



DIGESTIBILITY, CARCASS QUALITY AND ECONOMIC BENEFIT OF RABBITS FED VARIOUS AGRO-INDUSTRIAL BYPRODUCTS AS FIBRE SOURCES

¹Samson, K., ¹Yusuf, S. Z., ¹Abdullahi, A. I. and ²Aminu, S. I.

¹Department of Animal Science and Range Management, Modibbo Adama University, Yola, Nigeria

² Department of Animal Production Collage of Agriculture Ganye Adamawa State Nigeria

Corresponding Author's Email: sansonkaigama@gmail.com

ABSTRACT

This experiment was carried out to evaluate the response of growing rabbits to various diets containing different agro-industrial byproducts. Twenty-four (24) mongrel weaner rabbits of mixed sexes, aged between 6 to 8 weeks were used for the experiment. The rabbits were randomly allocated to four (4) experimental treatments of six (6) rabbits per treatment, replicated three (3) times in a completely randomized design with two (2) rabbits per replicate. Four experimental diets were formulated and designated as T1, T2, T3, and T4. T1 (control diet) contained 20% Maize Offal (MO), while T2, T3 and T4 contained 20% each of brewers dried grain (BDG), sorghum offal (SO) and millet offal (MLO) respectively as their main fibre sources. Data collected were subjected to one-way Analysis of Variance. Digestibility study showed all parameters were significantly influenced ($P < 0.05$) except for dry matter. The nutrients were properly digested due to the high values of nutrient digestibility recorded. Carcass characteristics showed significant differences ($P < 0.05$) in respect of live weight, slaughter weight, dressing weight, eviscerated weight, dressing percentage, hind limbs, thorax and loins among the dietary treatments except for forelimbs, neck and abdominal fats which were not significant ($P > 0.05$). Parameters measured on internal organs weight showed no significant difference ($P > 0.05$) among the treatment groups. Rabbits fed sorghum offal based diet recorded the highest cost savings of ₦208.38. It was concluded that rabbits performed best on sorghum offal-based diet. Hence, it was recommended that 20% sorghum offal-based diet can be included in the diet of weaner rabbits without negative effects on digestibility, carcass yield and economics of production as it reduces the high cost associated with the use of conventional feed ingredients in rabbits' production.

Keywords: Byproducts, Weaner, Rabbits, Carcass, Characteristics

INTRODUCTION

Feed constitute the dominant input in animal production ranging from 65 – 75% of the total cost of production while feed ingredient account for over 90% of compound feed industry (Esonu *et al.*, 2006). It has been reported that conventional protein and energy feed ingredients for non-ruminants including rabbits, are very scarce and expensive because of the competition between humans and livestock usage. This has necessitated the use of agro-industrial byproducts such as maize offal, wheat offal, rice offal, millet offal, yam peel meal, sweet potato peel meal, pawpaw seed meal, cassava peel meal, groundnut shell, palm kernel meal, brewers dried grains among others in compounding feed for the livestock (Makinde *et al.*, 2017). Rabbits are a group of livestock with the potential of supplying the protein needs of families particularly in the developing nations due to the relatively cheaper cost of production, meat handling and storage. When compared with other domestic livestock, rabbit meat is reported to contain lesser amounts of cholesterol, fat and calories with a higher amount of protein (Terry *et al.*, 2014). The potential of rabbit meat as a quality or nutritious food stemmed from its higher protein content, lower fat, lower sodium and cholesterol contents compared with other meat sources such as beef, pork, mutton, chevon and chicken (Ajayi *et al.*, 2017). Though rabbits have been found to perform best when fed on concentrates, the ever-increasing costs of grains has created a need to augment both the energy and protein requirement with agro-industrial by-products which are cheap and relatively available. For any livestock enterprise to be profitable and sustainable, it has become necessary to find alternative cheap feedstuff which can adequately replace the more expensive and highly competitive ones (Ayandiran *et al.*, 2021).



