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Effects of Composite Mango (*Mangifera indica*) Fruit Reject Meal on Growth Performance, Digestibility and Economics of Production of Rabbits

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Target Audience: Animal scientists, Animal nutritionists, Animal farmers, feed manufacturers, Food processors

Abstract

The experiment was conducted to determine the effect of mango fruit reject meal on growth performance, digestibility and economics of production of growing rabbits. Mango fruit rejects were sliced such that the peel and pulp were together and the seed discarded, sun dried until it attained about 10% moisture and milled to obtain mango fruit reject meal (MFRM). The MFRM was sub-sampled and its proximate composition determined. Five diets were formulated which contained 0, 5, 10, 15 and 20% MFRM and twenty weaned rabbits of mixed sex and breed were fed the diets for 70 days. Mean daily feed intake, weight gain, FCR, and final live weights measured were not significantly affected (P>0.05). Digestibility of nutrients was also similar (P>0.05) across the treatment groups. Inclusion of MFRM however significantly reduced (P<0.05) the cost per kg weight gain, with the rabbit group fed diet containing 20% MFRM being significantly (P<0.05) less costly. The profit was also significantly better at 20% MFRM. It was concluded that MFRM is a good feedstuff in rabbit diets and should be used. It was suggested that higher levels should be investigated to determine the optimum level of MFRM in rabbit diets to maximize profit.

Key words: rabbit; mango fruit reject; performance

Description of the Problem

The search for non-conventional feedstuffs which are more affordable and available in place of costly conventional feedstuff has become the priority of animal nutritionists because it is one way that could provide animal protein for a greater population of the world (1). The fact that feeding accounts for about 70% of the cost of producing non-ruminants animals is no news any longer among animal producers. This figure may differ depending on the management system adopted and the animal species involved since feed cost in rabbit as low as 26.57% of total cost (2)have been reported.

Rabbit is considered an alternative animal protein source capable of closing the deficit in animal protein consumption among people in poorer countries of the world, due to its low cost of production occasion by higher feed conversion ratio from cheaper feedstuffs, higher prolificacy and short generation intervals (3). Rabbits are

herbivores and have the ability to degrade substantial amount of fibre (4). The use of forages such as *Moringa oleifera* (5), Acacia (*Acacia nilotica*) (3) and *Leptadenia Hastata (6)*as feedstuff in rabbit diets have been reported. Fruit by-products such as Mango (*Mangifera indica*) seed kernel have also been used as feedstuff for rabbits (7).Mango (*Mangifera indica*) fruit is one of the most popular fruits, nutritionally rich and has good flavor, aroma, taste, and health promoting characteristics. The tree is believed to have originated from the Sub-Himalayan plains of the Indian sub-continent and belongs to the family of *Anacardiaceae* (8). Mango fruit is produced on a large scale around many countries of the world, with total world figure put at 38 million metric tones (9). Nigeria occupies the 8th position on the list of top-most producers of mango around the world (10).

Good as it is, the fruit becomes unfit for human consumption because of infections, bruises, improper handling, and activities of animals (especially birds) on the fruit, and therefore rejected (11). These rejected fruits, known as *cull fruits* litter the ground during its season, there by constituting environmental hazard (12).

Little has been done to convert rejected mango fruit pulp into useful products such as animal feed**.** However**,** the seed and peel of mango fruits have been used as animal feedstuffs. According to report Roa & co (13) dried mango peels included in finishing pig diets at 10% had no deleterious effect on feed conversion ratio, animal performance and economics of production. Another research by Odunsi (14) reported that growth performance was maintained at 10% inclusion of mango seed kernel meal in laying type birds' diet but egg laying was depressed even at 5% level of inclusion. Although the seed and peel of mango fruits have been utilized in animal feeding, a large quantity of the pulp and peel of rejected fruits waste away in Nigeria, especially Benue State (15). However, considering the high energy value of mango fruits (10), these rejected fruits could serve as a feed resource in animal feeding, mainly as a source of energy because of its high energy of 3533.57 kcal/kg DM (16)), and at the same time check environmental hazards they create. This research therefore investigated the effect of mango fruit reject on growth performance, digestibility and economics of production of grower rabbits.

