# Performance and nutrient digestibility of growing rabbits fed dietary processed kola nut (*Cola nitida*) pod-husk meal

**Samuel A. Adeyeye[1], Andrew B. Falowo[2], Olugbenga D. Oloruntola[2,*], Muyiwa H. Ogunsipe[3] and Johnson O. Agbede[4]**

[1]*Department of Animal Health and Production Technology, Federal College of Agriculture, Akure, Nigeria*
[2]*Department of Animal Science, Adekunle Ajasin University, Akungba Akoko, Nigeria.*
[3]*Animal Production Unit, Department of Agricultural Science, Adeyemi College of Education, Ondo, Nigeria*
[4]*Department of Animal Production and Health, The Federal University of Technology, Akure, Nigeria*

**Corresponding author email:* olugbenga.oloruntola@aaua.edu.ng

**This study examines the effect of dietary inclusion of processed kola nut (*Cola nitida*) pod-husk meal (PKPM) at varying levels on the performance and blood indices of the rabbit. A total of 120 rabbits were randomly allotted to four dietary treatment levels of PKRM: 0% (diet 1), 10% (diet 2); 20% (diet 3) and 30% (diet 4) in a completely randomized design arrangement. Each treatment group was replicated 10 times, with 3 rabbits/replicate. The result revealed that rabbit fed diet 3 (20% PKPM) had the highest final weight (1778g) and total weight gain (1255g) ($P \leq 0.05$), which was statistically similar to those fed diet 2 (10% PKPM) and diet 1 (control) but higher than those fed diet 4 (30% PKPM) ($P \leq 0.05$). The feed conversion ratios of rabbits on diets 1, 2 and 3 were similar ($P > 0.05$) but significantly ($P \leq 0.05$) better than those on diet 4. The apparent digestibility of the dry matter and crude protein of the rabbits fed diets 1, 2 and 3 were statistically similar (($P > 0.05$), but statistically better ($P \leq 0.05$) than those fed diet 4. No significant influence of PKPM was observed on haematological parameters (($P > 0.05$) across treatments. Rabbits fed PKPM diets had higher globulin counts and lower cholesterol values than those fed with no PKPM inclusion ($P \leq 0.05$). In conclusion, the inclusion of more than 20% PKPM could harm the rabbit's growth performance.**

**Keywords**: Agro-waste, anti-nutrients, rabbit, kola nut, performance, health

Rabbit (*Oryctolagus cuniculus*) is a non-ruminant, hindgut-fermenting herbivore requiring high fibrous feed materials (at least 20% of its diet) as the source of nutrients for maintenance and production. This is because rabbits possess distinctive digestive properties that can utilize high fibres (including hemicellulose, pectin, crude fibre and lignin) in the diet since low-fibre diets can cause reduced gut motility, reduced caecotroph formation and prolonged retention time of the digesta in the hindgut (Irlbeck 2001; Molina et al. 2015). This quality has necessitated the continuous search and utilization of low-cost agro-industrial by-products, such as cassava peel meal, cocoa pod husk meal and kola nut pod husk, as fibrous feed ingredients in the rabbit diet (Ozung et al. 2017; Eburu et al. 2020) to replace conventional feedstuffs or import dependent feed resources.

The kola nut (*Cola nitida*) pod husk, a by-product from the processing of kola nut fruit, usually regarded as waste until recently, when its nutritive potential was discovered (Fabunmi and Arotupin 2015). Kola nut pod husk is cheap and readily available across Nigeria. According to Fabunmi et al. (2019), kola nut pod husk constitutes over 50% of the kola fruit. Nutritionally, kola nut pod husk contains about 7.5% crude fibre, 13% crude protein and 2,546 Kcal/kg gross energy (Oluokun and Olalokun 1999). In terms of vitamin and mineral, Fabunmi et al. (2019) reported that kola nut pod husk contains 38.01 mg/100g ascorbic acid, 0.51 mg/100g retinol, 10.7 mg/100ml calcium, 6.86 mg/100ml sodium, 4.0mg/100 ml phosphorus and 4.5 mg/100ml potassium. However, the nutritional kola nut pod husk is also known to contain a relative amount of anti-nutritional properties such as, cyanide

0041–3216/2021/010047–056

(0.0015 µg/100g), caffeine (3.2%), theobromine, and nicotine (0.2%) among others (Jayeola et al. 2001; Okoli et al. 2012; Fabunmi et al. 2019) which could interfere with nutrient digestion and utilization and in turn affect growth performance, the immune system and carcass traits of the animal.

Different techniques, such as fermentation and enzymes supplementation was applied to detoxify the anti-nutritional factors (Fabunmi and Arotupin 2015). Eburu et al. (2020) found that the inclusion of fermented kola nut pod husk meal at above 20% significantly reduced the final weight, total weight gain, and apparent nutrient digestibility for rabbit compared to the control group that was fed 0% kola nut pod husk meal. In poultry, Emiola et al. (2006) and Fabunmi et al. (2019) also found that dietary inclusion of un-supplemented but sundried kola nut pod husk meal beyond 10% adversely affected the total body weight gain, dressing weight, dressing percentage and organ weights of the broiler chickens. However, in another study, Adeyeye et al. (2019a) reported dietary inclusion of un-supplemented but fermented kola nut pod husk at 10 and 20% improved carcass traits with no significant effect on the organ weights of rabbits compared to control.

