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EVALUATION OF CHEMICAL COMPOSITION AND FEEDING VALUE OF FERMENTED JACKFRUIT (*Artocapus heterophyllous*) SEED MEAL USING RABBITS

O. O. Effiong[1,*], V. N. Ebegbulem[1], N. P. Jimmy[1], A. Halilu[1], and O.O. Ekwe[2]

[1]University of Calabar, Nigeria
[2]Ebonyi State University, Abakaliki, Nigeria

[*]Corresponding Author's email: okokoneffiong48@gmail.com

ABSTRACT

The majority of Nigerian population, particularly those living in rural communities can no longer afford animal protein in their daily meals due to the high cost of these products especially from conventional sources (cattle, sheep, and poultry) caused by high cost of feeds and feedingstuffs. This calls for dependence on alternative meat sources like rabbits which can survive mainly on forages with concentrates supplementation. Because of the high cost of maize, which is a source of energy in diets of rabbits, this study was therefore designed to evaluate the chemical composition of processed jackfruit seed meal and its feeding value as an alternative energy source. Bunches of jackfruits were harvested, the seed separated from the pulp and divided into four groups of 10kg each for fermentation. The maize cob solution prepared by mixing 100 gm of ash obtained after burning maize cob into 1 litre of distilled water in a plastic bowl was added to the first capped plastic bowl containing 10kg of cracked jackfruit seeds. The rumen digesta filtrate was poured into the second capped plastic bowl containing 10kg of jackfruit seed, and plain water was added to the jackfruit seed in the third bowl. Each sample was fermented at room temperature for 48 hours and thereafter rinsed, sun-dried, and milled using a 2 mm mesh hammer mill. Five diets were formulated with fermented jackfruit seed meals replacing maize in the control diet. Thirty-five weaned (ages between 4-5 weeks old), crossbred rabbits were used for the experiment. The experimental design employed was completely randomized. Data collected were subjected to analysis of variance using the General Linear Model (GLM) procedures of GenStat 14th edition. The results showed that rumen digesta filtrate fermentation media increased the crude protein from 5.34% in the raw jackfruit seed meal to 7.10%. The rumen digesta filtrate media reduced ($P \leq 0.01$) the concentration of phytates (3.17 ± 0.56mg/100g), oxalates (34.10 ± 0.58 mg/100g), tannins (1.64 mg/100g), relative to other media. Rabbits fed control diet recorded a significant ($P \leq 0.01$) higher average daily weight gain (11.36g), which was similar to 10.75g for rabbits on rumen digesta filtrate fermented jackfruit seed meal (RDFFJM) diet. The feed conversion ratio of 3.80 recorded for rabbits on (RDFFJM) diet was superior (P=0.001) compared to those recorded for other treatment diets. Rabbits fed plain water fermented jackfruit seed meal recorded the highest percentage of protein (34.4+2.08), ash (32.0+1.15), and fibre (56.3+1.15) digestibility. Most of the haematological and serum biochemical parameters were within the normal ranges. It was concluded that the rumen digesta filtrate fermented jackfruit seed meal diet enhanced the performance of the growing rabbits relative to the maize-based diet and other treatment diets.

Keywords: Rumen digesta filtrate, maize cob, fermentation, jackfruit, growing rabbits, anti-nutrients

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INTRODUCTION

Livestock is one of the fastest-growing agricultural sub-sectors in Nigeria due to rapid increase in demand for meat and eggs. This increase is driven by population growth, urbanization, and increase in purchasing power of the population (Delgado, 2005). It necessitates improving livestock productivity and searching for alternate animal protein sources. The rabbits are considered a good source of low allergenic valuable proteins with good amino acid profiles and have high nutritional value (Gabriela *et al.,* 2023) rabbit meat is also low in fat and cholesterol due to its high content of unsaturated fatty acids (UFA), especially ω-3 and ω-6, and a good ratio of polyunsaturated fatty acids (PUFA, n-6/n-3, PUFA) (Pedro *et al.,* 2021; Alves dos Santos *et al*., 2022). Rabbit meat is also a very good source of minerals (P, K, Ca, Se, and Co) and vitamins (B_3, B_6, B_{12}, and E) (USDA, 2020). The low sodium level makes rabbit meat recommendable for children, pregnant women, people with cardiovascular diseases, and elderly people (Minardi *et al.*, 2020; Trombetti *et al.*, 2022).

