Sahel Journal of Life Sciences FUDMA (SAJOLS)
March 2025 Vol. 3(1): 72-78
ISSN: 3027-0456 (Print)
ISSN: 1595-5915(Online)
DOI: *https://doi.org/10.33003/sajols-2025-0301-09*

Research Article

Effect of Replacing Maize with Yam Peel Meal (YPM) on the Gastrointestinal Tract and Reproductive Tract Morphometry of Rabbit Does

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ABSTRACT

The present study was carried out at the livestock teaching and research farm, Joseph Sarwuan Tarka University Makurdi, Benue State. A total of sixteen 6-8 weeks old female rabbits of mixed breeds with average initial weights of 650-850g were used to examine the effect of replacing maize with graded levels of yam peel meal (YPM) on the gastrointestinal tract and reproductive tract morphometric of rabbit does. The rabbits were randomly allotted into four treatment groups designated as T1 (which served as the control), T2, T3, and T4 in a completely randomized design (CRD). Each treatment was replicated four times having one rabbit per replicate. Four experimental diets were formulated with YPM at varying levels of 0% in T1, 25%, 50% and 75% in T2, T3 and T4, respectively. Each of the diets was offered *ad libitum* to the rabbits with cool clean drinking water. After 12 weeks of ad libitum feeding, all the animals were sacrificed under humane conditions. The results showed similarities (P>0.05) between the diets for all the parameters evaluated. The results suggest that up to 70% replacement of maize with YPM in the diets of female rabbits may support normal gastrointestinal tract functions and the physiology of reproduction in female rabbits.

Keywords: Gastrointestinal tract; Reproductive tract; Morphometry; Yam peel meal; Rabbits

Citation: Ate, M.E., Adagi, J.M., Nyigba, M.T. & Answem, L.S. (2025). Effect of Replacing Maize with Yam Peel Meal (YPM) on the Gastrointestinal Tract and Reproductive Tract Morphometry of Rabbits. *Sahel Journal of Life Sciences FUDMA*, 3(1): 72-78. DOI: *https://doi.org/10.33003/sajols-2025-0301-09*

INTRODUCTION

Nearly 282 million people in Africa (about 20 percent of the population) are undernourished, an increase of 57 million people since the COVID-19 pandemic began. Nigeria is a country that prides herself as the giant of Africa with a growing population of over 218.54,541,212 million, a gross domestic product (GDP) of size (Constant 2015 $US $472.62 billion), a GDP per capita (Constant 2015 US $2162.6), and inflation rate 23.4 % (WHO, 2023). Yet, given these statistics by the World Bank, previous studies such as Beyene (2023), Theodore *et al.* (2023) and Iwu (2020) agree that Nigeria still suffers from food insecurity. Undoubtedly, the population of Nigeria has been steadily expanding over the years, leading to a corresponding rise in the need for improved quality of life and food provisions. Food supplies are insufficient and unavailable because of population increases, outpacing food production (Nwajiuba, 2013). Nigeria's score for protein quality is just 32 out of 100, indicating that the nutritional quality of protein in the diets of Nigerians is very poor and this low score highlights significant challenges in ensuring that the population receives adequate and high-quality protein essential for health and development (Kareem, 2024). Increases in protein consumption cannot be met easily by large animals because of their slow production cycles but may however be met by short-cycle animals like rabbits, poultry and pigs. Poultry and pigs require food sources which are in serious competition with man but rabbits can be produced on forage alone although, production can be improved by the

addition of other food by-products. Rabbits are also known for their high reproductive rates, short generation interval, rapid growth, and efficient feed conversion making them an attractive option for small-scale farmers looking to diversify their livestock enterprises (Aduku and Olukosi, 1990).

Traditional rabbit feeds often rely on maize, a staple ingredient known for its high energy content. While maize effectively supports growth and production, it is highly competed for by man and livestock and this has led to a growing interest in alternative feed sources (Uchegbu *et al*., 2008). One such alternative is yam peel meal (YPM) a by-product of yam processing that has shown promise as a viable feed ingredient (Ekpo *et al.,* 2015). Yam peel meal is derived from the outer skin of yams, which are commonly used in various food products. This by-product is often underutilized despite its nutritional potential. However, this by-product is gaining attention as a potential alternative feed ingredient in animal husbandry due to its nutritional and economic advantages. In particular, yam peels meal (YPM) is being explored for its feasibility as a feed ingredient for rabbits, which are valued for their efficient growth and high reproductive rates. Yam Peel Meal contains 95.34% dry matter, 4.89% crude protein, 12.24% crude fibre, 9.78% ash, 3.34% ether extract and 69.75% NFE (Popoola *et al*., 2021). The high fibre content of yam peel can support healthy digestion and prevent common gastrointestinal issues in rabbits, such as diarrhoea and constipation (Ajayi *et al.,* 2022).

