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Assessment of the economics of production of weaner and grower rabbit fed sunflower seed meal (SFSM) based diets with or without Ronoxyme® HiPhos enzyme

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A B S T R A C T

The cost-benefit analysis performance of weaner and grower rabbits fed processed sunflower (*Helianthus annuus*) seed meal (SFSM) and diets treated with enzymes in the research area was assessed. Nine diets (T1, T2, T3, T4, T5, T6, T7, T8, and T9) were administered to 72 rabbits in a completely randomized manner employing a 3x3 factorial configuration. Treatments T1, T2, and T3 had 0% inclusion rate of SFS meal and 0, 150, and 250 ppm of the enzyme. These diets were designed to be isocaloric (2500 kcal/kg, ME) and isonitrogenous (15%). All management protocols were adhered to produce grower and weaner rabbits. During the weaner phase, there were significant differences ($P<0.05$) in the average daily intake of feed, protein, and energy between levels. In contrast to 77.48g, 1532g, and 255.18g in 0% SF and 78.76g, 15.45g, and 25.56g in 10% SFSM, the highest values were 80.36g, 10.46g, and 262.73g in 20% SFSM. The 250ppm (15.85g) enzyme had a significantly ($P<0.05$) higher protein intake than 0ppm (15.49g) and 15.54g, which were not statistically ($P>0.05$) different from each other. The sunflower seed meal (SFSM)-based diet enhanced with an enzyme affected rabbit production economics. Rabbits fed 20% sunflower seed meal showed much better weight growth, revenue, and net income than rabbits fed 0% and 10% sunflower seed meal. The feed conversion ratio, cost per kilogram of weight gain, and cost of production per kilogram of weight gain were significantly ($P<0.05$) lower in rabbits fed 20% compared to those fed other diets. The 10% and 20% sunflower seed meal treatments, respectively, had significantly higher total feed consumption than the control diet ($P<0.05$).

Keywords: Economics of production, Rabbits, Sunflower seed meal, Enzymes

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Introduction

One solution to the dietary protein intake issues that are common in Nigeria and many other developing nations are to grow the rabbit industry (Offiong and Essien, 2021). Its low fat and cholesterol levels and excellent nutritional value are the reasons for this. Eating rabbit is not frowned upon in any country or religion and is considered socially acceptable. The meat is preferred by middle-aged, diabetic, and hypertensive people (Niran, 2024). Additionally, when given the proper care and hygiene, rabbits are extremely prolific and have a relatively low incidence of illnesses (Gachu, 2017). However, a significant worry is the high cost of feed production, which makes up about 80% of the expenses associated with intensive production in livestock farming (Haruna *et al.*, 2024). This is because cereals, particularly maize, make up a sizable