Recent research has generally shown that kola nut pod husk can offer great potential as feed ingredients if properly handled and processed to eliminate the anti-nutritional content (Eburu et al. 2020). Therefore, this study's objective was to examine the dietary inclusion of processed (ash treated and rumen liquor fermented) kola nut pod husk meal on growth performance and blood indices of the growing rabbit.

## Materials and methods

### *Collection of kola nut pod husk, corn stalk, pullet excrement, and ruminal liquor*

This study was conducted at the Teaching and Research Farm, Federal College of Agriculture (FCA), Akure, Ondo State, Nigeria. The experimental site is located at 7°25' N and 5°19' E. The average annual temperature is 25.3 °C, with average annual rainfall of 1455 mm. The freshly gathered kola nut pod husks were hosed down and sliced into tiny pieces, sundried for 14 days, milled to kola nut pod-husk meal (KPM). Excrement from the pullets was collected from the Poultry Unit of the FCA, spread lightly on a clean concrete paving, sundried for 14 days and autoclaved to destroy microbial growth during sundrying. The dried pullet excrement (PE) was hammer milled and kept until used. Molasses were procured from the livestock feed mill dealers in Akure, Nigeria.

Dried corn stalks were gathered from FCA's annual crop unit and blazed to corn stalk ash (CSA). After that, the procedure of Adamafio et al. (2004) and Adeyeye et al. (2017) was used to produce the corn stalk ash extract (CSAE). Precisely, 39.2 g of CSA was immersed in 100 ml of deionised water for 48 hours at room temperature and after that sieved through cheesecloth to get the CSAE. The ruminal liquor was pressed out of the rumen content from recently killed cattle at the FCA's slaughtering slab using a muslin cloth and used for fermentation almost immediately post collection.

### *Processing of kola nut pod-husk meal*

The KPM was put through two different treatment processes, ash treatment and fermentation. The KPM was ash treated by following the procedure of Adamafio et al. (2004) and Adeyeye et al. (2017). Precisely, 188g of KPM was thoroughly mixed with 1 ml of CSAE in a plastic container and covered tightly for 186 hours. The CSAE submersed KPM was transferred into bags, drained, spread lightly on the concrete floor, and allowed to dry under sunlight for two weeks to form the ash-treated kola nut pod-husk meal (AKPM).

After that the AKPM was treated by

following the procedure for ruminal liquor fermentation described by Oloruntola et al. (2017) and Oloruntola et al. (2016). The PE was mixed with AKPM at the rate of 100 g/kg; after that, the resultant mixture (PE + AKPM) was mixed with molasses at 50 ml/kg. Subsequently, the mixture of PE, molasses and AKPM was showered with freshly collected cattle ruminal liquor in a black container and fermented anaerobically for 168 hours. The fermented AKPM was spread lightly under sunlight for 7 days and labelled as processed cocoa pod husk meal (PKPM) and analysed for proximate composition (AOAC 1995), theobromine (Bisto et al. 2002), caffeine (Rade et al. 2008), tannin (Shad et al. 2013) and saponins (Obadoni and Ochuko 2002).

### *Experimental diets*

Four experiment diets were formulated, such that maize was replaced with PKPM at 0% (diet 1), 10% (diet 2), 20% (diet 3) and 30% (diet 4). The four experimental diets were pelletized to 4mm diameter and 8mm long. The gross energy of the four PKPM diets was determined with Combustion Calorimeter (Digital Data Systems (Pty) Limited, South Africa) (Table 1).

Table 1: Composition of the experimental diets and processed kola nut pod-husk meal

| Ingredients (g/kg) | Levels of PKPM inclusion (%) | | | |
|---|---|---|---|---|
| | 0 | 10 | 20 | 30 |
| | Diet 1 | Diet 2 | Diet 3 | Diet 4 |
| Maize | 16.00 | 15.80 | 15.50 | 14.50 |
| PKPHM | 0.00 | 10.00 | 20.00 | 30.00 |
| Wheat offals | 2.50 | 1.50 | 1.50 | 1.50 |
| SBM | 8.65 | 7.65 | 7.65 | 7.65 |
| BDG | 25.90 | 26.10 | 19.40 | 13.40 |
| Rice Bran | 26.90 | 18.90 | 15.90 | 12.90 |
| SBH | 5.00 | 5.00 | 5.00 | 5.00 |
| Maize husk | 13.00 | 13.00 | 13.00 | 13.00 |
| Bone meal | 1.00 | 1.00 | 1.00 | 1.00 |
| *Premix | 0.25 | 0.25 | 0.25 | 0.25 |
| Methionine | 0.15 | 0.15 | 0.15 | 0.15 |
| Lysine | 0.10 | 0.10 | 0.10 | 0.10 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 |
| Vegetable oil | 0.30 | 0.30 | 0.30 | 0.30 |
| Cal. comp. (g/kg) | | | | |
| **ME (kcal/kg) | 2541 | 2541 | 2533 | 2541 |
| Calcium | 5.00 | 5.10 | 5.30 | 5.00 |
| Phosphorus | 3.10 | 3.20 | 3.00 | 3.00 |
| Anal. comp. (%) | | | | |
| Crude protein | 16.26 | 16.30 | 16.28 | 16.27 |
| Crude fibre | 15.77 | 16.81 | 16.79 | 16.80 |
| Ether extract | 3.14 | 3.12 | 3.14 | 3.13 |

