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EFFECTS OF CASSAVA PEEL MEAL ON SEMEN QUALITY AND REPRODUCTIVE POTENTIAL IN GROWING MALE RABBITS

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ABSTRACT

The semen quality of Growing Male Rabbits Fed Graded Levels of Cassava Peel meal was investigated. Thirty (30) male rabbits of mixed breeds, of about six to seven months old with the average weight of 1050 grams were randomly assigned in a completely randomized design into five treatments groups with six rabbits per dietary treatment (six replicates and a rabbit per replicate). The diet was formulated such that cassava peel meal, replaced 20, 40, 60 and 80 percent of dietary maize while the control was 0%. Results showed that the rabbits fed 40% CPM had the most concentrated, viable and active sperm cells which is a critical factor for ensuring successful fertilization. It may therefore, be concluded that cassava peel meal can be considered a promising conventional energy source for rabbit's nutrition in terms of improving the semen quality, thereby potentially enhancing the overall fertility status.

Keywords: *cassava peels meal, growing male rabbits, semen quality,*

INTRODUCTION

Protein deficiency, in human diets, particularly from animal sources, remains a pressing issue in Africa and many developing countries. Although there have been slight improvements in recent decades, The average daily protein intake in Africa still remains approximately 62 grams per person, compared to the recommended 75 grams for a 90-kg adult (Schönfeldt *et al.,* 2024). This intake is significantly lower than global averages and varies widely between regions, with rural and low-income populations disproportionately affected due to economic and logistical barriers to accessing diverse protein-rich foods (Schönfeldt *et al*., 2024).

The problem of low intake of animal protein is due to poor economic situation as well as high cost of feeds in intensive commercial units. To ease this problem of low animal protein intake, there should be an expansion in the production of small, highly prolific livestock with rapid turnover rate at a very low cost. Recently, the rabbit has come under focus as an animal with enormous potential because of its attributes such as small body size, short generation interval, high reproductive potential, rapid growth rate, genetic diversity and ability to utilize forage. Rabbits are known for their efficient feed conversion rates, rapid growth, and adaptability to various environmental conditions, making them valuable assets in sustainable livestock farming systems (Lukefahr and Cheeke, 2021). However, challenges such as resource limitations, low adoption of intensive farming practices, and socio-economic disparities hinder progress. For instance, rural communities, particularly those involved in farming, often face barriers like low income and limited access to animal protein, which further exacerbates the protein deficiency problem (FAO, 2024). Among the challenges faced in rabbit production is the availability and cost of feed ingredients, which directly impact performance, physiological parameters, reproductive indices, and carcass characteristics of rabbits (Adeyemi *et al.,* 2021). This is mainly due to competition between humans and animals over energy sources in feed such as maize, that increase production cost. This has necessitated investigations into the potential of non-conventional, less expensive, safe and readily available ingredients for use in formulating rabbit rations. One of such ingredients is cassava peel meal. Cassava peel meal (CPM), derived from cassava peels, represents a potential feed resource rich in energy and fibre, with moderate levels of protein and essential nutrients (Ogunwole *et al.,* 2023). Proper nutrition ensures adequate energy reserves, hormonal balance, and functional reproductive systems, which are essential for optimal fertility and breeding outcomes (Milewski *et al*., 2023; HusFarm, 2023).

Cavallari *et al.* (2023) reported that recent studies confirm the significant connection between animal nutrition and reproductive performance, highlighting how balanced and optimized feeding enhances productivity and reproductive efficiency. For high-producing livestock, proper dietary management, including a mix of essential macronutrients, vitamins, and minerals, ensures reproductive health and optimal performance (Cavallari *et al.*,2023; Rocha and Potter, 2023). Reproductive efficiency remains a critical factor in livestock production, directly influencing productivity and profitability. Recent research highlights the importance of effective reproductive management in overcoming challenges like pregnancy loses, infertility, and low conception rate (Eman *et al.,* 2024). Inadequate consumption of energy, protein, vitamins, micro and

macro minerals have been linked to reduced reproductive performance (Mayila *et al*., 2018).

