Renewable
Journal of the Faculty of Renewable Natural Resources,
University of Ibadan, Ibadan, Nigeria
Volume 2, No. 1, December, 2022
https://journals.ui.edu.ng/index.php/ren/index
ISSN: 2971-5776 (Prints)
2971-5784 (Online)
pp. 1-8

Growth Performance and Nutrient Retention of Rabbits Fed Graded Levels of Dietary Cooked Mango Seed Kernel (*Mangifera indica*)

Olatunji, G. J.[1] and Adebiyi, F. G.[1]*
[1]Agricultural Biochemistry and Nutrition Unit, Department of Animal Science,
University of Ibadan, Ibadan, Nigeria
*Corresponding Author: +2348099118283, fgadebiyi@gmail.com, fg.adebiyi@ui.edu.ng

Abstract

Globally, maize is recognized as a major energy feed ingredient in the livestock industry. This has resulted in competition for maize between man and animals as a basic energy source in diets. The resultant effect is the high cost of maize translating into a high cost of animal feeds. This has necessitated the exploration of some unconventional ingredients such as mango seeds as substitutes or partial replacements for maize in animal feed. In an eight-week feeding trial experiment, forty-eight weaner chinchilla rabbits were randomly allotted to four treatments containing 0% (T1), 35% (T2), 40% (T3), and 45% (T4) inclusions of sun-dried Cooked Mango Seed Kernel (CMSK) as substitutes for maize in animal feed. Each treatment consisted of six replicates of two rabbits, each. Feed intake, weight gain, Feed Conversion Ratio (FCR), as well as fat and protein retention were determined. Data obtained were analysed at $p<0.05$ level of significance. The inclusion of CMSK did not significantly affect feed intake. The daily weight gain of rabbits in T1 (8.01 g), T2 (8.26 g), and T3 (8.10 g) were similar and significantly higher than the weight gain of rabbits fed T4 diet (7.23 g). However, FCR did not significantly differ among treatments. The fat retention of rabbits ranged from 66.36% (T4) to 85.21% (T1), while protein retention was least for rabbits fed T4 (45.73%) and highest for those fed T3 (61.38%) diet. The study revealed that CMSK (40% substitution) could be incorporated into rabbit diets without deleterious effects on growth performance, fat and protein retention.

Keywords: *Mangifera indica*, Digestibility, Feed intake, Weight gain, Rabbits.

Introduction

The competition for maize between man and animal as a basic energy source in diets has been a great concern in developing countries. This has necessitated the need for non-conventional feed ingredients as alternate food sources for animals. However, such alternatives must have comparable nutritional value to maize. The production of non-conventional feedstuff offers reduced feed costs in the production of animals for meat as well as animal products (Dafwang *et al*., 2001). Okike *et al*. (2022) suggested the waste-to-wealth approach, in which the energy resources in by-products and organic wastes are harnessed and directly utilised as livestock feeds, in order to achieve reduced feed cost. Hence, numerous studies have investigated the potentials of organic materials as alternative feed ingredients in Nigeria. For example, organic materials such as cocoa husk (Adeyeye *et al*., 2019, Olugosi *et al*., 2020), rice bran (Deniz *et al*., 2007; Zare-Sheibani *et al*., 2015), raw and treated mango seeds (Odunsi, 2005; Diarra and Usman, 2008) have been studied.