| | Quantity (%) | |
|---|---|---|
| Composition | PKPM | UKPM |
| Crude protein | 21.30 | 8.00 |
| Crude fibre | 12.38 | 26.29 |
| Ash | 17.33 | 7.45 |
| Ether extract | 1.80 | 12.20 |
| Theobromine | 1.59 | 5.22 |
| Caffeine | 1.07 | 3.51 |
| Tannin | 0.98 | 4.98 |
| Saponin | 0.89 | 2.11 |
| GE (KJ/g) | 979.30 | 1282.14 |

PKPM: processed kola nut pod-husk meal, UKPM : unprocessed kola nut pod-husk meal; SBM: soy bean meal; BDG: brewers' dried grain.; SBH: soy bean hay; * Vit A 1200 IU; Vit K3 0.67mg; Vit B1 0.67mg;Vit B2 2.0mg; Vit B6 0.67mg; Vit B12 0.0004mg; pantothenic acid 16.7mg; biotin 0.07mg; folic acid 1.67mg; choline chloride 400mg; Zn 22.3mg; Mn 10mg;Fe 25mg; Cu 1.67mg; $I_2$ 0.25mg; Se 0.033mg and Mg 133.4mg. GE: gross energy; **ME: metabolizable energy = 37x%CP) + (81.8xFat) + (35.5x% NFE) (Pauzenga, 1985).

*Experimental animals*

One hundred and twenty 5-week-old rabbits (Chinchilla x New Zealand) of equal sex were procured from a commercial rabbit farm in Osun State, Nigeria. The rabbits were assigned to the four dietary treatments (10 replicates/dietary treatment; three rabbits/experimental unit) using a completely randomised design. In each dietary treatment, five replicates were all female, while the remaining five replicates were male. The rabbits were raised in cages set in a well-aerated pen. They were given prophylactic treatment against parasites and bacterial infection by administering an anti-coccidial drug, ivermectin, and oxy-tetracycline LA. After the 7 day adaptation period, the rabbits were offered free access to their respective experimental diets and water for 56 days.

*Response criteria*

The rabbit weight gains were the differences between their initial weights taken on day 1 of the experiment and the final weights taken on day 56. The feed consumption was the difference between the feed offered and the feed leftover. The feed conversion ratio was the ratio of feed consumed to the weight gain.

The nutrient digestibility was determined using the European reference method (Perez et al. 1995). Ten 42-day old rabbits were indiscriminately hand-picked from each experimental dietary group (one rabbit/replicate), placed in individual wire meshed cages and fed their individual experimental diets *ad libitum*. The four-day-faecal-collection commenced 7 days post adjustment (i.e. between 49 – 53 days of age). During this time, feed intake and faecal yield were gathered both from the individuals placed in cages and from the other nine rabbits in each treatment replicate. The faecal gathering was done at about 08:00 h each morning prior to feeding. The complete faecal output was gathered in the same individually tagged polythene sample bag and kept in the freezer (-18$^{o}$C). Dried feed and faeces were analysed for proximate composition (AOAC 1995), acid detergent fibre, and neutral detergent fibre (Van Soest et al. 1991).

On day 56 of the experiment, 10 rabbits (one rabbit/replicate) were randomly picked from each treatment. These rabbits were exsanguinated, as described by Burnett et al. (2006). Blood from each selected rabbit was collected into a bottle containing potassium ethylene diamine tetraacetic acid (K-EDTA) and into a plain bottle. The blood in K-EDTA containing bottles was examined for haematological parameters with a Shenzhen Mind ray Auto Haematology Analyzer, Model Bc-3200 (Shenzhen Mind ray Biomedical Electronics Co. Hamburg 20537, Germany). The sera set apart from the blood collected into the plain bottle were analysed for serum proteins (total protein, albumin, globulin), serum biochemical (cholesterol, creatinine, bilirubin), and serum enzyme (aspartate amino transaminase, AST) using a Reflectron ® Plus 8C79 (Roche Diagnostic, GmbH Mannheim, Germany).

## Data analysis

Data were subjected to the analysis of variance using Statistical Package for Social Sciences (SPSS) version 20. The means were separated out using Duncan's multiple range tests. Relationships between PKPM replacement levels and total weight gain, total feed conversion, and feed conversion ratio were determined using linear regression analysis.

