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Feeding Value of Processed Breadfruit (*Artocarpus altilis sosberg*) Meal for Grower Rabbits

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Abstract: Effect of substituting cooked Breadfruit (*Artocarpus altilis*) meal (CBFM) for maize in grower rabbit diet was studied in an eight weeks feeding trial in a bid to find an alternative energy feed resource that can replace maize which is becoming very expensive. Ninety grower rabbits of mixed breed and sex average 870±5g were divided into six groups and the groups assigned to six grower diets in which CBFM was substituted for 30% (diet 2), 40% (diet 3), 50% (diet 4), 60% (diet 5) and 70% (diet 6) maize of the control diet (diet 1) in a completely randomized design. Parameters measured were feed intake, weight gain, feed conversion ratio, digestibility, carcass characteristics and economy of production. Data were analyzed by one-way analysis of variance using SAS. Average daily weight gain of the rabbits fed control (15.36g), 30% (15.0g), 40% (14.64g) and 50% (14.50g) CBFM were similar but the values obtained for those fed 60% (12.86g) and 70% (11.61g) were lower ($P<0.05$). Total weight gain, live weight, carcass weight, carcass yield, weight of the primal cuts, feed conversion ratio and nutrient digestibility followed the same trend. Feed intake was not significantly different among the rabbits that were fed diets 2 (62.21g), 3 (61.50g), 4 (60.70g) and control diet ((63.70g) but was significantly ($P<0.05$) lower in those fed diets 5 (56.50g) and 6 (55.20g). Rabbits that were fed 60% and 70% CBFM also had higher ($P<0.05$) feed conversion ratio, larger ($P<0.05$) kidneys, liver and heart than those fed whole maize based diet. Feed cost reduced ($P<0.05$) progressively with increased CBFM in the diets. Feed cost per kilogram weight gain was lower ($P<0.05$) in the rabbits fed 30% (N150.13), 40% (N150.19) and 50% (N147.30) CBFM than control group (N155.55) but higher ($P<0.05$) in those fed 60% (N160.19) and 70% (N162.60). It was concluded that CBFM can be substituted for up to 50% maize in grower rabbit's diet without any adverse effect on performance and with increase profit margin.

Key words: Feed intake · Weight gain · Feed conversion ratio · Nutrient digestibility · Production cost

INTRODUCTION

Intensive rabbit production requires the use of concentrate feeds in addition to the forages in order to achieve the maximum potential of the animal. Unfortunately however, the growing of rabbit industry in many African countries in the recent years is creating the food/feed crisis associated with poultry and pig farming for the rabbit breeders that depend on pellets and concentrate for their animals. The new impetus for rabbit production in most African countries therefore requires that alternative and cheap energy be sourced for rabbits to replace cereals in rabbit pellets in order to make the industry profitable.

An ecologically available forest based feed resource with good biomass production (16-32 tons/ha) [1] is breadfruit (*Artocarpus altilis)* which is an energy rich tropical and ultra tropical fruit tree that has been well adapted to the forest and derived savanna zone of Nigeria. Breadfruit belongs to the family of *Moraceae* and it occurs in wild in Iran and Micronesia but its secondary centre of diversity is believed to be polynesia. The fruit is usually produced in surplus during the fruiting season (March- May) which usually result in heavy loss as the fruit does not store for long once harvested [2].

Studies have shown that breadfruit meal can replace part of maize in rabbit diet [3, 4] The limitation imposed on the use of breadfruit meal as feed for livestock has been

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attributed to anti-nutritional factors such as tannin, oxalate, phytic acid, haemaglutinin and trypsin inhibitors [4, 5] that are contained in breadfruit. Processing by cooking has been successfully used to improve the nutritional value of some unconventional feeds like *Colocasia esculenta* [6] and sweet potato [7]. Also anti-nutritional factors in some legumes have been reduced or eliminated by cooking [8, 9]. The present study was therefore conducted to determine the effect of cooking on the utilization of breadfruit meal by growing rabbits.

MATERIALS AND METHODS

The study was conducted at the Rabbitary Unit of Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo State in the derived savanna zone of Nigeria. The study area is located between latitudes 8°07'N and 8°12'N and longitudes 4°04'E and 4°15'E. The mean annual rainfall is 1247mm with relative humidity of between75 and 95%. The location is situated at about 500mm above the sea level with a mean annual temperature of 26.2°C [10].

