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Performance response dynamics of rabbits (*Oryctolagus cuniculus*) to locally sourced, on-farm feed ingredients during the growing phase: Implications for the institutional rabbit multiplier project

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ABSTRACT

This study aimed to assess the growth performance and nutrient digestibility of rabbits in their growing phase fed with a formulated diet sourced out locally, containing the allocation of 17% *Moringa oleifera* leaf, 8% *Trichanthera gigantea* leaf, 20% *Morus alba* leaf, 4% *Psidium guajava* leaf, 19% *Zea mays* bits, 20% D1 (*Oryza sativa* bran), 3% *Saccharum officinarum* molasses, and 9% hydrolyzed *Gallus gallus domesticus* broiler feather meal. Three (3) treatment groups consisted of the CSU-formulated rabbit grower feed and two commercially available all-stage rabbit pellet feeds. Twenty-seven (27) composites of mixed-breed rabbits, aged 3–4 months and of varied sex, were randomly assigned to three dietary treatments, each comprising three replicates, following a completely randomized design. The rabbits had access to water, and the experimental feeds were given once a day for a period of 42 days. The proximate analysis of the CSU-formulated rabbit grower feed demonstrated 21.64% crude protein, 6.43% crude fat, 10.10 % ash, a moisture content of 7.86%, and a crude fiber of 6.73%. The results indicate that CSU-formulated rabbit grower feed was readily accepted and palatable to rabbits, as indicated by consistently elevated weekly consumption rates confirming comparable consumption levels with commercial feeds ($p > 0.05$). Average daily gain (ADG) exhibited no significant differences ($F = 0.110$, $p = 0.897$), denoting that all diets were nutritionally sufficient. For the entire period, no significant Feed Conversion Ratio (FCR) variances were found ($F = 1.060$, $p = 0.404$), wherein dietary impact was most evident in the later stage, implying how well the assigned groups assimilated the feeds. On the other hand, CSU-formulated rabbit grower feed had displayed clear financial benefits, as revealed by a benefit–cost ratio of 1.17, a return on investment (ROI) of 16.99%, a gross ratio of 0.85, and a net profit margin of 14.53%.

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INTRODUCTION

In rabbit operations, feed generally constitutes up to 70% of the total costs of production. This places a lot of pressure on manufacturers to find inexpensive but vigorous options. Commercial feeds, particularly those intended for multiple animal types, often fail to meet nutritional standards and tend to have lower crude fiber and protein, according to studies.

Rabbit can be a great choice because it contains a high proportion of protein, low fat and cholesterol, and healthy unsaturated fatty acids, in contrast to other meats such as pork. It is comparable to other red meats, where protein composition is easy to digest and complete, containing all the essential amino acids, and has omega-3 fatty acids and antioxidants (Nistor *et al.*, 2013; Petracci *et al.*, 2009; Siddiqui *et al.*, 2008). Feed efficiency is imperative; however, it can change a lot, which suggests that biological unpredictability makes it harder to formulate feed (Velasco-Galilea *et al.*, 2021). Rabbits can manifest digestive complications after they stop nursing and weaning. Tůmová et al (2016) state that limiting food intake to 20–25% below ad libitum levels can lessen these risks and boost compensatory growth progress. However, watchful supervision is desirable to avoid problems during the growth phase, such as mortality, which implies how important it is to find the right feeding approach or strategy (Birolo *et al.*, 2021).

Most of the rabbit feed is made up of corn, wheat, and soybean meal. But fluctuations in the prices of goods around the world and imports make the cost of feed high and unstable, thereby putting the economic viability of farming rabbits at risk. The ingredients of imported feed face difficulties with trade, rules, and logistics. Lengthier conveyance times can raise input costs by 22% because of tariffs on agricultural inputs, which can result in lost yield (Sneha Mali, 2025), and also moving feed ingredients from distant seats both contribute to carbon releases, and such actions go against sustainability goals (Dal Bosco *et al.*, 2025).

The agricultural landscape of the Philippines offers extensive accessibility to various yields and other cultivated agricultural by-products. These locally sourced materials have been employed as economical substitutes for traditional livestock feeds in rural and peri-urban areas. According to Gerez *et al.* (2025), utilizing these domestic feed ingredients condenses dependance on imported commercial feeds, and by renovating agricultural residues into usable and effective feedstuff, environmental sustainability is achieved.

The utilization of agricultural by-products when managed and correctly applied delivers high fiber, protein, and phytochemicals that can make meat taste better (Jones *et al.*, 2024). Thus, selecting the precise age-appropriate formulations is necessary.

