

## Meat and Carcass Quality of Weaner Rabbits Placed on Three Different Plant Protein-Based Diets

\*<sup>1</sup>E.B. Ibitoye, <sup>1</sup>A.A. Jimoh, <sup>1</sup>D.A. Okegbire, <sup>1</sup>D.O. Ishola, <sup>2</sup>P.B. Gwimi and <sup>3</sup>A.M. Alayande

<sup>1</sup>Department of Theriogenology and Animal Production, Faculty of Veterinary Medicine, Usmanu Danfodiyo University Sokoto, Nigeria.

<sup>2</sup>Department of Veterinary Public Health and Preventive Medicine, College of Veterinary Medicine, Federal University of Agriculture, Zuru, Nigeria.

<sup>3</sup>College of Agriculture and Animal Science, Bakura, Zamfara State, Nigeria.

[\*Corresponding Author: Email: [eb.ibitoye@gmail.com](mailto:eb.ibitoye@gmail.com); ☎: +2347038228200]

### ABSTRACT

The study assessed the effect of replacing groundnut cake (GNC) with palm kernel cake (PKC) or cotton seed cake (CSC) on the meat and carcass characteristics of rabbits. Sixty mixed breed weaner rabbits of both sexes with an age range of eight to nine weeks old were randomly divided into three treatments 1, 2, and 3 of 20 rabbits per group. Rabbits in the group one (T1) served as the positive control and were fed GNC-based diet, while those in treatments two (T2) and three (T3) were fed PKC-, and CSC-based diets respectively. The results differed non-significantly ( $p > 0.05$ ) in the final body weight and carcass quality of the rabbits in each group. Carcass evaluation varied non-significantly ( $p > 0.05$ ) in terms of visceral (liver, lungs, hearts, and kidneys) and weights of primal cuts (neck, forelimbs, hindlimbs, chest, and back). Also, some of the meat's physicochemical properties showed no difference. The meat ratios bone of groups fed PKC- and CSC-based diets were insignificant ( $p > 0.05$ ) above the control. CSC significantly ( $p < 0.05$ ) increased the moisture, while PKC significantly decrease the nitrogen and crude protein contents of the meat of experimental rabbits. This study suggests that rabbits could be raised on a diet formulated using CSC as a replacement for GNC, while a PKC-based diet tends to decrease the protein content of rabbit meat.

**KEYWORDS:** Carcass, Meat quality, Plant protein, Rabbits

### INTRODUCTION

In 2022, Nigeria's population as estimated is about 216.7 million people. Demographic projections had shown that this number might experience a steady increase in the next decades. By 2050, it has been forecast that Nigeria's population will double to over 450 million people, compared to 2019 (Yeboua *et al.*, 2022). Therefore, one of the most important objectives is to supply the population with sufficient food. This implies that the agricultural and animal production has to be persistently intensified. Ordinarily, large and small domestic ruminants, swine, and birds are the usual provider of animals protein (De Vries-Ten Have *et al.*, 2020), principally for those living in the urban areas, however their demand is far above supply in Nigeria (Melinda Gates Foundation, 2021). This negative trend has been attributed to skyrocketing cost of animal products as a result of increased production cost coupled with a poor level of animal productivity. Subsequently, Taiwo and his team (2005) and Ibitoye *et al.* (2010) had documented several advantages of rabbit over livestock in the tropics and had advocated that its production to be intensified in Nigeria. However, animal production in many developing nations is being retarded due to poor quality and the inadequate supply of animal feed resources (International Atomic Energy Agency, IAEA 2011). This has therefore necessitated the need to find alternatives and low-cost feed resources that can be utilized in the rations of animals, and especially rabbits in Nigeria. This has led to efforts being made to assess the potentials of employing agro-industrial wastes for feeding food animals (Owen *et al.*, 2009; Ibitoye *et al.*, 2010; Ani *et al.*, 2013; Imonikebe and Kperegbe, 2014). Consequently, there could be a reduction in environmental pollution due to agro-industrial wastes (Liu *et al.*, 2012) and the use of traditional feed ingredients such as

maize, soybeans and groundnut cakes that, apart from being expensive are also consumed by humans. This means that wastes or neglected agro-industrial resources could be used for animal nutrition and be converted into animal protein in the form of eggs and meat.

