ROASTED AFRICAN STAR APPLE (*Chrysophyllum albidum*) KERNEL MEAL IMPROVES GROWTH PERFORMANCE OF GROWING RABBITS[1]

[LA HARINA DE CÁSCARA ROSTIZADA DE LA MANZANA ESTRELLA AFRICANA (*Chrysophyllum albidum*) MEJORA EL CRECIMIENTO DE CONEJOS]

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SUMMARY

Nutritionally, *Chrysophyllum albidum* seeds have been reported to contain high amount of energy. However, the presence of anti-nutritional substances such as phytate, oxalate, saponin, and tannin in the seeds hinder animals from benefitting from it nutritionally. A 12-week study was carried out to examine the effect of substituting dietary maize with roasted African star apple kernel meal (RASAKM) on growth performance and blood indices of growing rabbits. A total of forty eight weaner rabbits (mixed breed, average weight, 590 g) were randomly allocated to four experimental diets containing 0, 5, 10 and 15 % RASAKM as substitute for dietary maize in a Completely Randomized Design. Roasted ASAKM influenced ($P< 0.05$) weight gain, feed conversion ratio and carcass parameters measured. Rabbits fed 5 and 10 % RASAKM diets had similar ($P>0.05$) weight gain (17.47 g and 16.69 g) with those fed the control diet (18.62 g). Rabbits fed 5 and 10 % RASAKM diets produced higher ($P< 0.05$) carcass compared with those fed 15 % RASAKM. Haematological indices analysed were not influenced ($P>0.05$) by the dietary treatments except for white blood cell and monocytes. It was concluded that RASAKM could be used up to 10 % to replace dietary maize in the diet of growing rabbits without compromising performance and carcass quality.

Key words; rabbits; African star apple; maize; performance; carcass.

RESUMEN

Nutricionalmente, se ha informado que las semillas de *Chrysophyllum albidum* contienen una gran cantidad de energía. Sin embargo, la presencia de sustancias anti-nutricionales como el fitatos, oxalatos, saponinas y taninos en las semillas impiden que los animales se beneficien nutricionalmente. Se llevó a cabo un estudio de 12 semanas para examinar el efecto de sustituir el maíz dietético con harina de cáscara de manzana estrella africana rostizada (RASAKM) en el crecimiento y parámetros sanguíneos de conejos en crecimiento. Un total de cuarenta y ocho conejos destetados (raza mixta, peso promedio, 590 g) se asignaron aleatoriamente a cuatro dietas experimentales que contenían 0, 5, 10 y 15% de RASAKM como sustituto del maíz dietético en un diseño completamente aleatorizado. El RASAKM influyó en la ganancia de peso ($P<0.05$), la relación de conversión alimenticia y los parámetros de la canal medidos. Los conejos alimentados con 5 y 10% de dietas RASAKM tuvieron una ganancia de peso similar ($P> 0.05$) (17.47g y 16.69 g) con aquellos alimentados con la dieta de control (18.62 g). Los conejos alimentados con 5 y 10% de dietas RASAKM produjeron mayor canal ($P<0.05$) en comparación con aquellos alimentados con 15% de RASAKM. Los parámetros hematológicos analizados no fueron influenciados ($P>0.05$) por los tratamientos dietéticos a excepción de glóbulos blancos y monocitos. Se concluyó que RASAKM podría usarse hasta en un 10% para reemplazar el maíz dietético en la dieta de conejos en crecimiento sin comprometer el rendimiento y la calidad de la canal.

Palabras clave: conejos; manzana estrella africana; maíz; rendimiento canal.

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INTRODUCTION

Nigeria's rapidly growing population has informed the need to increase livestock production to satisfy her animal protein requirement. Contributions of beef and poultry products to this national dilemma has been indeed marginal, providing succor to only a select few who mostly are urban and peri-urban dwellers, while leaving about 90% of the populace who reside in the hinterlands on consumption of less than 10 g as against recommended 35 g (Ahamefule *et al*., 2000) animal protein per day. This wide nutritional gap has fuelled the need to address the low per capita animal protein intake by Nigerians. Among the livestock of interest is rabbit, a cecotrophagus herbivore whose production has been low. What inspired the interest in rabbit are her short generation interval and good meat quality.