The importance of studying gastrointestinal tract morphometry in rabbits fed YPM lies in its potential to inform sustainable and cost-effective feeding strategies for rabbit production. Morphometric studies in the gastrointestinal tract are essential for understanding the anatomy and physiology of the digestive system. The gastrointestinal tract morphometry of female grower rabbits is a critical aspect of their overall health and productivity. The length and diameter of different segments of the rabbit's gastrointestinal tract can vary significantly with diet (Ozung *et al*., 2011) and it is also known to affect digestion (Jones *et al*., 2022). In female grower rabbits, the morphometry of the gastrointestinal tract plays a crucial role in nutrient digestion and absorption, ultimately influencing their growth and development.

Reproductive tract morphometry in animals is crucial, strengthening reproductive management and facilitating the implementation of biotechnology techniques tailored to their specific morphological characteristics (Carvalho *et al*., 2010). The knowledge of basic morphometric characteristics of the reproductive organs have been found to provide valuable information in the evaluation of breeding and fertility potential of the animals (Ogbuewu *et al*., 2010). The objective of this research work therefore, was to investigate the effects of replacing maize with varying levels of yam peel meal on the gastrointestinal tract and reproductive tract morphometry of rabbit does.

MATERIALS AND METHODS

Location and experimental site

The experiment was conducted at the Livestock Teaching and Research Farm, Joseph Sarwuan Tarka University, Makurdi, Benue State of Nigeria. Makurdi is located at longitude 8^{o} 21'E and latitude 17^{o} 14" N. It lies in the middle of the Guinea Savannah region of Nigeria. The area is warm with a temperature range of 24.20^{o}C -35.6^{o}C. Rainfall is between 108 –1016 mm and relative humidity is 39.50% - 64% (TAC, 2009).

Source and preparation of Yam Peel Meal (YPM) and other ingredients

The Yam peels used for the study were procured from households and restaurants in Makurdi town. Care was taken to remove all extraneous materials through hand picking and the yam peels were sun dried afterwards. The dried peels were then crushed at the feed mill of the Livestock Teaching and Research Farm Joseph Sarwuan Tarka University, Makurdi, before being incorporated into the experimental diets. Other ingredients such as soya beans, maize, bone meal, palm kernel cake (PKC), vitamin premix, and common salt were sourced from the open markets and livestock feed shops within the Makurdi metropolis.

Experimental Animals and Management

A total of sixteen female grower rabbits of mixed breed with an average weight of 850g were used for this study. The rabbits were obtained from commercial rabbit farms in the Makurdi metropolis and housed individually in hutches raised above the ground level. The hutches were constructed using wood and wire mesh with a roof over. Each hutch was equipped with a metal feeder and drinker. A week to the arrival of the experimental animals, the hutches were thoroughly washed using detergent and disinfectant and allowed to dry. The feeders and drinkers were also properly washed and dried before bringing them and placing in the various compartments.

On arrival, all the experimental rabbits were given anti-stress and antibiotics. They were also given Ivermectin subcutaneously after a two-week acclimatization period to guard against ecto and endo parasites. The animals were then weighed and randomly distributed into four experimental groups in a completely randomized design with four replicates per group. Feed and clean drinking water were given to the animals *ad libitum*.

Experimental Diets

Four experimental diets were formulated such that Treatment 1 (T1) without Yam Peel Meal (0% YPM) served as the control diet while the test ingredient Yam Peel Meal (YPM) replaced maize at 25%, 50% and 75% in Treatment 2 (T2), Treatment 3 (T3) and Treatment 4 (T4) respectively. All the diets contained 18% crude protein as required for growing rabbits.

Table 1: Experimental diets

Ingredient	T1(0%YPM)	T2(25%YPM)	T3(50%YPM)	T4(75%YPM)
Maize	29.00	21.75	14.50	7.25
Yam Peel Meal	0.00	7.25	14.50	21.75
Brewers Dried Grain	15.00	15.00	15.00	15.00
Soybean Meal	13.00	13.00	13.00	13.00
Palm kernel cake	38.00	38.00	38.00	38.00
Bone meal	3.85	3.85	3.85	3.85
Lysine	0.38	0.38	0.38	0.38
Vitamin mineral premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.27	0.27	0.27	0.27
Total	100.00	100.00	100.00	100.00

Experimental design

The completely randomized design (CRD), was used to assign all the animals to the experimental diets.

Evaluation of proximate composition of Yam Peels

Proximate analysis of yam peels was carried out according to the procedure of the Association of Official Analytical Chemists (AOAC, 1990) for moisture, ash, crude fibre and crude protein content. The carbohydrate was calculated by difference method (A.O.A.C., 1990) by subtracting the sum (g/100g dry matter) of crude protein, crude fat, ash and fiber from 100g.