Rabbit is noted for high prolificacy: attained puberty early; fairly short gestation; short generation length; and faster growth rate. Unlike poultry and swine, they do not compete with humans for feed stuffs, and are easily managed as they can be fed with kitchen wastes and other agro-industrial wastes, such as palm kernel cake (PKC) and cottonseed cake (CSC) (Świątkiewicz *et al.*, 2016; Umar *et al.*, 2019). They can convert feed to useful products efficiently, converting about 20% of the protein consumed in meat, while it is about 15 – 18% in pigs and 9 – 12% in cattle (Suttle, 2010), hence they are cheap and are cost-effective for subsistence production in homes (Cheeke *et al.*, 1988; Finzi and Amici, 1991). Rabbit meat is high in protein, low in calories and low in fat and cholesterol levels, it has been noted as a delicacy and a healthy food product, easy to digest, recommended in feeding children and old people, especially for candidates of cardiovascular illnesses and persons on a low sodium diet (Dalle Zotte *et al.*, 2020; Enser *et al.*, 1996; Hu and Willett, 2002). Rabbit meat is one of the best white lean meats available on the market, very tender and juicy. There is no religious taboo or social stigma regarding the consumption of this meat (Nistor *et al.*, 2013).

The common source of plant protein used in rabbit production is the groundnut cake (GNC) which is also being consumed by human and other monogastric animals, thereby leading to stringent competition for this product

between humans and animals making it very expensive and has resulted in high cost of production and inadequate feed supply. On the other hand, PKC is a waste product of palm oil industry. It is a potential non-conventional feed resource in animal production, since it is available and relatively cheap (Adesehinwa, 2007; Umar *et al.*, 2019). Its production is non-seasonal since the oil palm tree produces fruit year-round. The protein content of PKC has been reported to be 14–21%, the fibre content is 21–23%, the dry matter, lipid, ash and gross energy contents stood at 94%, 8 – 17%, 3–6% and 4,998 kcal/kg, respectively (Boateng *et al.*, 2008). Moreso, cottonseed cake (CSC) is a by-product of the oil and textile industries which is in abundance and an alternative protein source for use in poultry diets (Smith and Clawson, 1970; Świątkiewicz *et al.*, 2016). The crude protein, ash, crude fibre and crude fat content of CSC is 38 –50%, < 9%, 9– 16%, and < 2.5% respectively (Liu *et al.*, 2018). Furthermore, CSC contains a variety of amino acids, the content of lysine is around 1.6%, and it is 2.1% lower than that of soybean meal, and its methionine content is around 0.5%. The contents of arginine, proline, and phenylalanine are higher than those of soybean meal. In addition, CSC also contain a range of mineral elements and vitamins (Jalees *et al.*, 2011). However, the utilization of palm kernel cake and cotton seed cake in rabbit diets has not been extensively investigated. The objective of this research therefore was to determine and compare the effect of PKC and CSC with GNC on the meat and carcass characteristics of rabbits.

## MATERIALS AND METHODS

The experiment was done at the Rabbitry Unit of the Department of Theriogenology and Animal Production, Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto. Feed Ingredients such as maize, wheat bran, palm kernel cake (PKC), and groundnut cake (GNC) fish meal, salt, bone meal, and premix were obtained from two brothers Feed mill Company at Kaduna, Kaduna State, while the cotton seed cake (CSC) was obtained at Gusau central market, Zamfara State. The experimental diets (Table 1) were formulated and compounded manually, each containing one of the plant protein sources that have made all the ingredients available. Diet 1 is GNC-based, while diets 2 and 3 were PKC-, and CSC-based respectively. The design used for this study was completely randomized. The experimental diets and freshwater were given to the rabbits for five weeks *ad libitum*.