## Results

*The performance of growing rabbits fed processed kola nut pod-husks meal inclusive diets*

Table 2 shows the growing rabbits' performances fed graded levels of processed kola nut pod-husks meal (PKPM) inclusive diets. Rabbits fed a diet containing 20% PKPM had the highest final weight (FW, 1778 g/rabbit) and total weight gain (TWG, 1255 g/rabbit), which was statistically similar ((P > 0.05) to those fed diet 2 (10% PKPM) and diet 1 (control) but higher (P ≤ 0.05) than those fed diet 4 (40% PKPM). The feed conversion ratio (FCR) of the rabbits on diets 1, 2, and 3 were similar ((P > 0.05) but significantly (P ≤ 0.05) better than those on a diet 4. The result of linear regression revealed a significant (P ≤ 0.05) relationship between the inclusion level of PKPM and FCR with regression equation: $FCR = 0.0173PKPM + 2.6736$; $R^2 = 0.35$, P = 0.04. The linear relationships between PKPM and TWG ($R^2 = 0.23$, P = 0.12), and between PKPM and TFI ($R^2 = 0.02$, P = 0.71) were not significant.

The effect of graded levels of PKPM inclusive diets on the apparent digestibility of growing rabbits is shown in Table 3. The apparent digestibility (AD) of the dry matter and crude protein of the rabbits fed diets 1, 2 and 3 were statistically similar ((P > 0.05) but statistically better (P ≤ 0.05) than those fed the diet 4. The PKPM dietary inclusion did not influence the apparent digestibility of crude fibre, neutral detergent fibre and acid detergent fibre across treatment groups.

The haematological indices of the growing rabbits fed graded levels of processed kola nut pod husk meal inclusive diets are shown in Table 4. The results did not reveal a significant ((P > 0.05) effect of PKPM on packed cell volume (PCV), haemoglobin concentration (HBC), red blood cells (RBC), white blood cell (WBC) and platelet values compared to the control group.

Table 5 shows the serum biochemical constituents of growing rabbits fed graded levels of PKPM meal diets. The results revealed that total serum protein, albumin, creatinine, bilirubin and aspartate aminotransferase concentrations of the rabbits were not significantly ((P > 0.05) influenced by PKPM dietary inclusion. However, the rabbits fed diets containing PKPM had higher (P ≤ 0.05) globulin values than the control group. In contrast, the rabbits on the control diet had higher (P ≤ 0.05) serum cholesterol value than PKPM treated groups.

Table 2: Performance characteristics of growing rabbits fed graded levels of processed kola nut pod husk meal inclusive diets

| Performance characteristics | Diet 1 (0%) | Diet 2 (10%) | Diet 3 (20%) | Diet 4 (30%) | SEM | P value |
|---|---|---|---|---|---|---|
| Initial weight (g/rabbit) | 524.2 | 523.2 | 523.5 | 524.5 | 0.28 | 0.83 |
| Final weight (g/rabbit) | $1748^{ab}$ | $1712^{ab}$ | $1778^{a}$ | $1531^{b}$ | 41.65 | 0.03 |
| Total weight gain (g/rabbit) | $1224^{ab}$ | $1190^{ab}$ | $1254^{a}$ | $1006^{b}$ | 41.80 | 0.03 |
| Total feed intake (g/rabbit) | 3462 | 3233 | 3488 | 3356 | 56.44 | 0.25 |
| Feed Conversion Ratio | $2.84^{a}$ | $2.72^{a}$ | $2.79^{a}$ | $3.39^{b}$ | 0.10 | 0.05 |

| Parameters | Regression equations | $R^2$ | P value |
|---|---|---|---|
| Level of PKPM inclusion vs. TWG | $TWG = -5.8853PKPM + 1256.5$ | 0.23 | 0.12 |
| Level of PKPM inclusion vs. TFI | $TFI = -0.6278PKPM + 3394.1$ | 0.02 | 0.71 |
| Level of PKPM inclusion vs. FCR | $FCR = 0.0173PKPM + 2.6736$ | 0.35 | 0.04 |

Means with contrasting superscripts in the same row are significantly different (P ≤ 0.05); PKPM: processed kola nut pod-husk meal**;** TWG: total weight gain; TFI: total feed intake; FCR: feed conversion ratio

Table 3: Apparent nutrient digestibility of growing rabbits fed graded levels of processed kola nut pod-husk meal inclusive diets

| Parameters (%) | Diet 1 (0%) | Diet 2 (10%) | Diet 3 (20%) | Diet 4 (30%) | SEM | P value |
|---|---|---|---|---|---|---|
| Dry matter | $64.38^a$ | $63.42^a$ | $62.97^a$ | $49.16^b$ | 2.22 | 0.01 |
| Crude protein | $71.53^a$ | $68.68^a$ | $67.08^a$ | $55.52^b$ | 2.19 | 0.02 |
| Crude fibre | 43.63 | 43.47 | 43.03 | 41.09 | 0.86 | 0.76 |
| Neutral detergent fibre | 34.41 | 33.42 | 33.36 | 33.28 | 0.86 | 0.97 |
| Acid detergent fibre | 27.39 | 27.31 | 27.21 | 27.13 | 0.48 | 1.00 |

Means with contrasting superscripts in the same row are significantly different ($P \leq 0.05$).