Poor energy availability, resulting from inadequate calorie intake or excessive expenditure, can disrupt gonadotropin-releasing hormone (GnRH) secretion, a key regulator of reproductive functions (Mayila *et al*., 2018).

The reproductive effects of alternative feed ingredients like cassava peel meal (CPM) in male rabbits are not well-documented, raising concerns about fertility implications. Reproductive performance is crucial for sustainable rabbit farming, evaluating the impact of CPM on semen quality provides insights into its suitability as a feed ingredient. Therefore, the objectives of this study was to examine the effect of CPM on semen volume, concentration, and liquefaction of growing male rabbits and also to determine the influence of CPM on sperm viability and abnormalities of growing male rabbits

Materials and Methods

Location of the Experiment

The study was conducted at the Rabbitry Unit of the Teaching and Research Farm, Department of Animal Production, Prince Abubakar Audu University, Anyigba, located in Dekina Local Government Area, Kogi State. Anyigba is situated on latitude of 7°30'N and a longitude of 7°09'E, with an average altitude of 420 meters above sea level. The area falls within the tropical wet and dry climate zone of the Guinea savanna, characterized by an average annual rainfall of approximately 1600 mm and a daily temperature range between 25°C and 35°C (Aderibigbe *et al*., 2022).

Collection, Processing and Preparation of Experimental Diet.

Cassava peels of mixed varieties were collected within 24 hours after peeling the tuber from gari-processing plants in Anyigba in Dekina Local Government Area of Kogi State, Nigeria. They were washed and allowed to ferment for three days, then sun dried for 5 days. The dried peels were ground in a hammer mill. Other feed ingredients were purchased from the open market in Anyigba.

Experimental diet

The treatments were 5 experimental diets (diet 1, diet 2, diet 3, diet 4, and diet 5), formulated to contain about 17% crude protein, Metabolizable Energy of 2500kcal/kg and with cassava peels meal replacing 0, 20, 40, 60 and 80% of the maize in the diets (Tables 1). The proximate compositions of the diets are presented on Table 2. The study lasted for 8 weeks.

Table 1: Diet Composition of Experimental Diets for rabbits

Ingredients	%CPM				
	Diet 1 (0 %)	Diet 2 (20 %)	Diet 3 (40 %)	Diet 4 (60 %)	Diet 5 (80 %)
Maize	37.18	29.74	22.31	14.87	7.44
Cassava Peel Meal	0.00	7.44	14.87	22.31	29.74
FFSBM	16.35	16.35	16.35	16.35	16.35
Dry Brewers' Grain	20.00	20.00	20.00	20.00	20.00
Bambara nut Waste	23.12	23.12	23.12	23.12	23.12
Bone meal	2.50	2.50	2.50	2.50	2.50
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Vit. /Min premix	0.25	0.25	0.25	0.25	0.25
Salt	0.20	0.20	0.20	0.20	0.20
Total (%)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
calculated					
Crude Fibre (%)	7.26	7.78	8.38	8.94	9.49
Crude Protein (%)	17.95	17.66	17.37	17.09	16.79
Energy ME (kcal/kg)	2690.86	2616.21	2541.24	2466.17	2391.20