The rabbits have a fast reproduction rate with a short birth interval of 28–32 days (Obinne and Mmereole, 2010), therefore making them a wise production choice for nations facing protein shortages. Intensive rabbit domestication and production require the utilization of energy and protein-rich concentrate feeds in addition to forages to achieve the desired growth potential of the animal (Effiong and Wogar, 2007). The new impetus for profitable rabbit production requires alternative and cheap energy feedstuff to be sourced to replace cereals (Ibitye *et al*., 2010). The jackfruit seeds, an ecologically available forest-based feed resource with good biomass production in Nigeria, have been considered in this regard.

The jackfruit (*Artocarpus heterophyllous*) belongs to the family Moraceae and can thrive well only in humid tropical climates, yielding about 500 fruits per tree per year (Ndyomugyenyi *et al*, 2014). The seeds remaining after pulp consumption are of little value and are usually discarded (Ndyomugyenyi *et al.*, 2014). Jackfruit seed meal is a potential source of carbohydrates and may be used as an alternative to maize in rabbit and poultry diets. The jackfruit seed meal contains 344.99 kcal/100g of energy, 13.67 % crude protein, 0.75 % fat, 3.00%crude fibre, 69.39 % carbohydrate, and 2.41 ash. Sreletha *et al*. (2017) reported appreciable quantities of phosphorus (1.77mg/g), potassium (9.72mg/g), and calcium (1.82mg/g), in the jackfruit seed flour. Noor (2014) reported that seed contains sterols, triterpenes, coumarins, tannins, glycosides, alkaloids, reducing compounds, anthocyanin pigment, and saponins as phytochemicals, most of which are anti-nutritional factors.

The presence of anti-nutritional factors in the jackfruit seed has been reported to cause growth depressions, poor feed digestibility, and death in animals (Noor *et al.*, 2021). However, different processing techniques like chemical detoxification, boiling, roasting, and fermentation soaking in plain water or combinations of two or more treatments have been used to destroy these anti-nutrients (Sedeghi *et al*., 2009) with significant improvement in the nutritional value of the jackfruit seed meal. Effiong *et al*. (2016) noted that anaerobic incubation of different feedstuffs for 48 hours increased the microbial population, particularly bacteria, protozoa, and fungi, capable of producing enzymes responsible for the degradation of fibre and toxic substances. They further noted a significant reduction in crude fibre and anti-nutrient levels of the earth ball meal fermented in rumen digesta filtrate relative to the earth ball meal fermented in plain water. Effiong *et al*. (2016) noted an increase in crude protein contents of earth ball meal when fermented with rumen digesta

Information is scarce on the effects of rumen filtrate fermentation of jackfruit seed meal (JSM) on its chemical composition and nutritive value. Therefore, the present study was designed to compare changes in the chemical composition of the jackfruit seed meal following fermentation with different media and to evaluate its nutritive value in growing rabbits.

MATERIALS AND METHODS

The feeding trial was carried out at the Rabbitry unit of the Animal Science Teaching and Research Farm, University of Calabar, Calabar, Nigeria, between October and December 2021. Calabar is located between latitude 04.57^{o}N and longitude 08.20^{o}E, with annual rainfall ranging from 1260mm to 1280mm, temperature of 25-30^{0}C with relative humidity between 70 and 90% and an elevation above sea level of 99m (NMA 2016)

Sources and processing of jackfruit seeds: Bunches of jackfruit were harvested from the home garden in Calabar municipality, Nigeria, and opened up using a sharp knife to expose the seeds. The seeds were separated from the pulp and divided into four groups of 10 kg each for fermentation. The maize cobs were sourced from the local Akim market. At the same time, rumen digesta was obtained immediately after cattle slaughtering at abattoir and transported to the laboratory in an airtight polythene bag.

Fermentation media and fermentation process: The maize cob ash was prepared by burning the maize cob on direct fire till conversion into ash. The ash solution was prepared by thoroughly mixing 100 gm of ash into 1 litre of distilled water in a plastic bowl (Effiong *et al*., 2016). The rumen filtrate was prepared by rapidly submerging the rumen digesta into distilled water in a capped plastic bowl at the rate of 1 kg of digesta per litre of water. The mixture was vigorously mixed by using a metal rod to dislodge the microbes. The residue was filtered, and the filtrate was incubated for 48 hours at room temperature (26^{o}C) in a capped plastic bowl (Effiong *et al.,* 2016). The maize cob solution, rumen filtrate, and normal water were added to the first, second, and third capped plastic bowls each containing 300 grams of cracked jackfruit seeds. Each sample was fermented at room temperature for 48 hours with limited air penetration. At the end of the fermentation process, samples were drained, rinsed with clean water, sun-dried, milled by using a hammer mill with 2 mm mesh, and stored for further chemical analysis.