Mango seeds have been reported to contain nutrients which are comparable to that of maize (Diarra *et al*., 2011). The mesocarp, which is the fleshy component of the fruit, is used in the fruit industry for the production of canned juice, pulp, and mango cuts (Mutua *et al*., 2016). The size of the epicarp and endocarp account for 15 – 20% w/w and 20 –60% w/w of the whole fruit, depending on the variety, while the kernel accounts for 45 –75% of the endocarp (Ashoush and Gadallah, 2011). Mango Seed Kernel (MSK) is a good source of carbohydrate (58-80%), moderate protein (6-13%) and fat (6-16%). It has metabolisable energy (ME) value which is similar to that of maize (Diarra and Usman, 2008; Diarra *et al*., 2011). The protein present in MSK is of high quality due to its high essential amino acid content and protein quality index (Abdalla *et al*., 2007). Also, mango seeds are good sources of methionine and lysine which are usually low in other plant protein feedstuffs (Lebaka *et al*., 2021). Diarra (2014) documented that the value of lysine in MSK ranged from 3.13 to 5.0g/100g of protein. This level of lysine is higher than that found in maize and soya beans, which contain 0.26g and 2.22g, respectively. Considering the nutrient potentials of MSK, its inclusion in the diet of monogastric animals such as rabbits may help to reduce feed costs and consequently improve the production efficiency and profitability of the enterprise.

However, mango seed kernels have been reported to contain antinutritional factors which could hinder their utilization when taken by animals. Various treatment methods have been used to reduce or remove these anti-nutritional factors and hence, increase the intake of feed by animals. Some of the methods include soaking, roasting, and boiling in sodium hydroxide (NaOH) or hydrochloric acid (HCl) (EL Boushy *et al*., 2000).

Previous studies have evaluated the inclusion of mango seed kernels as a replacement for maize in poultry feed (Diarra *et al*., 2010; Weldegerima *et al*., 2015; Moustafa *et al*., 2019; Admasu *et al*., 2020). For instance, Moustafa *et al*. (2019), observed that 10% replacement of maize with sun-dried MSK had no negative effect on the growth of Gimmizah cockerels. However, at 20% replacement, adverse effects were observed. There is therefore, limited information on the inclusion of cooked MSK in the diet of rabbits.

The high energy content of mango seed kernel meal, as well as the fact that its production period (between April and July), coincides with the critical period for grain availability in Nigeria (Diarra *et al*., 2014); make it a potential feed ingredient. Therefore, this study investigated the effect of replacement of dietary maize with graded levels of cooked mango seeds on the performance, and fat and protein retention of weaned chinchilla rabbits.

Materials and Methods

Study Site

The experiment was conducted at the Rabbitry Unit of Vegolal Farm, Arulogun, Ibadan, Nigeria. The rabbits were raised in an intensive system with hutches and fed ad-libitum. The laboratory analyses were carried out at the Agricultural Biochemistry and Nutrition Unit of the Department of Animal Science, University of Ibadan, Ibadan, Nigeria. All procedures and techniques reported in this study were carried out in conformity with the guidelines for the ethical conduct and reporting of research done with animals at the University of Ibadan, Ibadan, Nigeria.

Processing of Mango Seeds

The kernels of fresh cherry mango seeds were collected from a fruit processing industry in Ibadan, Oyo State, Nigeria. The mango seeds were air-dried to allow for easy removal of the kernel from the endocarp. The seeds were boiled for 30 minutes, drained, sun-dried, milled, and kept for further use (Diarra *et al*., 2010). The proximate composition of the mango seed kernels (MSK) was determined using the AOAC (1990) method (Table 1).

Table 1: Proximate composition of cooked mango seed kernel (CMSK)

Constituents	Composition
Moisture (%)	8.00
Crude protein (%)	8.20
Ether extract (%)	15.35
Crude fibre (%)	2.50
Ash (%)	2.20
Nitrogen free extract (%)	63.75
Gross energy (kcal/kg)	4503

Experimental Diets

The experimental diets consisted of cooked mango seed kernel (CMSK) at inclusion levels of 0%, 35%, 40%, and 45% in the feedstuff, during the eight weeks feeding trial. The level of CMSK inclusion in the diets was premised on the documentation of Amao and Siyanbola (2013), who observed better growth performance in experimental animals fed 30% heat treated MSK inclusion when compared to the maize-fed control group. Furthermore, Diarra (2014) concluded that maize could be replaced with 25% and 50% treated MSK in monogastric diets without any deleterious effect on the experimental animals. The percentage composition of the experimental diets is shown in Table 2.