Sixty (60) weaner rabbits of mixed breeds (New Zealand white, Dutch black, and English spotted) of both sexes with an average initial weight of 780g and age range of eight to nine weeks were purchased from Sokoto metropolitan market and were used for this study. On arrival, the rabbits were dewormed with Levamisole and were given Vitalyte as anti-stress for the first three days and were allowed two weeks to acclimatize during which they were fed layers

mash and vegetables. Experimental diet replacement was gradually introduced after two weeks of acclimatization.

**Table 1:** Composition of experimental diet

Ingredients (kg)	Diet 1	Diet 2	Diet 3
Maize	55.57	55.57	55.57
Groundnut cake	17.43	0.00	0.00
Palm kernel cake	0.00	17.43	0.00
Cottonseed cake	0.00	0.00	17.43
Wheat bran	21.00	21.00	21.00
Fish meal	3.00	3.00	3.00
Bone meal	2.00	2.00	2.00
Salt	0.50	0.50	0.50
Premix	0.50	0.50	0.50
Total	100.00	100.00	100.00
Mathematically calculated proximate estimation			
Crude Protein (%)	17.96	13.40	17.26
Crude Fibre (%)	4.30	5.56	5.82
ME (kcal/kg)	2698.36	2727.99	2587.16

Key: ME = metabolisable energy

The animals were then randomly separated into three treatment groups (20 rabbits/treatment) and replicated twice (10 rabbits/replicate) in well cleaned and ventilated pens, each pen contained one feeder and one drinker. The pens were closely monitored throughout the experimental period of seven weeks, and cleaning of the equipment was done immediately as needed.

## Carcass and Meat Quality Analysis

Carcass characteristics and meat quality were determined. Twelve animals per treatment were selected at random, fasted for 12 h, weighed then slaughtered using the Halal slaughtering method. The skin was removed and the slaughter weight was measured using an SF-400 Electronic kitchen scale. The head, carpals, tarsals, tail and visceral were removed and the carcass was weighed again and expressed as percentage of live weight. The liver, kidney, heart, and lungs were isolated and weighed separately. The carcass was cut into parts such as hindlimbs, forelimbs, chest, and back and was also weighed separately. The Dressing percentage was expressed as:

$$\text{Dressing percentage} = \frac{\text{carcass weight}}{\text{Live weight}} \times 100\%$$

One hind leg per slaughtered rabbit per treatment was selected randomly and was dissected to provide the meat to bone ratio and a muscle portion weighing 10 g from the thigh of each skinned carcass was analyzed for the following parameters:

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### pH

Two grams of the meat sample was ground into pieces and was placed into a beaker, the electrode of the pH was rinsed with distilled water and was inserted into the beaker

containing the ground meat, while the pH of the meat was read on the pH meter (PHF 25) and was recorded. This was also repeated for each sample.

#### Moisture Content

A clean crucible (empty dish) was placed on a sensitive electronic weighing scale, the readings were recorded (as the weight of empty dish) while two grams of the meat sample was positioned in the empty dish and the weight was recorded the (as the weight of fresh sample). The crucible containing the meat sample was transferred to an Electric heater black dry box oven (101.1AB) and was heated overnight at 105°C until the sample was dried after which the sample was weighed again (as dry weight). The moisture content was calculated as follows:

$$\% \text{ moisture} = \frac{wA-wB}{wA-wC} \times 100\%$$

where: wC = mass of empty dish; wA = mass of fresh sample and wB = mass of dry sample.

#### Fat Content

Soxhlet apparatus was used to determine the fat content of the meat. Two grams of the grounded meat sample were placed into 20ml of Hexane in a round bottom flask, it was shaken thoroughly and kept overnight to make the solvent to extract the oil from the sample. After 6 hours it was mixed thoroughly, placed on a heating mantle (on the Soxhlet apparatus) for 3-4 hours after which it was allowed to cool. A petri-dish was picked, used as an empty flask and the lid/mouth of the round bottom flask containing the sample was opened gently to decant the solvent out of the oil. The collected solvent was placed on the heater again to evaporate the solvent leaving out the oil, then a clean flask was taken, weighed (as the weight of flask), the extracted oil was poured inside it and was weighed as again the (as the weight of oil). The fat content was calculated as follows:

$$\% \text{ fat} = \frac{\text{weight of flask} + \text{weight of oil}}{\text{weight of sample}} \times 100\%$$

