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Growth performance and haemato-biochemical indices of growing rabbits fed African Star Apple *(Chrysophyllum albidum)* kernel meal

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SUMMARY

The effect of African star apple kernel meal (ASAKM) on growth performance, nutrient digestibility and haemato-biochemical indices of growing rabbits were investigated. One hundred and twenty 35-d old crossbreed (New Zealand x California white) rabbits weighing 591.00±0.15 g were randomly assigned to five dietary treatments (24 rabbits per treatment; 6 rabbits per replicate) in a completely randomized design. Five experimental diets (pelleted; 3 mm diameter and 6 mm in length) were formulated such that ASAKM replaced dietary maize at 0 %, 25 %, 50 %, 75 % and 100 % in rabbit diets (Diets 1, 2, 3, 4 and 5, respectively). The study lasted for 56-d. At 35 to 65-d of age, the average body weight and average daily weight gain in rabbits fed diets 2 and 3 were similar (P>0.05) to those fed the control diet. Also, the feed conversion ratio in rabbits fed diets 1, 2 and 3 (3.27, 3.34 and 3.31 respectively) were superior (P<0.05) compared to rabbits fed diets 4 (5.06) and 5 (6.88). Within 35 to 91-d, rabbits fed diets 1, 2 and 3 gained weight more than those fed diets 4 and 5 (P<0.05). Also, feed conversion ratio of rabbits fed diets 2 and 3 (2.87 and 2.89 respectively) were similar (P>0.05) to the control diet (2.84). The crude protein and ether extract digestibility of rabbits fed diets 3, 4 and 5 decreased compared to those fed control diet (P<0.05). The dressing percentage of rabbits fed diets 2 and 3 (65.35 and 65.64 %) were similar (P>0.05) to those fed control diet (65.58%). At 91 d of age, the neutrophil level and aspartate aminotransferase concentration of rabbits fed diets 2, 3 and 4 decreased significantly (P<0.05) compared to those fed the control diet. It could be concluded that ASAKM can be used up to 50 % in growing rabbits' diets with no adverse effect on growth performance, nutrient digestibility and haemato-biochemical indices of the animals.

ADITIONAL KEYWORDS

African star apple kernels.
Maize.
Boiling.
Rabbits.
Performance.
Haemato-biochemical.

Rendimiento de crecimiento e índices hemato-bioquímicos de conejos en crecimiento alimentados con harina de grano de manzana estrella africana *(Chrysophyllum albidum)*

RESUMEN

El objetivo del presente estudio fue realizar una evaluación de las curvas de crecimiento de la raza aviar azul andaluza, que se encuentra en peligro de extinción y tiene su población concentrada en Andalucía. Aunque actualmente se ha criado como raza ornamental, su producción puede considerarse a la hora de desarrollar sistemas de producción alternativos, y el huevo, que es el producto principal, tiene características diferenciales cuando se compara con los comerciales. Para el análisis de los datos de crecimiento, se ajustaron los modelos Gompertz, Von Bertalanffy, Brody, Verhulst y logísticos, basados en los 5 criterios de bondad de ajuste y flexibilidad: error cuadrático mediano, Pseudo-R2, criterio de información de Akaike, criterio de información de Akaike corregido y criterio de información bayesiana. Para las mujeres, el modelo que mejor se adaptaba era el modelo Gompertz, mientras que Von Bertalanddy era el modelo que mejor se adaptaba a los hombres. Los valores para los parámetros a (peso adulto), b (constante) y k (tasa de crecimiento) o m (determinación del punto de inflexión) se obtuvieron al ajustar estos modelos según el sexo. Se obtuvieron valores de 1.861,96 y 3.000,81 g para un parámetro, para gallinas y gallos, respectivamente. b los valores fueron de 4.240 y 0,865 para hembras y machos, respectivamente, mientras que los valores k fueron de 0,021 (hembras) y 0,013 (machos), lo que indica que la raza azul andaluza tiene valores muy similares a otras razas mediterráneas que fueron seleccionadas inicialmente para la producción de huevos y que tradicionalmente se han criado en sistemas extensivos.

PALABRAS CLAVE

Granos de manzana estrella africana.
Maíz.
Ebullición.
Conejos.
Rendimiento.
Hemato-bioquímica.