Interest in alternative feeds is increasing; however, inadequate controlled studies have explored the effect of diets derived from locally sourced ingredients, such as region-specific forages or agricultural byproducts, on rabbit growth (Khan, 2016; Martignon *et al.*, 2021). Existing evaluations raise concerns about the anti-nutritional composition and the absence of information on rabbit inclusion rates, but then again, it is known that tropical botanicals, leaf meals, fodder, and forages could somewhat substitute available traditional concentrates. Thus, supplementary researches are needed in each region of the country to find out how to effectively and safely utilize local feed resources during significant growth stages. Animal scientists are exploring into botanical sources for rabbit diets. A few studies have found benefits in the growth performance dynamics, but the findings are not reliable enough to make imperative conclusions. Hence, more proof and standardized rules for feeding growing rabbits considering regional differences in the availability of local ingredients and their nutritional worth. Most of these studies don't take this dissimilarity into account or modify their preparations to suit local settings, which makes them less beneficial in other regions of the country.

Hence, the incubation of this study to investigate how rabbits thrive on locally grown feed ingredients in the Philippines, particularly in the Cagayan Valley Region, could help find long-lasting substitutes or alternatives to imported commercial diet components and make local feed more competitive. This research finding is timely with the government's advocacy of promoting rabbit farming as an alternative to pig enterprise, which is currently challenged by emerging diseases such as African swine fever. The utilization of local feeds can help people in rural areas to make a living, get enough food, and get out of poverty.

MATERIALS AND METHODS

Ingredients allocation and pelleting process

Plant materials were collected from the different campuses and partner government agencies of the University within the Province of Cagayan, Philippines, from the month of July to September 2025. The leaves and twigs were first separated, and the forages were then air-dried at room temperature for 5 to 7 days until they were completely dry. After drying, a disk mill with a 1.5 mm sieve was used to make sure that all the particles were the same size. The feed components were measured according to the specific recipes for each experimental treatment, and the measured ingredients were manually blended until they were all the same, making sure that the feed mixtures were the same for the next analysis. The formulation for the feed pellet included 17% malunggay, 8% madre *de agua*, 20% mulberry, 4% guava, 19% corn bits, 20% D1, 3% molasses, and 9% feather meal. Using a commercial machine, the feed was turned into powder first and then into pellet form. A commercial pelletizer housed in the College of Veterinary Medicine production area ensured that the pellets were all the same size, texture, and toughness.

Controlling the moisture and temperature while undergoing the pelleting process guarantees that the feed will retain its nutritional value.

Animal management

The rabbits were maintained in optimal condition, provided with regular nourishment, and monitored daily. Animals were provided with water on an ad libitum basis, and dietary feeds were given once a day, with the volume increased to 20 grams weekly from the initial 100 grams per animal. Artificial light was provided during nighttime so that the animal could still access their remaining feeds. All rabbits were medicated with Ivermectin injectable solution and multivitamins prior to experimentation.

Proximate analysis

One (1) kilogram of pellets from each preparation was sent to the Department of Agriculture Regional Office 02, Feed Laboratory Section, for the proximate analysis work and mineral examination to check the crude protein, crude fiber, fat, moisture, and ash content, and the calcium and phosphorus components, respectively.

Data collection

The experimental animals were monitored daily to investigate their progress. The performance evaluation and growth parameters were evaluated as follows: The rabbits' initial body weights (IBW) were measured with a digital scale that had a resolution of 10 grams. At the end of the study, the final body weights (FBW) of the rabbits were recorded. To figure out how much feed the animals consumed, subtract the amount of feed they were given from the amount that was left over. To find out how much weight someone had gained, subtract their starting weight from their ending weight. To examine the average daily gain (ADG), divide the weight gain by the number of days of feeding. The formula FCR = cumulative feed intake/body weight gain was used to figure out the feed conversion ratio (FCR).