Collection and Processing of Test Ingredient: Mature fruits were harvested from breadfruit trees around Ogbomoso township of Oyo State, Nigeria. The fruits were cut into four equal parts (quarter) and then poured into the boiling water (100°C) for 30 minutes. The water was drained and each quarter further cut into about 4cm thickness and sun-dried for 7 days until the products attained moisture content of about 13%. The dried product was hammer milled to obtain a meal called cooked breadfruit meal (CBFM).

Feed Preparation: A rabbit grower's diet (diet 1) which served as the control was formulated to contain 16.4% crude protein, 23.9Kcal/g metabolizable energy and 12.2% crude fibre. Five other diets (diets 2, 3, 4, 5 and 6) were formulated by replacing 30, 40, 50, 60 and 70 percents maize, respectively in the control diet with CBFM. All the diets were balance for protein, energy and fibre and were pelleted. The gross composition of the diets is presented in Table 1.

Animals and Management: Ninety six (96) mixed breeds and sex grower rabbits average weight 0.87± 0.02kg were divided into six equal groups of 16 rabbits each. The groups were randomly assigned to any of the six diets in a completely randomize design (CRD) each rabbit constituting a replicate. The rabbits were housed individually in hutches measuring 60x50x45cm. The animals were treated for ecto-parasites and endo- parasites prior to the commencement of the experiment. Rabbits were served water and pelleted feed *ad libitum.* The study lasted for 56 days.

Table 1: Gross composition of the experimental diets (%)

	Level of cooked breadfruit meal in the diet (%)					
	0	30	40	50	60	70
Ingredient	(1)	(2)	(3)	(4)	(5)	(6)
Maize	30.00	21.00	18.00	15.00	12.00	9.00
Breadfruit meal	0.00	9.00	12.00	15.00	18.00	21.00
Soy bean meal	18.00	18.00	18.00	18.00	18.00	18.00
Wheat offal	2.00	8.00	10.00	12.00	14.00	15.00
Corn bran	10.50	10.50	10.50	10.50	10.50	10.50
Palm kernel meal	14.00	14.00	14.00	14.00	14.00	15.00
Fish meal	1.00	1.00	1.00	1.00	1.00	1.00
Rice husk	21.00	15.00	13.00	11.00	9.00	7.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Common salt	0.25	0.25	0.25	0.25	0.25	0.25
*Vitamin Premix	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Determined analysis Crude protein (%)	16.40	16.30	16.20	16.10	16.00	15.85
**Metabolizable energy (Kcal/g)	23.90	23.80	23.74	23.60	23.40	23.10
Crude fibre (%)	12.20	11.60	11.40	11.30	11.30	11.10

* Premix used contained per kilogram: Vitamin A, 120IU; Vitamin E, 400g; Vitamin K, 30mg; Vitamin B1, 30mg; Vitamin B2, 80mg; Vitamin B6, 60mg; Vitamin B12, 3mg; Niacin, 400mg; Pantothenic acid, 120mg; Folic acid, 10mg; Biotin, 10mg; Antioxidant, 10mg; Choline chloride, 300mg; Manganese, 800mg; Iron, 400mg; Zinc, 600mg; Cobalt, 30mg; Iodine, 10mg and Selenium, 20mg.

** Calculated value

Data Collection: Data were collected on feed intake, weight gain and mortality while feed conversion ratio was determined from feed intake and weight gain. Feed intake was estimated weekly from the feed offered and the left over after one week. Animals were weighed individually at the beginning of the study and thereafter weekly and weight gain estimated as the difference in the weight of the animal in two successive weeks. Feed conversion ratio was determined from feed intake and weight gain.

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed intake}}{\text{Weight gain}}$$

Cost Estimation: Feed cost was determined from the cost of the feed ingredients used in feed preparation. Cost of breadfruit was estimated from the farm gate price of breadfruit, costs incurred on transport, labour and energy. Cost of total feed consumed was calculated from feed cost and total feed consumed. Cost per kilogram weight gain was determined as the product of feed conversion ratio and feed cost per kilogram.

Digestibility Trial: Digestibility study was conducted from which digestibility of various nutrients (Dry matter, crude protein, crude fibre, ether extract and nitrogen free extract) were determined. Faecal collection lasted for 5 days after a pre-collection period of 4 days. Faeces were collected daily and oven dried at 60°C for 48 hours. The faeces were bulked at the end of the trial, milled and representative sample collected for laboratory analysis.