#### Fibre Content:

The meat sample was poured into a cleaned conical flask, 20 ml of 10% H<sub>2</sub>SO<sub>4</sub> was added to it and was heated for 30 minutes after which it was taken to the tap and was filtered leaving the residues using a sieve. The residues were transferred to the flask again, 200 ml of water and 20 ml of 10% NaOH was added for distillation process and was heated for another 30 minutes, it was filtered and the residues was transferred into a crucible, placed on the heater to burn into ash, it was allowed to cool and was weighed (as ash weight). The fibre content was calculated as follows:

$$\% \text{ fibre content} = \frac{\text{Dry weight} - \text{Ash weight}}{\text{weight of sample}} \times 100\%$$

#### Nitrogen Content

The method used for this procedure is called the Micro-Kjeldahl method (digestion and distillation apparatus). Half a gram (0.5 g) of the rabbit meat sample was placed into the Kjeldahl flask and a digestion tablet (selenium which is a catalase that aids the speed of the reaction during digestion) was added. Ten milliliters of concentrated sulphuric acid were added and was placed on the heater for digestion, allowed to cool, and distilled water was added to dilute it. A measuring cylinder was used to measure the volume (as the volume of the sample after dilution) after which it was poured into a container and digestion is completed.

For the distillation procedure, aliquots of the digestion sample were transferred into a Kjeldahl flask, 20 ml of 40% NaOH was added, and the mouth of the flask was covered with a cork and was heated. A clean conical flask containing 20 ml of boric acid was placed under the Kjeldahl flask to trap ammonia gas released. For the titration process, 0.01 molar of H<sub>2</sub>SO<sub>4</sub> was used to titrate the trapped gas until it appeared pinkish in color. The volume of the acid used was recorded as titre value. The nitrogen content of the meat was calculated as follows:

$$\% \text{ Nitrogen} = \frac{TV \times 0.01 \times NF \times V}{W \times DF} \times 100\%$$

Where TV = Titre value, NF = nitrogen factor (0.014), V = volume of sample (ml), W = Weight of sample used and DF = Dilution factor.

The protein content was estimated using the relationship:  
% Protein = % Nitrogen × 6.25

#### Carbohydrate Content

The formula below was used to calculate the carbohydrate content of the meat.

$$\% \text{ Carbohydrate} = 100 - (\% \text{ nitrogen} + \% \text{ ash} + \% \text{ fat} + \% \text{ protein} + \% \text{ fibre})$$

#### Data Analysis

Data generated from the study were subjected to a one-way analysis of variance (ANOVA), using SPSS software version 20.0 and the results were expressed as mean ± standard deviation of mean. Differences between mean values of different groups were considered statistically significant at p < 0.05, using Tukey HSD as the post hoc test.

## RESULTS

### Carcass Characteristics and Organ Weight Analysis

The result presented in Table 2 are the carcass and relative organs characteristics of weaner rabbits fed three different formulated diets. No significant ( $p > 0.05$ ) difference was observed in terms of carcass characteristics and organs weight of experimental rabbits. However, final body weight was biologically highest ( $1165.67 \pm 138.06$  g) in the group fed GNC-based diet, closely followed by those fed PKC-

based diet ( $1147.00 \pm 160.89$  g), while it was lowest in the rabbit that received CSC-based diet ( $1090.67 \pm 125.86$  g). Conversely, carcass percentage was quadratically heaviest in the group fed CSC-based diet ( $50.63 \pm 6.77\%$ ) and lowest in the PKC treated group ( $48.65 \pm 2.13\%$ ). It was also revealed that the GNC treated group had the highest weights for lung, neck, hindlimbs, and back; the CSC group was highest for evaluated kidneys, heart, and chest while PKC had the heaviest weights of liver and forelimbs.