INFORMATION

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INTRODUCTION

The inclusion of alternative feedstuffs in animal diets might be interesting in some circumstances (relative price, feed quality), but it is limited because of the lack of information on their nutritive value. This is the case with African star apple (*Chrysophyllum albidum*) kernel meal, a by-product generated after the consumption of the fruits. African star apple as a conventional feedstuff are gotten mainly from plants which form the primary sources of medicine, food and shelter used by human on daily basis as their roots, leaves, fruits and seeds often provide food for humans (Amaechi, 2009). The fruits are also high in minerals, fibre and vitamins which are inevitable for human health (Ali and Deokule, 2009).

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 (Adisa and Fajola, 2000). 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; Ukana *et al.,* 2012; Agbabiaka *et al*., 2013) have reported on the nutritional and medicinal importance of *Chrysophyllum albidum*. Agbabiaka *et al*. (2013) reported that *Chrysophyllum albidum* seeds contain 14.66 % moisture, 10.13 % crude protein, 1.22 % crude fibre, 9.72 % lipid and 7.25 % ash while Ukana *et al.* (2012) reported the crude protein contents of African star apple peel; pulp and seed to be 6.68 %, 4.73 % and 8.75 % respectively with an average of 6.73 %. Fat contents of the peel, pulp and seed were 8.94 %, 10.00 % and 3.45 % respectively with an average of 7.46 %. Ukana *et al.* (2012) observed that the fat content of seed can be a good energy source, improve transport of fat soluble vitamins, insulate and protect internal tissues and contribute to vital cell process.

Many agricultural waste products have been harnessed and found suitable as substitutes for some conventional feed stuffs in rabbit diets (Sikiru *et al.*, 2019; Makinde *et al*., 2020). Jiya *et al.* (2018) noted that growing rabbits could tolerate up to 50 % raw tallow (*Detarium microcarpum*) seed meal in their diets with no adverse effect on growth performance. Also, Ogunsipe and Agbede (2012) observed that growth performance and blood parameters of growing rabbits were improved when fed with millet offal-based diets.

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 present paper reports experiment designed to investigate the growth performance, apparent nutrient digestibility and haemato-biochemical indices of growing rabbits fed different levels of African star apple kernel meal diets.

MATERIALS AND METHODS

The experiment was conducted at the Rabbitry Unit of the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, 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 annual rainfall of between 1100 and 1600 mm and temperature range between 210C to 36.50C (Climatemp, 2016; Makinde *et al*., 2017a). Minna experiences two distinct seasons (dry, from November to March and wet or rainy season, from April to October).

ANIMAL MANAGEMENT

One hundred and twenty 35-d old crossbred (New Zealand x California white) weaner rabbits of equal sexes weighing 591.00±0.15 g, certified healthy by a veterinarian, were allotted to 5 dietary treatments (24 rabbits per treatment; 6 rabbits per replicate) in a completely randomized design. The rabbits were housed in wire meshed cages, accommodated in a well-ventilated pen, supplied water and experimental diets *ad libitum* and the pen was cleaned and disinfected daily for 56 d which the study lasted.

PROCESSING OF THE TEST INGREDIENTS

The African star apple kernels used for this study were sourced from African star apple fruit farmers in Osogbo, Nigeria. African star apple seeds are always available between December and April. The seeds were gathered, washed with water to clean the dirts, allowed to dry under the shed for 3 d and carefully crushed with palm kernel machine so as to separate the kernel from the seed coat. Then, dried African star apple kernel was subjected to boiling at 100 °C for 15 minutes at the rate 1 kg kernel to 5 litre of water (Ahamefule *et al*., 2008; Jimoh *et al*., 2014) after which water was drained off by means of 10 mm sieve and the boiled kernels were air dried under the shed for 72 h, milled using hammer mill with a sieve size of 3 mm and analysed for dry matter, crude protein, ash, ether extract (AOAC, 2006); crude fibre (Goering and Van Soest, 1970); tannin, saponin, oxalate, phytate (AOAC, 2000) as shown in **Table I.** Gross energy was determined using adiabatic bomb calorimeter (Model: 1266, Parr Instrument Co., Moline, IL.) and benzoic acid as an internal standard while the digestible energy was estimated at 0.65 of the gross energy (Xiccato and Trocino, 2010).

Table I. Chemical constituents of African star apple kernel meal (Componentes químicas de la harina de grano de manzana estrella africana).