Adedokun and Ayandiran (2022) described agro-industrial by-products also known as waste products arising from the processing of crops or animals' products usually by an agro-industrial firm. The use of non-conventional feed materials such as agro-industrial byproducts is a possible opportunity, which can reduce their pollution of the environment (Lamya, 2021). Locally processed brewers dried grain (Burukutu waste) was reported to contain 93% dry matter, 22.39% crude protein, 19.1% crude fibre, 4% ash, 48.6% nitrogen free extract, gross energy of 2280kcal per kg, 6.2% ether extract (Obidinma, 2009). It was also reported to contain very high fibre which made it very difficult for monogastrics such as poultry to utilize effectively at high levels in their diets (Makinde *et al.*, 2013). Maize offal is a byproduct of maize milling processes, second to wheat offal as the most preferred and utilized conventionally in livestock feeds in Nigeria. Maize offal contains about 110 to 120g/kg crude protein and 80 to 90g/kg crude fibre. The relatively low crude fibre content compared to other agro-industrial byproducts could be an advantage in fibre nutrition however, the low protein content appears to be a limiting factor. Rice offal has high lysine and methionine content and it is available in large quantities all year round in many towns in the rice growing areas of Nigeria. However, its phytate content, enzyme inhibitor, high fibre content and oxidative rancidity may have deleterious effects on poultry. Rice offal may become rancid and decrease poultry growth performance and lipid stability of meat. It is suggested to include it at relatively low levels (up to 15% only) in poultry diets as higher levels may result in low calcification, decreased feed intake and even mortality above 80% inclusion in the diets. (Makinde *et al.*, 2017).

Millet offal contained higher crude protein, crude fibre and ash concentrations than maize or sorghum offals; Gross energy content of sorghum offal is closer to that of maize grain and higher than values for maize or millet offals (Uko *et al.*, 1999) while Sorghum on the other hand contains more crude protein than maize, it is cheaper than maize, and is one of the most abundant cereal grain in the drier areas of Africa, Asia and Australia (Gbenge *et al.*, 2019). Despite the availability of non-conventional feedstuff and various nutrients in agro-industrial byproducts, information on the response of rabbits when fed these byproducts in the diets is not readily accessible to local farmers. Therefore, the exploitation and utilization of agro-industrial byproducts as feedstuff for rabbits will reduce the over dependence and competition associated with the use of conventional feed sources such as maize, soyabeans meal, groundnut cake thereby reducing the cost of rabbit production thereby promoting the supply of quality animal protein in the agricultural value chain of Nigerians and beyond. The aim of this study is to assess the response of weaner rabbits to diets containing different agro industrial byproducts, as it affects the digestibility, carcass and organs characteristics and economics of production. Also, the findings from this study will provide useful information on the use of various agro-industrial byproducts in the diets of weaner rabbits to researchers, animal nutritionist, local farmers and agro-industries.

MATERIALS AND METHOD

Experimental Site

The study was conducted at the Rabbit Unit of the Department of Animal Science and Range management, Modibbo Adama University, Yola. Yola is located in the Northern Guinea savannah ecological zone of Nigeria within latitude 9°10'N and longitude 12°35'E of the equator; and altitude of 185.5m with a minimum and maximum temperature of 20°C and 48°C, respectively (Alexander 2015). The mean relative humidity ranges from 30-50% with a minimum in February to March when it drops to as low as 10% and a maximum of 90% in August (Adebayo and Tukur, 1999).

Sources of Experimental Materials

The agro-industrial byproducts used in this study are brewers dried grain (burukutu waste), maize offal, millet offal and sorghum offal which were purchased around neighboring market within Jimeta Yola, Adamawa State.

Experimental Design and Management of Rabbits

Twenty-four (24) mongrel weaner rabbits of mixed sexes, aged between 6 to 8 weeks were procured from the local rabbit farmers in Jimeta Yola, Adamawa State. The rabbits were pre-conditioned for three (3) days, during which they were treated against parasitic infestation. They were

given access to feed and clean water ad libitum during the 56 days in which the experiment lasted. At the commencement of the study, the rabbits' initial average weight was determined and randomly allocated to four experimental treatments of six rabbits per treatment, while each treatment was replicated three times in a completely randomized design (CRD) with two (2) rabbits per replicate. Each replicate was kept in a standard battery cage of 150cm x 100cm x 120cm in a three-tier hutch raised 120cm above the floor.

Experimental Diets

Four (4) experimental diets were formulated and designated as T1, T2, T3, and T4. T1 (control diet) contained 20% maize offal (MO) as its main fibre source while T2, T3 and T4 contained 20 % each of brewers dried grain (BDG), millet offal (MLO) and sorghum offal (SO) respectively as their main fibre sources. The gross composition of the experimental diets is presented on Table 1 below.

Proximate Analysis

Proximate composition of different agro industrial byproducts and experimental diets were analyzed using the methods described by AOAC (2006). The samples were analyzed for dry matter (DM), crude protein (CP), lipid, crude fibre (CF), nitrogen free extract NFE), moisture and ash.