**Table 2:** Final body weight, carcass and relative organ Weight of rabbits fed formulated diets

	GNC-Based Diet	CSC-Based Diet	PKC-Based Diet
Final BW (g)	1165.67 ± 138.055	1090.67 ± 125.864	1147.00 ± 160.886
<b>Carcass and relative organ weight (%) of experimental rabbits</b>			
Carcass weight	49.99 ± 1.59	50.63 ± 6.77	48.65 ± 2.13
Liver	2.94 ± 0.23	3.23 ± 0.39	3.39 ± 0.31
Lung	0.67 ± 0.06	0.60 ± 0.17	0.64 ± 0.02
Kidneys	0.62 ± 0.07	0.68 ± 0.07	0.66 ± 0.09
Hearts	0.21 ± 0.06	0.28 ± 0.05	0.21 ± 0.02
Neck	2.74 ± 0.20	2.34 ± 0.53	2.67 ± 0.34
Forelimb	3.33 ± 0.29	3.81 ± 0.49	4.27 ± 0.62
Hindlimbs	6.86 ± 0.18	6.84 ± 0.97	6.50 ± 0.25
Chest	7.78 ± 0.48	9.48 ± 1.50	8.08 ± 1.01
Back	17.65 ± 0.96	16.71 ± 2.02	16.26 ± 0.38

Key: GNC: groundnut cake; CSC: cotton seed cake; PKC: palm kernel cake; BW: body weight

### Meat Quality Analysis of Rabbit Fed Three Different Plant Proteins

These feeding trials affected the meat quality of weaner rabbits in terms of moisture, nitrogen, and protein content as shown in Table 3. The moisture content of meat from rabbits fed CSC was higher ( $p < 0.05$ ) than observed in the control (GNC) group. There was no difference ( $p > 0.05$ ) in moisture content between GNC and PKC and between CSC and PKC. The meat nitrogen and protein content were significantly ( $p < 0.05$ ) higher in GNC ( $14 \pm 0.01\%$  and  $19.60 \pm 0.05\%$ ) and CSC ( $3.09 \pm 0.03\%$  and  $19.44 \pm 0.24\%$ ) treated groups when compared the PKC group. It was also noted that meat to the bone ratio ( $6.55 \pm 0.34$ ) and fat ( $3.00 \pm 0.00\%$ ) were biologically highest for the CSC treated group, while these parameters were lowest in the GNC treated group ( $5.81 \pm 0.34$  and  $2.67 \pm 0.17\%$ ).

## DISCUSSION

Although PKC is known to contain anti-nutritional factors such as phytic acid, tannic acid, and oxalate (Akinoye *et al.*, 2011), rabbits have been reported to efficiently hydrolyzed phytic acid in their caecum (Marounek *et al.*, 2003), while tannic acid and oxalate are in low values that are expected not to compromised nutrition (Santish and Chauchan, 1986). The non-significant effect of PKC and

CSC with the control group on the final body weight observed in this study was in agreement with the findings of Aduku *et al.* (1998) who reported that PKC compared favorably with GNC in the diets of weaned rabbits without significant difference in the final live weight. Although the present study and that of Aduku *et al.* (1998) used different inclusion levels, it indicated that the effect of dietary CSC and PKC might not be dose-dependent.

The carcass weight was shown to be heaviest in the group fed CSC-based diet as the protein source, this might be due to the higher amount of fat and moisture accumulated in this group. The weights of the neck, chest, back, forelimbs, and hindlimbs did not show any significant differences across the groups. This is an indication that all experimental diets had no adverse effect on the carcass traits of rabbits. From the results of this study, there is an indication that CSC and PKC are non-toxic to the study animals, as a result of the non-significant impact on organs like the liver and heart (Akinmutimi *et al.*, 2004). However, the results obtained in this study did not reveal any effect on the weights of the kidney, lungs, liver, and heart. On the meat quality of rabbits in this study, the feeding trials significantly ( $p < 0.05$ ) affected the moisture in the meat in the PKC and CSC groups might have been due to higher fibre content in

the PKC-and CSC-based diets, which might have triggered increased in water consumption (Gita, 2020). According to Chodová and Tůmová (2013) and Wang *et al* (2016), the

proteins of rabbit's meat have a high nutritional value, because it contains all essential amino acids.