Intensive approach to rabbit production would however entail the use of alternative plant energy sources other than the conventional ones to enable 'keepers' produce meat at affordable price. Such alternative plant energy sources are currently under investigation in Nigeria; they are being evaluated for nutritiveness, availability, acceptability and affordability. It is in light of the above that roasted African star apple (*Chrysophyllum albidum*) kernel, a relatively unexploited energy source, is being assayed for its feed value.

African star apple (*Chrysophyllum albidum*) popularly called "Agbalumo" among the Yoruba tribe of Western Nigeria is also known as "Agwaluma" and "Udara" in Hausa and Igbo languages respectively. It is primarily cultivated for its sweet fleshy fruits which had been reported as an excellent source of vitamin C, iron, thickener or jam and flavours to diets, and raw materials to some manufacturing industries such as resin (Adisa and Fajola, 2000). Star apple belongs to the *Sapotacae* family and is believed to have originated from the low-lands of Central America and West Indian. It is common in both urban and rural centres in Nigeria especially during the months of December through April. The ripe fruit is highly perishable, and deteriorate within five days of harvest (Adisa and Fajola, 2000).

Several researchers (Adewoye *et al.*, 2010; Edem and Miranda, 2011; Agbabiaka *et al*., 2013) have reported on the nutritional and medicinal importance of *Chrysophyllum albidum*. Apart from the report of Jimoh *et al.* (2014) on haematological changes in the blood of *Clarias gariepinus* fed *Chrysophyllum albidum* seed meal as energy source, there is dearth of information on the potential of African star apple seeds/kernels as alternative feed source. Therefore, this study was aimed at evaluating the effect of roasted African star apple (*Chrysophyllum albidum*) kernel meal on the growth performance of growing rabbits.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Rabbit Unit of the Teaching and Research Farm of the School of Agriculture and Agricultural Technology of the Federal University of Technology, Gidan Kwano Campus (Permanent site), Minna, Niger State. Minna is located within latitudes 4°30' 09°30' and 09°45'N and longitudes 06° 30' and 06°45'E with an altitude of 1475 m above sea level (Climatemp, 2016). The area falls within the southern guinea savannah vegetation zone of Nigeria with average annual rainfall of between 1100 and 1600 mm and a mean temperature of between 21°C and 36.5°C (Climatemp, 2016). Minna experiences two distinct seasons; dry season (November to March) and wet or rainy season (April to October).

Experimental design and management of experimental animals

A total of forty eight (48) weaner rabbits of composite breeds and mixed sexes, aged between 5 and 6 weeks were procured from the rabbit section of National Animal Production Research Institute (NAPRI), Shika – Zaria, Kaduna State, Nigeria. They were randomly divided into four groups of twelve (12) rabbits per treatment with each treatment replicated thrice (4 rabbits per replicate) in a completely randomized design. The rabbits were housed according to treatments in a well-ventilated room in hutches. The hutches were fitted with drinkers and feeders. The rabbits were pre-conditioned for two weeks, during which they were treated twice (once a week) against parasitic infestation with Ivermectin subcutaneously. They had access to diet and clean water *ad libitum* over 12 week experimental period.

Experimental diets

Four experimental diets were formulated and designated as T1, T2, T3 and T4. Diet T1 served as control diet while Diets T2, T3 and T4 contained 5, 10 and 15 % Roasted African star apple kernel meal as substitute for maize in rabbit diets as shown in Table 1. A known quantity of the diets was served twice daily at 8.00am and 4.00pm and supplemented with 10g of *Tridax procumbens* per animal per day.