Data collection

Gastrointestinal tract morphometry: At the end of the trial period, two animals were selected per treatment group and slaughtered under humane conditions by first, stunning the animals with a blunt object rendering them unconscious, and then, severing the jugular vein. The animals were then eviscerated and the gastrointestinal tract was removed intact and completely emptied. The weight and length of the esophagus, stomach, small intestine, colon, and caecum were then taken using a sensitive weighing scale and a meter rule.

Reproductive tract morphometry: Each animal was dissected immediately after slaughter and the reproductive tract was obtained intact and completely, trimmed free of fat and adhering connective tissue before morphometric analysis. The ovary was then carefully removed from its ovarian bursa at the end of its infundibulum. The infundibulum was next to be removed followed by the oviduct. The uterine horn was then taken from the end of the two cervixes to the rosette projection of the utero-tubal junction. Morphometric evaluations were done using highly sensitive digital balances while linear measurements were taken with well-calibrated rules and a Vernier caliper.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) for a completely randomized design.

RESULTS AND DISCUSSION

Proximate and Nutrient composition of Yam Peel Meal (YPM)

Proximate composition of Yam Peel Meal (YPM)

The proximate composition of Yam Peel Meal is presented in Table 2. The proximate composition was determined using the AOAC method (AOAC, 1990). The crude protein content of 4.38% obtained in the present study is higher than the values of 3.62% and 3.46% reported by Jekayinfa and Omisakin (2005) and Lawal *et al*. (2014) respectively. Higher values ranging from 9.14% to 12.17% have been reported by other scientists (Akinmutimi *et al*., 2006; Ekenyem *et al*., 2006; Akinmutimi and Onen, 2008; Ezieshi and Olomu, 2011). The CF content (5.46%) and Ash (4.76%) are also lower than 8.40% and 9.30% as reported by Ekenyem *et al.* (2006) and Akinmutimi and Onen (2008) respectively. The value of ash content observed is an indication that yam peel contains moderate amounts of minerals for livestock performance. The result also indicated that yam peel meal recorded a very low fat content of 1.67% which is similar to the findings of Ekeyem *et al*. (2006) and Akinmutimi and Onen (2004). The NFE values of 83.73% implies that YPM has a high level of soluble carbohydrate and will enhance palatability and therefore, increase feed intake and digestibility. The ME (3262.33 kcal/kg) of the test ingredient is higher than the value of 2604 kcal/kg

obtained by Akanno (1998). These variations may be attributed to the variety of yams used, sources of yam peels, processing methods, soil conditions, or the different environments in which the yams were cultivated.

Gastrointestinal Tract Morphometry

The effect of feeding graded levels of YPM as a replacement for maize on the weight and length of the gastrointestinal tract of rabbits is presented in Tables 3 and 4 respectively.

No significant differences were observed in both the weight and length of the gastrointestinal tract when rabbits were fed graded levels of Yam Peel Meal as a replacement for maize.

The weight of the stomach in the present study ranged from 19.39-20.22g and is slightly higher than the values obtained by Ozung *et al*. (2011). While the values obtained for the weight of the oesophagus and small intestine were comparable to values obtained by Ozung *et al*. (2011), the weights of 25.26-30.47g and 20.58-22.77g observed for the colon and caecum in the present study are lower than values obtained by Ozung *et al*. (2011).

The small intestine length which ranged from 284.85-351.35cm obtained in the present study is similar to the length of 330cm recorded by Aduku and Olukosi (1990), and higher than the range of 128.67-267.67 reported by Oko *et al*. (2018) while the range of 112.70-153.00cm obtained for the large intestine in the present study is higher than the values obtained by Oko *et al*. (2018) and Ozung *et al*. (2011). Caecum length in the present study ranged from 49.50-58.10 and is comparable to the values reported by Oko *et al*. (2018) and higher than the values reported by Aduku and Olukosi (1990) and Ozung *et al*. (2011). The length of the esophagus in the present study ranged from 10.90-13.05cm and is higher than the range of 8.95-10.38cm reported by Ozung *et al*. (2011). The difference in values obtained in the present study compared to those of other researchers could be due to differences in weights at slaughter, diet as well as breed differences.

The gastrointestinal tract (GIT) is the main digestive and absorptive organ in the animal as it permits the uptake of dietary substances into the systemic circulation and excludes pathogenic compounds (Clissold *et al*., 2010). According to Allen (1996), one factor limiting dry matter intake (DMI) is gastrointestinal tract capacity.

Increased relative gastrointestinal tract size indicates a relatively larger area available for absorption of nutrients, allowing for greater nutrient absorption and, thus, increased digestibility (Van Soest, 1994). Increasing the digestibility of a feed means that more of the feed is used and less is excreted as waste product. This will result in increased energy available to the animal (Clissold *et al*., 2010). The non-significant effect of diet on the gastrointestinal tract could infer the normal function of the GIT.