Experimental Birds and Management

Using a completely randomised design, forty-eight chinchilla weaned rabbits (820-850 g weight), were randomly allotted to four treatment groups: 0% (T1), 35% (T2), 40% (T3), and 45% (T4) CMSK inclusions in feedstuff. Each treatment consisted of six replicates of two rabbits each. Feed and water were given ad-libitum.

Data Collection

Daily feed intake for each treatment group was recorded by finding the difference between the feed served and the leftover feed after 24 hours. The animals' live weights were measured using a digital weighing scale (PS-C30KS-30kg) at the start of the experiment and at weekly intervals, throughout the trial. The total weight gain was determined using the weekly weight gain data. The Feed Conversion Ratio (FCR) was calculated using the data obtained from weight gain and feed intake as stated in Eqn. 1:

$$FCR = \frac{\text{Total Feed intake (g)}}{\text{Total weight gain (g)}} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Determination of Nutrient Retention

Faeces and urine of the rabbits were collected within 72 hours to the end of the trial. The feed intake was also recorded during this period. The faeces were weighed, oven dried at 80°C for 24 hours and reweighed. The urinary outputs collected were measured using a measuring cylinder and the aliquots were kept in screw-capped glass bottles, and stabilized by adding 0.1N H_2SO_4. The urine and faeces were analysed for protein using the Kjeldahl method, while the faeces were analysed for fat retention following standard procedures (AOAC, 1990). The weights of diets consumed, as well as urine and faecal samples collected were used to calculate the nutrient intake and output, respectively. The nutrient retention was calculated using Eqn. 2:

$$Nutrient\ Retention = \frac{Nutrient\ Intake - Nutrient\ Output}{Nutrient\ Intake} x\ 100\% \ldots\ldots\ldots\ldots (2)$$

Statistical Analysis

The data collected were analysed using one-way ANOVA in version 25 of SPSS computer analytical software. Means of significantly different treatments were separated using Duncan's Multiple Range test. Significant variations were accepted at $p<0.05$.

Table 2: Experimental diets compounded with varying amounts of cooked mango seed kernel and their calculated nutrient composition

Ingredients	T1 (%)	T2 (%)	T3 (%)	T4 (%)
Maize	50.00	15.00	10.00	5.00
Cooked Mango seed kernel	0.00	35.00	40.00	45.00
Soya bean meal	20.00	20.00	20.00	20.00
Rice husk	14.35	14.35	14.35	14.35
Blood meal	5.00	5.00	5.00	5.00
Bone meal	1.50	1.50	1.50	1.50
Palm oil	7.00	7.00	7.00	7.00
DL –Methionine	0.10	0.10	0.10	0.10
*Vitamin/Mineral premix	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00
Calculated Nutrient Composition				
Crude protein (%)	18.06	18.15	18.10	18.04
Metabolisable energy (kcal/kg)	2815	2814.56	2815.89	2820.30
Crude fibre (%)	6.10	5.96	5.93	5. 89

*Vit. A -10,000,000 IU; Vit. D3 - 2,000,000 IU; Vit. E - 8,000 IU; Vit. K - 2,000 mg; Vit. B1 - 2,000 mg; Vit. B2 - 5,500 mg; Vit. B6 - 1,200 mg; Vit. B12 - 12 mg; Biotin – 30 mg; Folic acid – 600 mg; Niacin - 10,000 mg; Panthothenic acid - 7,000 mg; Choline chloride - 500,000 mg; Vit. C - 10,000 mg; Fe - 60,000 mg; Mn 80,000 mg; Cu - 8,000mg; Zn -50,000 mg; I - 2,000 mg; Co -450 mg; Se – 100 mg; Mg - 100,000 mg; Antioxidant - 6,000 mg.
T1 - 0% CMSK, T2 - 35% CMSK, T3 - 40% CMSK, T4 - 45% CMSK