**Table 3:** Proximate analysis, pH and meat to bone ratio of meat from rabbits fed three different plant protein sources

	GNC-Based Diet	CSC-Based Diet	PKC-Based Diet
<b>Meat: Bone Ratio</b>	5.81 ± 0.34	6.55 ± 0.34	6.23 ± 0.64
<b>pH</b>	6.04 ± 0.16	5.76 ± 0.16	5.82 ± 0.05
<b>Moisture (%)</b>	70.50 ± 0.00 <sup>b</sup>	71.67 ± 0.33 <sup>a</sup>	71.33 ± 0.17 <sup>a, b</sup>
<b>Fat (%)</b>	2.67 ± 0.17	3.00 ± 0.00	2.83 ± 0.17
<b>Ash (%)</b>	4.50 ± 0.00	4.50 ± 0.00	4.67 ± 0.17
<b>Nitrogen (%)</b>	3.14 ± 0.01 <sup>a</sup>	3.09 ± 0.03 <sup>a</sup>	2.87 ± 0.01 <sup>b</sup>
<b>Crude protein (%)</b>	19.60 ± 0.05 <sup>a</sup>	19.44 ± 0.24 <sup>a</sup>	17.97 ± 0.06 <sup>b</sup>
<b>Carbohydrate (%)</b>	2.23 ± 0.21	0.99 ± 0.47	2.53 ± 0.63
<b>Fibre (%)</b>	0.50 ± 0.00	0.50 ± 0.00	0.50 ± 0.00

Means within the same row with different superscripts <sup>a, b</sup> are significantly different at  $p < 0.05$ ; GNC = groundnut cake; CSC= cotton seed cake; PKC = palm kernel cake

As reported in this study, the crude protein content in the meat of experimental rabbits differs significantly among the treatment groups with the GNC group having the highest followed by CSC and lower in PKC. In agreement with the conclusion of Wolfe (2012) that increased dietary protein positively correlated with increased muscle protein, in this study protein sources had respectively furnished their protein in the meat of experimental animals. The increased value in the GNC group might be due to the higher level of the total crude protein composition of GNC-based diet, closely followed by CSC group and very low in the PKC group might also be as a result of the total crude protein composition in them being very low compare to GNC- and PKC-based diets. As reported by Fraga *et al.*(1983) and Drummen *et al.* (2018) that if the diet has an excess of protein in relation to energy, retention of nitrogen may be slightly improved. As obtained in this study, the group with the highest protein content in the meat analysis had the highest nitrogen content and this goes with the other diets.

There was no significant difference in the meat pH analysis of the three diets, however; that of the GNC-based diet is slightly higher than that of CSC- and PKC-based diets. Although, the pH of meat is influenced by the glycogen stores in the muscle at the time of slaughter, and in rabbits it usually lies between 5.3 and 6 (Hulot and Ouhayoun, 1999). The pH value depends on the balance of muscle energy metabolism and represents a key role in the maintenance of meat quality during storage (Dalle Zotte, 2002). Also, the meat to bone ratio did not differ significantly ( $p > 0.05$ ), except that of CSC and PKC groups that were slightly higher than that of the GNC group. This is an indication that rabbits were more able to efficiently convert their diets.

## CONCLUSION

This study has revealed the potential of CSC and PKC in the nutrition of rabbits. Cotton seed cake group favorably compare with GNC group in terms of crude protein content, while the PKC group is low in protein contents but had favorable body weight and meat to bone ratio and lower fat content. Therefore, CSC apart from being cheap is of good nutritional quality and can be included in the diet of rabbits up to 17.43% to replace GNC without adversely affecting the meat quality and carcass characteristics of rabbits, but PKC must be used with caution as it lowered the protein that could be furnished by rabbit meat.

