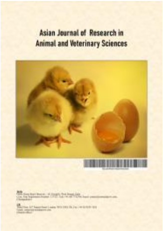

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Effect of Feeding Mango Fruit Rejects as Feed Ingredient on Production Performance of Non-Pure Breed Rabbits

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Novel feedstuffs have great potential for sustainability of the livestock industry because they minimize cost of production and increase availability of animal products. This study was conducted to assess the usefulness of Mango fruits Rejects Meal (MFRM) as a feed ingredient for rabbits. MFRM was incorporated into rabbit diets at 0, 22, 28, 34 and 40 % levels respectively, replacing maize in equal amounts to evaluate its effect on growth performance, carcass characteristics internal organs and economics of production of rabbits. Twenty (20) weaner rabbits with average weight of 392.75 g were randomly allotted to five dietary treatments of four replicates each in a completely randomized design (CRD) and fed for 70 days. Feed intake, weight gain and feed conversion ration were evaluated. Also, three rabbits were randomly selected from each group, starved of feed, stunned and slaughtered for carcass and organ evaluation at the end of the study.

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The dressed carcass was cut into primal parts and internal organs were separated and weighed. Growth performance indices, carcass yield and organs measurements were similar (p>0.05) across all the treatments except for large intestine and caeca which varied without pattern. Costs decreased (P<0.05) as MFRM in the diets increased while benefits improved (p<0.05) as MFRM increased in diets. Thus, it was concluded that MFRM is a safe and profitable feed resource for rabbit production, which could also reduce environmental pollution if adequately harnessed. Hence, it is recommended that MFRM should be incorporated in rabbit diets up to 40% or completely replaced maize in rabbit diets.

Keywords: Mango fruit; reject; internal organs; carcass; growth performance.

1. INTRODUCTION

The cost of conventional feedstuff and animal feeds have skyrocketed giving rise to reduced activities in livestock industry, high cost of animal products and deficiency in animal protein consumption. Meanwhile, the exploding human population has high demand for animal protein which must be met in order to prevent malnutrition and maintain a healthy society. One approach to this is the promotion of animals such as rabbits that can effectively utilize less valuable or waste materials, and another is the recycling/diversion of materials unfit for human consumption to animal feeding.

Rabbit is considered one of the most productive animals whose feeding habit is less competitive with humans compared to chicken [1]. Rabbit is an alternative animal protein source, which can alleviate the animal protein consumption deficiency among people in poorer countries of the world, due to its low cost of production occasioned by higher feed conversion ratio from cheaper feedstuff, higher prolificacy and short generation intervals [2].

Non-conventional feed resources generally refer to those feedstuffs that have not been traditionally used for feeding livestock and are not commercially used in the production of livestock feeds. The list of non-conventional feed resources is inexhaustible comprising of fruit wastes/rejects [3], crop residues, by-products such as rice offal [4] and wield or some horticultural plants such as neem plant [5]. They are essentially generated from agricultural and agro-industrial processes, most of them are usually regarded as waste but can be converted and utilized by livestock to bring forth products that are beneficial to man [6].

High output of fruit rejects is recorded yearly as a result of pest attacks, improper handling, transportation stress and poor storage facilities [7]. Though highly cherished by humans, Mango fruit, which is nutritious with unique flavor, fragrance, taste, and health promoting qualities, making it a common ingredient in new functional foods [8], suffers rejection and is abandoned in several heaps to rot around due to the fore mention reasons thereby causing environmental pollution. Mango fruits flabby for human consumption are usually rejected and wasted despite the enormous quantity of the material, 56 million metric tonnes [9] which could take the place of conventional energy sources for adequate and quality meat yield. Based on the nutritional value of mango fruit, there is need to channel the rejects to a profitable venture and alleviate the problem of feeding cost in animal production as well as environmental pollution. Poor performance of broiler chicken on diets containing more than 15% of Mango fruit reject meal was reported due to the effect of some anti-nutritional factors, which poultry could not effectively handle [8]. Conversely, Orayaga [7], reported high performance with rabbits fed up to 20% (50% replacement of maize) MFRM based diets where the performance parameters were not significantly different from the control. This study is aimed at testing the feed efficiency of MFRM at higher levels in rabbit diets.

2. MATERIALS AND METHODS

2.1 Experimental Location

The experiment was conducted at the Experimental Rabbitry House of the Livestock Unit, on the Teaching and Research Farm, Federal University of Agriculture, Makurdi, Benue State, Nigeria. The area is warm with a minimum temperature range of 21.71 $\pm$ 3.43°C and a maximum temperature range of 32.98 $\pm$ 2.43°C [10].