Materials and Methods

Experimental site

The experiment was conducted at the Rabbit Section of the Livestock Unit, on the Teaching and Research Farm, University of Agriculture Makurdi, Benue State, Nigeria. The area is warm with a minimum temperature range of 24.20 $\pm$ 1.40^{o}C and a maximum temperature range of 36.33 $\pm$ 3.70^{o}C (17).

Preparation of Mango fruit reject and diets

The mango fruit rejects(test ingredient) were collected together as a composite irrespective of variety from mango tree stands and fruit markets' refuse sites around Makurdi town and its surroundings during mango fruit season, which is between March and May. The composite half-ripe mango fruits which comprised chiefly of Alphonso, Julie,

Hindi, Peter, local mango and John varieties was cleaned, sliced to a thickness of 1-3mm such that peel and pulp were together. The seeds were discarded and the slices sun dried by spreading them out on polyethylene sheet, placed directly under the sun for seven (7) days, when the material was dried to 10% moisture and stored in polyethylene sacks until it was used. Before the composite mango fruit reject was incorporated into the diets, it was milled using corn milling machine to obtain mango fruit reject meal (MFRM). Mango fruit reject meal was then sub-sampled and the proximate composition determined following standard procedure (18) before it was incorporated in rabbit diets at 0, 5, 10, 15 and 20% to produce diets D1 (0% MFRM), D2 (5% MFRM), D3 (10% MFRM), D4 (15% MFRM) and D5 (20% MFRM) as presented in Table 1.

Table 1: Composition of experimental diets

Ingredient (%)	**0 % MFRM**	**5 % MFRM**	**10 % MFRM**	**15 % MFRM**	**20 % MFRM**
Maize	40.00	35.00	30.00	25.00	20.00
MFRM	0	5.00	10.00	15.00	20.00
Soya bean cake	24.00	24.00	24.00	24.00	24.00
Brewers dried grain	6.25	6.25	6.25	6.25	6.25
Rice offal	22.00	22.00	22.00	22.00	22.00
Fish meal	3.50	3.50	3.50	3.50	3.50
Bone ash	3.00	3.00	3.00	3.00	3.00
Methionine	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Vitamin/Mineral premix*	0.25	0.25	0.25	0.25	0.25
Table salt	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00
Calculated nutrients					
Crude Protein %	19.51	19.23	18.94	18.65	18.36
Metabolisable energy kcal/kg	2568.17	2548.12	2528.07	2508.02	2487.97
Fibre %	12.76	13.18	13.60	14.02	14.43
Ether extract %	2.39	2.34	2.29	2.24	2.19
Lysine %	1.09	1.08	1.06	1.05	1.04
Methionine %	0.64	0.63	0.62	0.61	0.60

MFRM= Mango fruit reject meal

Vitamin/Mineral premix*= Animal care vitamin/mineral premix included at 0.25 %, translating to 24000 iu vitamin A, 6000 iu vitamin B, 60mg vitamin E, 5 mg vitamin K3, 2 mg Folic acid, 80 mg niacin, 4 mg vitamin B1, 10 mg Vitamin B2, 7 mg vitamin B6, 0.04 mg Vitamin B12, 0.16 mg biotin and 250 mg antioxidant per kg diet. The minerals values per kg diet were: cobalt 0.5 mg, copper 16 mg, selenium 0.5 mg, iodine 24 mg, iron 80 mg, manganese 140 mg, zinc 120 mg and chloride 400 mg

Experimental animals and design

A total of twenty (20) weaned rabbits of mixed breed and sex, aged approximately five weeks with a mean live weight of 454.21 ± 20.62g were purchased from the Rabbitry Section, Livestock unit, Teaching and Research Farm, University of Agriculture Makurdi, Benue State, Nigeria and used for the study. The animals were randomly allocated to five dietary treatment groups of four rabbits per

group, and each rabbit formed a replicate in a completely randomized design with the following model:

$$X_{jk}=\mu+\alpha_j+\varepsilon_{jk}$$

where
X_{jk} = an observation in which k is the replicate of treatment j,
μ = mean of the observed values,
α_j = effect of the treatment and
ε_{jk} = experimental error

Housing and management of experimental animals

The rabbits were housed in hutches with a dimension of 60cm X 60cm X 60cm inside a wall less structure. The initial weights of the animals were taken, balanced and the rabbits were randomly allocated to the hutches. Diets were served daily from bulk measured weekly and cool clean water served *ad-libitum* throughout the feeding trial which lasted for 70 days. Necessary management practices (19) were duly observed.

