

CONCLUSION

Mango seed kernel meal (MSKM) as substitute for up to 20 % of maize in rabbit rations, increased crude protein, phosphorus, potassium and zinc contents of the meat. However, feed intake and growth rates of the animals reduced significantly, as maize substitution increased up to 20% inclusion. The use of MSKM in place of maize, however, had no effects on carcass parameters and organ weights. It is recommended that where available, mango seed kernel meal could be used to substitute up to 20% of maize in rabbit rations, to improve Zinc, Phosphorus and Potassium contents of meat, reduce livestock competition with humans over maize, and minimize possible environmental pollution associated with disposal of mango seeds at processing sites. Future studies should assess the sensory characteristics of meat of rabbits fed diets containing MSKM. Processing of mango seed kernel meal could be commercialised, to reduce the overhead cost of its production, and improve profitability of its use.

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Table 1: Ingredient composition of the experimental feed (%)

Ingredient (Kg)	T1	T2	T3
Maize	40	36	32
MSKM	-	4	8
Fishmeal	15	15	15
PKOR	15	15	15
Soy Bean meal	12.5	12.5	12.5
Wheat Bran	15	15	15
Oyster Shell	0.75	0.75	0.75
Salt	0.5	0.5	0.5
Vitamin Premix	1.25	1.25	1.25
Total	**100.0**	**100.0**	**100.0**

MSKM - Mango seed kernel meal; PKOR – Palm Kernel oil residue; Vitamin Premix (0.25%) provides the following: Vit A 10.000 IU; Vit D3 2,000 IU; Vit E 15mg; Vit 1;K3 stab 1.5 mg; Vit B1 0.5 mg; Vit B2 2.5 mg; Vit B6 1.0 mg; Vit B12 6µg; Niacin 5 mg; 2 Calpan 4 mg; Folic Acid 100 µg; manganese 60 mg; iron 40 mg; zinc 50 mg; copper 2.5 mg; 3 iodine 1 mg; Selenium 0.2 mg; choline 100 mg; antioxidant 125 mg

Table 2: Proximate composition of the experimental diets

Parameters	Treatments			SED	P-value
	T1	T2	T3		
Dry matter (%)	86.20	85.70	86.43	0.28	0.062
Crude protein (%)	18.54^{b}	18.83^{b}	20.58^{a}	0.16	0.001
Ether extract (%)	5.06	5.10	5.20	0.06	0.052
Ash (%)	6.09	5.62	5.33	0.43	0.066
NFE (%)	56.37	56.15	55.06	0.53	0.059
ME (Kcal/kg)	3051.78	3057.80	3112.23	26.99	0.056

NFE – Nitrogen Free Extract; ME – Metabolizable Energy; SED - Standard Error of Difference Means in the same row with similar superscripts are not significantly different (*p>0.05*)

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Table 3: Growth performance of rabbits fed diets containing MSKM

Parameter	Dietary Treatments			SED	P-value
	T1	T2	T3		
Initial weight (g)	531.00	519.00	518.00	67.60	0.062
Daily feed intake (g)	73.90[ab]	86.20[a]	63.60[b]	5.46	0.043
Growth rate (g/day)	26.00[ab]	27.28[a]	21.44[b]	1.54	0.024
Feed Conversion Ratio (FCR)	2.90	3.19	3.06	0.20	0.084
Cost of 100kg Feed (GH₵*)	162.86	140.09	130.31	-	-

SED= Standard Error of Difference; Means in the same row with similar superscripts are not significantly different (*p>0.05*); * 1$ (USD) = 5 GH₵

Table 4: Proximate and Mineral Compositions of Meat of Rabbits Fed MSKM-based diets

PARAMETERS (%)	TREATMENTS			SED	P-value
	T1	T2	T3		
Moisture	72.05	71.96	72.82	0.30	0.056
Protein	20.24[b]	21.03[ab]	21.66[a]	0.21	0.014
Fat	10.25[b]	14.91[a]	8.81[c]	0.14	0.001
Mineral composition (g/100g)					
Calcium	1.04	1.04	1.02	0.04	0.058
Magnesium	0.11	0.11	0.11	0.00	0.054
Copper	18.83[b]	25.14[a]	14.04[c]	1.89	0.000
Iron	370.30[a]	328.00[b]	294.60[c]	6.17	0.000
Potassium	9159.00[bc]	9223.00[b]	9827.00[a]	206.1	0.016
Sodium	3491.00[a]	2734.00[c]	3033.00[b]	171.80	0.000
Phosphorus	5103.00[b]	5493.00[b]	6248.00[a]	346.10	0.002
Zinc	75.49[c]	86.90[b]	106.39[a]	4.57	0.004

Means in the same row with similar superscripts are not significantly different, SED = Standard Error of Difference

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Table 5: Some carcass characteristics of rabbits fed diets containing MSKM-based diets

Parameter	Treatments			SED	P-value
	T1	T2	T3		
Warm weight (g)	1092.67	1184.67	1101.00	76.81	0.364
Chilled weight(g)	1064.67	1152.67	1068.00	76.40	0.066
Dressing (%)	56.40	58.90	57.60	4.47	0.062
pH 45	5.86	5.79	5.82	0.03	0.074
pH_u (Ultimate pH)	5.63[a]	5.57[b]	5.59[ab]	0.01	0.024
Chilling loss	1.45	1.59	1.75	0.17	0.072

Means in the same row with similar superscripts are not significantly different, SED = Standard Error of Difference

Table 6: Organ Characteristics of rabbits fed diets containing MSKM

	Diet			SED	P-value
Parameter (g)	T1	T2	T3		
Heart	3.67	5.00	4.67	0.92	0.057
Lungs	13.67	16.00	16.00	1.39	0.240
Liver	58.70	61.70	61.70	4.57	0.068
Kidney	14.30	12.70	14.30	2.33	0.064

SED = Standard Error of Difference

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