FFSBM= full fat soyabean meal, ME = metabolizable energy, CPM= cassava peel meal

Experimental rabbits and management procedure

Thirty (30) male rabbits of mixed breeds, of about six to seven months old with the average weight of 1050 grams were randomly assigned in a completely randomized design into five treatments groups with six rabbits per dietary treatment (six replicates). The diet was formulated such that cassava peel meal, replaced 20, 40, 60 and 80 percent of dietary maize in the control. The rabbits were housed in individual cages measuring 76 x 62 x 42cm, elevated from the ground to a height of 90cm and bounded around with galvanized wire. The cages were equipped with feeding and drinking troughs. The cages' floors were made of perforated metal slates to allow for easy passage of faeces and urine. The experiment lasted for eight

weeks. Before the arrival of the rabbits, the cages, feeders and troughs were thoroughly disinfected and washed. The rabbits were fed commercial hybrid feed growers mash to stabilize them for one-week during which they were also prophylactically treated against internal and external parasites using ivermectin (0.2ml/rabbit) subcutaneously, other drugs used were; embazine forte (0.5grams/litre) in their drinking water for five days and tetracycline (0.5grams/litre) in their drinking water for five days to prevent coccidiosis and bacterial infection. The initial weights of the rabbits were taken before they were introduced to the experimental diets. The rabbits in each treatment were served 250g feed daily between 7 - 8.00am and forages (corn leaves and banana leaves) were also fed daily by 3pm. Water was supplied *ad libitum*. Daily feed consumption was recorded for each rabbit, weight gain was calculated weekly on an individual basis.

Collection of samples

Semen collection

Semen traits were evaluated by collecting semen with the aid of artificial vagina (AV). Does were used as teasers on the day of semen collection. The volume of the semen was read on the collection tube attached to the artificial vagina and was recorded, after which skimmed milk extender was used to prevent the semen from cold shock and was packed in an ice pack to slow the sperm metabolism and prolong sperm viability for a few hours as described by Ari and Foote (2002) before it was taken to the laboratory for evaluation. Sperm concentration and sperm counts were estimated using Neubauer Hemocytometer. The total number of sperm cells in each ejaculate were counted and the sperm concentration was calculated by multiplying the concentration by the ejaculate volume.

Semen morphology

Sperm motility: An aliquot of the semen sample was made on a slide using a dropper covered with a slip and viewed through a Zeiss microscope on a warm stage at a magnification of x 100. The percentage motility was estimated for each sample.

Percentage live sperm cells were determined using florescent stains.

Statistical analysis

Data collected was subjected to one way analysis of variance (ANOVA) as appropriate for Completely Randomized Design using Statistics software package (SAS) version 9.4. Distinctions between means were discerned using Fisher's Least Significant Difference (LSD) method at 5% level of significance.

RESULTS AND DISCUSSION

Results

The Proximate Composition of Cassava Peel Meal (CPM) and Experimental Diet of Growing Male Rabbits is shown in Table 2. There was a decrease in dry matter from 95.90% to 94.83% (from 0% to 60% inclusion levels) then rose to 95.89% at 80% inclusion level while the dry matter in CPM was 94.85%. Crude protein decreased from 17.95% to 14.91% in the experimental diet while 3.55% was observed in CPM. Crude fat followed the same trend as crude protein decreasing from 4.60% 1.49% while 0.53% was observed in the CPM. Crude fiber rose from 3.45% to 5.00% while the observed CPM was 9.89%. Ash content exhibited only slight variations, staying relatively stable. NFE rose from 6.77% to 72.60% while CPM was 79.17%.

Table 2: Proximate Composition of Cassava Peel Meal (CPM) and Experimental Diet of Growing Male Rabbits

Parameters	CPM	0%	20%	40%	60%	80%
Dry matter (%)	94.85	95.90	94.91	94.84	94.83	95.89
Crude protein (%)	3.55	17.95	16.90	16.00	15.85	14.91
Crude fat (%)	0.53	4.60	3.78	2.64	2.01	1.49
Crude fibre (%)	9.89	3.45	3.64	4.53	4.88	5.00
Ash (%)	1.71	2.13	1.99	1.86	1.94	1.89
NFE (%)	79.17	67.77	68.60	69.81	70.15	72.60