## REFERENCES

- Adesehinwa, A. O. K. (2007). Utilization of Palm Kernel Cake as a Replacement for Maize in Diets of Growing Pigs: Effects on Performance, Serum Metabolites, Nutrient Digestibility and Cost of Feed Conversion. *Bulgarian Journal of Agricultural Sciences*, **13**: 593-600.
- Aduku, A. O., Dim, N. J. and Agange, A. A. (1998). Note on comparative evaluation of palm kernel meal, peanut meal and sunflower meal diets for weanling rabbits. *Journal of Applied Rabbit Research*, **11**(5): 264–265.
- Akinmutimi, A. H., Ewa, E. U., Ojewola, G. S., Okoye, F. C. and Abasiekong, S. F. (2004). Effects of replacing soyabean meal with lima bean meal on finishing broiler chicken. *Global Journal of Agricultural Science*, **3**(1 & 2): 1–4.
- Akinyeye, R., Ekiti, A., Adeyeye, E. and Ekiti, A. (2011). Physico-chemical properties and anti-nutritional factors of palm fruit products (*Elaeis guineensis*

- jacq) from Ekiti State Nigeria. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, **10**(5): 2190–2198.
- Ani, A. O., Kalu, I., Ugwuowo, L. C. and Iloh, E. A. (2013). Dietary effect of rice milling waste and supplementary enzyme on performance of broiler chicks. *African Journal of Biotechnology*, **12** (34): 5326 – 5332.
- Boateng, M., Okai, D. B., Baah, J. and Donkoh, A. (2008). Palm kernel cake extraction and utilisation in pig and poultry diets in Ghana. *Livestock Research for Rural Development*, **20** (7):1-8.
- Cheeke, P. R., Grobner, M. A. and Patton, N. M. (1988). Fiber Digestion and Utilization in Goats. *OSU Rabbir Research Center, Oregon State University*, 25–30.
- Chodová, D. and Tůmová, E. (2013). The effect of feed restriction on meat quality of broiler rabbits: A review. *Scientia Agriculturae Bohemica*, **44**(1): 55–62.
- Dalle Zotte, A. (2002). Perception of rabbit meat quality and major factors influencing the rabbit carcass and meat quality. *Livestock Production Science*, **75**(2022):11–32.
- Dalle Zotte, A., Ricci, R., Cullere, M., Serva, L., Tenti, S. and Marchesini, G. (2020). Effect of chicken genotype and white striping–wooden breast condition on breast meat proximate composition and amino acid profile. *Poultry Science*, **99**(3): 1797–1803.
- De Vries-Ten Have, J., Owolabi, A., Steijns, J., Kudla, U. and Melse-Boonstra, A. (2020). Protein intake adequacy among Nigerian infants, children, adolescents and women and protein quality of commonly consumed foods. *Nutrition Research Reviews*, **33**(1): 102–120.
- Drummen, M., Tischmann, L., Gatta-Cherifi, B., Adam, T. and Westerterp-Plantenga, M. (2018). Dietary protein and energy balance in relation to obesity and co-morbidities. *Frontiers in Endocrinology*, **9**: 1–13
- Enser, M., Hallett, K., Hewitt, B., Fursey, G. A. J. and Wood, J. D. (1996). Fatty acid content and composition of English beef, lamb and pork at retail. *Meat Science*, **42**(4): 443–456.
- Finzi, A. and Amici, A. (1991). Traditional and alternative rabbit breeding systems for developing countries. *Rivista di Agricoltura Subtropicale e Tropicale*, **85**: 103–125.
- Fraga, M. J., De Blas, J. C., Pérez, E., Rodríguez, J. M., Pérez, C. J. and Gálvez, J. F. (1983). Effect of diet on chemical composition of rabbits slaughtered at fixed body weights. *Journal of Animal Science*, **56**(5): 1097–1104.
- Gita, C. (2020). XVIII. Water in Animal Nutrition. In: *A Guide to the Principles of Animal Nutrition* (1st Ed.).
- Hu, F. B. and Willett, W. C. (2002). Optimal Diets for Prevention of Coronary Heart Disease. *Journal of the American Medical Association*, **288**(20): 2569–2578.
- Hulot, F. and Ouhayoun, J. (1999). Muscular pH and related traits in rabbits: a review. *World Rabbit Science*, **7**(1): 15–36.
- Ibitoye, E.B., Olorede, B.R., Jimoh, A.A. and Suleiman, N. (2010). The rabbit industry and alternative feedstuffs: a review. Proc. 35th Conf., Nig. Soc. for Anim. Prod. 14- 17 March, 2010, Univ. of Ibadan, Nigeria. Pp. 207– 211.
- Imonikebe, U. G. and Kperegbeyi, J. I. (2014). Effect of Substitution of Maize with Brewer's Dried Grain In Pig Starter Diet on The Performance of Weaner Pig. *Global Journal of Agricultural Research*, **2**(4), 42-48.
- International atomic energy agency, Nuclear Security Recommendations on Radioactive Material and Associated Facilities, IAEA Nuclear Security Series No. 14, IAEA, Vienna (2011).
- Jalees, M. M., Khan, M. Z., Saleemi, M. K. and Khan, A. (2011). Effects of cottonseed meal on hematological, biochemical and behavioral alterations in male Japanese quail (*Coturnix japonica*). *Pakistan Veterinary Journal*, **31**: 211–214.
- Liu, X., Farmer, M. and Capareda, S. (2012). Supply Variation of Agricultural Residues and Its Effects on Regional Bioenergy Development. *AgBioForum The Journal of Agrobiotechnology Management & Economics*, **15**(3): 315-327.
- Liu, J., Wu, C., Ma, G., Zhuo, M. and Zhang, W. (2018). Nutritional values of fermented cottonseed meal and its application in animal production. *China Animal Husbandry and Veterinary Medicine*, **45**: 1258–1265.
- Marounek, M., Duskova, D. and Skrivanova, V. (2003). Hydrolysis of phytic acid and its availability in rabbits. *British Journal of Nutrition*, **89**: 287–294.
- Melinda Gates Foundation (2021). sector: agriculture - poultry. The poultry specific trade show. Aug. 06-08, 2020. NIPOLI 2020 Ibadan. In *International Show for Livestock and poultry*.
- Nistor, E., Bampidis, V., Păcală, N., Pentea, M., Tozer, J. and Prundeanu, H. (2013). Nutrient Content of Rabbit Meat as Compared to Chicken, Beef and Pork Meat. *Journal of Animal Production Advances*, **3**(4): 172.
- Owen, O.J., Alawa, J.P., Wekhe, S. N., Isirimah, N. O., Chukuigwe, E.C., Aniebo, A.O., Ngodigha, E. M. and Amakiri, A. O. (2009). Incorporating poultry litter in rabbit feed: A solid waste management strategy. *Egyptian Journal of Animal Production*, **46**(1), 63 – 68.
- Santish, K. and Chauchan, B. M. (1986). Antinutritional