Results and Discussion

The CMSK contained 8% moisture, 8.2% crude protein, 15.35% ether extract, 2.5% crude fibre, 2.2% ash, and 63.75% nitrogen-free extract on a dry matter basis. This proximate composition indicated that CMSK is a potential quality ingredient with a nutrient profile comparable to maize (Diarra, 2014; Mutua *et al*., 2016). The low moisture content of CMSK suggests that the feed ingredient would have a longer shelf life when included in rabbit diets. This is because moisture forms an important factor in feed formulation (Islam *et al*., 2015). Rabbit feed ingredients (especially grains) with more than 12% moisture content, have been reported to be at high risk of spoilage, with the likelihood of fungi growth, and proliferation of aerobic bacterial (Kaushik and Singhai, 2019). The crude protein, ash, crude fibre, and moisture content obtained in this study were similar to those earlier reported by Ashifat *et al*. (2012) and Mutua *et al.* (2016). The values also compare well with that of maize grains. This suggests that CMSK is a nutritious feed ingredient and could potentially contribute to the growth and well-being of rabbits.

In this study, the ether extract of the CMSK was higher than that of maize. Ether extract shows the crude fat content of a feed. Fat is an essential nutrient needed in the absorption of certain vitamins in the gut of animals and plays a major role in the provision of energy. The ether extract (15.53%) was higher than the values reported by Mutua *et al*. (2016) and Orijajogun *et al*. (2014). This higher value of fat content in CMSK might be due to differences in the varieties of mango species used in the different studies. Nevertheless, the fat content of CMSK was similar to that documented by Diarra (2014), who reported that mango seed kernel (MSK) was a good source of fat (6 – 16%) and proteins (6 – 13%). The inclusion of CMSK did not significantly affect the nutrient composition of the diets except for ether extract which was highest in 45% inclusion (Table 3). This corroborates the findings of Moustafa *et al*. (2019), that high fat contents were present in diets containing partial replacement of corn with dietary MSK.

There was no significant difference ($p = 0.067$) in the feed intake of rabbits fed graded levels of CMSK inclusion (Table 4). This implies that the boiling method used for processing the mango seed kernels improved feed intake to a level comparable to that of maize-based diets. The results conformed with the findings of Shittu *et al*. (2013), who recorded no significant differences in the average daily feed consumption of rabbits fed varying levels of sun-dried and parboiled MSK which were quantitatively substituted for maize. Likewise, Omer *et al*. (2019) found that the inclusion of CMSK at 0%, 25%, and 50% in feed had no significant effect on feed intake of sheep.

The daily weight gain of rabbits fed varying levels of CMSK differed significantly ($p = 0.034$) among the treatments (Table 4). The posthoc analysis revealed that daily weight gain of T1 (8.01 g), T2 (8.26 g), and T3 (8.10 g) were similar but higher than T4 (7.23 g). The similarity in weight gain among the three treatments could be an indication of the bioavailability of protein in the diets and the rabbits were able to convert it to muscle tissue. The lower inclusion of CMSK may also have resulted in lower anti-nutritional factors in the diets. Rabbits have been shown to utilize and convert protein to muscle mass at lower concentrations of anti-nutritional factors in MSK (Arogba, 2000). In addition, the observed decrease in weight gain of rabbits fed 45% CMSK inclusion could also be due to decreased feed intake.

The FCR which ranged from 8.19 (T1) to 8.80 (T4), did not significantly differ ($p = 0.052$) among the treatments (Table 4). This implies that feed ingested and converted to one kilogram of rabbit live weight was similar across treatments. Shittu *et al*. (2013), also reported that there were no significant differences in the FCR of rabbits fed with sun-dried and parboiled MSK meals.

The fat retention of rabbits fed T1 (85.21%), T2 (85.17%), and T3 (83.80%) were similar, but differed from that of T4 (66.36%). On the other hand, the protein retention followed a similar trend (Table 4). The reduction in fat and protein retentions at 45% CMSK may be attributed to the fact that CMSK may still contain a higher quantity of anti-nutritional factors which rabbits could not tolerate.