amount of human food and are the main source of energy for animals with a single stomach. As a result, an alternative energy source needs to be used in place of this widely used conventional rabbit feed. Because they can eat and digest food, yet lack four stomach compartments and do not chew their cud or regurgitate, Ibrahim *et al.* (2017) categorize rabbits as monogastric herbivores. They can produce some of the necessary amino acids by eating their own waste, a process known as coprophagy. According to Ayeni *et al.* (2023), ruminant species, pigs, and poultry, especially chickens, provide the majority of the meat currently consumed in Nigeria, especially in the urban and peri-urban areas. The average Nigerian consumes 7.9g of animal protein daily, which is much less than the 35g that the Food and Agriculture Organization (FAO) recommends an average adult consume daily for optimal health (Presicce, 2020). The situation may get worse unless there is a deliberate shift in focus that tries to boost output in the livestock sub-sector. According to Bamgbose *et al.* (2004), efforts have primarily focused on the primary traditional livestock species, including cattle, sheep, goats, pigs, and chickens, meaning that rabbits have gotten minimal attention. Presicce (2020) hence supported the need to look into novel, lesser-known, but potentially plentiful, animal protein sources, including rabbit. Nigeria needs to increase rabbit production to boost its animal protein supply because cattle, hogs, and chickens are costly (Ibitoye *et al.*, 2023). However, because of the high cost of feeds, raising fast-maturing animals like rabbits do not contribute to the goal of expanding the supply of affordable animal protein, especially in developing countries. Feed accounts for 70–80% of the costs of rearing livestock, according to Ogundeji *et al.* (2025). Due to intense competition from food chain channels that have a higher priority and can command higher prices than the compound feed industry, traditional feed ingredients—particularly cereals and protein sources—are used to formulate feed and are therefore costly and scarce. It has been observed that the high cost of feed ingredients constrains the expansion of the protein supply. Another limiting factor in rabbit production, according to Ayeni *et al.* (2023), is the presence of antinutritional components in different feedstuffs utilized in rabbit diets that interfere with feed consumption. Tropical plants include significant amounts of protein, fat, minerals, and carbs, which can help with growth and yield. Most of these plants, however, contain anti-nutritional traits that hinder the absorption, utilization, and digestion of nutrients. Consuming feed containing these substances can, in some cases, result in chronic intoxication and interfere with the digestion and utilization of dietary protein and carbohydrates, which can then interfere with the availability of certain minerals (Ayeni *et al.*, 2025). These elements may also have an impact on growth rate and feed efficiency, which may have an impact on edible product production. Exogenous feed enzymes are increasingly being employed in monogastric diets, especially for chicken, to improve food component digestion and bird performance while counteracting the detrimental effects of antinutritional elements (Al Moqbali, 2016). Therefore, enzymatic supplementation can improve the nutritional value of cereals that contain high amounts of soluble non-starch polysaccharides. A population's general health and well-being are directly impacted by the quantity of animal protein they consume (Nathaniel, 2023). Nigeria eats 3.24g of animal protein daily, significantly less than the recommended 35g per capita, like most developing countries (Adebisi *et al.*, 2023). This acute lack of animal protein affects most rural families in developing countries, and it may be linked to the decline in the protein production of livestock caused by the high cost of rearing livestock, because feed expenses account for 70% of production costs. Therefore, any effort to find alternatives to reducing the cost of feeding would be one of the possible approaches. According to Lawal *et al.* (2021) reports, which used Nigeria as a case study, suggested producing short-circuits micro-livestock, such as rabbits, to guarantee sustained animal protein sufficiency in developing countries. According to Cherwon (2020), domestic rabbits have the potential to be a high-quality, reasonably priced protein source that may greatly increase the quantity of animal protein produced and eaten in these countries. Rabbits have a high potential for reproduction and a high rate of growth due to their strong feed utilization ability (Egbeyale *et al.*, 2023). The development of these potentials depends on efficient feed consumption. Consequently, the addition of enzymes to animal feed is becoming increasingly important since they improve digestion and nutritional absorption. For instance, rabbits fed diets enriched with enzymes up to 30% of the time at the expense of maize grains fared better than

rabbits fed diets without enzymes, as evidenced by the performance response criteria and nutritional digestibility data gathered (Soji *et al.*, 2025). As previously said, improved feed composition and techniques for boosting rabbit production potential have not yet been completely employed, especially in the rainfed regions of the world. Examining the economics of raising weaner and grower rabbits fed a diet consisting of sunflower seed meal (SFSM) with or without the Ronoxyme® HiPhos enzyme is the aim of this study.

Materials and Methods

The study was conducted at Teaching and Research Farm, Faculty of Agriculture, Nasarawa State University in Keffi, Shabu-Lafia Campus, Nigeria. It is situated in the North Central Guinea Savanna Zone. Latitude 08 35N and longitude 08 33E are its coordinates. Monthly rainfall ranges from 168 to 190 mm, monthly relative humidity is 74.67%, and monthly maximum and lowest temperatures are 35.06°C and 20.16°C, respectively (Yashim *et al.*, 2020).

Experimentation layout

A preliminary screening was conducted to select the most suitable processing method for the test ingredient.

Boiling

The supplier of the sunflower seeds (SFS) was Gambali Unique Gardens in Jos, Plateau State. Four sections were created from the sorted sunflower seeds. To represent treatments T2, T3, T4, T5, and T6, a sample of the SFS was placed in boiling water at 100°C and cooked for 60, 90, 120, 150, and 180 minutes, respectively. After varying amounts of time, the seeds were taken out, drained, and allowed to dry in the sun until their weight remained constant. A laboratory mortar and pestle were used to crush each sample. The raw material was regarded as the T1 control.

Fermentation

A third portion of the SFS was cooked at a boiling point of about 100 °C for 1 hr., oven dried to a constant weight, crushed, partitioned into 4 portions, and packaged in air-tight polyethylene bags to allow for natural fermentation for 3, 4, 5, and 6 days, representing treatments T2, T3, T4, and T5, respectively.