Table 4: Haematology of growing rabbits fed graded levels of processed kola nut pod-husk meal inclusive diets

| Parameters (%) | Diet 1 (0%) | Diet 2 (10%) | Diet 3 (20%) | Diet 4 (30%) | SEM | P value |
|---|---|---|---|---|---|---|
| Packed cell volume (%) | 33.48 | 33.52 | 34.33 | 34.26 | 0.18 | 0.18 |
| Haemoglobin conc. (g/dl) | 11.65 | 11.87 | 12.03 | 11.66 | 0.09 | 0.48 |
| Red blood cells ($\times 10^{12}$/l) | 5.24 | 5.48 | 5.59 | 5.45 | 0.11 | 0.77 |
| White blood cells ($\times 10^9$/l) | 4.04 | 4.10 | 4.14 | 4.08 | 0.03 | 0.59 |
| Platelets ($10^9$/l) | 185.00 | 200.00 | 194.67 | 194.84 | 4.51 | 0.75 |

Table 5: Serum biochemical constituents of growing rabbits fed graded levels of processed kola nut-pod meal inclusive diets

| Parameters (%) | Diet 1 (0%) | Diet 2 (10%) | Diet 3 (20%) | Diet 4 (30%) | SEM | P value |
|---|---|---|---|---|---|---|
| Total protein (g/l) | 67.02 | 67.78 | 66.40 | 67.84 | 0.63 | 0.87 |
| Albumin (g/l) | 52.65 | 54.83 | 55.79 | 55.57 | 0.58 | 0.21 |
| Globulin (g/l) | $14.79^b$ | $15.45^{ab}$ | $15.55^a$ | $15.32^{ab}$ | 0.12 | 0.03 |
| Cholesterol (mmol/L) | $1.36^a$ | $0.74^b$ | $0.59^b$ | $0.65^b$ | 0.12 | 0.04 |
| Creatinine (mg/dl) | 59.45 | 59.52 | 58.05 | 59.96 | 0.44 | 0.50 |
| Bilirubin (μ/l) | 1.05 | 1.10 | 1.07 | 1.08 | 0.04 | 0.97 |
| Aspartate aminotransferase (μ/l) | 11.90 | 11.42 | 10.69 | 13.81 | 0.61 | 0.34 |
| Alanine aminotransferase (μ/l) | 63.64 | 62.67 | 63.48 | 62.32 | 0.24 | 0.12 |
| Alkaline phosphate (μ/l) | 144.40 | 148.19 | 132.75 | 155.19 | 4.95 | 0.49 |

Means with contrasting superscripts in the rows are significantly different ($P \leq 0.05$).

## Discussion

In this study, the highest final weights and total weight gains were recorded in rabbits fed diet 3 (20% PKPM), which were statistically similar to those fed diet 1 (0% PKPM) and diet 2 (10% PKPM), but significantly higher than those fed diet 4 (30%PKPM). This suggests the suitability of PKPM as a good feed ingredient that can satisfactorily replace maize (up to 20%) in the growing rabbit diets. It also suggests that the ash and rumen liquor fermentation (techniques adopted in this study) is appropriate and efficient in detoxifying the anti-nutrients in the test ingredient to a tolerable level and improving its nutritive value (Oloruntola et al. 2018a). High intake of anti-nutrients from rations has been reported to produce a depressive effect on rabbit growth rates because of their ability to block metabolic pathways and reduce the bioavailability of many nutrients such as proteins, vitamins and minerals (Theil et al. 1997; Oloruntola et al. 2018b). This result contrasts with Eburu et al. (2020), who reported lower final weights and total weight gains in rabbits fed diets supplemented with fermented kola nut pod-husks meal at 20, 40, 60 and 80%, compared to the control group.

Similarly, this result also disagrees with Eniola et al. (2006), who reported that the dietary inclusion of unfermented kola nut husk meal at 10, 20 and 30% significantly decreased animal growth rates. The feed intake was not affected by increasing levels of PKPM, indicating the suitability of PKPM as an alternative feedstuff to reduce the maize requirement to feed the rabbit. This result is in line with Oluokun and Olalokun (1999) finding and Eburu et al. (2020), who reported an insignificant effect of kola nut pod meal and kola nut husk meal, respectively, on feed intake of the rabbit. The similar feed conversion ratios recorded for the rabbits in diets 1, 2 and 3 suggest comparable dietary nutrients' utilization in the rabbits up to 30% PKPH inclusion level, beyond which suboptimal nutrient utilization may occur.