Table 3: Proximate composition of experimental diets formulated with varying levels of cooked mango seed kernel

Nutrient content	T1	T2	T3	T4	p value	SEM
Moisture (%)	10.50	9.00	10.00	10.00	0.052	0.75
Dry matter (%)	89.50	91.00	89.50	90.00	0.061	2.00
Crude protein (%)	19.20	19.22	19.00	19.17	0.054	0.72
Ether extract* (%)	8.00^{a}	8.25^{a}	9.05^{b}	10.06^{b}	0.034	1.20
Crude fibre (%)	15.10	15.25	15.58	15.62	0.056	1.02
Ash (%)	8.00	8.03	8.05	8.08	0.058	0.89
Nitrogen free extract (%)	39.20	39.53	37.92	37.21	0.060	2.30

* Indicates significant difference at $p < 0.05$ level of significance. Mean values with different superscript in the horizontal rows were significantly different. T1 - 0 % CMSK, T2 - 35 % CMSK, T3 - 40% CMSK, T4 - 45% CMSK
CMSK: Cooked Mango Seed Kernel, SEM: Standard Error of Mean

Table 4: Growth performance and nutrient retention of rabbits fed graded levels of cooked mango seed kernel

Parameters	T1	T2	T3	T4	p-value	SEM
Daily Feed intake (gram/day)	65.62	66.11	68.04	64.20	0.067	4.11
Daily weight gain (gram)	8.01 [a]	8.26[a]	8.10 [a]	7.23 [b]	0.034	1.35
FCR	8.19	8.25	8.4	8.80	0.052	0.71
Protein retention %	60.92 [a]	60.22 [a]	61.38 [a]	45.73 [b]	0.043	3.76
Fat retention %	85.21 [a]	85.17 [a]	83.80 [a]	61.38 [b]	0.036	1.86

FCR - Feed conversion ratio, CMSK: cooked mango seed kernel, SEM: standard error of mean
T1- 0 % CMSK, T2 - 35 % CMSK, T3 - 40% CMSK, T4 - 45% CMSK
Mean values in the same column with different superscripts were significantly different at $p < 0.05$

Mango seed kernels contain several anti-nutritional factors like tannins, phytate, cyanide, antitrypsin, oxalate, and saponins. These limit its utilization as feed ingredients for monogastric animals (Diarra, 2014). Nevertheless, fat and protein retentions of rabbits fed 35% and 40% CMSK compared favourably with the control diet (i.e., 50% maize). The cooking of the MSK caused structural changes in protein molecules and increased nutrient availability (Fayeye and Joseph, 2004). Therefore, low inclusion levels of heat-treated mango seed kernels in the diets of monogastric animals would enhance growth and development (Diarra *et al*., 2011).

Conclusion

This study revealed that the replacement of maize with cooked MSK (up to 40%), in the diets of weaned rabbits did not have any deleterious effect on their growth performance, protein, and fat retention. Therefore, CMSK, a non-conventional feedstuff, could be a valuable substitute for maize in the formulation of feed for weaned Chinchilla rabbits. However, further studies are required to determine the effects of CMSK inclusion on the haematology, biochemical indices, and carcass quality of the rabbits.

Acknowledgements

The authors are grateful to Vegolal Farm, Arulogun, Ibadan, Nigeria for granting access to facilities used to carry out the study. Also acknowledged is Chi Fruit Industry, Ibadan, Nigeria for supplying mango seeds used in this experiment. We thank the Laboratory Technologists at the Agricultural Biochemistry and Nutrition Unit of the Department of Animal Science, University of Ibadan, Ibadan, Nigeria for assisting with the laboratory analyses.

References

Abdalla, A. E., Darwish S. M., Ayad, E. H. and El-Hamahmy, R. M. (2007). Egyptian mango by-product 1. Compositional quality of mango seed kernel. *Food Chemistry* 103:1134–1140. doi: 10.1016/j.foodchem.2006.10.017.