2.2 Preparation of Mango Fruit Rejects and Diets

Mango fruit rejects (test ingredient) were collected from mango tree stands of mixed varieties around Makurdi town and environs in its season (February through May). The composite rejected mango fruits were cleaned and sliced using kitchen knife such that the peels and pulp were together (about 3mm thick) and the seeds were discarded. Sliced pieces of composite mango fruit reject were sun-dried until it attained moisture content of less than 10% and milled using a corn milling machine, to obtain the mango fruit reject meal (MFRM). Before MFRM was incorporated into rabbit the diets, it was sub-sampled for determination of proximate composition in compliance with standard procedures [11], and strategically added to rabbits' diets at 0, 22, 28, 34 and 40% to produce diets coded T1, T2, T3, T4, and T5, respectively (Table 1).

2.3 Experimental Animals, Design and Management

Twenty (20) weaner rabbits with average weight of 392.75 g were randomly divided into five groups with four per treatment group and each animal serving as a replicate in a completely randomized design (CRD). Animals were dewormed with ivermectin at the onset of the experiment. The experimental animals were housed and raised in hutches fitted with drinkers and feeders and served weighed feed twice a day for seventy days. Other sanitary measures were put in place to ensure good health.

2.4 Data Collection

2.4.1 Growth performance

Data was collected such that feed intake and initial and final weights were recorded. Weight gain, protein intake, feed conversion ratio, protein intake and protein efficiency ratio were calculated as outlined [7].

2.4.2 Carcass evaluation

At the end of the experiment, three rabbits from each treatment were starved overnight, weighed, stunned and slaughtered for carcass evaluation.

Table 1. Percentage composition and nutrient content of weaner rabbits' diets containing MFRM (g/100g)

Ingredients	0.00 % (T1)	22.0 % (T2)	28.0 % (T3)	34.0 % (T4)	40.0 % (T5)
Maize	40.0	18.0	12.0	6.0	0.0
Maize offal	5.0	5.0	5.0	5.0	5.0
MFRM	0.0	22.0	28.0	34.0	40.0
Soybean Meal	28.9	28.9	28.9	28.9	28.9
Rice Offal	19.15	19.15	19.15	19.15	19.15
Palm oil	1.0	1.0	1.0	1.0	1.0
Blood meal	2.0	2.0	2.0	2.0	2.0
Bone ash	3.0	3.0	3.0	3.0	3.0
Methionine	0.3	0.3	0.3	0.3	0.3
Lysine	0.2	0.2	0.2	0.2	0.2
*Vit/Min Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.2	0.2	0.2	0.2	0.2
Total	**100**	**100**	**100**	**100**	**100**
Calculated Nutrients					
Metabolizable energy (Kcal/kg)	2670.34	2582.12	2558.06	2534.00	2509.94
Crude protein %	19.5	18.34	17.97	17.63	17.28
Calcium %	1.57	1.62	1.64	1.65	1.66
Phosphorus	1.00	0.95	0.98	0.98	0.97
Ether extract	3.47	3.25	3.19	3.13	3.07
Crude fibre	11.15	13.00	13.5	14.0	14.51
Lysine	1.07	1.03	1.03	1.02	1.01
Methionine	0.65	0.62	0.61	0.60	0.60

MFRM = Mango fruit reject meal

** Animal care vitamin/mineral premix contained 24000 IU vitamin A, 6000 IU vitamin B, 60 mg 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, 0.5 mg cobalt, 16 mg copper, 0.5 selenium, 24 mg iodine, 80 mg iron, 140 mg manganese, 120 mg zinc and 400 mg chloride*

The bled animals were singed, eviscerated, dressed and cut into parts. The cut parts were weighed and expressed as percentage of dressed weight, while organs were weighed and expressed as percentage live weight [12].

2.4.3 Economics of production

Data on economics of production included cost per kg diet, cost due to feed consumed, miscellaneous cost, cost per rabbit, total cost, revenue, benefit or profit, cost benefit ratio and percentage feed cost. The cost of the feed ingredients including services such as transportation and processing, were used to arrive at a realistic cost of the feeds used in the study. The formulation for each diet was used to determine the cost per kg of feed by multiplying unit cost (₦) of each ingredient by its proportion in the diet to determine its cost contribution to the diet. The sum of all the cost contributions from all the ingredients that made up each diet gave the unit cost ((₦) kg^{-1}) diet.