Table 1: Gross Composition of Experimental Diets

	Control	Roasted Kernels		
Ingredients (%)	0%	5%	10%	15%
Maize	40.00	38.00	36.00	34.00
Roasted ASAKM	0.00	2.00	4.00	6.00
Maize offal	25.00	25.00	25.00	25.00
Rice offal	18.00	18.00	18.00	18.00
Soyabean meal	2.00	2.00	2.00	2.00
Fish meal	1.20	1.20	1.20	1.20
Groundnut cake	10.00	10.00	10.00	10.00
Limestone	1.00	1.00	1.00	1.00
Bonemeal	2.00	2.00	2.00	2.00
Salt	0.20	0.20	0.20	0.20
*Premix	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20
Lysine	0.10	0.10	0.10	0.10
Total	100	100	100	100
Calculated Nutrients				
Crude protein (%)	17.41	16.85	16.85	16.85
Energy (Kcal/kg ME)	2647.50	2604.03	2604.03	2604.03
Crude fibre (%)	10.35	10.05	10.05	10.05
Ether extract (%)	4.08	4.11	4.11	4.11
Ca (%)	1.05	1.12	1.12	1.12
Avail. P	0.69	0.51	0.51	0.51

*Premix in diets provided per kg: Vit. A 10000 IU, Vit. B 2000 IU, Vit. E 13000 IU, Vit. K 1500mg, Vit. B12 10mg, Riboflavin 5000mg, Pyridoxine 1300mg, Thiamine 1300mg, Panthothenic acid 8000mg, Nicotinic acid 28000mg, Folic acid 500mg, Biotin 40mg, Copper 7000mg, Manganese 48000mg, Iron 58000mg, Zinc 58000mg, Selenium 120mg, Iodine 60mg, Cobalt 300mg, Choline 27500mg, ASAKM=African star apple kernel meal

Table 2: Proximate Composition of Roasted African star apple kernels

Nutrients,%	Raw kernel	Roasted kernel
Dry matter	93.21	93.09
Crude Protein	12.03	10.81
Crude fibre	5.10	5.10
Ether extract	1.45	1.70
Ash	1.85	1.55
Nitrogen free extract	72.78	73.93
Gross energy (Kcal/kg)	4001.0	4012.1
Metabolizable energy (Kcal/kg DM)	3147.23	3163.37

Table 3: Antinutrient Composition of roasted African star apple kernels

Antinutrients mg/100g	Raw kernels	Roasted kernels
Saponin	5.00	0.35
Tannin	7.33	1.08
Oxalate	12.41	2.00
Phytate	10.06	0.17

Data collection

Growth performance study

Rabbits were weighed individually at the beginning of the experiment and weekly thereafter for the duration of the experiment using weighing scale. Weighing was done before the morning feeding. The parameters determined for the evaluation of growth performance were initial weight (g), average feed intake (g), average weight gain (g) and feed conversion ratio. Weight gain for each animal was calculated by subtracting the initial weight (g) from the final weight (g), while the feed conversion ratio was calculated by dividing the average feed intake (g) by the average weight gain (g).

Blood collection

At the end of the study period, 5ml of blood was collected from three rabbits per treatment through the jugular vein of each slaughtered rabbit and put into bottles containing Ethylene Diaminetetra- acetic Acid

(EDTA) for haematological analysis. All the analysis was done at the General hospital, Minna according to the methods described by Kohn and Allen (1995).

Carcass and Organs Weight determination

At the end of the feeding trial, three rabbits per treatment were selected for carcass evaluation. The rabbits were fasted overnight but allowed access to water so as to empty the gut and allow excretion of the undigested feed residue. They were weighed, slaughtered, defurred using flame (singering) and then eviscerated. Internal organs (heart, liver, kidneys, lungs, viscera and spleen) were weighed and expressed as percentage of the live weight. The dressed carcasses were weighed and dressing percentage was calculated as a percentage of the dressed weight using the formula.

$$\text{Dressing percentage (\%)} = \frac{\text{Dressed weight}}{\text{Live weight}} \times 100$$

The carcass were subsequently cut into different portions viz: head, pelt, shoulder, rack/ribs, loin and hind legs, weighed on sensitive weighing scale and expressed as percentage of the dressed weight following the standard procedures described by Njidda and Isidahomen (2011).

Chemical analysis

Proximate composition of roasted African star apple kernel and experimental diets were analysed using the methods described by AOAC (2006).

Statistical analysis

Data collected were subjected to analysis of Variance using SAS software (SAS, 2008) while significant means were separated with Duncan multiple range test at 5% level of significance.