Parameters (%)	Quantity
Dry matter	92.83
Crude protein	13.26
Crude fibre	5.20
Ether extract	1.55
Ash	1.25
Nitrogen free extract	71.57
Gross energy (Kcal/kg)	4012.00
Digestible energy (Kcal/kg)	2607.80
Phytochemicals (mg/100 g)	
Tannin	0.61
Saponin	0.33
Oxalate	1.54
Phytate	0.17

All values are means of triplicate determinations expressed in dry weight basis (Todos los valores son medias de determinaciones por triplicado expresadas en peso seco.).

FEED FORMULATION

Five experimental diets (diets 1, 2, 3, 4 and 5) were formulated to support optimal rabbit growth (de Blas and Mateos, 2010) as shown in Table II. Diets 1 to 5 contained 0 %, 25 %, 50 %, 75 % and 100 % ASAKM, respectively as substitute for dietary maize. The diets were pelleted to 3 mm diameter and 6 mm in length and then analysed for chemical composition (**Table II**). Gross energy was determined using adiabatic bomb calorimeter (Model: 1266, Parr Instrument Co., Moline, IL.) and benzoic acid as an internal standard while the digestible energy was estimated at 0.65 of the gross energy (Xiccato and Trocino, 2010). The recommendations and guidelines for applied nutrition and experiments in rabbits were followed in management of the rabbits (Fernández-Carmona *et al.*, 2005).

One hundred and twenty 35-d old crossbred (New Zealand x California white) weaner rabbits of equal sexes weighing 591.00±0.15 g, certified healthy by a veterinarian, were allotted to 5 dietary treatments (24 rabbits per treatment; 6 rabbits per replicate) in a completely randomized design. The rabbits were housed in wire meshed cages, accommodated in a well-ventilated pen, supplied water and experimental diets ad libitum and the pen was cleaned and disinfected daily for 56 d which the study lasted.

DATA AND SAMPLE COLLECTION

The initial weights of the rabbits and feed were taken before the commencement of the study and wee-

Table II. Gross Composition of Experimental Diets (%) (35 – 91 d) (Composición bruta de las dietas experimentales (%) (35– 91 d).

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Ingredients (%)	0%	25%	50%	75%	100%
Maize	40.00	30.00	20.00	10.00	00.00
*Boiled ASAKM	00.00	10.00	20.00	30.00	40.00
Maize offal	25.00	25.00	25.00	25.00	25.00
Soyabean meal	12.00	12.00	12.00	12.00	12.00
Fish meal	1.20	1.20	1.20	1.20	1.20
Groundnut cake	18.00	18.00	18.00	18.00	18.00
Limestone	1.00	1.00	1.00	1.00	1.00
Bonemeal	2.00	2.00	2.00	2.00	2.00
Salt	0.20	0.20	0.20	0.20	0.20
**Premix	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
Chemical composition (%)					
Dry matter	91.61	93.70	91.51	93.90	92.12
Crude protein	15.70	16.42	16.03	16.18	15.33
Ether extract	4.00	5.15	5.06	4.25	4.75
Ash	3.81	3.64	4.29	3.46	3.66
Neutral detergent fibre	35.05	36.00	35.98	35.94	36.07
Acid detergent fibre	18.65	19.20	19.84	20.07	20.68
Acid detergent lignin	30.04	32.76	32.98	33.02	33.65
Gross energy (Kcal/kg)	4156.06	4137.91	4134.84	4176.07	4140.26
Digestible energy (Kcal/kg)	2701.44	2689.64	2687.65	2714.44	2691.17

*Boiled ASAKM=African star apple kernel meal. **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.

kly thereafter and the average daily feed intake, average daily weight gain and the feed conversion ratio were calculated for the 35-65 d, 66-91 d and overall 35-91 d periods. Blood samples were collected from 12 rabbits per group at 91 d of age for determination of haemato-biochemical indices. The selected rabbits were fasted overnight before blood collection. About 2.5 mL of blood were collected from the prominent ear vein of the rabbits using a ten-gauge hyposeranic needles. The blood sample was collected into labelled sterile bottles containing ethylenediamine tetra-acetic acid (EDTA) as anti-coagulant for the determination of haematological parameters, while another blood sample for serum analysis was collected into anticoagulant-free bottles, allowed to clot at room temperature and centrifuged at 3000 rpm for 10 min. The supernatant sera were harvested and stored at 4 °C in a refrigerator for subsequent biochemical analysis. At 91 d, after the collection of blood samples, the selected rabbits were weighed, tagged, stunned and euthanised as described by Blasco *et al.* (1993). The head, legs, skin, and intestines were removed and the dressing percentage was then calculated. The weights of internal organs (kidney, liver, spleen, lung, and heart) were determined separately and expressed as the percentage of live weight.