Adeyeye, S. A., Ayodele, S. O., Oloruntola, O. D. and Agbede, J. O. (2019). 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. https://doi.org/10.1186/s42269-019-0096-8

Admasu, S., Wondifraw, Z. and Gash, M. (2020). Effects of replacing maize with boiled mango (*Mangifera indica*) seed kernel on feed intake, body weight gain and feed conversion ratio of Cobb 500 Broiler Chicken. *Poultry, Fisheries and Wildlife Sciences* 8: 1–10. https://doi.org/10.35248/2375-46X.20.8.211

Amao, E. A. and Siyanbola, M. F. (2013). Carcass and physiological response of broilers fed dry heat treated mango (*Mangifera indica*) kernel based diets. *International Journal of Livestock Production* 4 (3): 30-34.

Arogba, S. S. (2000). Mango (*Mangifera indica*) kernel: chromatographic analysis of the tannin, and stability study of the associated polyphenol oxidative activity. *Journal of Food Composition and Analysis* 13 (2): 149- 156.

AOAC. (1990). Official Methods of Analysis. 15th Edition, Association of Official Analytical Chemist, Washington DC.

Ashifat, A. A., Omotubga, S. K., Kehinde, A. S., Olayinka, O. O., and Edugbola, G. O. (2012). Proximate evaluation of nutritional value of mango (*Mangifera indica*). *International Journal of Research in Chemistry and Environment* 2: 244–245.

Ashoush, I. S. and Gadallah M. G. E. (2011). Utilization of mango peels and seed kernel powders as sources of phytochemicals in biscuit. *World Journal of Dairy and Food Sciences* 6:35–42.

Dafwang, J. I., Ikani, E. J., Chikwendu, D. O., Adesheinwa, A. O. K., Annate, A. I. and Iwuayanwa, I. E. J. (2001). An assessment of adoption of non-conventional feed stuffs by poultry and rabbit. *Poultry and Rabbit Research* (3): 3-5.

Deniz, G., Orhan, F., Gencoglu, H., Eren, M., Cengiz, S. and Turkmen, I. (2007). Effects of different levels of rice bran with and without enzyme on performance and size of the digestive organs of broiler chickens. *Revue de Medecine Veterinaire* 158: 336–343.

Diarra, S. S. and Usman, B. A. (2008). Growth performance and some blood variables of broiler chickens fed raw or boiled mango kernel meal. *International Journal of Poultry Science* 7 (4): 315-318.

Diarra, S. S., Usman, B. A. and Igwebuike, J. U. (2010). Replacement value of boiled mango kernel meal for maize in broiler finisher diets. *Journal of Agricultural and Biological Science* 5 (1): 47-52.

Diarra S. S. (2014). Potential of mango (*Mangifera indica* L.) seed kernel as a feed ingredient for poultry: a review. *World's Poultry Science Journal* 70: 279–288.

Diarra, S. S., Saleh, B., Kwari, I. D. and Igwebuike, J. U. (2011). Evaluation of boiled mango kernel meal as energy source by broiler chickens in the semi-arid zone of Nigeria. *International Journal of Science and Nature* 2 (2): 270-274.

El Boushy, A. R. Y. and van der Poel, A. F. B. (2000). Handbook of poultry feed from waste: processing and use. Second Edition. Springer-Verlag New York, 428

Fayeye, T. R. and Joseph, K. (2004). Effect of dietary dehulled, sundried mango kernel meal on growth and carcass characteristics of fryer rabbit. *Journal of Agricultural Research and Development* 3: 129-137

Islam, Md. S., Haque, Md. M. and Shakhawat Hossain, M. (2015). Effect of corn moisture on the quality of poultry feed. *Journal of Poultry Science and Technolology* 3 (2): 24–31.

Kaushik, R. and Singhai, V. (2019). An approach for the development of a sensing system to monitor contamination in stored grain. The Sixth International Conference on Signal Processing and Integrated Networks (SPIN), 2019, pp. 880-884, doi:10.1109/SPIN.2019.8711604.