The observed significant correlation between PKPM inclusion level and feed conversion ratio showed that as PKPM increases in diet, the feed conversion ratio also increases. This might explain why the rabbits on diet 4 (30% PKPM) had higher feed conversion ratios than the control and other treatments. This result is further supported by the regression of PKPM inclusion vs feed conversion ratio (Table 2). In another study, dietary inclusion of processed kola nut pod husk beyond 10% produces higher FCR in rabbit (Eburu et al. 2020). This variation may be due to some disparity in the processing techniques used in the two studies.

The observed lower apparent nutrient digestibility of dry matter and crude protein recorded in rabbit fed diet 4 (30% PKPM) compared to diet 1 (0% PKPM), diet 2 (10% PKPM), and diet 3 (20% PKPM) could be attributed to the inability of rabbits to properly utilize nutrients (particularly crude protein) in the diets due to the presence of anti-nutrients (Hamzat and Adeola 2011), since rabbits can utilize diets with high crude fibre (up to 20%) without causing any adverse effect on growth performance and nutrient digestibility (Battaa et al. 2017). This might further explain why rabbits fed diet 4 had the lowest growth rate and worst feed conversion ratio compared to other treatments. This result is in line with Eburu et al. (2020). They found that rabbits fed diets containing 20 – 80% fermented kola nut husk meal had lower apparent nutrient digestibility due to inherent anti-nutrient factors compared to the control. However, no significant differences were recorded in crude fibre, neutral detergent fibre and acid detergent fibre apparent digestibility across treatments, probably because the fibre content of the PKPM were easily degraded in the diet compared to the outcome of another study (Eburu et al. 2020). Evidence has revealed that high dietary fibre can significantly improve crude fibre, crude protein, energy efficiency and dry matter digestibility with the sequential increase in growth performance (Battaa et al. 2017). This result is in line with Emiola et al. (2006), who reported no significant difference in broiler chickens fed diets containing 10, 20 and 30% processed kola nut pod husk meal.

The observed non-significant effect of PKPM on packed cell volume, haemoglobin concentration, red blood cells, white blood cells, and platelets further confirms PKPM treatments' safety in supporting the normal haemapoietic process in the experimental rabbits. The higher globulin value recorded in rabbit fed diet containing PKPM at 10, 20 and 30% compared to control could be ascribed to the PKPM diet's ability to produce more immunologic action in the system. Globulins are a group of proteins synthesized in the liver by the immune system to elicit necessary immunologic action in the body to boost immunity and prevent infection and mortality (Battaa et al. 2017). Similarly, the observed lower cholesterol value in rabbits fed diets containing PKPM at 10, 20 and 30% compared to the control signifies possible anti-hypercholesterolemic compounds (e.g. tannin) in PKPM. Tannin was reported to possess the anti-hypercholesterolemic effects by reversing cholesterol transportation and reducing intestinal cholesterol absorption (Tebib et al. 1994). A report has shown that excessive cholesterol production can be a risk factor for atherosclerosis cardiovascular disease (Oloruntola et al. 2018b), which may easily predispose animals to other infections or illness. The observed non-significant influence of PKPM on total protein, albumin, creatinine, bilirubin, aspartate aminotransferase, alanine aminotransferase and alkaline phosphate across treatments further confirm the safety of the diets in maintaining the normal physiological functions in the rabbit. The values observed for these parameters were comparable to earlier reported normal values for the total protein: 66.61 – 73.29 g/l, albumin: 50.88 – 55.21 g/l, alkaline phosphate: 80.84 – 169.99µ/l (Oloruntola et al. 2018a), alanine aminotransferase: 53.50 – 60.25 µ/l (Adeyeye et al. 2019b), bilirubin: 1.27 – 1.44 mg/dl (Oloruntola et al. 2018c), creatinine: 66.05 – 73.10 mg/dl (Oloruntola et al. 2018d) and aspartate aminotransferase: 11.90 – 13.20 µ/l (Adeyeye et al. 2017).

## Conclusion

There have been variations in rabbits' responses to kola nut pod-husk meal dietary inclusion across the literature. However, findings from this study have shown that PKPM can be successfully included in rabbit rations up to 20% without causing any detrimental effect on their growth performance, nutrient digestibility and health status. This result is a departure from earlier studies that have reported reduced growth performance, carcass traits and nutrient digestibility in animal fed kola nut pod husk above 10% inclusion rate.

## References

Adamafio, N.A., E. Cooper Aggrinage, E.O. Onaye, J.K. Laary, and J. Onaye. 2004. "Effectiveness of Corn Stalk Ash in Reducing Tannin Level and Improving *In Vitro* Enzymatic Degradation of Polysaccharides in Crop Residues." *Ghana Journal of Science* **44:**87–92. DOI: 10.4314/gjs.v44i1.15904

Adeyeye, S.A., J.O. Agbede, V.A. Aletor, O.D. Oloruntola, S.O. Ayodele, A.A. Fadiyimu, and K. Sule. 2019a. "Carcass Traits and Relative Organs Weights of Growing Rabbits Fed Graded Levels of Processed Kola Nut (*Cola nitida*) Pod Husk." *Nigeria Journal of Animal Production* **46 (5)**: 112–119.