Carcass Analysis: At the end of eight weeks of the study, six rabbits that had their weights close to the mean weight of their group were selected for carcass evaluation. The rabbits were fasted for 24 hours. This was followed by stunning using electroshock method described by DalleZotte [11]. Bleeding was carried out by neck slit using sharp knife. The animals were flayed and the skin weighed. The animals were opened and the internal organs (liver, kidneys and heart, visceral fat and visceral organs) were carefully excised, clean of blood and weighed using electronic weighing scale. These were then expressed as percentages of the live weight of the animals. Lengths of the gastrointestinal tract and caecum were also measured using measuring tapes. The carcasses were cut into primal cuts as described by Blasco and Ouhayoum [12]. These were also expressed as the percentages of the live weight of the rabbits.

Laboratory Analysis: Samples of the CBFM, feeds and faeces were analyzed for proximate composition according to the methods of AOAC [13] while gross energy was determined using par adiabatic bomb calorimeter. Calcium in the test ingredient was determined using a Perkin Elmer Model 2380 atomic and absorption spectro-photometer after wet digestion of the samples. Phosphorus was determined using a spectrophotometric phosphoammonium vanadate reaction as described by Ravindran and Sivakanesan [14]. Tannin was extracted from the samples by the method of Hagerman and Butler [15] while Folic- Denis method described by Hoff and Singleton [16] was employed to estimate tannic acid in the extracts. Phytic acid was determined spectrophotometrically after enzymatic hydrolysis with phytase from *Aspergillus ficuum* [17]. Total oxalate was determined according to the method described by Yan *et al*. [18].

Data Analysis: Data generated were analyzed by one-way analysis of variance using the General Linear Model Procedure of SAS [19]. Significance was determined at $P< 0.05$ and where significance were indicated, Duncan [20] option of the same software was used to separate the means.

RESULTS

The proximate composition of CBFM is presented in Table 2. The crude protein, crude fibre, calcium and phosphorus content of CBFM were 4.86%, 4.98%, 0.76g/100g and 1.81g/100g respectively.

The performance and economic implication of feeding cooked breadfruit meal to growing rabbits is presented in Table 3. No significant ($P>0.05$) difference was observed in the final weight,

Table 2: Chemical composition of cooked breadfruit meal on dry matter basis

Component	Amount
Dry matter	90.0
Crude protein (% DM)	4.86
Crude fibre (% DM)	4.98
Ether extract (% DM)	1.90
Ash (% DM)	5.10
Ca (g/100g)	0.76
P (g/100g)	1.81
Oxalate (mg/kg)	2.42
Tannin (mg/kg)	5.72
Phytic acid (g/100g)	0.75

Table 3: Performance and economic implication of feeding cooked breadfruit meal to grower rabbits

	Level of cooked breadfruit meal in the diet (%)						
	0	30	40	50	60	70	
Parameter	(1)	(2)	(3)	(4)	(5)	(6)	SEM
Initial weight (Kg)	0.87	0.88	0.87	0.86	0.88	0.87	-
Final weight Kg)	1.73a	1.72a	1.69^{ab}	1.67^{ab}	1.60b	1.52b	0.08
Total weight gain (Kg)	0.86^{a}	0.84^{a}	0.82^{a}	0.81^{a}	0.72^{b}	0.65^{b}	0.08
Average daily gain (g)	15.36^{a}	15.0^{a}	14.64^{a}	14.50^{a}	12.86^{b}	11.61^{b}	1.30
Average daily feed intake (g)	63.7^{a}	62.21^{a}	61.50^{a}	60.70^{a}	56.50^{b}	55.20^{b}	3.80
Feed conversion Ratio	4.15^{b}	4.14^{b}	4.20^{b}	4.19^{b}	4.59^{a}	4.75^{a}	0.18
Mortality	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed cost (N/kg)	37.5^{a}	36.2^{b}	35.8^{bc}	35.1^{c}	34.9^{cd}	34.1^{d}	0.90
Cost of feed consumed (N)	133.8^{a}	126.1^{b}	123.2^{c}	119.3^{d}	110.4^{e}	105.7^{f}	2.6
Cost /kg weight gain (N)	155.6^{b}	150.1^{c}	150.2^{c}	147.3^{d}	160.2^{a}	162.6^{a}	2.6

abcdef: Means bearing different superscripts along the same row are significantly different (P<0.05)

Table 4: Nutrient digestibility of grower rabbits fed cooked breadfruit meal.