RESULTS

Tables 2 and 3 show the proximate and antinutrient compositions of the raw and roasted African star apple kernel used for the study. Table 4 and Figure 1 show the result of the effect of roasted African star apple kernel meal on growth performance of growing rabbits. There were significant (P<0.05) differences in the daily weight gain and feed conversion ratio of the rabbits. Daily weight gain and feed conversion ratio of rabbits fed 0, 5 and 10 % RASAKM diets were similar (P>0.05). The lowest daily weight gain was recorded among rabbits fed 15 % RASAKM diet. There was no significant (P>0.05) difference in the daily feed intake of rabbits.

Table 5 shows the result of the effect of roasted African star apple kernel meal on carcass characteristics of growing rabbits. There were significant (P<0.05) differences in the parameters measured except the weight of thigh, loin, foreleg, head and pelt (P>0.05). Rabbits fed 0, 5 and 10 % RASAKM diets recorded higher values (P>0.05) in most of the parameters measured.

Table 6 shows the result of the effect of roasted African star apple kernel meal on organ weight of growing rabbits. Significant differences (P<0.05) were observed on liver, intestinal weight and length while other organs were not influenced (P>0.05) by the dietary treatments.

Table 7 shows the result of the effect of roasted African star apple kernel meal on haematological parameters of growing rabbits. There were no significant (P>0.05) differences in the parameters measured except in the values of white blood cell and monocytes.

Table 4: Effect of roasted African star apple kernel meal on growth performance of growing rabbits

Levels, %	Initial weight, g	Final weight, g	Total weight gain, g	Daily weight gain, g	Daily feed intake, g	FCR	PER	EER
0	584.39	1948.60^{a}	1364.21^{a}	16.24^{a}	59.93	3.69^{a}	1.84^{a}	1.89
5	594.60	1868.64^{a}	1274.04^{a}	15.17^{a}	61.18	4.04^{a}	1.78^{a}	1.94
10	587.94	1899.20^{a}	1311.26^{a}	15.61^{a}	60.95	3.91^{a}	1.69^{a}	1.56
15	591.44	1773.07^{b}	1181.62^{b}	14.07^{b}	60.08	4.28^{b}	1.58^{b}	1.82
SEM	7.05	38.93	36.05	1.66	1.53	0.20	0.11	0.21
P-val	0.229	0.001	0.001	0.001	0.699	0.001	0.001	0.101
LOS	NS	**	**	**	NS	**	**	NS

abc= means with different superscripts on the same column are significantly different (P<0.05*, P<0.01**), SEM= Standard error of mean, P = Probability value. LOS = Level of significant. NS = Not significant. FCR= feed conversion ratio. PER = Protein efficiency ratio. EER = Energy efficiency ratio

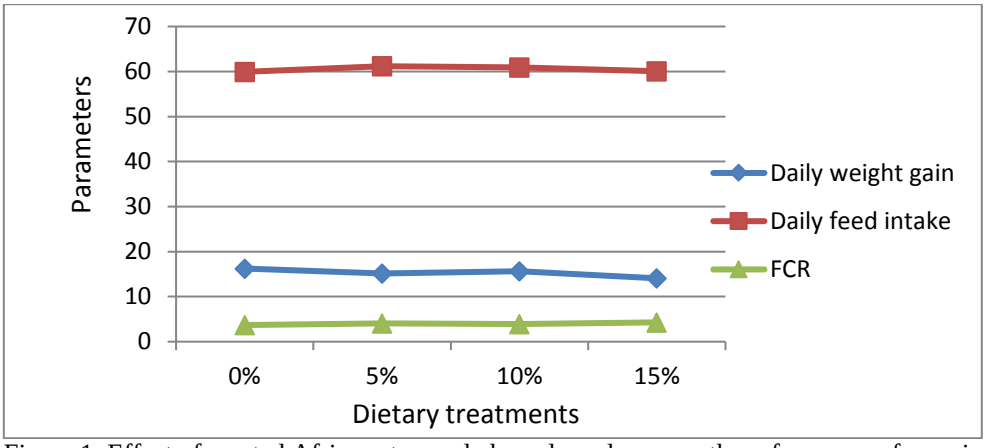

Figure 1: Effect of roasted African star apple kernel meal on growth performance of growing rabbits

Table 5: Effect of roasted African star apple kernel meal on carcass characteristics of growing rabbits