Data collection and analysis

Growth performance

The performance parameters measured were initial live weight, weekly weight, and final weight. Weekly feed intake was determined as difference between feed served and feed left over within seven days. Weekly weight gain was calculated as difference in live weight between the previous and the current week and total weight gain was determined as the difference between the initial and final live weight. Average feed conversion ratio (FCR) was calculated using the formula:

$$\text{FCR} = \frac{\text{Feed consumed (g)}}{\text{Weight gain (g)}}$$

While daily feed intake and daily weight gain were also calculated by dividing their totals against the number of days that the feeding trial was conducted (70).

Digestibility trial

Seven days to the end of the feeding trial, three rabbits per treatment were fed known amount of feed, faecal materials were collected whole, oven dried and weighed. After that, both faecal and feed were analyzed for proximate composition according to standard procedures (18). Nutrients' weights in diets and faeces were calculated using the weights of diets consumed and faecal material collected and their determined compositions, from which apparent digestibility coefficients were calculated as stated (20):

Economic analysis

Economic parameters were determined as outlined (21) and economic parameters determined were cost per kg diet, cost per kg weight gain, cost due to feed consumed per rabbit, *other costs*(cost of housing, hutches, feeders and drinkers measured using straight line depreciation according to their life span as recorded at the University of Agriculture Makurdi Animal Teaching and Research Farm and cost of medication), total cost, revenue, profit and cost-benefit ratio. Relative costs for feed consumed, weaner rabbit and *other costs* were also determined. Other costs included cost of housing, hutches, feeders and drinkers measured using straight line depreciation according to their life span as recorded at the University of Agriculture Makurdi Animal Teaching and Research Farm. Also included in *other costs* was the cost

of medication.

Data analysis

Data generated were subjected to analysis of variance using statistical software (22), which was configured to automatically separate means that were significantly different, using its Duncan multiple range taste. Data on digestibility were first transformed before they were subjected to analysis of variance.

Results and Discussions

Performance

The result of the performance parameters which included average final live body weight (1431.25±86.23g to 1718.75±70.25g), daily feed intake (56.61±2.28g to 66.59±2.78g), daily weight gain and feed conversion ratio is presented on Table2. There was no significant difference (P>0.05) among the treatment groups for all the performance parameters. Though the mango fruit reject used in this experiment had low protein content (3.24 %) compared to maize with 8.9 % CP (20), and according to report (23) mango pulp and peel (24) are said to be low in crude protein ranging from 2.70 to 6 % and 4.70 to 9 %, respectively**,** all the diets had the protein level optimum for grower rabbits, which ensured their similar performance. The metabolizable energy (determined using a formula {25}) of mango fruit reject (3059.55 kcal/kg) was also lower than that of maize (3420 kcal/kg), the major source of energy in the diets, and even as the energy decline quantitatively with increase in MFRM (0 to 20%), it did not affect the performance of the animals. The final weight and weight gain recorded in this research were higher than 1390.17g to 1462g and 12.85 to 14.08g reported by (26) when rabbits were fed diets containing mango seed kernel. Mango peels are reported to contain reasonably high level of tannins (27), and MFRM is also known to contain tannin and implicated for depressed performance of broiler chickens (28). This was not the case with rabbits because they were not adversely affected. Rabbits are reported to tolerate anti-nutritional factors better than chickens (4).Although there was no significant difference (P>0.05) in feed intake and final weight, the steady increase of these growth performance parameters suggests that it was not a chance occurrence, but the effect of the diets on the animals. Mango fruit is reported to be palatable and used as a spice in many food formulas for human consumption (11). Rabbits may have equally appreciated this flavour, counting the test diets more palatable and consuming the test diets more (quantitatively) than the control. The effect of more consumption, similar feed conversion ratio and digestibility produced higher final weight of rabbits, though not significant (P>0.05), resulted to significantly better (P<0.05) economics of production on diet containing 20% MFRM.