DIGESTIBILITY TRIAL

Digestibility study was carried out at 91 d of age according to the European reference method (Perez et al., 1995). Two rabbits per replicate were placed in their respective metabolic cages according to their treatments and were adapted for 2 d. Faecal samples were collected daily for 3 d, and oven dried at 60°C and ground to 2 mm sieve prior to chemical analysis. AOAC (2000) procedures were used to determine dry matter, crude protein, crude fibre, ash and ether extract compositions of the faeces.

BLOOD ANALYSIS

Packed cell volume and haemoglobin concentration determination followed the procedures outlined by Dacie and Lewis (2001). Red blood cell and differential total white blood cell counts were carried out using the Neubauer haemocytometer after appropriate dilution. Mean corpuscular haemoglobin concentratio, mean corpuscular haemoglobin and mean corpuscular volume were calculated as described by Makinde et al. (2017b). Cholesterol and serum total protein and its components (albumin and globulin) were obtained by the biuret method (Reinhold, 1953). Mineral elements were determined with atomic absorption spectrophotometer (Model 490, Gallenkamp and Co. Ltd., London). Serum urea nitrogen, creatinine, alanine transaminase, aspartate transaminase and alkaline phosphate were measured using the methods of Reitman and Frankel (1957) with modifications.

STATISTICAL ANALYSIS

Data were subjected to analysis of variance in a completely randomized design using SAS software (SAS Institute, 2015, Version 9.3). Significant difference between individual means was highlighted by Duncan's procedure of the same software. Mean differences were considered significant at $P<0.05$.

Table III. Effect of Boiled African star apple kernel meal on growth performance of growing rabbits (35 – 91 d) (Efecto de la harina hervida de manzana estrella africana en el rendimiento de crecimiento de conejos en crecimiento (35 – 91 d).

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	*P-value*
No. of rabbits	24	24	24	24	24		
35 to 65 d							
AIBW at 35-d (g)	590.34	591.00	591.13	591.18	590.45	0.74	0.9824
ABW at 65 d (g)	1127.20^{a}	1111.15^{a}	1125.64^{a}	944.57^{b}	851.96^{c}	21.82	0.0246
ADWG (g/d)	17.89^{a}	17.33^{a}	17.82^{a}	11.78^{b}	8.72^{c}	0.58	0.0038
ADFI (g/d)	58.56	57.89	59.01	59.59	60.00	0.70	0.6152
FCR	3.27^{a}	3.34^{a}	3.31^{a}	5.06^{b}	6.88^{c}	0.18	0.0410
66 to 91 d							
ABW at 91 d (g)	1792.64^{a}	1777.76^{a}	1792.57^{a}	1614.67^{b}	1518.62^{c}	6.72	0.0134
ADWG (g/d)	25.59	25.64	25.65	25.77	25.64	0.07	0.8543
ADFI (g/d)	63.71	64.52	65.87	64.24	66.27	0.86	0.7094
FCR	2.49	2.52	2.57	2.49	2.58	0.03	0.6177
35 to 91 d							
ABWG (g)	1202.30^{a}	1186.76^{a}	1201.44^{a}	1023.49^{b}	928.17^{c}	27.41	0.0154
ADWG (g/d)	21.49^{a}	21.19^{a}	21.45^{a}	18.28^{b}	16.57^{c}	0.08	0.0161
ADFI (g/d)	60.95	60.97	62.20	61.75	62.91	0.61	0.7142
FCR	2.84^{a}	2.87^{a}	2.89^{a}	3.38^{b}	3.80^{c}	0.09	0.0282

abc = means with different superscripts on the same row are significantly different ($P<0.05$), SEM= Standard error of mean, P = Probability value. AIBW=Average initial body weight. ABW=Average body weight. ABWG=Average body weight gain. ADWG=Average daily weight gain. ADFI=Average daily feed intake. FCR=Feed conversion ratio

RESULTS

The results of the effect of African star apple kernel meal on growth performance of growing rabbits are presented in **Table III**. At 35 to 65-d of age, the average body weight, average daily weight gain and feed conversion ratio in rabbits fed diets 1, 2 and 3 were better (P<0.05) than those fed diets 4 and 5. At 66 to 91-d of age, the average body weight in rabbits fed diets 1, 2 and 3 were superior compared to those fed diets 4 and 5 (P<0.05). Similar observations were made within 35 to 91-d.