Parameters	0%	5%	10%	15%	SEM	P-value
Live weight, g	1984.60^{a}	1868.64^{a}	1899.20^{a}	1773.07^{b}	81.74	0.018
Slaughter weight, g	1861.15^{a}	1781.19^{a}	1811.75^{a}	1685.62^{b}	79.16	0.016
Dressed weight, g	1345.52^{a}	1265.56^{a}	1296.12^{a}	1169.99^{b}	77.05	0.015
Dressing %	69.05^{a}	67.70^{a}	68.23^{a}	65.95^{b}	1.32	0.026
Thigh %	8.15	6.95	6.34	7.22	0.78	0.504
Loin %	6.04	6.36	6.33	5.88	0.87	0.214
Hind leg %	2.87^{a}	2.14^{a}	2.31^{a}	2.10^{b}	0.17	0.005
Fore leg %	6.37	5.25	5.98	5.44	0.92	0.054
Head %	9.63	7.17	8.33	8.28	0.72	0.209
Pelt %	8.24	6.83	6.87	7.26	0.99	0.316

abc= mean with different superscripts on the same row are significantly different (P<0.05), SEM= Standard error of mean, P = Probability value. (means expressed as % of dressed weight)

Table 6: Effect of roasted African star apple kernel meal on organ weight of growing rabbits

Parameters	0%	5%	10%	15%	SEM	P-value
Lungs %	0.37	0.21	0.24	0.29	0.14	0.051
Kidney %	0.58	0.49	0.41	0.49	0.10	0.356
Liver %	1.21^{b}	1.24^{b}	1.31^{b}	1.98^{a}	0.24	0.023
Heart %	0.18	0.13	0.14	0.11	0.03	0.059
Spleen %	0.06	0.02	0.04	0.06	0.01	0.057
Intestinal weight, %	15.45^{a}	11.11^{b}	11.16^{b}	11.04^{b}	1.61	0.033
Intestinal length, cm	20.91^{a}	16.27^{b}	16.45^{b}	17.96^{b}	1.71	0.028

abc= mean with different superscripts on the same row are significantly different (P<0.05), SEM= Standard error of mean, P = Probability value. (means expressed as % of live weight).

DISCUSSION

The reduction in crude protein from 12.03% to 10.95 % observed in the roasted Star apple kernels in this work (Table 2) is in agreement with previous findings of Amaefule *et al*. (2003), Akinmutimi (2004) and Emenalom and Udedibie (1998) who obtained similar results with different legumes. This may be partly due to the burning off of some nitrogenous compounds during roasting (Emenalom and Udedibie, 1998). However, Emiola *et al*. (2002) reported increase in crude protein content of raw kidney beans when subjected to roasting. The anti-nutritional factors in the raw kernels were greatly reduced by roasting (Table 3). This is in agreement with the findings of Grant *et al*. (1991) that traditional processing methods can effectively reduce anti-nutritional factors in seeds of different plants.

Table 7: Effect of roasted African star apple kernel meal on haematological parameters of growing rabbits

Parameters	0%	5%	10%	15%	SEM	P-value
White blood cell ($X10^3/mm^3$)	8.37^{b}	9.40^{ab}	8.09^{b}	12.61^{a}	1.35	0.012
Red blood cell ($X10^6/mm^3$)	4.95	5.73	6.44	6.37	1.11	0.383
Haemoglobin (g/dl)	11.14	12.29	11.78	13.06	1.20	0.319
Packed cell volume (%)	38.44	40.34	43.60	45.48	6.07	0.521
Basophils (%)	1.33	1.71	1.54	1.52	0.42	0.752
Neutrophils (%)	40.87	44.91	46.51	44.68	4.98	0.584
Monocytes (%)	2.56^{c}	2.92^{c}	4.74^{ab}	3.50^{bc}	0.61	0.011
Lymphocytes (%)	47.98	65.32	55.46	64.79	7.74	0.073
MCH (pg)	22.61	22.08	18.92	21.31	4.78	0.791
MCV (fl)	77.37	73.49	70.36	74.61	20.34	0.979
MCHC (g/dl)	29.39	30.70	27.19	28.84	3.56	0.710

abc= mean with different superscripts on the same row are significantly different (P<0.05), SEM= Standard error of mean, P = Probability value. MCV= Mean corpuscular volume. MCH= Mean corpuscular haemoglobin. MCHC=Mean corpuscular haemoglobin concentration