Table 1: Gross Composition of Experimental Diets

Ingredients (kg)	Treatments			
	T1 (20% MO)	T2 (20% BDG)	T3 (20% SO)	T4 (20% MLO)
Maize	45.00	45.00	45.00	45.00
Groundnut cake	15.00	15.00	15.00	15.00
Fish meal	3.00	3.00	3.00	3.00
Soyabean	15.00	15.00	15.00	15.00
Maize offal	20.00	0.00	0.00	0.00
Brewers Dried Grain	0.00	20.00	0.00	0.00
Sorghum Offal	0.00	0.00	20.00	0.00
Millet Offal	0.00	0.00	0.00	20.00
Bone meal	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated Nutrients (%)				
Crude protein	21.60	23.00	21.20	21.96
Crude fibre	5.06	6.66	8.66	4.36
Ether extract	3.93	4.57	4.37	3.38
Metabolizable Energy	2889.20	2785.20	2929.20	2890.40
(M.E) (kcal/kg)				

Table 2: Proximate Composition of the Experimental Diets Fed to Weaner Rabbits

Parameters (%)	Treatments			
	T1 (MO)	T2 (BDG)	T3 (SO)	T4 (MLO)
DM	97.60	97.00	96.70	97.20
CP	21.30	18.70	19.00	22.60
CF	27.60	31.30	30.60	28.20
EE	6.20	5.80	7.10	5.70
Ash	12.20	14.10	16.60	18.30
NFE	30.30	27.10	23.40	22.40

MO: Maize Offal, SO: Sorghum Offal, BDG: Brewers Dried Grain, MLO: Millet Offal, DM: Dry matter, CP: Crude protein, CF: crude fibre, EE: ether extract, NFE: Nitrogen free extract

Data Collection

Nutrient Digestibility of Weaner Rabbits

Three (3) rabbits per treatment (one from each replicate) were randomly selected and transferred to metabolic cages. Two (2) days adaptation period was observed and the faecal sample was collected for a period of five (5) days. The faeces were collected using metallic sheet inserted under each metabolic cage and sun dried. Representative of the faecal sample was analyzed to determine the proximate composition. The digestibility values for dry matter (DM), crude protein (CP), nitrogen free extract (NFE), crude fibre (CF), lipid, ash and moisture were calculated using the methods described by AOAC (2001).

$$\text{Nutrient Digestibility} = \frac{\text{Nutrient Intake} - \text{Nutrient in Faeces}}{\text{Nutrient intake}} \times 100$$

Carcass and Organs Weight Determination

At the end of the feeding trial, three (3) rabbits per treatment (i.e 1 per replicate) were selected for carcass evaluation. The rabbits were fasted overnight but allowed access to water so as to empty the gut. They were weighed, slaughtered, defurred using flame (singering) and then eviscerated. Individual internal organ (small and large intestine, heart, liver, kidneys, lungs, stomach and caecum) were weighed and expressed as percentage of the live weight. The dressed carcass was weighed and dressing percentage calculated as a percentage of the live weight using the formula below:

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

The carcass was subsequently cut into different portions viz: forelimbs, neck, ribs/thorax, loin and hind legs, weighed on sensitive weighing scale and expressed as percentages of the carcass following the standard procedures described by Njidda and Isidahomen (2011).

Economics of Production

Feed cost was calculated based on the prevailing cost of ingredients per kg as at the time, the experiment was conducted. Feed cost/kg diet was calculated by multiplying the proportion of each ingredient in the diets with its cost per unit weight as of the time, the experiment was conducted. Cost of Feeding was computed as a product of the Cost of the diet and the amount of the diet taken it during the experiment and feed cost per kg weight gain was determined by dividing the cost of feeding by the total weight gain.

- i. Cost/kg diet = Cost/kg ingredient x kg Inclusion in Diet
- ii. Cost of Feeding = Cost/kg diet x Total Feed Intake
- iii. Feed Cost/kg Weight Gain = $\frac{\text{Cost of feeding}}{\text{Total weight gain}}$

Data Analysis

All data collected from the experiment were subjected to one-way Analysis of Variance (ANOVA) in a completely Randomized Design as described by Gomez (Steel and Torrie, 1980). Treatment Means were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS

Digestibility of Diets Containing Various Agro-industrial Byproducts Fed to Weaner Rabbits

The results for nutrient digestibility of weaner rabbits fed various agro-industrial byproducts is as shown in table 3. Dry matter (DM) digestibility was not significantly ($P>0.05$) different among the treatments. The values recorded ranged from 82.37% on T1 to 90.12% on T4. Crude protein (CP) digestibility was significantly ($P<0.05$) different among the treatments. The values recorded ranged from 75.11% on T1 to 82.63% on T3. Similarly, the crude fibre (CF) digestibility was significantly higher ($P<0.05$) on T4 (78.01%) and lower on T2 (62.68%). Ether extract (EE) digestibility was significantly higher ($P<0.05$) in T2 (70.68%) and lower in T1 (59.67%). Ash digestibility was significantly higher on T1 (76.22%) and lower on T2 (61.70%). Nitrogen free extract (NFE) digestibility was significantly different ($P<0.05$) among the treatments. The values obtained ranged from 73.66% on T4 to 79.53% on T1.