Quality analyses of jackfruit seed meal: The proximate analysis of raw and fermented jackfruit seed meals was carried out using the standard procedures of AOAC (2010). The raw and fermented jackfruit seed meals were analyzed for anti-nutritional factors including phytic acid (Eskin and Latta, 1980), tannins (Joslyn, 1970) oxalate (Karamad *et al*., 2019 and saponin (AOAC, (2010).

Experimental diets: Five experimental diets were formulated to supply 15% crude protein and 2700 kcal/kg of metabolizable energy during grower phase of the rabbit. A basal diet (control; Diet-1) was formulated by using maize as a source of energy. The diet 2, contained Raw JSM in complete replacement of maize from the basal diet. The diets 3, 4, and 5 were formulated by replacing maize of the basal diet with jackfruit seed meals fermented with plain water, maize cob solution, and rumen digesta filtrate, respectively.

Table 1. Feedstuff and nutrient composition of the experimental diets.

Ingredients	Control/Basal Diet	RJFM*	PWFJM*	MCFJM*	RDFFJM*
Maize	39.40	0.00	0.00	0.00	0.00
Jackfruit seed meal	0.00	39.40	39.40	39.40	39.40
Soybean meal)	8.60	8.60	8.60	8.60	8.60
Wheat offals	24.00	24.00	24.00	24.00	24.00
Palm kernel cake	25.00	25.00	25.00	25.00	25.00
Vitamin/mineral Premix**	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20
L-lysine	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30
Dicalcium phosphate	2.00	2.00	2.00	2.00	2.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Analysed nutrient composition (%)					
Crude protein	15.67	14.22	14.09	14.14	14.92
Crude fibre	6.39	7.26	6.86	6.84	6.83
ME(Kcal/Kg)	2622.00	2409.67	2268.77	2412.00	2469.92

*PWFJ = Plain water fermented jackfruit; MCAFJ = Maize cob ash fermented jackfruit; RDFFJ = Rumen digesta filtrate fermented jackfruit.
**Vitamin/mineral Premix: give details here

Experimental animals and management: Thirty-five weaned (aged between 5 to 6 weeks), cross-bred (New Zealand white and American chinchilla) male rabbits, sourced from a local farm, were individually weighed and distributed into five groups each having seven rabbits, these groups were made on a weight equalization basis. Groups were randomly assigned to one of the five experimental diets in a completely randomized design. Animals were housed individually in a two-tier cage, measuring 78 cm x 78 cm x 60 cm. The experimental diets (150 gm) were served early in the morning while fifty (50) gm of *Tridax procumbens* was supplemented to all groups in the afternoon. The experimental diets and drinking water were served in concrete troughs.

Data collection

Growth performance: The data on body weight and feed intake was recorded on daily basis. Thereafter, average daily weight gain and feed intake were calculated to determine the average feed conversion ratio for the growing phase. The experiment lasted for twelve (12) weeks.

Nutrient Digestibility: Seven days before the end of the growth trial, three rabbits from each treatment were randomly picked for the nutrient digestibility trial. Each rabbit was fed 80g of feed (a quantity they can consume all at once) daily, and total faeces were collected for four days. The composite samples of feed and feces were utilized for further sub-sampling and nutrient analysis. A preliminary period of three days was allowed before the commencement of the faecal collection. Dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), and ash were determined according to AOAC (2010).

Blood Analysis: The blood samples were collected at the end of the rabbit growth phase through the marginal ear vein with a sterile syringe into plain sample bottles and allowed to clot to obtain serum for biochemical investigations using a standard biochemical kit (RANDOX United Kingdom).. Blood samples for haematology parameters were collected by using EDTA sample containers. Serum glucose, cholesterol, total protein, triglycerides, albumin, calcium, high-density lipoprotein (HPL), low-density lipoprotein (LDL), and very-low-density lipoprotein (VLDL) were determined. The haematological indices measured include white blood cells (WBC)**,** red blood cells (RBC)**,** haemoglobin (Hb)**,** hematocrit (HCT)**,** mean corpuscular volume (MCV)**,** mean corpuscular haemoglobin (MCH)**,** mean corpuscular haemoglobin concentration (MCHC)**,** platelet blood test (PLT), and lymphocytes (LYM).

Statistical analysis: The experimental design employed was a completely randomized design. Data collected were subjected to analysis of variance using the GenStat (2010). Significant difference among means were compared by Duncan's New Multiple Range Test (P ≤0.01).