The cost of weaner rabbit, fixed capital (housing, drinkers, feeders and hutches) and variable (drugs and fuel) as well as operational costs were also recorded. Cost of housing was determined using linear depreciation. Operational cost was the sum labour and payments for services. Labour cost was only assumed based on the minimum wage of that category of work force of the private sector in the state.

Total feed consumed by a rabbit in kg multiplied by unit cost of the feed gave the feed cost of producing a rabbit.

The cost of feed per kg weight gain for a rabbit was calculated by multiplying the feed conversion ratio (FCR) determined on as-fed basis by cost per kg of diet. Total cost of production was recorded as the sum of weaner rabbit cost, feed cost, housing/hutch and operational cost. Percentage of cost components (diet, weaner, housing and operational costs) was determined as component cost over total cost multiplied by 100 $\{Y = \frac{cost\ of\ component}{total\ cost} X\ 100\}$, where Y is the percentage cost of component [13]. Total revenue was computed from total sales per rabbit, while the benefit was determined as the difference between revenue and cost of production. Cost to benefit ratio was calculated as the ratio of cost to benefit [13].

2.5 Statistical Analysis

Data collected from the experiment were analyzed using one-way analysis of variance in SPSS version 16 [14] and means were compared using Duncan's multiple range test at 0.05 significance level using the same statistical software. Data in percentages were first transformed using arcsine transformation before subjecting it to statistical analysis.

3. RESULTS

3.1 Growth Performance

Result of growth performance of weaner rabbits, fed mango fruit reject meal based diets is shown in Table 2. Average final weights were not significantly different (p>0.05) among treatment groups. Feed intake was also similar(p>0.05) across treatment groups. No significant (p>0.05) effect of mango fruit reject meal was observed on daily live weight gain and feed conversion ratio of weaner rabbits.

3.2 Carcass Characteristics

Results of carcass characteristics of weaner rabbits is presented in Table 3. Live weight, dressed weight and prime cuts were not significantly different (*p*>0.05) among treatment groups.

Table 2. Effect of Mango fruit reject meal (MFRM) on growth performance of weaner rabbits

Parameters	Groups					
	0.00 % (T1)	**22.0 % (T2)**	**28.0 % (T3)**	**34.0 % (T4)**	**40.0 % (T5)**	**SEM**
Initial weight	391.25	395.75	393.00	390.25	393.50	-
Daily feed intake	57.23	66.20	59.40	66.08	60.07	4.40
Daily protein intake	10.54	10.25	9.98	10.87	9.37	0.78
Daily weight gain	15.34	14.37	15.38	16.21	15.24	0.80
Total feed intake	4010.00	4633.75	4157.67	4625.75	4204.80	402.50
Final body weight	1478.67	1401.50	1487.33	1525.00	1445.67	46.95
Feed conversion ratio	3.71	4.18	3.87	4.10	3.84	0.02
Protein efficiency ratio	1.48	1.40	1.54	1.49	1.68	0.08

MFRM = Mango fruit reject meal SEM= standard error of mean

3.3 Internal Organs and Gastrointestinal (GIT) Morphometry

Table 4 shows organ and GIT characteristics of rabbits fed mango fruit reject meal. Liver, heart, kidney, spleen, gall, lungs weights, Small intestinal length and weight as well as caecal length did not vary significantly (*p*>0.05) among treatments groups. Large intestinal weight and length and caecal weight were significantly (*p*<0.05) different among treatment groups. Large intestinal measures decreased with increasing inclusion of mango fruit reject meal.

3.4 Economics of Production

Economics of production of rabbits fed diets containing MFRM is presented in Table 5. The cost per kg diet steadily declined as the level of MFRM increased in the diet and completely replaced maize at T5. Cost due to feed intake, cost per kg weight gain, total cost, percentage feed cost and cost-benefit ratio all significantly declined (p<0.05) as the level of MFRM increased in diets. Cost due to feed tended to decrease as MRFM level increased. Cost per Kg weight gain also decrease from T1 (₦403.91 Kg^{-1}), T2 (₦ 340.14 Kg^{-1}), T3 (₦ 286.02 Kg^{-1}), T4 (₦ 272.20 Kg^{-1}) and T5 (₦ 226.25 Kg^{-1}). Total cost decreased from ₦ 1984.00 Kg^{-1} to ₦ 1749.67 Kg^{-1}, while profit increased (P<0.05) with increase in MFRM. The cost Benefit ratio of T1, T2 and T3 were similar (P>0.05) with T3 also having similar value with T4 and T5. Percentage feed cost decreased from T1 (₦ 21.90) to T5 (₦ 11.54). T1 had the highest value, while T2, T3, T4, were not significantly different (p>0.05) among themselves and T5 had the lowest value.