Table 3: Nutrient Digestibility of Diets Containing Various Agro-industrial Byproducts Fed to Weaner Rabbits

Parameters (%)	Treatments				SEM
	T1 (MO)	T2 (BDG)	T3 (SO)	T4 (MLO)	
Dry matter (DM)	82.37	87.01	89.34	90.12	0.91 ^{NS}
Crude Protein (CP)	75.11 ^b	79.67 ^{ab}	82.63 ^a	76.54 ^b	0.91*
Crude Fibre (CF)	62.68 ^b	67.84 ^b	71.56 ^{ab}	78.01 ^a	1.72*
Ether Extract (EE)	59.67 ^b	70.68 ^a	67.60 ^{ab}	63.15 ^b	1.27*
Ash	76.22 ^a	61.70 ^c	74.09 ^b	74.86 ^b	1.76*
Nitrogen Free Extract (NFE)	79.53	76.75	75.64	73.66	0.58*

a, ab, b, bc, c Means with different superscripts across a given row differ significantly ($P < 0.05$). * = Significant difference, NS = Non Significant difference, MO: Maize Offal, SO: Sorghum Offal, BDG: Brewers Dried Grain, MLO: Millet Offal, CP: Crude protein, NFE: Nitrogen free extract, DM: Dry matter, SEM: Standard error of mean.

Carcass Yield and Internal Organs Weight of Weaner Rabbits Fed Various Agro-industrial Byproducts

The carcass yield and internal organs weight of weaner rabbits fed various agro-industrial byproducts diets are presented in table 4. The results showed significant differences across the dietary treatments. Live weight and slaughter weights showed significant difference among treatments. The values for live weight ranged from 696.67g in T4 to 1020.67 in T1. Similarly, the values for slaughter weight ranged from 591.33 g in T4 to 966.33g in T1. Dressed weight was highest in T1 (821.00 g) and lowest in T2 (427.33g). Dressing percentage ranged from 68.62% in T3 to 80.09% in T1 indicating significant difference affected by diets nutrients composition as well as feed intake. There were significant ($P < 0.05$) differences in eviscerated weights with values ranging from 260.00g in T2 to 547.67g in T1. There were significant ($P < 0.05$) differences among treatments for hind limbs, ribs/thorax and loin while forelimbs showed no significant difference among the treatments. The values recorded for hindlimbs was higher in T1 (14.65%) and lowest in T2 (7.26%). The values recorded for ribs/thorax ranged from 8.27% in T4 to 11.32% in T1. The values recorded for loins ranged from 9.96% in T3 to 15.28% in T1. The values recorded for forelimbs ranged from 2.71% in T3 to 4.93% in T1. There was no significant ($P > 0.05$) difference among treatments weights for neck and abdominal fat. The values recorded for neck ranged from 2.06 in T3 to 2.79 in T2. The values for abdominal fat ranged from 0.22% in T3 to 0.29% in T2 and T4. There were no significant ($P > 0.05$) differences among treatments for liver, lungs, heart, kidney, stomach, small intestine and caecum. The values recorded for liver was highest in T4 (5.10%) and lower in T1 (3.15%). The values for lungs ranged from 0.45% in T1 to 0.76% in T2. The values recorded for heart ranged from 0.22 in T3 to 0.41 in T4. The values recorded for kidney ranged from 0.71% in T3 to 0.93% in T4. The values recorded for stomach ranged from 1.13% in T2 to 1.89% in T1. The values obtained for small intestine ranged from 1.51% in T4 to 2.04% in T1. The values obtained for large intestine ranged from 2.49% in T2 to 3.66% in T4. The values recorded for caecum ranged from 0.87% to 1.78% in T2. Rabbits in T4 recorded numerically higher weights for liver and large intestine weights.