RESULTS

Nutrient composition of differently fermented jackfruit seed meals: The proximate composition of raw and differently fermented jackfruit seed meals is given in Table 2. It was noted that type of fermentation media resulted in significant (P≤0.01) changes in the nutrient composition of JSM. The dry matter contents were reduced from 91.05% in the raw JSM to 74.85, 83.85, and 85.85%, in the plain water, maize cob ash, and rumen digesta filtrate fermented JSM, respectively. The crude protein contents of JSM were increased from 5.34% in the raw sample to 7.10% in the rumen digesta filtrate fermented JSM. The crude fibre contents were reduced (P≤0.01) by all the fermentation media. The CF contents were lower in the rumen digesta filtrate fermented sample (3.11%) than the raw sample (4.21%). The ether extract concentration was significantly increased from 2.56% in the raw samples to 3.01% for the maize cob solution fermented samples and 5.74% in the rumen digesta filtrate fermented samples. The ash contents were significantly higher (5.61%) in the rumen digesta filtrate fermented JSM than those of raw (4.45%), plain water (4.01%), and maize cob (4.23%) fermented JSM. Raw JSM had the highest nitrogen-free extract (NFE) value of 74.50%, while the plain water fermented medium significantly reduced its content to 59.71%.

Table 2. Proximate composition of differently fermented jackfruit seed meal*

Nutrients (%)	RAW**	PWFJ**	MCAFJ**	RDFFJ**	P-value
Dry matter	91.05+ 0.03	74.85+ 0.02	83.85+ 0.05	85.85+ 0.07	≤0.001
Crude protein	5.34+0.06^{b}	5.00+0.00^{b}	5.13+0.02^{b}	7.10+0.06^{a}	≤0.001
Crude fibre	4.21+0.01^{a}	3.21+0.06^{b}	3.15+0.01^{b}	3.11+0.01^{b}	≤0.001
Ether extract (%)	2.56+0.06^{c}	2.43+0.06^{c}	3.01+0.00^{b}	5.74+00.02^{a}	≤0.001
Ash (%)	4.45+0.06^{b}	4.01+0.01^{b}	4.23+0.06^{b}	5.61+0.06^{a}	≤0.001
Nitrogen free extract	74.50+0.56^{a}	59.71+0.06^{c}	68.34+0.56^{b}	64.30+1.15^{b}	0.003

^{abcd}Means in the same row with different superscripts differ significantly (P≤0.05)
*Values are Means ± SD (n=3)
**RAW= Raw jackfruit seed meal; PWFJ = Plain water fermented jackfruit; MCAFJ = Maize cob ash fermented jackfruit; RDFFJ = Rumen digesta filtrate fermented jackfruit.

Phytochemical composition of differently fermented jackfruit seed meals: A significant (P≤0.001) reduction in phytochemical compounds, usually considered as anti-nutritional factors, *viz.,* phytate, oxalate, tannin, and saponin was noted in JSM in response to different fermentation mediums (Table 3). The raw seed phytate contents were reduced from 11.28 to 3.17 (mg/100g) by the rumen digesta filtrate. Further, the oxalates (80.07 mg/100 g) and tannins (8.07 mg/100 g) were equally reduced to 34.10 mg/100 g and 1.64 mg/100g, respectively, by the same fermentation media. Remarkably, the saponins were completely removed from the JSM when subjected to maize cob solution and rumen filtrate as fermentation medium.

Rabbits Growth performance and economic appraisal: The data on rabbits' growth performance indicated significant (P≤0.05) improvement in total and average body weight gain in rabbits fed rumen digesta filtrate fermented JSM than those fed diets containing plain water and maize cob fermented JSM (Table 4) However, no difference (P>0.05) was noted in total and average body weight gain in rabbits fed control and rumen digesta filtrate fermented JSM diet. The feed conversion was significantly (P=0.001) better in rabbits fed diets containing rumen digesta filtrate fermented JSM than in control and other treatments. The data on economics of feeding diets containing JSM (Table 4) indicated significantly (P≤0.001) low cost of producing a kilogram of rabbit feed by the dietary replacement of maize with raw and fermented JSM. The cost of feed consumed by rabbits was significantly reduced from 0.199 US$ in the control diet to 0.102 US$, 0.099 US$, 0.110US$, and 0.108US$, respectively, for diets containing raw, and fermented JSM with plain water, maize cob ash, and rumen digesta filtrate, respectively. Producing a kilogram weight of rabbit with rumen digesta filtrate fermented JSM was cheaper than with raw jackfruit fermented in plain water and maize cob ash solution. In general, the dietary replacement of maize with JSM significantly reduced (P≤0.001) the cost of rabbit production.