Table 2: Effect of MFRM on performance of grower rabbits

Parameter(g)	0 % MFRM Mean ± SEM	5 % MFRM Mean ± SEM	10 % MFRM Mean ± SEM	15 % MFRM Mean ± SEM	20 % MFRM Mean ± SEM	LS
IBW	456.25± 64.85	462.50± 9.46	463.75± 30.64	462.50± 62.5	462.50± 65.75	NS
FBW	1431.25± 86.23	1483.00± 77.55	1537.50± 54.49	1481.25± 47.19	1718.75± 70.25	NS
DBWG	13.93± 1.06	14.59± 1.14	15.34± 0.58	14.55± 1.54	17.95± 0.37	NS
DFI	56.61± 2.28	61.82± 4.65	63.41± 3.38	60.13± 4.15	66.59± 2.78	NS
FCR	4.12± 0.22	4.27± 3.39	4.14± 0.21	4.20± 0.21	3.71± 0.12	NS
Mortality	0	0	0	1	1	-

MFRM = Mango fruit reject meal SEM= standard error of mean,NS = no sig nificant difference (P>0.05), FCR = Feed conversion ratio (feed intake/weight gain), IBW = Initial body weight, FBW = Final body weight,DBWG = Daily body weight gain, DFI = Daily feed intake, LS = level of significance (P<0.05)

Digestibility

The results of apparent digestibility coefficients of nutrients by rabbits fed diets containing MFRM as presented in Table 3 were not significantly affected ($p<0.05$) among treatment groups. The fibre digestibility range of 57.26±3.89 % to 70.19±6.29 %was low compared to the apparent digestibility coefficients of other nutrients. They were however higher than 40.31% - 66.15% reported by (6) and 15.63 to 38.92% reported by (2). In many works reported on the digestibility of nutrients in rabbits, fibre digestibility is low compared to other nutrients. Dry matter, crude protein and ether extract digestibility coefficients were all high and within the normal range as reported (4). The crude protein digestibility range of 34.37 to 53.04% reported (6) is less than 87.95±1.02 to 90.88±1.67 % recorded in this research but similar on average to 71.63% to 93.08%(29). Mango fruit contains micro-nutrients such as vitamins and useful polyphenols that help maintain cell integrity and functionality (10). They very healthy condition of intestinal cells and tissues due to the presence of these nutrients from the mango fruit (pulp and peel together) may be one of the reasons why the digestibility of nutrients was high compared to several past reports. Mango pulp is also reported to contain acids (10). These acids at a tolerable level become advantageous in helping to bread down feed material thereby increasing digestibility of nutrients.Digestibility coefficients for ether extract (86.63±2.90 to 92.72±0.64 %) and nitrogen free extract (79.92±1.46 to 84.45±0.99 %) were equally high and within the acceptable range (29). The reason adduced for protein digestibility similarly holds for these nutrients.

Table 3: Effect of MFRM on digestibility of nutrients by grower rabbits

Parameter (%)	0 % MFRM Mean ± SEM	5 % MFRM Mean ± SEM	10 % MFRM Mean ± SEM	15 % MFRM Mean ± SEM	20 % MFRM Mean ± SEM	LS
Dry matter	80.31±1.39	75.23±1.79	81.35±3.71	80.50±3.71	76.71±1.80	NS
Crude protein	90.60±0.90	88.40±0.64	90.88±1.67	89.97±2.18	87.95±1.02	NS
Fibre	62.35±2.99	57.26±3.89	70.19±6.29	69.84±5.46	61.27±2.35	NS
Ether extract	92.72±0.64	86.63±2.90	91.98±1.57	90.89±1.36	87.87±0.94	NS
Nitrogen free extract	84.45±0.99	79.92±1.46	84.24±2.98	84.24±2.98	82.34±1.51	NS

MFRM = Mango fruit reject meal, SEM= standard error of mean, NS = no significant difference (P>0.05), LS = level of significance (P<0.05),