Table 4: Carcass Yield of Weaner Rabbits Fed Various Agro-industrial Byproducts

Parameters	Treatments				SEM
	T1 (MO)	T2 (BDG)	T3 (SO)	T4 (MLO)	
Live weight (g)	1020.67 ^a	719.00 ^b	921.33 ^{ab}	696.67 ^b	50.55*
Slaughter weight (g)	966.33 ^a	632.00 ^b	795.67 ^{ab}	591.33 ^b	54.32*
Dressing weight (g)	821.00 ^a	427.33 ^c	632.33 ^b	466.67 ^c	52.69*
Eviscerated weight (g)	547.67 ^a	260.00 ^c	328.00 ^b	283.00 ^c	34.93*
Dressing %	80.09 ^a	68.64 ^b	68.62 ^b	72.24 ^{ab}	2.11*
Hind limbs (%)	14.65 ^a	7.26 ^b	8.02 ^b	9.90 ^{ab}	0.94*
Forelimbs (%)	4.93	3.45	2.71	4.40	0.31 ^{NS}
Ribs/thorax (%)	11.32 ^a	9.20 ^b	8.71 ^{bc}	8.27 ^{bc}	0.52*
Loin (%)	15.28 ^a	10.26 ^b	9.96 ^{bc}	11.19 ^b	0.92*
Neck (%)	2.20	2.79	2.06	2.60	0.11 ^{NS}
Abdominal fat (%)	0.25	0.29	0.22	0.29	0.02 ^{NS}
Organs weight					
Liver (%)	3.15	4.78	4.07	5.10	0.26 ^{NS}
Lungs (%)	0.45	0.76	0.63	0.74	0.04 ^{NS}
Heart (%)	0.25	0.29	0.22	0.41	0.02 ^{NS}
Kidney (%)	0.84	0.78	0.71	0.93	0.03 ^{NS}
Stomach (%)	1.89	1.13	1.45	1.29	0.09 ^{NS}
Small intestine (%)	2.04	1.78	1.57	1.51	0.08 ^{NS}
Large intestine (%)	3.04	2.49	2.93	3.66	0.15 ^{NS}
Caecum (%)	1.05	1.78	0.87	1.15	0.11 ^{NS}

a, ab, b, bc, c Means with different superscripts across a given row differ significantly ($P < 0.05$). * = Significant difference, NS = Non Significant difference, MO: Maize Offal, SO: Sorghum Offal, BDG: Brewers Dried Grain, MLO: Millet Offal, CP: Crude protein, NFE: Nitrogen free extract, DM: Dry matter, SEM: Standard error of mean.

Economics of Producing Rabbits Fed Various Agro-industrial Byproducts

Table 5 shows the results of the economics of raising weaner rabbits fed with various agro-industrial byproducts. The total feed intake per kilogram per rabbits showed no significant difference ($P > 0.05$) among the experimental diets. Feed cost in naira per kilogram was similar in all treatments. The cost of feed intake showed no significant difference ($P > 0.05$) among the treatments but varied numerically from 1,123.32₦/kg in T4 to 1,189.32₦/kg in T3. Total weight gain, feed cost/kg gain and cost savings were significantly different ($P < 0.05$) among the treatments. Where T3 had the highest total weight gain (1.67kg), lowest feed cost/kg gain and also recorded the highest cost savings of ₦208.38.

Table 5: Economics of Producing Weaner Rabbits Fed Various Agro-Industrial Byproducts

Parameters	Treatments			
	T1 (MO)	T2 (BDG)	T3 (SO)	T4 (MLO)
Total feed intake (kg/rabbit)	6.46	6.25	6.60	6.24
Feed cost (₦/kg)	180.06	180.10	180.20	180.02
Cost of feed intake (₦/kg)	1,163.18	1,125.62	1,189.32	1,123.32
Total weight gain (kg/rabbit)	1.25	0.80	1.67	0.75
Feed cost/kg gain (₦/kg)	930.54	1,407.02	712.16	1,497.76
Cost saving (₦)	0.00	-486.48	208.38	-577.22