The results of the effect of boiled African star apple kernel meal on carcass and relative internal organs of growing rabbits at 91 d of age are presented in **Table IV**. The results of slaughter weight, dressing percentage and liver weights of rabbits fed diets 1, 2 and 3 were significantly better compared to those fed diets 4 and 5 (P<0.05).

Table V showed the results of effect of African star apple kernel meal on nutrient digestibility of growing rabbits at 91 d of age. The crude protein and ether extract digestibility of rabbits fed diets 1 and 2 were significantly better (P<0.05) compared to those fed diets 3, 4 and 5.

The results of the effect of boiled African star apple kernel meal on haematological parameters of growing rabbits at 91 d of age are presented in **Table VI**. There were no significant differences (P>0.05) in all the parameters measured except neutrophil. The neutrophil level of rabbits fed diets 2, 3 and 4 decreased significantly compared to those fed the control diet.

Table VII showed the results of the effect of boiled African star apple kernel meal on serum biochemistry of growing rabbits at 91 d of age. There were no significant differences (P>0.05) in all the serum parameters analysed. Albumin, globulin, total protein, glucose, cholesterol, triglyceride and urea were not influenced (P>0.05) by the dietary treatments.

The results of the effect of boiled African star apple kernel meal on serum enzymes and electrolytes of growing rabbits at 91 d of age are presented in **Table VIII**. Compared to the rabbits fed the control diet,

Table IV. Effect of Boiled African Star Apple Kernel Meal on Carcass and relative internal organs (% live weight) of Growing Rabbits (35 – 91 d) (Efecto de la harina hervida de manzana estrella africana en la canal y los órganos internos relativos (% de peso vivo) de conejos en crecimiento (35 – 91 d).

Parameters (%)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	*P-valu*
No. of rabbits	12	12	12	12	12		
Slaughter weight (g)	1706.32^{a}	1691.45^{a}	1706.25^{a}	1528.35^{b}	1461.40^{c}	4.34	0.0075
Dressing percentage	65.58^{a}	65.35^{a}	65.64^{a}	61.85^{b}	61.36^{b}	0.13	0.0132
Lung	0.33	0.35	0.37	0.25	0.29	0.02	0.0725
Kidney	0.52	0.56	0.60	0.39	0.51	0.03	0.1187
Liver	1.73^{a}	1.83^{a}	1.89^{a}	1.53^{b}	1.37^{b}	0.08	0.0370
Heart	0.15	0.16	0.17	0.13	0.14	0.01	0.7689
Spleen	0.05	0.05	0.06	0.04	0.05	0.01	0.6196

abc = means with different superscripts on the same row are significantly different (P<0.05), SEM= Standard error of mean, P = Probability value. DW=Dressed weight. LW=Live weight. Dressing percentage=Hot carcass weight/live weight×100.

Table V. Effect of Boiled African star apple kernel meal on haematological parameters of growing rabbits (35 – 91 d) (Efecto de la harina hervida de manzana estrella africana sobre los parámetros hematológicos de conejos en crecimiento (35 – 91 d).

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	*P-value*
No. of rabbits	12	12	12	12	12		
White blood cell (x 10^3/mm^3)	9.24	10.67	8.75	7.61	9.37	0.39	0.0938
Red blood cell, (x 10^6/mm^3)	5.41	5.27	4.93	5.46	5.62	0.25	0.8343
Haemoglobin (g/dl)	10.42	10.75	10.62	10.55	10.39	0.21	0.9515
Packed cell volume (%)	31.34	31.45	32.67	31.67	31.15	0.28	0.2828
Basophil (pg)	1.45	1.29	1.27	1.40	1.32	0.15	0.4088
Neutrophil (%)	44.93^{a}	41.73^{b}	43.28^{b}	40.84^{c}	44.62^{a}	0.33	0.0384
Monocyte (%)	3.29	3.61	3.31	3.72	3..00	0.25	0.3599
Lymphocyte (%)	50.33	53.37	52.14	54.04	51.06	2.91	0.4187
Mean corpuscular haemoglobin (pg)	19.61	20.90	21.54	19.68	18.48	0.94	0.7117
Mean corpuscular volume (fl)	58.74	61.18	66.75	59.25	55.42	2.95	0.6295
Mean corpuscular haemoglobin concentration (g/dl)	33.25	34.21	32.58	33.32	33.38	0.76	0.9371