Economics of production

The cost per kg diet (₦70.32 to ₦89.32) steadily declined as the level of mango fruit reject meal increased in the diet (Table 4). This was expected since the cost per kg maize (₦70.00) was much higher than the cost per kg MFRM (₦ 5.00), the test ingredient that displaced maize in equal amounts in the diets. Results of feed cost, total cost, percentage feed cost, weaner rabbit cost and *other costs* and revenue (Table 4), were not significantly affected (P>0.05). While feed cost tended to decrease as MFRM level increased, the revenue tended to increase. The non-significant but profitable tendency of the effect of MFRM in diets observed on cost of production and revenue became obvious, making cost per kg weight gain (₦260.81±8.20 to ₦366.95±19.84), benefit per rabbit (₦753.57±90.90 to ₦ 1124.72±71.84) and benefit-cost ratio to be significantly better (P<0.05) at D5 (20%MFRM). Non-conventional feedstuffs cost less and could be gotten relatively free (1). However the challenge of their usefulness has been that of efficiency of utilization by farm animals because of high fibre, presence of anti-nutritional factors or even poisons (30), making some of them economically unprofitable since their nutrients cannot be efficiently converted to meat for market. In this research, the utilization (feed intake and nutrient digestibility) was not hindered, making diets containing MFRM more economically profitable than maize based diets. Percentage feed cost (34.01±1.62 to 37.35±1.99 %) was less than 70%, usually considered as feed cost in monogastrics. This is likely to be as a result of soaring price of weaned rabbits which occupied as high as 50% or more of the total cost of production. On the other hand it might be normal for rabbit production to have a lesser percentage cost coming from feeding since (2) reported even lower values (26.57 to 28.88 %) for cost due to feed.

Table 4: Effect of MFRM on economics of production of grower rabbits

Economic indices (₦)	0 % MFRM Mean ± SEM	5 % MFRM Mean ± SEM	10 % MFRM Mean ± SEM	15 % MFRM Mean ± SEM	20 % MFRM Mean ± SEM	LS
Cost per kg diet	89.32	84.57	79.83	75.07	70.32	-
Cost per weaner rabbit	500.00	500.00	500.00	500.00	500.00	-
Other costs	110.00	110.00	110.00	110.00	110.00	-
Feed cost per rabbit	353.93± 14.27	365.98± 27.51	354.35± 18.86	315.95± 21.82	327.78± 13.69	NS
Total cost	963.93± 19.84	975.98± 27.51	964.35± 18.86	925.95± 21.82	937.75± 13.69	NS
Cost per kg gain (₦/kg)	366.95± 19.84^{b}	360.98± 23.43^{b}	330.66± 17.15^{b}	315.04± 16.12^{b}	260.81± 8.20^{a}	S
Revenue per rabbit	1717.50± 103.47	1780.50± 93.06	1845.00± 65.38	1777.50± 56.63	2062.50± 84.30	NS
Benefit per rabbit	753.57± 90.90^{b}	804.52± 76.36^{b}	880.65± 61.02^{b}	851.55± 38.43^{b}	1124.72± 71.84^{a}	S
Benefit-cost ratio	0.78± 0.09^{b}	0.82± 0.07^{b}	0.91± 0.06^{b}	0.92± 0.03^{b}	1.20± 0.06^{a}	S
%feed cost	36.68± 0.93	37.35± 1.99	36.67± 1.25	34.01± 1.62	34.91± 0.93	NS
%cost of weaner rabbit	51.91± 0.77	51.34± 1.47	51.91± 1.02	54.09± 1.33	53.35± 0.76	NS
%other costs	11.42± 0.17	11.30± 0.32	11.42± 0.23	11.90± 0.29	11.74± 0.17	NS

^{a,b}means on the same row with different superscripts are significantly different (P<0.05), SEM= standard error of mean, MFRM = Mango fruit reject meal, NS = no significant difference (P>0.05), S = significantly different (P<0.05) LS = level of significance (P<0.05), other costs= these included cost of housing, hutches, feeders and drinkers measured using straight line depreciation according to their life span as recorded at theAnimal Teaching and Research Farm, University of Agriculture Makurdi, and cost of medication. ₦ = Nigerian Naira (₦220 = one US Dollar at the time of this research)

Conclusion and Application

Mango fruit reject meal in rabbit diets supported performance as good as maize, and have surpassed maize in terms of the economics of production. It is therefore concluded that:

- MFRM is a good feed resource in rabbit nutrition.
- MFRM feeding to rabbits is economical and should be included in rabbit diets at 20% level.
- It is recommended that further investigations should be carried out at higher levels (above 20%) of MFRM in rabbit diets.

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