MO: Maize Offal, SO: Sorghum Offal, BDG: Brewers Dried Grain, MLO: Millet Offal

DISCUSSION

Digestibility of Weaner Rabbits Fed Various Agro-industrial Byproducts

The results for digestibility of various agro-industrial byproducts fed to weaner rabbits is as shown in table 4.4. High fibre in rabbit diets depress digestibility as it reduces the period of exposure of food to the digestive enzymes and absorptive surface (Amaefule *et al.*, 2004). The digestible



nutrients were properly digested by the rabbits, due to the high values of nutrient digestibility recorded in this study. The dry matter digestibility of agro-industrial byproduct diets in this study was higher than 41.65% - 69.31% reported by Ayandiran and Adekunle (2023) for rabbits fed corn gluten residue meal, soybean gluten residue meal, and sorghum brewer dry grain while the crude protein digestibility of all diets was higher than 60.49% - 71.27% reported by Nsa *et al.*, (2018) for agro-industrial byproduct-based diets. The digestible crude fibre of maize offal, sorghum offal, brewer's dried grain and millet offal were higher than 39.42% - 54.88% reported by Mohammed *et al.*, (2013) for rabbits fed bovine blood-rumen content mixture. The ether extract digestibility in this study are similar to 60.83-70.41% reported by Abubakar, *et al.*, (2023). While the ash digestibility values in this study are within the range of 56.15 – 84.17% reported by Wafar *et al.*, (2017). The nitrogen free extract (NFE) of agro-industrial byproduct diets in current study were between 73.66% - 79.53% which are higher than 50.16% - 51.72% reported by Ayandiran and Adekunle (2023) for rabbits fed corn gluten residue meal and sorghum brewer dry grain respectively.

Carcass Yield and Internal Organs Weight of Weaner Rabbits Fed Various Agro-industrial Byproducts

Most of the carcass parameters measured except for live weight, slaughter weight, dressing weight, eviscerated weight, dressing percentage, hind limbs, ribs/thorax and loins were similar. The non-significant variation recorded in most of the carcass parameters of grower rabbits fed maize offal, brewer's dried grain, sorghum offal and millet offal are in consonance with the findings of Umar *et al.* (2021); they reported no significant differences ($P>0.05$) in most parameters measured, except for the lungs, when weaner rabbits were fed palm kernel cake (PKC) as a replacement for wheat offal. The dressing percentage in the current study falls within the range of 68.62% to 80.09% which is higher than 43.24% to 53.83% recorded by Umar *et al.* (2021), and 55.35% to 57.35% reported by Nuamah *et al.* (2019). However, these findings contrast with those of Mafimidiwo *et al.* (2024), who observed significant differences in carcass and internal organs weight when grower rabbits were fed with urea-molasses treated maize cob as a replacement for wheat offal. Carcass/slaughter weight in the present study varied from 591.3g to 966.33g with dressing percentage of 68.62% to 80.09%. Jadori *et al.*, (2024) reported lower carcass weights between 514.70g to 569.33g, with dressing percentage ranging from 42.28% to 46.71%. Okocha *et al.* (2024) noted carcass weights ranging from 825.49g to 1123.09g, Anongo *et al.* (2023) reported a dressing percentage range of 60.51% to 65.55% which are similar to the values recorded in present study. The similarity observed in forelimbs, neck and abdominal fat weights in this study is in contrast with Anongo *et al.* (2023) who reported differences in the head, neck, ribs, and forelimbs. This might be as a result of differences in protein content, fiber levels or energy availability in the test ingredients as compared to other agro-industrial byproducts. Organs weight of liver, lungs, heart, kidney, stomach, small intestine, large intestine and caecum showed no significant variations ($P>0.05$) across all dietary treatments. However, Okocha *et al.* (2024) found significant differences ($P<0.05$) in liver and kidney weights across treatments with rice husk, while Anongo *et al.* (2023) reported differences in organ weights, particularly in the heart, liver, and pancreas, across different rice by-product treatments. This variability in organs weight in current study could be due to differences in the nutritional composition of the by-products and their effects on organ development.

Economics of Producing Weaner Rabbits Fed Various Agro-industrial Byproducts

The total feed intake in kilogram per rabbits showed no significant difference among the dietary treatments. Feed cost in naira per kilogram was similar in all treatments. The cost of feed intake showed no significant difference among the treatments but varied numerically from 1,123.32N/kg in T4 to 1,189.32N/kg in T3. Total weight gain, feed cost/kg gain and cost savings were significantly different among the treatments. Where T3 had the highest total weight gain (1.67kg). It was observed that feed cost/kg gain was least (N712.16) on rabbits fed sorghum offal-based diet and lower (N930.54) on rabbits fed maize offal diets. On the other hand, rabbits fed millet offal (MLO) had higher (N1,497.76) feed cost/kg gain compared to those on brewer's dried grain (BDG) based diets (N1,407.02). Cost saving was higher in sorghum offal-based diet (T3) with the cost of N208.38



as against ₦486.48 in T2 (brewer's dried grain based diet) and ₦577.22 in T4 (millet offal-based diet). This result agrees with that of Bello *et al.*, (2024) who reported that lower feed cost/kg gain was recorded in Dutch rabbits fed sorghum-based diet.