Table 3. Effect of Mango fruit reject meal (MFRM) on carcass characteristics of weaner rabbits

Parameters (%)	Groups					
	0.00 % (T1)	22.0 % (T2)	28.0 % (T3)	34.0 % (T4)	40.0 % (T5)	SEM
Live weight	1401.00	1423.67	1487.33	1558.00	1445.67	0.26
Eviscerated weight	76.72	69.38	71.03	67.49	69.19	0.26
Dressed weight	53.04	52.99	54.71	49.31	49.51	2.73
Hind limb	16.22	18.50	19.15	15.04	15.23	2.13
Fore limb	8.17	11.38	12.00	8.17	8.34	2.06
Back/loin	18.16	17.87	21.74	17.94	17.07	1.49
Racks	7.76	8.19	10.61	8.03	8.12	1.32
Neck	2.22	2.42	2.60	2.26	2.59	0.15
Head	7.19	6.90	7.72	7.04	7.56	0.19
Tail	0.41	0.54	0.47	0.43	0.48	0.07
Feet	1.81	1.99	1.99	2.06	1.92	0.10

MFRM = Mango fruit reject meal; SEM= standard error of mean

Table 4. Effect of mango fruit rejects meal on internal organs and gastro-intestinal morphometry of weaner rabbit

Parameters	Groups					
	0.00 % (T1)	22.0 % (T2)	28.0 % (T3)	34.0 % (T4)	40.0 % (T5)	SEM
Liver % LW	8.51	9.43	9.37	9.37	8.94	0.32
Heart % LW	2.86	2.65	2.84	2.66	3.00	0.14
Spleen % LW	0.93	0.81	0.93	0.87	0.93	0.05
Kidney % LW	4.48	4.56	4.85	4.83	4.67	0.14
Gall % LW	0.87	0.99	0.87	0.87	0.93	0.05
Lungs % LW	3.65	2.50	3.57	3.57	3.78	0.55
Small intestine % LW	10.30	9.77	10.44	11.02	10.37	0.88
Large intestine % LW	9.35^{a}	7.60^{b}	6.77^{b}	7.60^{b}	7.32^{b}	0.51
Stomach % LW	6.33	6.46	7.00	6.65	6.59	0.32
Caeca % LW	7.78^{a}	6.57^{ab}	5.98^{b}	6.94^{ab}	7.02^{ab}	0.53
Small intestine length	49.21	49.80	53.93	53.73	52.94	1.56
Large intestine length	29.31^{ab}	30.59^{a}	26.89^{c}	26.82^{c}	28.00^{bc}	

MFRM = Mango fruit reject meal SEM= standard error of mean
% LW = Percentage live weight

Table 5. Effect of mango fruit rejects meal on the economics of production of weaner rabbit

Parameters	Groups					
	0.00 % (T1)	**22.0 % (T2)**	**28.0 % (T3)**	**34.0 % (T4)**	**40.0 % (T5)**	**SEM**
Cost per kg diet (₦)	108.97	81.47	73.97	66.47	58.95	-
Cost per weaner rabbit (N)	1000.00.	1000.00	1000.00	1000.00	1000.00	-
Cost due to feed (₦)	436.97^{a}	338.60^{b}	307.54^{b}	307.48^{b}	202.17^{c}	24.00
Miscellaneous cost (₦/rabbit)	547.50	547.50	547.50	547.50	547.50	-
Cost per kg weight gain (₦)	403.91^{a}	340.14^{b}	286.02^{c}	272.20^{cd}	226.25^{d}	14.69
Total cost (₦)	1984.00^{a}	1888.35^{ab}	1855.04^{ab}	1854.98^{b}	1749.67^{c}	24.15
Revenue (₦)	2365.87	2242.40	2379.73	2440.00	2313.07	75.12
Benefit (₦)	381.87^{b}	354.05^{b}	524.69^{a}	585.03^{a}	517.83^{a}	60.91
Cost benefit ratio (₦)	5.40^{a}	5.50^{a}	3.83^{ab}	3.30^{b}	3.39^{b}	0.52
Percentage feed cost (₦)	21.90^{a}	18.54^{b}	16.58^{b}	16.58^{b}	11.54^{c}	1.0

^{abc}=means different superscripts are significantly different ($p<0.05$) ₦400 = 1 USD
MFRM = Mango fruit reject meal SEM= standard error of mean