Adeyeye, S.A., S.O. Ayodele, O.D. Oloruntola, and J.O. Agbede. 2019b. "Processed Cocoa Pod Husk Dietary Inclusion: Effects on the Performance, Carcass, Haematogram, Biochemical Indices, Antioxidant Enzyme, and Histology of the Liver and Kidney in Broiler Chicken." *Bulletin of the National Research Centre* **43**:54.

Adeyeye, S.A., J.O. Agbede, V.A. Aletor, and O.D. Oloruntola. 2017. "Processed Cocoa (*Theobroma cacao*) Pod Husks in Rabbits Diet: Effect on Haematological and Serum Biochemical Indices." *Asian Journal of Advances in Agricultural Research* **2 (4):** 1–9. https://doi.org/10.1186/s42269-019-0096-8.

AOAC. 1995. *Official Methods of Analysis*. Arlington, VA, 16th ed. The USA. Association of Official Analytical Chemists Inc.

Battaa, A., M.E, Zeedan, I.I. Kh, and L.A.I. Abd El. 2017. "The Effect of Different Levels of Dietary Fibre Fractions on Performance and Immunity of Growing

Rabbits. I- The Effect of Using Corn Cubs as a Resource of Acid Detergent Fibre on Growth Performance, Digestion, Blood Constitute and Immunity System." *Egyptian Poultry Science* **33 (1):** 51–71.

Bisto, M.S., M.C.C. Veloso, H.L.C. Pinheiro, R.F.S. De Oliveira, J.O.N. Reis, and J.B. De Andrade. 2002. "Simultaneous Determination of Caffeine, Theobromine, and Theophylline by High-Performance Liquid Chromatography." *Journal of Chromatographic Science* **40**:45.

Burnett, N., K. Mathura, K.S. Metivier, B.B. Holder, G. Brown and M. Campbell. 2006. "An Investigation into Haematological and Serum Chemistry Parameters of Rabbits in Trinidad." *World Rabbit Science* **14**:175–187.

Eburu, P.O., P.O. Ozung, and R.O. Edem. 2020. "Replacing Dietary Maize with Kolanut Husk Meal can Influence Growth Performance and Apparent Nutrient Digestibility of Rabbits." *Merit Research Journal of Agricultural Science and Soil Sciences* **8 (1):** 15–20.

Emiola, I.A., O.O. Ojebiyi, R.A. Hamzat, T.A. Rafiu, G. Ogunwuyi, and A. Lawal. 2006. "Growth Response, Nutritional Digestibility and Organ Characteristics of Broiler Chicken Fed Graded Levels of Kola Pod Husk Meal (KPHM) in a Derived Savannah Zone of Nigeria." *International Journal of Poultry Science* **5 (9):** 885–889.

Fabunmi, T.B. and D.J. Arotupin. 2015. "Proximate, Mineral and Antinutritional Composition of Fermented Slimy Kola Nut (*Cola verticillata*) Husk and White Shell." *British Journal of Applied Science and Technology* **6 (5)**: 550–556.

Fabunmi, T.B., D.J. Arotupin, D.V. Adegunloye, M. Orunmuyi, and B.S. Odole. 2019. "Effects of Kola Nut Husk Formulated Feed at Graded Levels on Growth Performance and Health of Ross Broilers with and without Enzyme Inclusion." *Acta Scientific Agriculture* **3 (2)**: 105–113.

Hamzat, R.A. and O. Adeola. 2011. "Chemical Evaluation of Co-Products of Cocoa and Kola as Livestock Feeding Stuffs." *Journal of Animal Science Advances* **1**:61–68.

Irlbeck, N.A. 2001. "How to Feed the Rabbit (*Oryctolagus cuniculus*) Gastrointestinal Tract." *Journal of Animal Science* **79:**343–346.

Jayeola, C.O. 2001. "Preliminary Studies on the Use of Kola Nut for Soft Drink Production. *Journal of Food Technology in Africa* **6 (1):** 25–26.

Molina, J., J. Martorell, M. Hervera, J. Perez-Accino, V. Fragua, and C. Villaverde. 2015. "Preliminary Study: Fibre Content in Pet Rabbit Diets, Crude Fibre versus Total Dietary Fibre." *Journal of Animal Physiology and Animal Nutrition* **99 (1)**: 23–28.

Obadoni, B.O. and P.O. Ochuko. 2002. "Phytochemical Studies and Comparative Efficacy of the Crude Extracts of Some Haemostatic Plants in Edo and Delta States of Nigeria." *Global Journal of Pure and Applied Science* **8 (2):** 203–208.

Okoli, B.J., K. Abdullahi, O. Myina, and G. Iwu. 2012. "Caffeine Content of Nigerian Cola." *Journal of Emerging Trends on Engineering and Applied Sciences* **3 (5):** 830–833.