The growth performance data shows that rabbits fed 15 % RASAKM replacement level had lowest final weight and average daily weight gain. This could be attributed to the effect of anti nutritional factors which were not completely eliminated in the roasted kernel. The average daily weight gain of rabbits fed 0, 5 and 10 % RASAKM diets (18.62, 17.47 and 16.69 g/d respectively) were similar. This shows that growing rabbits can tolerate up to 10 % RASAKM in their diets without adverse effect on the growth performance. The observed values for daily weight gain in this study were similar to the weight range of 17.65 to 18.80 g/d recorded by Agunbiade *et al.* (1999) for rabbits fed cassava leaf and peel meal in association with palm oil sludge as energy source. The values however surpassed 8.40 to 11.67 g/d reported for rabbits placed on varying levels of *Centrosema pubescens* or *Calapogonium mucunoides* (Aderinola *et al,* 2008) and 12.60 to 16.09 g/d reported by Uko *et al.* (1999) for rabbits fed cereal by-products. Ogunsipe *et al.* (2014) reported the daily weight gain of 21.14 to 25.36 g/d for rabbits fed Sorghum-offal based diets as energy source. The differences in these observations could be attributed to the variations in the chemical composition of various ingredients used and climatic factors such as temperature since these studies were conducted at different locations. Lebas (1983) had earlier reported that high ambient temperature such as the one in the tropics depresses feed intake and weight gain in rabbits. The similarity in the average feed intake of rabbits across the treatment groups could be probably due to lack of variation in the nutrient content of the various diets fed.

The result of carcass yield followed the same pattern as growth performance. The trend observed for these important indices of carcass composition was considered as an indication of the superior quality of the 0 %, 5 % and 10 % RASAKM diets over the 15 % RASAKM diet. The mean value for the carcass yield (65.95 to 69.05 %) in this study was higher than 46.86 to 51.55% reported for rabbits fed cassava root meal by Eshiet *et al.* (1980) and 47.17 to 51.77 % for rabbits fed sorghum offal based diets (Ogunsipe *et al.,* 2014). The significant difference observed on liver across the treatment groups suggested the presence of anti nutritional factors on the test ingredients. Agunbiade *et al*. (2002) and Ojebiyi *et al.* (2010) however reported non detrimental effects on liver of rabbits when cassava peel meal (CPM) and cassava peel and leaf meal mix respectively were fed as replacement for maize in diets of growing rabbits. The higher liver weight observed among rabbits fed 15 % RASAKM diet could be as a result of the activity of the liver to detoxify the possible anti-nutrients in the diet fed (Duya *et al.,* 1986). The significant differences (P<0.05) reported in some of the organs studied conform to the findings from previous researchers that dietary treatments exert some influences on certain organ weights (Agbede and Aletor, 2003; Ogunsipe and Agbede, 2010).

The values observed for all the blood indices measured showed that feeding RASAKM diets up to 15% replacement for dietary maize to growing rabbits was able to support normal rabbit growth. The value (8.37 to 12.61 $X10^3/mm^3$) obtained for WBC, though significantly higher for rabbits fed 15% RASAKM diet, was still within the normal physiological range for rabbits (RAR, 2007). The RBC values indicate that rabbits have normocytic and normochromic red cells (Aderemi and Wuraola, 2010). Thus, explaining that feeding RASAKM diets up to 15% replacement for dietary maize to growing rabbits does not affect the utilization of iron. The low value of eosinophil showed that the animal had no respiratory problem as high level of eosinophil could cause pulmonary dysfunction (Chattopadhyay *et al.,* 2007). The low value of monocyte, which is responsible for breaking

down foreign materials, suggests that the animals were not affected by disease (Chattopadhyay *et al.*, 2007).

CONCLUSION

The results of this study revealed that 10 % RASAKM can be substituted for dietary maize in rabbit diet. Above this level, there appears to be a decrease in performance characteristics of the growing rabbits.

Acknowledgement

The authors gratefully acknowledge Abuks, John Kambai, Ijalana Hellen and Abdullahi Nafiu for their assistance in the collection of data pertaining to this study.

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