CONCLUSION AND ERECOMMENDATION

The findings of this study revealed that rabbits fed 20% sorghum offal-based diet performed best among the various fibre sources studied in terms of digestibility, carcass yield and economic benefits. Based on the result of this findings, 20% sorghum offal can be included in the diet of weaner rabbits as it indicated no negative effects on digestibility, carcass yield and economics of production thereby reducing the high cost associated with the use of conventional feed in rabbit production.

REFERENCES

- Abubakar, A., Doma, U. D., Egbo, M. L. and Muhammad, A. S. (2023). Performance, digestibility and cost benefits of weaner rabbits fed dietary levels of maize milling residue. *Nigerian Journal of Agriculture and Agricultural Technology (NJAAT)*. **3**(1):131-135.
- Adebayo, A. A. and Tukur, A. L. (1999). Adamawa in the Maps. 1st Edition Paraclete Publishers, Yola. P. 112p.
- Adedokun M. A, Ayandiran S. K, (2022). Performance Characteristics of Growing Rabbits Fed Molasses Improved Sorghum Brewers Dried Grain. *Proceedings of the 11th ASAN-NIAS Joint Annual Meeting. October 23rd – 27th. Bauchi.* 409-412.
- Ajayi, A. P, Farinu G. O, Oyebiyi O. O, and Olayemi T. B (2017). Performance evaluation of Male Weaner Rabbits fed Diet containing graded level of blood wild Sunflower leaf meal mixture. *Journal of Agricultural Science*. **3**(2):250-255.
- Alexander, C. B. (2015). Statistical Analysis of Seasonal Temperature Variation and Thunderstorm Activity over Yola. North-East Nigeria. *American Journal of Educational Research*, **3**(7):873-880. doi: 10.12691/education-3-7-10.
- Amaefule K. U, Nwaokwo C. C, Uheukumore F. C. (2004). The effect of feeding graded levels of raw pigeon pea (*Cajanus cajan*) seed meal on performance, nutrient retention and carcass characteristics of wean rabbits. *Nigerian Journal of Animal Production*. **31**:194-199.
- Anongo, T. T., Shaahu, D. T., Ahemen, T., Tuleun, C.D. and Carew, S. N. (2023). Growth Performance and Nutrients Digestibility of Weaner Rabbits Fed Diets Containing Par-Boiled and Non-Parboiled Rice Milling By-Products. *Journal of Experimental Agriculture International*, **45**(11):64–73.
- AOAC, Association of Official Analytical Chemists, (2006). Official Method of Analysis of the AOAC (W.Horwitz Editor) 18th Edition. Washington D.C, AOAC.
- AOAC, Association of Official Analytical Chemists, (2001). Official Method of Analysis of the AOAC (W.Horwitz Editor) 17th Edition. Washington D.C, AOAC.
- Ayandiran S. K and I Adekunle. (2023). Performance characteristics and digestion of growing rabbits fed Corn Gluten Residue Meal (CGRM), Soybean Gluten Residue Meal (SGRM), and Sorghum Brewer Dry Grain (SBDG). *International Journal of Agricultural Science and Food Technology*. **9**(2):031- 035.
- Ayandiran, S. K., Oladokun, A. A., Olaogun, Y.A, Akande, A. A. and Adekunle, I. (2021). Pawpaw seed meal-based diets enhanced growth performance of rabbits. *Nigerian Journal of Animal Production*. **48**(2):75 - 78.
- Bello, K. M., Jama'a, N.A. and Adamu, N. (2024). Growth Performance and Carcass Yield of New Zealand White and Dutch Rabbits Fed Two Energy Sources as Means of Employment for Graduate Animal Scientists. *Nigerian Journal of Agriculture and Agricultural Technology (NJAAT)*. **4**(2):238-244.
- Duncan, D. B. (1955). Multiple Range and Multiple F. tests. *Biometrics*, **11**:1- 42
- Esonu B. O., U. D. Ogbonna, G. A. Anyanwu, O. O. Emenalom, M. C. Uchegbu, E. B. Etuk and A. B. I. Udedibie (2006). Evaluation of Performance, Organ Characteristics and Economic Analysis