NFE =Nitrogen Free Extract, CPM= cassava peel meal

The effect of graded levels of cassava peel meal on semen volume, concentration and sperm cell count in growing male rabbits is shown in Table 3. Apart from the volume, concentration and sperm cell count measured, were significantly ($p < 0.05$) affected by the levels of cassava peel meal. The volume of semen produced across the treatments ranged from 1.05 to 1.15mL, diets with 0% and 40% CPM recorded the highest semen volume, followed by diets with 20% CPM, while diets with 60 and 80% CPM inclusion levels had the least volume. Sperm concentration and sperm cell count measured followed the same trend. Diets with 0% and 40% inclusion levels were similar but significantly ($p < 0.05$) different from 20% and 60% inclusion levels. Rabbits fed diet with 40% inclusion level of cassava peel meal had the highest sperm concentration and total cell count, while rabbits fed diet with 60% inclusion level of cassava peel meal had the lowest sperm concentration and total cell count.

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Table 3: The Effect of Graded Levels of Cassava Peel Meal on Semen Volume, Concentration, and Sperm Cell Count in Growing Male Rabbits

Parameters	%CPM					
	0%	20%	40%	60%	80%	SEM
Volume (ml)	1.15	1.10	1.15	1.05	1.05	0.13
Total cell count ($x10^6$)	288.50^a	198.00^b	298.50^a	195.00^b	247.50^{ab}	31.43
Sperm concentration(ml)	333.15^a	216.70^b	342.05^a	206.40^b	258.40^{ab}	41.79

^{ab}Means with different superscript along the same rows show significant difference at p>0.05, SEM= Standard Error of Means. CPM= cassava peel meal.

Viability was significantly (p<0.05) different. The range observed was from 52.50% to 69.50%. The most viable semen was recorded in diet with 40% CPM while the least was in the diet with 80% CPM. However, diets with 0% and 40% CPM were similar but different from other diets. For active semen, there was significant (p<0.05) difference among the treatments. The range of values were from 47.00% to 71.00%. However, diets with 0%, 40% and 60% CPM were similar but different from the diets with 20% and 80% CPM. The percentage normal sperm cells observed ranged from 65 to 76% with 40% CPM having the highest normal sperm cells and diet with 60% CPM having the least. While the abnormal sperm cells ranged from 24 to 35% with 40% CPM recording the lowest and diet with 60% CPM recording the highest abnormal sperm cells.

The most active semen was observed in the rabbits fed 40% inclusion level of cassava peel meal. For sluggish semen, there were significant (p<0.05) difference among the treatments However, semen of rabbits fed 20% and 80% inclusion levels were similar but different from semen of the rabbits fed 0%,40% and 60% inclusion levels. For dead cell, the observed values were significantly (p<0.05) different. A range of 8.00% to 19.00% was observed. Dead cell semen followed the same trend as the sluggish semen. Rabbits fed 40% and 60% showed the lowest dead cell percentage in their semen, followed by those fed with 0% CPM

Table 4: The Influence of Graded Levels of Cassava Peel Meal on sperm viability and abnormalities in Growing Male Rabbits

Parameters	%CPM					
	0%	20%	40%	60%	80%	SEM
Viability (%)	69.00^a	59.00^b	69.50^a	57.50^{bc}	52.50^c	2.43
Normal (%)	74.50	66.50	76.00	65.00	65.50	4.85
Abnormal (%)	25.50	33.50	24.00	35.00	34.50	34.50
Active (%)	69.00^a	52.00^b	71.00^a	67.50^a	47.00^b	2.88
Sluggish (%)	21.00^b	30.00^a	21.00^b	21.00^b	30.00^a	1.10
Dead cell (%)	10.00^b	19.00^a	8.00^b	8.00^b	19.00^a	2.68

^{abc}Means with different superscript along the same rows show significant difference at p>0.05, SEM= Standard Error of Means. CPM= cassava peel meal.