Nutrient digestibility of rabbits fed on differently fermented jackfruit seed meal diets: The nutrient digestibility data revealed that replacing maize with the differently processed JSM significantly (P≤0.05) influenced the utilization of various nutrients by the rabbits (Table 5). The fat utilization was maximum (57.8%) in rabbits fed diet containing MCAF and minimum in RAW diet (24.5%) Rabbits on PWFJ were most effective in utilizing crude protein (34.4±2.08%), ash (32.0±1.15), crude fibre (56.3±1.15) and the nitrogen-free extract (34.5±0.58) than control and other treatments. The raw-fed rabbits indicated least utilization of fat, ash and crude fibre than other fermented JSM. Similarly, rabbits placed on control diet recorded the least nitrogen extract digestibility (26.1±1.15). Rabbits fed RAW, PWFJ and MCAFJ diets were observed to record a similar nitrogen extract digestibility.

Table 3 Phytochemical composition (mg/100g) of differently fermented Jackfruit seed meal[*].

Phytochemicals	RAW**	PWFJ**	MCAFJ**	RDFFJ**	P-value
Phytates	11.28±0.56[a]	7.95+0.56[b]	7.94±0.56[b]	3.17±0.56[c]	≤0.001
Oxalates	80.07±2.89[a]	50.11±2.89[c]	75.53±1.73[b]	34.10±0.58[d]	≤0.001
Tannins	8.14±0.58[a]	4.72±0.58[b]	2.06±0.01[c]	1.64±0.06[d]	≤0.001
Saponins	2.68±0.58[a]	0.01±0.01[b]	N/D	N/D	≤0.001

[abc] Means in the same row with different superscripts differ significantly (P≤0.05)
[*]Values are Means ± SD (n=3)
[**]RAW= Raw jackfruit seed meal; PWFJ = Plain water fermented jackfruit; MCAFJ = Maize cob ash fermented jackfruit; RDFFJ = Rumen digesta filtrate fermented jackfruit.

Table 4: Performance of rabbits fed diets containing differently fermented jackfruit seed meal.

Parameter	Control	RAW**	PWFJ**	MCAFJ**	RDFFJ**	+SEM	P-value
Initial weight(g)	613	647	645	633	673	1.97	≤0.001
Final weight gain(g)	1567[a]	1335[b]	1359[b]	1319[b]	1576[a]	4.80	0.018
Total weight gain(g)	954[a]	688[b]	714[b]	686[b]	903[a]	4.80	≤0.001
Average daily weight gain(g)	11.36[a]	8.19[b]	8.50[b]	8.17[b]	10.75[a]	0.79	0.001
Average daily feed intake(g)	49.82	38.69	37.70	40.58	40.88	0.55	0.598
Feed conversion ratio	4.39[a`]	4.72[a]	4.43[a]	4.97[a]	3.80[b]	0.32	0.001
Economics of production							
***Cost of kg feed (US$)	0.132[a]	0.091 [b]	0.095 [b]	0.094 [b]	0.097 [b]	0.007	≤0.001
Cost of feed consumed (US$)	0.199 [a]	0.102[bc]	0.99[c]	0.11[b]	0.108[bc]	0.15	≤0.001
Cost/kg gain (US$)	0.552[a]	0.296[c]	0.301[c]	0.320[b]	0.333[b]	0.04	≤0.001

[ab]Means in the same row with different superscripts differ significantly (P≤0.05)
[*]Values are Means ± SD (n=3)
[**]RAW= Raw jackfruit seed meal; PWFJ = Plain water fermented jackfruit; MCAFJ = Maize cob ash fermented jackfruit; RDFFJ = Rumen digesta filtrate fermented jackfruit.
[***] The cost of feed produced was calculated by multiplying the cost/kg of the feed ingredient by the quantity included in the diet.

Table 5. Nutrient digestibility in rabbits fed fermented jackfruit meal diets (on dry matter basis)

Nutrient* (%)	Control	RAW**	PWFJ**	MCAFJ**	RDFFJ**	P-value
Fat	35.6+1.15[b]	24.5+0.58[d]	28.8+0.58[c]	57.8+1.15[a]	27.5±0.58[c]	0.000
Crude protein	20.0+0.58[c]	26.0+1.15[b]	34.4+2.08[a]	24.1+0.58[b]	25.0+0.58[b]	0.000
Ash	23.4+0.58[c]	22.9+0.58[c]	32.0+1.15[a]	29.5+0.29[ab]	27.6+1.15[b]	0.000
Crude fibre	52.8+1.15[ab]	44.0+2.31[c]	56.3+1.15[a]	45.8+2.89[c]	47.1+1.15[bc]	0.005
Nitrogen free extract	26.1+1.15[b]	34.5+0.58[a]	31.8+0.58[a]	32.4+1.15[a]	28.3+1.15[b]	0.001

[abc]Means in the same row with different superscripts differ significantly (P≤0.05)
[*]Values are Means ± SD (n=3)
[**]RAW= Raw jackfruit seed meal; PWFJ = Plain water fermented jackfruit; MCAFJ = Maize cob ash fermented jackfruit; RDFFJ = Rumen digesta filtrate fermented jackfruit.