- Factors in Moth Bean (*Vigna aconitifolia*): Varietal Differences and Effects of Methods of Domestic Processing and Cooking. *Journal of Food Science*, 51(3): 591–594.
- Suttle, N. F. (2010). Mineral Nutrition of Livestock. In *Mineral deficiencies in grazing dairy cattle in Kordofan and Darfur regions in Western Sudan* (4th ed.).
- Świątkiewicz, S., Arczewska-Włosek, A. and Józefiak, D.(2016). The use of cottonseed meal as a protein source for poultry: An updated review. *World's Poultry Science Journal*, 72: 473–484.
- Taiwo, A.A., Adejuigbe, A.D., Adebowale, E.A., Oshotan, J.S. and David, O.O. (2005). Performance and nutrient digestibility of weaned rabbits fed forages supplemented with concentrate. *Nigerian Journal of Animal Production*, 32(1): 74 – 78.
- Umar, A. M., Muhammad, A. S., Adamu, N. and Modi, M. (2019). Positive response of rabbits fed varying levels of palm kernel cake as a replacement for wheat offal. *Nigerian Journal of Animal Production*, 46(1): 143 – 148.
- Wang, J., Su, Y., Elzo, M. A., Jia, X., Chen, S. and Lai, S. (2016). Comparison of carcass and meat quality traits among three rabbit breeds. *Korean Journal for Food Science of Animal Resources*, 36(1): 84–89.
- Wolfe, R. R. (2012). The role of dietary protein in optimizing muscle mass , function and health outcomes in older individuals. *British Journal of Nutrition*, 108: 88–93.