Discussion

Proximate Composition of Cassava Peel Meal (CPM) and Experimental Diet of Growing Male Rabbits

The proximate values of experimental diets differ from that of CPM, which listed lower crude protein (3.55%) and crude fat (0.53%) content, but higher crude fiber (9.89%) than what was observed. The discrepancies between the observed values of CPM and that of the experimental diets can be attributed to several factors:

Crude Protein decrease: The decrease in protein content in the experimental diets with as CPM level increases could be a result of compared to the value of CPM could be due to the inclusion of cassava peel meal in the diet and post-harvest handling could also contribute to protein content differences. Crude Fat increase: The increase in crude fat compared to the labels claim 4% may be explained by the inclusion of fat-soluble compounds from the velvet tamarind leaves or by residual oil from other diet ingredients. Additionally, slight variations in leaf maturity or harvest timing could affect the fat content, as younger leaves often contain higher fat levels.

The Effect of Graded Levels of Cassava Peel Meal on Semen Volume, Concentration, and Sperm Cell Count in Growing Male Rabbits

Semen quality is a critical fertility index for male rabbits and is often the primary determinant of breeding success. The volume of semen produced

across the treatments ranged from 1.05 to 1.15mL. This value is within the range 0.7 to 1.2 mL and 0.5 to 1.5 mL for normal volume as reported by Eruvbetine *et al.* (2019) and Olukosi *et al.* (2020). This is an indication that the rabbits had optimal hormonal balance, particularly testosterone, which regulates reproductive function leading to good sperm quality and quantity which is essential for successfully breeding and overall well-being of the rabbits. The values were not affected by the treatments and is in line with Chinaka *et al*. (2020) who reported that moderate levels of CPM inclusion do not negatively affect semen volume in rabbits but in contrasts with the work of Castellini *et al*. (2019) who reported that semen volume in male rabbits typically ranges between 0.4 and 1.0 mL per ejaculate. The rabbits fed 0% and 40% CPM had the highest semen volume compared to other diets. This is however in contrast to Olukosi *et al.* (2020) who found that rabbits fed 10% CPM had significantly higher semen volume compared to those fed 0% or 20% CPM. However, older males generally producing higher volumes compared to younger, sexually immature males (Castellini *et al*., 2019). High inclusion levels (above 25%) have been associated with reduced semen volume, potentially due to a decline in fluid secretion from the accessory glands (Chinaka *et al*., 2020). The Sperm concentration obtained in this study was significantly ($p<0.05$) affected by the treatments. It ranged from 206.40 to 342.05 million/mL which is within the range of 200.00-400.00 million/mL reported by Olukosi *et al.* (2020). The most concentrated sperm was recoded with the rabbits fed 40% CPM. This result is not in agreement with Adeyemo *et al.* (2019) who reported that moderate levels of CPM (up to 15-20% of the diet) generally do not significantly affect sperm concentration in rabbits, with values remaining comparable to those fed traditional diets. Also, not in agreement with Okeke *et al.* (2020) who opined that higher inclusion levels (30% and above) may reduce sperm concentration. The least concentrated sperm was from the rabbits fed 60% followed by 20% CPM. The variation in the sperm concentration may likely be due to the combined effects of increased fibre and residual cyanogenic compounds, which may interfere with spermatogenesis and the efficiency of sperm production (Okeke *et al*., 2020). The values obtained for total cell count was significantly ($p<0.05$) different and in contrast with the values reported by Eruvbetine *et al*. (2019) and Olukosi *et al*. (2020) who reported a range of 600-700 million/mL and 500-800 million/mL for normal range in growing rabbits. The values reported by these authors were better than those observed in this experiment (195.00 to 298 million/mL).