Haematological indices of rabbits fed differently fermented jackfruit seed meal diets: The data on haematological indices of rabbits fed diets containing differently fermented JSM are presented in Table 6. It was noted that the concentrations of white blood cells (WBC), haemoglobin (Hb), packed cell volume (PCV), platelet count, and mean corpuscular haemoglobin concentration showed significant (P≤ 0.01) differences among the treatment groups. Rabbits fed on diets containing PWFJ had the highest concentration of WBC (10.0 x 103 µl), than those fed MCFJ (4.7 x 103 µl). The variation in the WBC concentration between rabbits fed RAW and those fed MCFJ was non-significant (P > 0.05). The Hb and PCV values were highest (13.2 g/100 ml and 44.1%, respectively) in rabbits fed a control diet. Platelet count in rabbits fed PWFJ was significantly lower (P≤ 0.01), than in rabbits fed control and other treatment diets

The data on serum biochemical indices (Table 6) indicated that all parameters evaluated except albumin and low-density lipoprotein (LDL) were not influenced (P > 0.05) by the treatments. Rabbits fed on RDFFJ had the highest albumin concentration (3.850 g/dl) and lowest in RAW (2.12 g/dl). The LDL concentration was highest in MCAFJ (2.99mg/dl) and lowest (1.57 mg/dl) in RDFFJ.

Table 6: Haematological and Serum biochemical indices of growing rabbits fed fermented jackfruit seed meal diets.

Parameters*	Control	RAW**	PWFJ**	MCAFJ**	RDFFJ**	+ SEM	P value	Normal Range***
Haematological indices								
White blood cell ($x10^3/\mu l$)	9.6^a	5.7^c	10.0^a	4.7^c	7.0^b	0.60	0.002	5.5-12.5
Red blood cell ($x10^6/\mu l$)	6.3	5.6	5.3	4.8	5.2	0.28	0.154	5.46-7.94
Haemoglobin (g/100ml)	13.2	11.8	11.0	12.4	11.4	0.20	0.151	10.4 -17.4
Packed cell volume (%)	44.1^a	39.7^{ab}	36.3^{bc}	33.0^c	37.6^b	1.20	0.000	33 – 50
Mean corpuscular volume (fl)	70.4	70.5	69.8	69.5	72.4	0.60	0.745	55.8- 66.5
MCH (Pg)	22.9	21.8	21.4	21.1	21.8	0.40	0.249	18.7-22.7
MCHC (%)	27.2^b	30.5^a	30.4^a	30.4^a	30.1^a	0.60	0.001	33 – 50
Platelet count	458.0^a	430.6^a	316.3^b	418.6^a	405.6^a	14.7	0.001	304 -656
Lymphocytes	92.1	97.6	95.5	91.4	93.4	1.01	0.014	28 -50
Serum biochemical indices								
Glucose (mmol/l)	4.45	4.59	4.41	4.04	4.62	0.11	0.567	3.83-10.71
Cholesterol (mmol/l)	3.96	4.49	3.90	4.98	3.56	0.24	0.482	10-80
Total protein (gl)	52.8	56.7	51.6	57.0	52.9	0.15	0.942	54-75
Triglycerides (mg/dl)	1.27	1.28	0.99	1.10	1.14	0.07	0.013	-
Albumin (g/dl)	2.54^b	2.12^d	2.29^c	2.53^{bc}	3.85^a	0.21	0.007	3.86-4.40
Calcium (mg/dl)	2.12	2.34	2.22	2.31	2.03	0.09	0.047	3.44-3.7
HDL (mg/dl)	0.60	0.74	0.83	0.66	0.63	0.03	0.063	-
LDL (mg/dl)	1.82^c	2.19^b	1.88^c	2.99^a	1.57^d	0.28	0.027	-
VLDL (mg/dl)	0.25	0.25	0.19	0.22	0.22	0.01	0.597	-

[abc]Means in the same row with different superscripts differ significantly (P≤0.05)
[*]Values are Means ± SD (n=3)
[**]RAW= Raw jackfruit seed meal; PWFJ = Plain water fermented jackfruit; MCAFJ = Maize cob ash fermented jackfruit; RDFFJ = Rumen digesta filtrate fermented jackfruit.
[**] Jain (1986), Zimmerman *et al*. (2010), Shaahu and Tiough (2019)., Mitruka and Rawnsley (1979), Hewitt *et al.* (1989), Yu *et al.* (1979), Melillo (2007)