Toasting

The fourth raw portion of SFS was dry–toasted in an open pan for about 30 minutes, until the seeds turn brown, producing a sweet aroma similar to that obtained in groundnut processing. The toasted sample was crushed, tagged T2, and compared with the raw (T1). All the treatments were replicated 3 times and subjected to laboratory analyses.

Analyzing the proximate

Using the standard approach of, a proximate analysis of SFSM was conducted at the Animal Science Laboratory of the Faculty of Agriculture, Nasarawa State University, Keffi, and Shabu-Lafia Campus. The formula for calculating Nitrogen Free Extract (NFE) was NFE (%) = 100 – CP + CF + EE + Moisture + Ash was used to determine metabolizable energy: ME = 37 x % CP + 81 x % EE + 35.5 x % NFE.

Diets experimentation

T1-T9 were the nine experimental diets that were made to be isocaloric (2500 kcal/kg, ME) and isonitrogenous (15% CP). Treatments T1, T2, and T3 included 0% SFS meal and 0, 150, and 250 PPM of enzyme supplementation. Treatments T4 through T6 and T7 through T9 maintained the same levels of enzyme supplementation as T1 through T3, but their SFS meal inclusion rates were 10% and 20%, respectively. For T2 and T3, T5 and T6, and T8 to T9, respectively, this arrangement means that T1, T4, and T7 act as the control diets. According to Pinheiro and Gidenne (2024), additional ingredients were introduced to satisfy the nutrient needs of growing rabbits.

Experimentation of rabbit management

From Dagwom Farms, National Veterinary Research Institute (NVRI), Vom, Jos, and Plateau State, we purchased seventy-two crossbred weaner rabbits. The bunnies weighed an average of 567g and were between 6 and 7 weeks old. Following randomization, the rabbits received an anti-stress vitamin/mineral premix orally at the required dosage before the experiment's commencement. They also had constant access to food and water. Other methods of management were employed. The rabbits were paired and assigned to each of the nine treatments, each of which was duplicated four times, resulting in a 3x3 factorial arrangement that was fitted into a completely randomized design.

Data collection

The performance of the growth of the weaner and grower phases

Data on growth performance for both the weaner and grower stages were collected, including initial weight, final weight, daily weight increase, total feed intake, feed conversion ratio, and other performance indicators. To get this data, the rabbits were weighed once a week for 84 days using a weighing scale. The weight difference between the delivered and unconsumed feed will be used to compute the feed intake. The calorie and protein intake will be determined by multiplying the amount of each nutrient in the feed by the feed intake. The energy efficiency ratio is calculated by dividing the increase in body weight by the energy used. Feed efficiency was determined by dividing weight gain by feed intake. The performance index was calculated by dividing the weight increase by the feed efficiency.

Economics of production

All operation's expenses were noted as they happened. By multiplying the cost (₦) of each ingredient by its fraction per unit of the diet, the cost contribution of each ingredient to the diet was calculated using the composition of feed ingredients per kilogram of diet.

Cost of feed ₦/Kg: The cost of feed ₦/kg was determined using the market price of ingredients at the time of the study.

Cost of feed consumed: This was calculated by multiplying the unit cost of feed in naira by the amount of feed consumed by one rabbit in kilograms.

Cost of feeds ₦/kg weight gain: The feed conversion ratio as fed-basis was multiplied by the cost per kilogram of diet to determine the cost of feed per kilogram of weight increase for a single rabbit.

Net income ratio: This was calculated as the cost of production divided by the net income/rabbit.

Total revenue: This was calculated as the total sales of rabbits (value in ₦/rabbit)

Net income: This represented the discrepancy between production costs and revenue.

Return on naira invested in capital: This was determined by dividing net income by the total cost of production or total expenses.

Data analysis

Two-way analysis of Variance (ANOVA) was performed on all experiment data using the Statistical Package for Social Sciences (SPSS) software. The Duncan's Multiple Range Test (DMRT) was used to separate the means if substantial differences were discovered.