- of Broiler Finisher Fed Dried Rumen Digesta. *International Journal of Poultry Science* **5**(12):1116-1118.
- Gbenge Alfred Aondoakaa and Ikurior Steven Aondona (2019). The Effect of Grain Type on Growth Performance and Economics Production of Rabbits. *Journal of Agriculture and Veterinary Science (IOSR-JAVS)*. **12**(10):17-23.
- Jadori, M. S., Muhammad, A. S., Abubakar, A. A., Balarabe, S., and Salifu, U. A. (2024). Effect of Utilizing Varying Levels of Millet Offal as Replacement for Maize Offal in the Diets of Growing Rabbit. *African Journal of Agricultural Science and Food Research*. **16**(1):68-83.
- Lamya Ouzzir (2021). Agro-industrial byproducts in rabbit food: Case of the complex of detoxified apricot kernel cake and dehydrated tomato pulp. Article in *Veterinary World*· March 2021. DOI: 10.14202/vetworld.2021.744-750.
- Lebas F, Coudert P, Rochambeau H, Thebault R.G. (1997). The rabbit husbandry, health and production. New edition. FAO, Rome. 1997.
- Mafimidiwo, A. N., Sobayo, R. A., Muhammad, S. B., Williams, G. A., and Adesanya, O. F. (2024). Carcass characteristics of weaner rabbits fed graded levels of urea molasses treated maize cob as a replacement for wheat offal. *Nigerian Journal of Animal Production*. 1669–1673.
- Makinde, O. John, Sikiru Akeem B, Ajibade, A. Johnson, Opoola, Emmanuel, Ibe, E. Agwor and Ibikunle K. Yemiola (2017). Effects of Different Agro Industrial by-Products on the Growth Performance, Carcass Characteristics and Blood Profiles of Growing Rabbits. *International Journal of Research in Agriculture and Forestry*. **4**(7):1-8.
- Makinde, O. J., Maidala, A., Sikiru, A. B., and Ajibade, A. J. (2013). Converting agro industrial wastes into feed ingredient for growing rabbits (*Oryctolagus cuniculus*) in Northern Nigeria. Proceedings of 4th International Conference on Agricultural and Food Engineering 2018.
- Mohammed G, Adamu S. B, Igwebuike J. U, Alade N. K, Asheikh L. G. (2013). Nutrient digestibility and carcass measurement of growing rabbits fed graded levels of bovine blood-rumen content mixture. *Pakistan Journal of Nutrition*. **12**(10):929-933.
- Njidda, A. A. and Isidahomen, C. E. (2011). Hematological parameters and carcass characteristics of weanling rabbits fed sesame seed meal (*Sesamum indicum*) in a semi-arid region. *Pakistan Veterinary Journal*. **31**(1):35-39.
- Nsa E. E, Ukoha O. A, Onunkwo D. N. (2018). Growth response, nutrient digestibility and cost benefit of feeding growing rabbits with selected agro-industrial byproducts-based diet. *Nigerian Journal of Animal Production*. **45**(4):279-287.
- Nuamah, E., Teye, M., Odoi, F. N. A., and Teye, P. K. (2019). Growth performance and carcass characteristics of cross-bred rabbits fed diets containing palm kernel oil residue. *African Journal of Agricultural Research*. **14**(33):1764-1771.
- Obidinma, V. N. (2009). Brewers Dried grain as energy source in poultry production. Ph.D Thesis. Imo State University Owerri, Nigeria.
- Okocha, C. N., Apiakason, E., Nzotta, A. O., Nsidinanya, N. O. and Ogbonna, A. C. (2024). Comparative Performance of Weaner Rabbits Fed Graded Levels of Rice Husk in Place of Wheat Offal. *Nigerian Journal of Animal Production*. 1068–1070.
- Terry Ansah, Kamara Francis, Ninkarb Seth Joejoe and Takinam Rockson Kwaku (2014). Growth, carcass and blood profile of rabbits fed agro-industrial by-products in Northern Ghana. *Ghana Journal of Science, Technology and Development*. **1**(1):38-45.
- Uko, O. J., A. M. Ataja and H. B. Tanko (1999). Response of Rabbits to Cereal By-products as Energy Sources in Diets. *Archivos de Zootecnia*. **48**:285-294.
- Umar, M. M., Maigado, A. I., Sadiq, M. S., and Shuaibu, A. (2021). Response of weaner rabbits fed graded levels of palm kernel cake (PKC) as replacement of wheat offal. *Nigerian Journal of Animal Science*. **23**(3):151-159.
- Wafar, R.J., B. Yakubu and B. C. Lalabe (2017). Effect of Feeding Raw Kapok (*Ceiba pentandra*) Seed Meal on the Growth Performance, Nutrient Digestibility, Carcass and Organ Weights of Weaner Rabbits. *Asian Research Journal of Agriculture*. **5**(3):1-8.