Lebaka, V. R., Wee, Y. J., Ye, W. and Korivi, M. (2021). Nutritional composition and bioactive compounds in three different parts of mango fruit. *International Journal of Environmental Research and Public Health* 18 (2): 741 doi: 10.3390/ijerph18020741.

Moustafa, K. M. El-Breakaa, M. A., El-Saadany, A. S. and Farag, M. El. E. (2019). Effect of dietary mango seed kernel (*Mangifera indica*) as partial replacement of corn on productive and physiological performance of growing gimmizah cockerels. *Egyptian Poultry Science Journal* 39: 865–879.
doi.org/10.21608/epsj.2019.67507

Mutua, J. K., Imathiu, S. and Owino, W. (2016). Evaluation of the proximate composition, antioxidant potential, and antimicrobial activity of mango seed kernel extracts. *Food Science and Nutrition* 5 (2): 349-357. doi: 10.1002/fsn3.399.

Odunsi, A. A. (2005). Response of laying hens and growing broilers to the dietary inclusion of mango (*Mangifera indica* L.) seed kernel meal. Tropical *Animal Health and Production* 37 (2): 139-150.

Okike, I., Wigboldus, S., Samireddipalle, A., Naziri, D., Adesehinwa, A. O. K., Adejoh, V. A., Amole, T., Bordoloi, S. and Kulakow, P. (2022). Turning waste to wealth: harnessing the potential of cassava peels for nutritious animal feed. In: Thiele, G., Friedmann, M., Campos, H., Polar, V. and Bentley, J. W. (Eds.), Root, Tuber and Banana Food System Innovations: Value Creation for Inclusive Outcomes. Springer International Publishing, Cham, pp. 173–206. https://doi.org/10.1007/978-3-030-92022-76

Olugosi, O., Agbede, J., Onibi, G., Adebayo, I. and Ayeni, A., (2020). Biologically upgraded cocoa pod husk: Effect on growth performance, haemato-biochemical indices and antioxidant status of broiler chickens. *Journal of Food, Nutrition and Agriculture* 3: 26. https://doi.org/10.21839/jfna.2020.v3.333

Omer, H., Tawila, M., Gad, S. and Abdel Magid, S. (2019). Mango (*Mangifera indica*) seed kernels as untraditional source of energy in Rahmani sheep rations. *Bulletin of the National Research Centre* 43: 10. https://doi.org/10.1186/s42269-019-0241-4

Orijajogun, J. O., Batari L. M. and Aguzue O. C. (2014). Chemical composition and phytochemical properties of mango (*Mangifera indica*) seed kernel. *International Journal of Advanced Chemistry* 2: 185–187.

Shittu, M. D., Olabanji, R. O., Ojebiyi, O. O., Amao, O. A. and Ademola, S. G. (2013). Nutritional evaluation of processed mango (*Mangifera indica* - Kent) seed kernel meal as replacement for maize in the diet of growing crossbred rabbits. *Online Journal of Animal Feed Research* 3 (5): 210-215.

Weldegerima, G., Niguse, M., Gebresilassie, L., and Berhe, A. (2015). Evaluation of replacing maize with mango (*Mangifera indica*) kernel on fertility and hatchability parameters of layer hens. *Livestock Research for Rural Development* 27: 1-10.

Zare-Sheibani, A. A., Arab, M., Zamiri, M. J., Rezvani, M. R., Dadpasand, M. and Ahmadi, F. (2015). Effects of extrusion of rice bran on performance and phosphorous bioavailability in broiler chickens. *Journal of Animal Science and Technology* 57 (1): 1-5. https://doi.org/10.1186/s40781-015-0059-z

Renewable

Olatunji, G. J. and Adebiyi, F. G.
Journal of the Faculty of Renewable Natural Resources,
University of Ibadan, Ibadan, Nigeria
Volume 2, No. 1, December, 2022
https://journals.ui.edu.ng/index.php/ren/index
ISSN: 2971-5776 (Prints); 2971-5784 (Online)
pp. 1-8