Results and Discussion

Effect of sunflower seed meal on the economics of production of rabbits

Table 1's results demonstrate that adding sunflower seed meal (SFSM) to a rabbit's diet has a significant impact on production economics. Rabbits fed 20% SFSM (1760.00 g) had a considerably greater final live weight than rabbits fed 0% and 10% inclusion levels, indicating that sunflower seed meal promoted strong growth performance at higher inclusion rates. Similarly, compared to the 0% and 10% lower inclusion levels, overall weight gain rose significantly at 20% SFSM (988.33 g), indicating that SFSM improved growth efficiency and nutrient utilization. In contrast to the lower ratios seen in the 0% and 10% SFSM groups, the feed conversion ratio (FCR) dramatically improved with 20% inclusion (5.19), indicating improved efficiency of turning feed into body mass. The enhanced growth rate and efficiency at 20% offset the greater feed consumption, lowering the cost per kilogram of weight gain even though the overall feed consumption was much higher at 10% and 20% SFSM. Additionally, cost-benefit analysis showed that higher SFSM inclusion resulted in a slight increase in feed cost and total cost of production because of higher feed intake. However, a superior production process made up for this. At 20% SFSM, the cost of production per kilogram weight gain and the cost of feed per kilogram weight gain were at their lowest, demonstrating increased cost effectiveness. The rabbits given 20% SFSM had the highest net income (₦1809.18) and the highest probability/significant worth of revenue (₦4280.00) when compared to the other groups. At 20% SFSM, the gross margin also increased, demonstrating the financial benefits of this degree of inclusion. It's interesting to note that, despite the overall rise, the net income ratio was marginally lower at 20% SFSM (1.37), as opposed to 10% SFSM (1.72). This could be attributed to higher feed consumption and production expenses. It may be inferred that adding up to 20% sunflower seed meal to rabbit diets improves development and profitability without having a detrimental effect on production costs.

Table 1. Effect of sunflower seed meal on the economics of production of rabbits

Parameters	0SF	10SF	20SF	SEM	LOS
Final weight (g/rabbit)	1636.67	1626.67	1760.00	43.20	*
Total weight gain (g/rabbit)	835.00^{b}	842.50^{b}	988.33^{a}	39.32	*
Feed conversion ratio (FCR)	5.93^{a}	6.02^{a}	5.19^{b}	0.27	*
Total feed intake (g/rabbit)	4948.65^{b}	5069.04^{a}	5128.86^{a}	36.04	*
Cost of feed consume (₦)	836.91^{b}	853.78^{ab}	870.82^{a}	6.10	*
Cost of feed per kg weight gain (₦)	1023.26^{a}	1049.37^{a}	889.51^{b}	45.60	*
Cost of production per kg weight gain (₦)	2918.46^{a}	2912.50^{a}	2500.03^{b}	131.33	*
Total cost of production (₦)	2436.91^{b}	2453.78^{ab}	2470.82^{a}	6.10	*
Revenue (₦)	3876.67^{b}	3880.00^{b}	4280.00^{a}	127.22	*
Net income (₦)	1439.76^{b}	1426.22^{b}	1809.18^{a}	126.38	*
Gross margin (₦)	37.13^{ab}	36.78^{b}	42.27^{a}	1.85	*
Net income ratio	1.69^{ab}	1.72^{a}	1.37^{b}	0.13	*

ab = means on the same row having different superscript differ significantly (P<0.05); SEM = standard error of mean; LOS = level of significance; SF = sunflower

Effect of sunflower seed meal (SFSM) based diet supplemented with enzyme on the economics of production of rabbits

The impact of an enzyme-supplemented diet based on sunflower seed meal (SFSM) on the profitability of rabbit production is displayed in Table 2. Compared to rabbits fed 0% and 10% sunflower seed meal, rabbits fed 20% sunflower seed meal showed considerably better total weight increase, revenue, and net income. Rabbits given 20% of other diets had significantly (P<0.05) reduced feed conversion ratios, costs per kilogram of weight increase (₦889.51), and production costs per kilogram of weight gain (₦2500.03). The 10% and 20% sunflower seed meal treatments, respectively, resulted in considerably (P<0.05) greater total feed intakes (₦5069.04 and ₦5128.86) than the control diet (₦4948.65). The interaction between sunflower and enzyme supplementation did not significantly (P>0.05) alter any of the production cost indicators that were observed during the trial. It is implied that the combination of sunflower seed meal and enzyme supplementation did not result in a significant decrease or increase in production costs because the results showed that not all cost of production indicators were significant at a 95% confidence level, influenced by the interaction of the two. In other words, when taken as a complementary package, neither the potential improvement from enzyme supplementation nor the substitution impact of sunflower seed meal produced a significant economic benefit in terms of cost efficiency.