4. DISCUSSION

4.1 Growth Performance

Similarity in growth performance of weaner rabbits fed graded levels of MFRM has been reported and attributed to the feed value of the composite meal [7]; though at lower levels of inclusion. Mango fruit is reported to be high in nutrients with energy of 3533.57 kcal/kg [15] which is higher than maize. However the pulp with the peel (MFRM) was reported to contain 3019kcal/kg ME [8] which is lower than that of maize; 3420 kcal/kg ME [16], which was replaced by MFRM. Mango is also considered as a good source of dietary fibre, and fibre promotes intestinal health giving room for animals to properly utilize the diet and perform well. The daily weight gain of 14.37-16.21g per rabbit per day were lower than 17.65-18.57g/day reported by Agunbiade et al.[17] and 18.00-20.00g reported by Aduku et al. [18], but was higher than 4.94-14.80g/day reported by Bawa et al. [19] and 8.70-9.91 g/day reported by iyeghe-erakpotobor and Muhammed (20) who fed rabbits on different levels of groundnut haulms and 11.59 – 15.04 g/day reported by Adejo et al. [20], when rabbits were fed with diets containing Mucuna leaf meal. Variations among research reports in any of the parameters measured may not be strictly a dietary factor. Other factors such as strain/breed, management, age, sex, season and addition of additives may count.

4.2 Carcass Characteristics

The effect of mango fruit reject meal on prime cuts was also not significant. The similarity in carcass values indicates that MFRM had no negative impact on muscle/lean meat deposition of the rabbits. Orayaga et al. [21], who fed rabbits with MFRM ranging from 5 - 20% also reported similarities in carcass values as well as offal. It is evident that MFRM has no adverse effect on rabbits, rather was well utilized by the animals for optimum growth. Though MFRM may be low in protein, it is reported to be high in fibre compared to maize and rabbits being hind gut fermenters are able to utilize fibrous material through fermentation and caecotrophy to meet their nutritional needs. Having high energy and fibre at the same time is unarguably advantageous to rabbit nutrition, hence the adequate carcass characteristics.

4.3 Internal Organs

Organs are often used as indicators of diets' safety and or quality for an animal. Their inflammation/increase in size could suggest toxicity from the diet or ill health of the animal. On the other hand their abnormal reduction in size relative to the body weight could also be an indication of abnormality. However, none of these were observed on the internal organs, indicating that the animals were well nourished by the experimental diets, to support its tissue accretion and general wellbeing, similar to the control.

Gastrointestinal morphometry evaluation conducted by weight and length showed variation in large intestine and caeca measurements. There was a reduction in large intestinal weight and caeca weight compared to the control group.

Large intestinal length also varied but without a pattern. This result could not be clearly explained as it excepted that with the increased fibre components in the diet, the caeca and large intestine would increase in size due to increased activities but it was not so. This result also differed from that of Orayaga et al. [21] who fed up to 20% MFRM but reported similarities in gastrointestinal morphometry. The significant variations in caecum and large intestine in this result could not be explained.

4.4 Economics of Production

Cost Kg^{-1} diet decreased steadily as MFRM increased in the diets from ₦ 108.97 Kg^{-1} to ₦ 58.95 Kg^{-1}. This was expected since the cost per kg maize was much higher than the cost per kg MFRM; which was acquired free of monetary cost except for processing. This result corroborates the report of Adejo et al. [20] who reported that, non-conventional feedstuffs such as Mucuna leaf meal cost less and could be gotten relatively free. Cost due to feed consumed ranged from ₦436.97 in T1, to ₦202.17 in T5. It was highest in T1(₦436.97) and T2, T3, T4 were not significantly different, while T5 had the significantly lowest cost. The significant decline in cost due to feed, cost per Kg weight gain, total cost, cost benefit, percentage feed cost upheld the profitability of MFRM in rabbit feed, indicating an optimal utilization of a relatively cheaper energy source compared to maize. The increase in benefit as MFRM increased in diets was normal since cost was reduced and effect of MFRM on growth performance was similar to maize [22-23].

5. CONCLUSION

The following conclusions were drawn:

Mango fruit rejects meal is an alternative feed resource for rabbit's utilization and can replace 100% of maize in rabbit's diets without adverse effect on growth performance, carcass characteristics and internal organs.

Economics of production was better with 100% replacement of maize with MFRM.

6. RECOMMENDATIONS

It was recommended that mango fruit reject meal should be used as a source of energy in place of maize for rabbit production to reduce the competition over maize for food and feed. Also, it was recommended that MFRM should be used so as to ameliorate the environmental pollution that comes with mango fruit rejects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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