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

Table VI. Effect of Boiled African star apple kernel meal on haematological parameters of growing rabbits (35 – 91 d) (Efecto de la harina hervida de manzana estrella africana sobre los parámetros hematológicos de conejos en crecimiento (35 – 91 d).

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	*P-value*
No. of rabbits	12	12	12	12	12		
White blood cell (x 10^3/mm^3)	9.24	10.67	8.75	7.61	9.37	0.39	0.0938
Red blood cell, (x 10^6/mm^3)	5.41	5.27	4.93	5.46	5.62	0.25	0.8343
Haemoglobin (g/dl)	10.42	10.75	10.62	10.55	10.39	0.21	0.9515
Packed cell volume (%)	31.34	31.45	32.67	31.67	31.15	0.28	0.2828
Basophil (pg)	1.98	1.29	1.48	1.34	1.67	0.15	0.4088
Neutrophil (%)	46.93^a	41.73^b	43.28^b	37.24^c	48.72^a	1.33	0.0384
Monocyte (%)	3.29	3.61	3.31	2.72	3.99	0.25	0.3599
Lymphocyte (%)	57.33	53.99	52.14	51.03	64.06	2.91	0.4187
Mean corpuscular haemoglobin (pg)	19.61	20.90	21.54	19.68	18.48	0.94	0.7117
Mean corpuscular volume (fl)	58.74	61.18	66.75	59.25	55.42	2.95	0.6295
Mean corpuscular haemoglobin concentration (g/dl)	33.25	34.21	32.58	33.32	33.38	0.76	0.9371

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

Table VII. Effect of Boiled African star apple kernel meal on serum chemistry of growing rabbits (35 – 91 d) (Efecto de la harina hervida de grano de manzana estrella africana en la química sérica de conejos en crecimiento (35 – 91 d).

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	*P-value*
No. of rabbits	12	12	12	12	12		
Albumin (g/dl)	1.93	2.59	2.54	2.37	2.74	0.15	0.2946
Globulin(g/dl)	4.14	3.37	3.39	4.53	3.53	0.27	0.3552
Total protein(g/dl)	6.08	5.96	5.92	6.90	6.26	0.20	0.3136
Glucose (mmol/L)	3.06	2.44	3.01	2.54	1.95	0.32	0.6287
Cholesterol (mmol/L)	1.48	1.34	0.78	1.72	1.61	0.11	0.0514
Triglyceride (mmol/L)	1.31	2.20	1.32	1.97	1.21	0.19	0.1880
Urea (mmol/L)	2.20	3.21	3.02	2.85	2.79	0.24	0.5380

SEM= Standard error of mean, P = Probability value.

aspartate aminotransferase concentration in rabbits fed diets 2, 3, 4 and 5 (-15.92 iu/L, -29.31 iu/L, -18.86 iu/L and -12.68 iu/L, respectively; P=0.0043) reduced significantly.

DISCUSSION

The similarity observed in the average daily weight gain of rabbits fed diets 1, 2 and 3 suggests these diets were able to meet up with the nutrients required for rabbit growth and that growing rabbits would tolerate up to 50 % ASAKM in their diets without adverse effect on growth performance. Thus by implication, increased replacement of ASAKM for maize beyond 50 % level would lead to reduction in the average daily weight gain and poor feed conversion ratio of the rabbits. Similar observation was made by Jiya *et al*. (2018), who reported that growing rabbits could tolerate up to 50 % raw tallow seed meal in their diets and any level beyond this would have adverse effect on growth performance of rabbits. The observed decrease in the average daily weight gain and poor feed conversion ratio recorded among rabbits fed diets 4 and 5 could be attributed to poor utilization of the feed as a result of the presence of residual anti-nutrients such as oxalate, phytate and tannin in the diets compared to maize based diet. Obun et al. (2011) had earlier reported that anti nutritional factors (ANFs) interfere with metabolic process such that growth and bioavailability of nutrients are negatively influenced.