	Level of cooked breadfruit meal in the diet (%)						
	0	30	40	50	60	70	
Parameter	(1)	(2)	(3)	(4)	(5)	(6)	SEM
Dry matter	63.50^{a}	63.20^{a}	62.75^{a}	62.40^{a}	60.30^{b}	60.10^{b}	1.60
Crude Protein	70.80^{a}	70.40^{a}	70.16^{a}	69.90^{a}	67.30^{b}	67.10b	1.50
Crude fibre	55.10^{a}	54.70^{a}	54.80^{a}	54.30^{a}	49.67^{b}	49.32^{b}	1.60
Ether extract	74.23^{a}	74.21^{a}	73.81^{a}	73.70^{a}	70.30^{b}	70.25^{b}	1.70
Nitrogen free extract	76.40^{a}	76.28^{a}	75.96^{a}	75.88^{a}	72.40^{b}	72.20^{b}	1.80

ab: Means bearing different superscripts along the same row are significantly different (P<0.05)

Table 5: Carcass characteristics, organ weight and intestinal length of grower rabbits fed cooked breadfruits meal.

	Level of cooked breadfruit meal in the diet (%)						
	0	30	40	50	60	70	
Parameter	(1)	(2)	(3)	(4)	(5)	(6)	SEM
Live weight (kg)	1.600^{a}	1.560^{a}	1.540^{a}	1.535^{a}	1.360^{b}	1.350^{b}	0.05
Carcass weight(g)	1002.40^{a}	972.66^{a}	927.39^{a}	915.42^{a}	780.60^{b}	787.32^{b}	100.00
Carcass yield(% LW)	62.65^{a}	62.35^{a}	61.22^{a}	60.22^{ab}	58.32^{b}	57.25^{b}	2.50
Skin (% LW)	10.70	9.96	9.90	10.20	9.95	9.62	1.30
Hind limb (% LW)	16.14^{a}	15.95^{a}	15.81^{a}	15.72^{a}	12.12^{b}	11.32^{b}	2.20
Fore limb (% LW)	12.16^{a}	11.98^{a}	11.75^{a}	11.70^{a}	9.13^{b}	9.10^{b}	1.50
Breast (% LW)	10.82^{a}	10.78^{a}	10.66^{a}	10.58^{a}	8.87^{b}	8.85^{b}	1.00
Lumber region(%LW)	15.55^{a}	14.95^{a}	14.65^{a}	14.58^{a}	12.15^{b}	12.13^{b}	1.50
Kidneys (% LW)	0.96^{b}	0.98^{b}	1.01^{b}	1.03^{b}	1.30^{a}	1.32^{a}	0.08
Liver (% L W)	2.82^{b}	2.97^{b}	2.99^{b}	3.01^{b}	3.31^{a}	3.32^{a}	0.30
Heart (% LW)	0.38^{b}	0.40^{b}	0.42^{b}	0.45^{ab}	0.49^{a}	0.52^{a}	0.10
Visceral fat (% LW)	0.80	0.78	0.76	0.75	0.73	0.72	0.11
Visceral organ(%LW)	19.23^{b}	19.25^{b}	20.93^{ab}	21.12^{ab}	23.01^{a}	23.03^{a}	2.00
Intestinal length (m)	2.51	2.60	2.58	2.55	2.62	2.61	0.30
Caecal length (cm)	30.90	31.23	30.60	28.90	29.14	29.95	3.00

ab: Means bearing different superscripts along the same row are significantly different (P<0.05)

L W = Live weight

total weight gain and average daily weight gain of the rabbits that had 30%, (diet 2), 40% (diet 3) and 50% (diet 4) maize in their diets replaced with CBFM. Those that had 60% (diet 5) and 70% (diet 6) of maize in their diets replaced however had significantly ($P<0.05$) lower values for these parameters.

Average daily feed intake of the rabbits that were fed diets 5 and 6 was significantly ($P<0.05$) lower than that of other groups including the control. Dietary treatments however had no significant ($P>0.05$) effect on the mortality. Rabbits that received 60% and 70% CBFM diets had poor feed utilization as evident by higher ($P<0.05$) feed conversion ratio.

Feed cost and cost of total feed consumed reduced ($P<0.05$) progressively with increase CBFM in the diets. Feed cost per kilogram weight gain of the rabbits fed 30%, 40% and 50% CBFM were significantly ($P <0.05$) lower than that of the group fed whole maize based diet, the lowest being diet 5 that contained 50% CBFM. However, values that were obtained for those fed 60% and 70% CBFM were higher ($P<0.05$) than that of the control group.