DISCUSSION

A significant increase in the CP contents of fermented JSM meal, especially with the rumen digesta filtrate fermentation, may be attributed to protein hydrolysis and release of free amino acids for microbial protein synthesis. Magdi (2011) observed that microbes secrete extracellular proteolytic enzymes into their substrate in an attempt to make use of starch as a source of carbon skeleton for protein synthesis. Effiong *et al*. (2016) noted that an increase in the growth and proliferation of the fungi and bacteria complex in the form of single-cell proteins in 72 hours of cultured rumen digesta filtrate accounted for the apparent increase in the protein content of the *I. manni* meal. Aburime (2012) reported that fermentation of African yam bean (*Sphenostylie stenocardia*) in tap water for 24 hours and in lime water for 24 and 48 hours, caused a significant increase in the CP content from 24.19 to 33.08%. The increase in CP contents was also reported by Anyiam *et al.* (2023) following fermentation of *Macrotermes nigeriensis*, cassava and mahewu. The CP of raw JSM (5.00–7.10%) was lower than values reported by Mohamad *et al*. (2019) and Okafor *et al*. (2015) for JSM (10.78%) and maize (10.75%), respectively. However, the CP values were higher than those of non-conventional feedstuffs such as cassava and sweet potatoes as reported at 1-3% (Morgan and Choct, 2016) and 4.39% (Rostagno *et al*., 2005), respectively

The significant reduction in the crude fibre composition of the fermented jackfruit seed meal could be linked to the actions of the fibre digesters and micro-organisms such as fungi present in the fermentation media (Effiong *et al*., 2016). Rumen digesta filtrate may have contained a greater proportion of these microbes relative to other fermentation media, hence its ability to effectively reduce the fibre level of the JSM. The crude fibre contents of the unfermented and fermented JSM (3.11–4.21%) were higher than for maize (2.50%) and lower (5.06%) for water-fermented JSM (Okafor *et al*., 2015). The present findings of crude fiber values are in agreement with Mohamad *et al*. (2019) who reported a value of 3.00% for the JSM. Similar to the present findings, Anyiam *et al.* (2023) noted a reduction in the crude fibre contents of *Macrotermes nigeriensis*-cassava mahewu after 48–72 hours of fermentation and attributed it to the activity of hydrolyzing enzymes such as *cellulase* and *α-galactosidase,* which hydrolyze the dietary fibre constituents as sources of energy, thereby loosening the food matrix further. A decrease in the nitrogen-free extract of fermented JSM was attributed to the high utilization of energy by microflora during fermentation, as observed in earlier studies (Magdi, 2011; Gudeta and Admassu, 2017; Anyiam *et al*., 2023; Boukhers *et al.,* 2022). The ether extract contents of JSM were higher than the reported values of 0.75 (Mohamad *et al*., (2019) and 4.29% (Joy *et al*., 2018). The ash content of the JSM (4.01–5.61%) in the present study was higher than the 1.4% (maize) and 3.03% for water-fermented JSM (Okafor *et al*., 2015). The ash content of 2.32% reported by Adharsh and Manmath (2023) for jackfruit seed was equally lower than the values presented in this work. The increase in the ash content of the rumen-filtered fermented JSM could be attributed to the enzymatic degradation of mineral-phytate complexes by microorganisms to release free minerals, causing an increase in mineral content and bioavailability (Ahmed, *et al*., 2020; Anyiam *et al.,* 2023). The results of this study were consistent with the findings of Adejuwon *et al*. (2021), Hassan *et al.* (2015) and Anyiam *et al.* (2023) who reported an increase in the ash content of fermented sweet potato, cocoyam, and *Macrotermes nigeriensis*-cassava mahewu, respectively.

The significant reduction in the phytochemical contents may be attributed to the degradation of the products through the secretion of enzymes such as phytase, tannase, and non-starch polysaccharides by the microorganisms. The critical function of enzymatic hydrolysis in fermented foods includes a reduction in levels of anti-nutrients, *viz.*, tannins and phytic acid (degradation with the help of phytases), resulting in enhanced bioavailability of simple sugars or polysaccharides (amylases), proteins (proteases), free fatty acids (lipases), and iron (Sharma *et al.*, 2020).