Table 2. Effect of sunflower seed meal and enzyme supplementation on economics of production of rabbit.

Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	SEM	LOS
Final weight (g)	1667.50	1582.50	1660.00	1630.00	1657.50	1592.50	1745.00	1735.00	1800.00	74.83	NS
Total weight gain (g)	885.00	762.50	857.50	850.00	905.00	772.50	925.00	982.50	1057.50	68.10	NS
FCR	5.53	6.56	5.78	5.96	5.58	6.59	5.49	5.28	4.85	0.47	NS
Total feed intake (g)	4891.40	5002.28	4952.26	5064.43	5050.08	5092.61	5073.23	5188.08	5125.29	62.43	NS
Cost of feed consumed	824.49	845.43	840.80	854.57	848.36	858.41	859.66	881.40	871.40	10.56	NS
Cost of feed per kg weight gain	948.09	1124.89	996.79	1031.44	992.64	1124.03	930.66	911.02	826.86	78.98	NS
Cost of production per kg weight gain (₦)	2739.54	3207.12	2846.41	2887.73	2705.37	3182.40	2659.09	2525.60	2337.02	227.47	NS
Total cost of production (₦)	2424.49	2445.43	2440.80	2454.57	2448.36	2458.41	2459.66	2481.40	2471.40	10.56	NS
Revenue (₦)	3902.50	3747.50	3980.00	3890.00	3972.50	3777.50	4235.00	4205.00	4400.00	220.36	NS
Net income (₦)	1478.01	1302.07	1539.21	1435.43	1524.14	1319.09	1775.34	1723.60	1928.60	218.91	NS
Gross margin	37.87	34.75	38.67	36.90	38.37	34.92	41.92	40.99	43.83	3.21	NS
Net income ratio	1.64	1.88	1.59	1.71	1.61	1.86	1.39	1.44	1.28	0.23	NS

ab = means on the same row having different superscript differ significantly (P<0.05); NS = not significantly different (p>0.05); SEM = standard error of mean; LOS = level of significance; SF = sunflower

Discussion

The boiling technique of processing may be responsible for the improvement in nitrogen-free extract and metabolizable energy of 3-hour-boiled sunflower seed meal (SFSM). The SFSM seed's highly lignified outer layer may have lessened the impact of nutrient leaching or bleaching, which could explain the non-significant difference in mineral, vitamin, and amino acid composition across treatments. Trypsin inhibitor concentration in SFSM was decreased by boiling, and the values (13.01–23.56 TUI/mg) obtained in this study were greater than the 1.78.24–4.24 TUI/mg previously reported by Matthew and Alu (2016) for cooked shear butter and the 11.57–19.26 TUI/mg previously reported by for cooked kidney bean seeds. According to earlier research, adding exogenous enzymes to rabbit meals increases the availability of nutrients; nonetheless, in the majority of experiments, the rabbits showed reduced responsiveness, and their performance was affected in several ways. By evaluating cellulase, observed improvements in the mortality and feed conversion of rabbits weaned at 23 days of age. The study's non-interaction effect between sunflower and enzyme supplementation suggests that the sunflower itself, rather than the addition of enzymes, was the cause of the economic performance observed in rabbits given sunflower. The higher average daily weight gain and feed efficiency observed when the animals were fed increasing amounts of sunflower seed meal may be the reason for the better values observed in head weight, forelimbs, lumbar region, cervical region, lungs, and intestinal length, which increase (0% < 10% < 20%) with increased levels of sunflower seed meal.

Conclusion

The assessment of the economics of producing weaner and grower rabbits fed diets based on sunflower seed meal (SFSM), with or without enzyme, showed that SFSM can be used as an alternative protein source in rabbit production that is both economical and nutritionally sound. When compared to traditional diets, the addition of SFSM, especially at higher doses, enhanced growth performance, feed consumption, and ultimate live weight, increasing economic returns. Enzyme supplementation also improved growth response and nutrient digestibility, which improved feed conversion ratios and decreased production costs. Overall, the results indicate that SFSM may save feed costs, increase profitability, and promote sustainable rabbit production, particularly when paired with enzyme supplementation. Therefore, in order to optimize both biological performance and economic efficiency, rabbit farmers are urged to implement SFSM-based diets that include enzymes.

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