The Influence of Graded Levels of Cassava Peel Meal on sperm viability and abnormalities in Growing Male Rabbits

Sperm viability was affected by the treatments in this study. The range was from 52.00 to 69.50%. This value is lower than the normal values of 85 to 90% (Jenkins, 2017) and 80 to 90% (Oyebade *et al*., 2020). The most viable sperm was recoded from the semen of rabbits fed 40% CPM. This result is not in agreement with Salami and Ogunka (2020) who reported that moderate inclusion of cassava peel meal (up to 20%) does not significantly impact sperm viability, with viability rates comparable to those observed in rabbits fed standard diets. However, this study also showed a reduction in sperm viability at higher inclusion level, this is in agreement with Fasuyi *et al*. (2016) who observed a reduction in sperm viability at higher inclusion. This is likely to be due to cyanide-induced oxidative stress, which can damage sperm cells and reduce their functional capacity (Fasuyi *et al*., 2016). This oxidative damage can lead to compromised cell membranes and reduced energy levels, contributing to decreased viability (Fasuyi *et al*., 2016). The percentage of normal and abnormal cells were not significantly affected by CPM. Normal sperm cells have been shown to improve sperm motility (Olukosi *et al*., 2020), increase sperm concentration (Eruvbetine *et al*., 2019) and have been linked to improved sperm morphology which is essential for successful fertilization and critical for successful breeding (Olukosi *et al.*, 2020). while abnormal sperm cells have been shown to reduce sperm motility, decrease sperm concentration and have been linked to poor sperm morphology making it difficult for successful fertilization and negatively impact breeding success (Olukosi *et al.*, 2020). The range of normal cells in this study ranged from 65 to 76% while the abnormal ranged from 24 to 35%. This study showed that rabbits fed 40% CPM had the highest percentage of normal sperm cells and lowest abnormal sperm cells compared to those fed other diets. This is in contrast with a study by Olukosi *et al*. (2020) who found that rabbits fed graded levels of CPM (5-15%) have been shown to increase the percentage of normal sperm cells and reduce the abnormal sperm cells in growing male rabbits The percentage of the active sperm cells was ($p>0.05$) significantly affected by CPM with a range from 47.00 to 71.00%. This value is lower than the normal range of 65 to 75% (Eruvbetine *et al*., 2019) and 60.00 to 80.00% (Olukosi *et al.*, 2020). The rabbits fed diet with 40% CPM had the highest active sperm cells while the rabbits fed 80% CPM had the least this is not in line with the study by Olukosi *et al*. (2020) who found that rabbits fed 10% CPM had a significantly ($p>0.05$) higher percentage

of active sperm cells compared to those fed 0% or 20% CPM. The percentage of the sluggish sperm cells was significantly affected. It ranged from 21.00 to 30.00%. this value is lower than the normal range 12.00 to 18.00% reported by Eruvbetine *et a*l. (2019) and 10.00 to 20.00% (Olukosi *et al*., 2020). This study observed that rabbits fed 0,40, and 60% CPM had a significantly lower percentage of sluggish sperm cells compared to those fed 20% or 80% CPM. This is contrast with Eruvbetine *et al.* (2019) who found that rabbits fed 12.5% CPM had a significantly lower percentage of sluggish sperm cells compared to those fed 0% or 25% CPM. The percentage of dead cells was also significantly affected by CPM. The range of dead cell in this study was from 8 to 19%. This study showed that rabbits fed 40 and 60% CPM had a significantly lower percentage of dead sperm cells compared to those fed 0%, 20% and 80% CPM. This is in contrast with a study by Oyebade *et al*. (2020) who found that rabbits fed 10% CPM had a significantly lower percentage of dead sperm cells compared to those fed 0% or 20% CPM.

Conclusion

Based on the observed results in this research work, it can be concluded that there are potential benefits of incorporating cassava peel meal into the diet of rabbits at varied inclusion levels as they have noticeable impact on the semen quality of growing male rabbits. The steady increased values obtained from rabbits fed 40% CPM demonstrate that cassava peel meal inclusion has the potential to influence the overall fertility status of the growing male rabbits. It may therefore be concluded that cassava peel meal can be considered a promising non-conventional energy source for rabbit's nutrition in terms of improving the semen quality, thereby potentially enhancing the overall fertility status for ensuring successful fertilization.

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