This observed decrease in digestibility of protein and ether extract could be ascribed to the tannin that is likely to increase as ASAKM increased in diets 4 and 5. Tannin as observed by some researchers has the ability to lock up or lower nutrients availability and digestibility (Agbede and Aletor, 2003). This might have led to poor availability, digestion, absorption and utilization of nutrients in feeds among rabbits fed these diets. These digestibility results suggest that 50 % was the optimum level of inclusion of ASAKM, above which digestibility of crude protein and ether extract could be adversely affected. The observations made in this study are similar to the results of digestibility of nutrients reported by Pinheiro *et al*. (2012) for rabbits fed raw potato starch as replacement for wheat starch.

The significant differences observed on slaughter weight and dressing percentage could be attributed to the variation in the final live weights of experimental rabbits, which was lowest in rabbits fed diets 4 and 5. This suggests that inclusion of African star apple kernel meal up to 50 % in diet of growing rabbit could promote the growth of edible portion of the rabbits (Devi *et al*., 2015) and that the anti-nutrients present in African star apple kernel meal exert direct or indirect effects on animal metabolism, probably by modulating animal metabolism in favour of increasing the development of edible portions of the rabbits (Valenzuela-Grijalva *et al*., 2017).

Of the entire relative internal organs weights measured, only the weights of liver was influenced by the dietary treatments. Ayodele *et al*. (2016) reported that relative weights of the internal organ of animals may increase or reduce abnormally in response to the presence of toxins in the diet. The liver, known as the largest gland in the body principally functions in the formation and secretion of bile, metabolism of nutrients and vitamins, inactivation of toxins, steroids and other hormones and synthesis of plasma protein such as acute-phase protein, albumin, clotting factors and steroid binding and other hormone-binding proteins (Williams, 2001). The liver weights range (1.37-1.89 % live weight) in this study was lower than 2.30-2.41 % body weight for rabbits fed diets containing soaked cassava peels (Oluremi and Nwosu, 2002) and 2.94-3.07 % live weight reported for rabbits fed millet offal-based diets (Ogunsipe and Agbede, 2012). The stability of the relative weight of other internal organs (heart, lung, kidney, and spleen) across the treatments as observed in this study also suggests the uncompromised health status of the experimental rabbits.

The blood profiles have been used widely to establish the health status of animals particularly when they are subjected to dietary treatment that could affect their well-being. Thus, Aro and Akinmoegun (2012) and Isaac et al. (2013) identified haemoglobin (Hb), PCV, WBC, RBC, MCH and MCHC among others as blood parameters that are useful in feed toxicity and feed quality monitoring and their effect on health status of the animals. In this study, only neutrophils was significant among the haematological parameters measured. The range of 37.24-48.72 % observed for neutrophil is within the normal range reported by Mitruka and Rawnsley (1977) for growing rabbits. The non-significant difference observed among most of the haematological parameters measured implies that the haematopoietic activity was enhanced identically by the dietary treatments and by extension the health status of the rabbit was not compromised by replacing maize with African star apple kernel meal in the diets of growing rabbit. Thus, in most cases the blood parameters reported here falls within the ranges reported by Latimer *et al.* (2003) and Ibrahim *et al*. (2014). Aspertate transaminase (AST) is being found in tissues such as liver, skeletal and cardiac muscles. It has been reported that an increase in enzyme's activity in serum may indicate problem in the cell population from which the enzyme is derived (Agbede *et al.*, 2011). The reduction observed in the mean values of AST from 87.46 to 58.15 iu/L among rabbits fed diets containing African star apple kernel meal cannot be attributed to liver disease or muscle damage since these values fall within the normal range of 33-99 iu/L reported by Flecknell (2000) and 35 -130 iu/L reported by Research Animal Resource (2009). The adequacy of the dietary treatment was further supported by the stability of the total protein, albumin, globulin, cholesterol, urea, creatinine, bilirubin and alkaline phosphate among the dietary treatments as there were no significant dietary effects observed for the rabbits.

CONCLUSION

The result obtained from this study showed that African star apple kernel meal can be considered as a high energy source in place of maize and growing rabbits could tolerate up to 50 % ASAKM in their diets without impairing the growth response and haemato-biochemical indices of the animals.

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