The improvement in daily weight gain of the rabbits fed fermented JSM diets, particularly with the rumen digesta filtrate fermented JSM, could be attributed to the significant increase in protein contents and reduction in anti-nutrients and fibre of raw JSM. It was well reported that fermentation can be effectively employed to improve the nutritional quality of feedstuffs by increasing protein content and digestibility (Inyang and Zakari, 2008), as well as the available lysine content and relative nutritive value (Inyang and Zakari, 2008). Fermentation was also known to inactivate or decrease the anti-nutritional components like decrease in trypsin inhibitory activity, amylase inhibitor activity, phytic acid and tannins (Abdel Haleem *et al.,* 2008) contents. Oladunjoye *et al.* (2010) observed that reduction or complete elimination of anti-nutritional factors in raw JSM with the rumen digesta filtrate fermentation contributes positively to the improvement in rabbits' weight gain. However, in contrast to the present study Adedokun and Ayandiran (2022) reported slightly higher average daily weight gain (12.03–13.52gm) in rabbits fed molasses and improved sorghum brewers dried grain. The non-significant effect on the average daily feed intake between rabbits on control diet and those fed fermented JSM diet showed that fermented JSM did not contain any substance whose activity can cause a reduction in feed intake. Bello and Abdulkarim (2015) fed rabbits with diets containing cassava root meal resulted in daily feed intake (35.12 g–44.36 g) similar to the present findings (37.70 - 49.82 g). The average daily feed intake (39.67 - 42.87 g) reported by Adedokun and Ayandiran (2022) for rabbits fed molasses improved sorghum brewers dried grain diet were also close to the values obtained in this study. Low palatability and dustiness of feed are some of the factors known to reduce feed intake. In this experiment, dietary supplementation of honey at 0.001% across the treatment groups was used to reduce these effects. The better FCR was noted among rabbits fed rumen digesta filtrate fermented JSM diet over those fed control and diets containing raw, plain water and maize cob ash fermented JSM diets implied that the feed was converted to flesh more efficiently.

In agreement with the present findings Shaahu and Tiough (2019) and Adedokun and Ayandiran (2022) reported slightly higher or similar FCR values when fed rabbits with cassava root-forage composite meal (FCR: 3.80–4.79) and molasses improved sorghum brewers dried grain (FCR: 3.02–4.29) diets.

Improvement in the nutrients digestibility in rabbits fed JSM diets implied that the fermentation processing methods enhanced the digestion of nutrients in JSM. The difference in digestibility values reported by other researchers (Gbenge, 2022; Adegbola and Okonkwo, 2002) in rabbits fed yam-cassava peel composite meal as a replacement for maize and cassava leaf meal in their studies might be due to differences in diet types and processing methods used.

The haematological values of growing rabbits obtained in this study were within the normal range. The WBC (7.0–10.0 $\times 10^3/\mu l$) was normal when compared to the standard value (5.5–12.5 $\times 10^3/\mu l$) reported by Jain (1986) and Zimmerman *et al*. (2010), indicating that the rabbits were in good health condition and were not under any form of stress. Togun *et al*. (2007) reported a significantly low lymphocyte count indicated a reduction in the ability of the experimental rabbit to produce and release antibodies when infection occurs. The experimental rabbits were able to produce a high number of lymphocytes in order to fight infections. The RBC count, haemoglobin concentration, PCV, and platelet count reported by Jain (1986), Zimmerman *et al*. (2010), Shaahu and Tiough (2019), Mitruka and Rawnsley (1979) were in agreement with the values obtained in the present study. A non-significant ($P \leq 0.05$) difference in the MCV and MCH indicated that the sample did not contain any substances whose effects were detrimental to the animals. A normal MCV, MCH, and MCHC values as indicated in this study implied that the rabbits were not anaemic. The serum biochemical indices recorded in the present study were similar to the normal range reported by Mitruka and Rawnsley (1979), Hewitt *et al.* (1989), Yu *et al*. (1979), and Melillo (2007). Low HDL, LDL, and VLDL values suggested that the treatment samples did increase the fat concentration of the experimental rabbits.

Reductions in the cost of feed production, the cost of feed taken by rabbits, and the cost for every kilogram of weight gain arising from replacing maize with JSM showed that JSM could stand as a good substitute for maize in rabbit feed compound diets.

Conclusion: In conclusion, the fermentation media improved the chemical composition of the jackfruit seed meal, with the rumen digesta filtrate being the best that have also improved the live performance of the growing rabbits. It indicated that maize could be replaced by the rumen digesta filtrate fermented jackfruit seed meal for the optimum performance of rabbits during the growth period.

Authors' contribution: O. O. Effiong conceived and designed the study. V. N. Ebegbulem, N. P. Jimmy and O.O. Ekwe executed the experiment. And A. Halilu analyzed the data. All authors interpreted the data, critically revised the manuscript for important intellectual contents and approved the final version.

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