Oloruntola, O.D., J.O. Agbede, G.E. Onibi, and F.A. Igbasan. 2016. "Replacement Value of Rumen Liquor Fermented Cassava Peels for Maize in Growing Rabbit Diet." *Archivos de Zootecnia*. **65 (249)**: 89–97.

Oloruntola, O.D., J.O. Agbede, G.E. Onibi, F.A. Igbasan, and S.O. Ayodele. 2017. "Chemical Characterisation, Energy, and Zinc Bio-Availability of Cassava Starch Residues Fermented with Rumen Liquor and Different N-Sources." *Animal Research International* **14 (3)**: 2842–2859.

Oloruntola, O.D., J.O. Agbede, G.E. Onibi, F.A. Igbasan, S.O. Ayodele, M.A. Arogunjo, and S.T. Ogunjo. 2018a. "Rabbits Fed Fermented Cassava Starch

Residue I: Effect on Performance and Health Status." *Archivos de Zootecnia* **67 (260):** 578–586.

Oloruntola, O.D., J.O. Agbede, S.O. Ayodele, and D.A. Oloruntola. 2018b. "Neem, Pawpaw and Bamboo Leaf Meal Dietary Supplementation in Broiler Chickens: Effect on Performance and Health Status." *Journal of Food Biochemistry* **43 (2)**: e12723. https://doi.org/10.1111/jfbc.12723

Oloruntola, O.D., J.O. Agbede, G.E. Onibi, F.A. Igbasan, M.H. Ogunsipe, and S.O. Ayodele. 2018c. "Rabbits Fed Fermented Cassava Starch Residue II: Enzyme Supplementation Influence on Performance and Health Status." *Archivos de Zootecnia* **67 (260):** 588–595.

Oloruntola, O.D., J.O. Agbede, S.O. Ayodele, E.S. Ayedun, O.T. Daramola, and D.A. Oloruntola. 2018d." Gliricidia Leaf Meal and Multienzyme in Rabbits Diet: Effect on Performance, Blood Indices, Serum Metabolites, and Antioxidant Status." *Journal of Animal Science and Technology* **60:** 24.

Oluokun, J.A., and E.A. Olalokun. 1999. "The Effects of Graded Level of Brewers Spent Grains and Kola nut Pod Meal on the Performance Characteristics and Carcass Quality of Rabbits." *Nigerian Journal of Animal Production* **26**:71–77.

Ozung, P.O., O.O.K. Oko, E.A. Agiang, P.O. Eburu, E.I. Evans and C.E. Ewa. 2017. "Growth Performance and Apparent Nutrient Digestibility Co-Efficient of Weaned Rabbits Fed Diets Containing Different Forms of Cocoa Pod Husk Meal." *Agricultural and Food Sciences Research* **4 (1)**: 8–19.

Pauzenga, U. 1985. "Feeding Parent Stock." *Zootech. International*. pp. 22-25.

Perez, J.M., F. Lebas, T. Giddene, L. Maertens, G. Ziccato, R. Parigi-Bini, A. Dalle Zotte, M.E. Cossu, A. Carazzolo, M.J. Villamide, R. Carabano, M.J. Fraga, M.A. Ramos, C. Cervera, E. Blas, J. Fernandez, L. Falcao-eCunha, and F.J. Bengala. 1995. "European Reference Method for *in vivo* Determination of Diet Digestibility in Rabbits." *World Rabbit Science* **3**:41–43. DOI: 10.4995/wrs.1995.239

Rade, I., S. Branislava, P. Matevz, B. Marija, K. Katarina, and S. Borut. 2008. "Determination of Caffeine and Associated Compounds in Food, Beverages, Natural Products, Pharmaceuticals, and Cosmetics by Micellar Electrokinetic Capillary Chromatography." *Journal of Chromatographic Science* **46:**137–143.

Shad, M.A., H. Nawaz, T. Rehma and M. Ikram. 2013. "Determination of Biochemicals, Phytochemicals, and Antioxidative Properties of Different Parts of *Cichorium intybus* L.: A Comparative Study." *The Journal of Animal and Plant Science* **23 (4):** 1060–1066.

Tebib, T., P. Besancon, and J.M. Rouanet. 1994. "Dietary Grape Seed Tannins Affect Lipoproteins, Lipoprotein Lipases and Tissue Lipids in Rats Fed Hypercholesterolemic Diets." *The Journal of Nutrition* **124 (2)**: 2451–2457.

Theil, E.C., J.W. Burton, and J.L. Beard. 1997. "A Sustainable Solution for Dietary Iron Deficiency Through Plant Bio-Technology and Breeding to Increase Seed Ferritin Control." *European Journal of Clinical Nutrition* 51:28–31.

Van Soest, P.J., J.B. Robertson, and B.A. Lewis. 1991. "Methods for Dietary Fibre, Neutral Detergent Fibre and Non-Starch Polysaccharides in Relation to Animal Nutrition." *Journal of Dairy Science* **74**:3583–3597. doi: 10.3168/jds.S0022-0302(91)78551-2.