Reproductive Tract Morphometry

Reproductive morphometry of female grower rabbits fed yam peel meal (YPM) as a replacement for maize is as presented in Table 5. All reproductive tract morphometry parameters studied were not significantly affected (P>0.05) by the dietary treatments. The weight of the vagina obtained in the present study ranged from 1.15-3.49g which is similar to the values obtained by Ozung *et al*. (2011) when female rabbits were fed cassava peel meal-based diets but higher than the range of 0.36-0.98g obtained by Bitto *et al*. (2006). Values obtained for cervix weight in the present study are higher than the values reported by Bitto *et al*. (2006). The weights of the right oviduct and left oviduct in the present study ranged from 1.21-1.95g and 1.22-1.34g respectively and were higher than values reported by Ozung *et al*. (2011) while values for the left uterine horn and right uterine horn weights obtained in the present study are comparable to the values reported by Ozung *et al*. (2011). Disparities in values obtained in the present study with those of others could be due to age or species differences.

According to Hernandez *et al*. (2010), age and body weight are factors associated with morphologic changes in the reproductive tract. According to Evans *et al*. (2022), a longer reproductive tract length shows an accurate sexual formation and this will assist every reproductive procedure as a long vagina length assists intromission and successful parturition while a wider and longer uterus allows room for the formation and development of the foetus in the uterus which eventually leads to smooth conception and delivery (Osinowo, 2006; Evans *et al*., 2022).

The non-significant effect of diet on reproductive tract morphometry obtained in this study suggests that the development of the reproductive organs, reproductive processes, and perhaps fertility may not be affected when up to 70% of maize is replaced with YPM in the diets of female rabbits.

Table 2: Proximate and Nutrient Composition of Yam Peel Meal (YPM)

Nutrient	Percentage
Dry Matter	89.80
Moisture	10.20
Ash	4.76
Ether Extract	1.67
Crude Fiber	5.46
Crude Protein	4.38
NFE	83.73
Metabolizable energy (Kcal/Kg)	3262.33

Table 3: Effect of feeding Graded Levels of YPM as a Replacement for Maize on the Weight of the gastrointestinal tract of Rabbits

Parameter(g)	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	SEM	P-Value	LS
Oesophagus	1.27	1.60	1.60	1.42	0.08	0.49	NS
Stomach	20.17	19.39	20.08	20.22	0.56	0.97	NS
Small intestine	37.35	29.92	26.95	24.55	2.30	0.23	NS
Colon	30.47	26.44	25.26	29.38	1.19	0.45	NS
Caecum	21.14	22.77	20.58	21.70	1.02	0.94	NS

SEM= Standard Error of Mean
LS= Level of significance (P>0.05)

Table 4: Effect of feeding Graded Levels of YPM as a Replacement for Maize on the Length of the gastrointestinal tract of Rabbits

Parameter(cm)	T1	T2	T3	T4	SEM	P-Value	LS
Small Intestine	351.35	290.85	311.50	284.85	14.19	0.40	NS
Colon	112.70	125.60	153.00	121.40	7.36	0.26	NS
Caecum	49.50	50.75	58.10	49.50	2.38	0.63	NS
Oesophagus	12.75	10.90	13.05	12.50	0.50	0.52	NS

Table 5: Reproductive Tract Morphometry of Rabbit Does Fed Graded Levels of Yam Peel Meal as a Replacement for Maize

Organ weight (g)	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	SEM	P-value	LS
Vestible	1.99	1.94	3.09	1.93	0.93	0.69	NS
Vagina	1.15	3.49	3.13	2.07	0.46	0.29	NS
Cervix	1.27	2.24	2.01	1.37	0.25	0.54	NS
Left uterine horn	1.04	1.49	1.76	1.87	0.21	0.77	NS
Right uterine horn	1.05	1.58	1.87	1.42	0.22	0.73	NS
Right oviduct	1.95	1.33	1.21	1.28	0.03	0.38	NS
Left oviduct	1.22	1.31	1.34	1.32	0.04	0.72	NS
Left ovary	1.08	1.13	1.11	1.08	0.01	0.85	NS
Right ovary	1.65	1.13	1.11	1.12	0.01	0.40	NS

SEM = Standard error of the mean, LS = level of significance, P-value = probability

CONCLUSION

The study revealed that replacing 70% maize with YPM did not affect the gastrointestinal tract and reproductive tract morphometry of rabbits.

When experimental conditions are same with the present study, 70% maize can be replaced with Yam Peel Meal in the diets of female rabbits as this has been shown to support optimum gastrointestinal tract morphology and growth and development of the reproductive tract of female rabbits.

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