The nutrient digestibility of grower rabbits fed CBFM in replacement for maize is shown in Table 4. Treatment effects of diets had significant ($P<0.05$) effect on the digestibility of various nutrients. Significant ($P<0.05$) depression was observed on the digestibility of dry matter, crude protein, crude fibre, ether extract and nitrogen free extract at 60% and 70% substitution level. However, such depression was not observed at 30%, 40% and 50% replacement levels.

The carcass characteristics, organ weight and intestinal length of grower rabbits fed cooked breadfruit meal are presented in Table 5. Live weight, carcass weight and carcass yields of rabbits that had 30%, 40% and 50% maize in their diets replaced (diets 2, 3 and 4 respectively) were similar to that of the control group. Those that were fed diets in which 60% and 70% maize was replaced (diets 5 and 6 respectively) however had lower ($p< 0.05$) values with respect to these parameters. Substitution of cooked breadfruit meal for maize in the diets had no significant ($P> 0.05$) effect on the lengths of the caecum, intestine, skin weight and visceral organ weight. Weights of hind limb, fore limb, breast and lumber region of the rabbits that were fed 60% CBFM and 70% CBFM were significantly ($p<0.05$) lower than those fed control diet (diet 1) while those that were fed diets 2, 3 and 4 had comparable values with the control. Rabbits that received diets 5 and 6 also had larger ($p<0.05$) kidneys, liver and heart than those fed whole maize based diet.

DISCUSSION

The crude protein and crude fibre contents obtained for CBFM in this study agree with the value reported by Oladunjoye *et al.* [21] and Ravindran and Sivakanesan [14]. The protein value was however lower than the value reported by Oso *et al.* [4]. The difference could be due to difference in cultivars or stage of maturity. The presence of oxalate, tannin and phytic acid in the test ingredient indicate the inadequacy of cooking in eliminating these anti-nutritional factors in breadfruit [22].

In this study, weight gain and feed conversion efficiency of rabbits that were fed diets 2, 3 and 4 were similar to that of the control. This indicates that CBFM can be used to replace 50% maize in grower rabbit diet. The depression observed in the weight gain and poor feed utilization of those that were fed 60% and 70% CBFM seems to suggest that rabbit can not tolerate more than 50% CBFM in their diets at this age. The depression in weight gain and poor feed utilization can be attributed to residual anti-nutritional factors in cooked breadfruit meal which probably reached a threshold at these inclusion levels.

The reduction that was observed in feed intake of the rabbits at 60% and 70% substitution level could be due to change in the texture or taste of the diet [23] at these inclusion level. Taste impairment could have resulted from high concentration of tannin at the high inclusion level of breadfruit meal in these diets.

The fact that no mortality was observed throughout the duration of the study suggests that the diets did not contain lethal dose of any toxic compound.

The reduction in the feed cost and cost of feed consumed was a direct consequence of lower cost of breadfruit compared to maize. The fact that cost/kg weight gain was drastically reduced using diets 2, 3 and 4 means that it is more economical to use these diets than using whole maize based diet (diet 1). However the most economical of all the diets is the one that contained 50% CBFM (diet 4).

Poor digestibility of nutrients that was observed in diets that contained 60% and 70% CBFM could be due to residual anti-nutritional factors which probably reached a threshold at these levels. Ability of phytate to interact with the utilization of protein and minerals has been reported [24, 25].

The reduction that was observed in the live weight, carcass weight and carcass yield of the rabbits fed diets 5 and 6 can be attributed to poor feed digestibility and nutrient utilization [4] which was caused by anti-nutritional factors [26]. The low weight observed in the primal cut of the same rabbits could also be due to poor growth resulting from poor feed digestibility and utilization.

Larger kidney, liver and heart that were observed in the rabbits at higher substitution level can also be attributed to residual anti-nutritional factors in the meal. Uchegbu *et al.* [27] attributed similar increase observed in the heart and liver of chicken fed raw *Napoleona imperialis* seed meal to anti-nutritional factors.

CONCLUSION

The results of this study indicate that cooked breadfruit meal has some nutritional benefits in rabbit feeding and that up to 50% may be included in rabbit ration to maximize the profit. Growth performance, nutrient utilization and profit margin tend to decline beyond this level of inclusion.

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