Economic analysis and profitability ratios

Whether it was financially sound and cost-effective to use locally grown ingredients in rabbit meals, an economic analysis was performed. Considered herein are the costs of the rabbits, their food, labor, housing, equipment, utilities, and other expenditures, as well as the total revenue from rabbit sales and the net profit.

$$NP = TR - TCP$$

Total Cost Production=TCP; Net Profit=NP; Total Revenue=TR

Also, profitability ratios were used to show how much production factors were used to make the most money. Formulas based on Nworgu *et al.* (2014) where: Benefit Cost Ratio = BCR

This is used to figure out how profitable a rabbit business is. It compares the total costs of the poultry operation to the total benefits (revenue) it brings in. A BCR of more than 1 means that a business is making money, while a BCR of less than 1 means that it is losing money.

$$BCR = \frac{TR}{TCP}$$

Return On Investment = ROI. This is used to figure out how much money the rabbit business makes compared to how much it costs. The ROI shows exactly how much profit (or loss) each unit of investment makes.

$$ROI = \frac{NP}{TCP} \times 100$$

Gross Ratio = GR. To see how well an operation is running, compare total costs to total revenue. It shows how much money is generated after paying for production. A lower gross ratio means that resources like feed, labor, housing, and so on are used more efficiently, which leads to a profitable business.

$$GR = \frac{TCP}{TR}$$

Net Profit Margin = NPM. This is used to show the percentage of revenue that remains as net profit after all expenses are deducted. It is used to measure the overall profitability of a rabbit production operation.

$$NPM = \frac{NP}{TR} \times 100$$

Data analysis

Statistical analysis was conducted by inputting the gathered data into Microsoft Excel and utilizing SPSS statistical software to assess the impact of various feeding regimes on rabbit performance. An Analysis of Variance (ANOVA) at a 5% significance level was performed using SPSS, followed by Tukey's Post Hoc test to investigate significant differences further.

Ethical consideration

A permit from the Institutional Animal Care and Use Committee (IACUC) of Cagayan State University was sought before the conduct of this study.

RESULTS AND DISCUSSION

The recorded proximate analysis (Table 1) of 21.64% crude protein and 6.43% crude fat is sufficient to meet the nutritional needs of growing rabbits. The moisture content was 7.86%, which is within the acceptable range (Mattioli *et al.*, 2019). Because the moisture level was much lower than 14%, water was provided *ad libitum* to animals to prevent compromising digestion and assimilation. The 6.73% crude fiber content was slightly lower than the recommended level for optimal digestion in rabbits. According to Varga (2013), a crude fiber range of 10–15% is best for maximizing the growth performance of rabbits. The yielded ash content of 10.10% means that rabbit feed has 10.10 g of total inorganic minerals per 100 g of dry matter, which is within the standard recommendation. Depending on the ingredients, commercially made and formulated rabbit feeds usually have 6–10% dry matter ash content (Alvarenga *et al.*, 2017; Purwin *et al.*, 2019).

Table 1. Proximate and mineral composition of the CSU-formulated rabbit grower feed (%).

Parameter	Composition (%)
Crude protein	21.64
Crude fat	6.43
Moisture content	7.86
Crude fiber	6.73
Ash content	10.10
Calcium	1.86
Phosphorus	0.88

The recorded crude protein level of 21.6% is higher than the recommended range of 16–19%, and such intake can be linked to problems with gut flora and respiratory health, especially in pet rabbits (Chamorro *et al.*, 2007; Varga, 2013). The crude fat level of 6.4%, which is higher than the recommended range of 2.5% to 4%, may cause rabbits to become obese, change how they eat and metabolize food (Arrington *et al.*, 1974; Varga, 2013). Even so, during the entire observation period of 42 days, no signs or symptoms indicative or suggestive of the mentioned related ailments were detected. This implies that rabbits have assimilated and bio-transformed the formulated pellets efficiently. On the other hand, the CSU-formulated rabbit grower feed had remarkable levels of calcium (1.86%) and phosphorus (.88 %), which exceeded the minimum requirements for growth and bone development. Nonetheless, there are supporting studies that such intake is tolerated by rabbits because of their unique metabolism (Varga, 2014).

Over the course of 42 days, Treatment 1 showed the highest total intake (Table 2) at 5,200g, followed by Treatment 3 at 4,910g and Treatment 2 at 4,830g. ANOVA results indicated no significant differences in feed intake across treatments ($p > 0.05$). During both days 1–21 and days 22–42 periods, Treatment 1 (CSU-formulated rabbit grower feed) consistently demonstrated the highest feed intake, with minimal differences among the treatments overall. Over the course of 42 days (Table 1), Treatment 1 showed the highest total intake at 5,200g, followed by Treatment 3 at 4,910g and Treatment 2 at 4,830g. ANOVA results indicated no significant differences in feed intake across treatments ($p > 0.05$), confirming equivalent consumption levels. The results indicate that the formulated feed was readily accepted and palatable to rabbits, as indicated by consistently elevated consumption rates. Compared to heavily processed commercial pellets, diets that mainly contain forages are more likely to be palatable to rabbits and may make feed more appealing (Dal Bosco *et al.*, 2025; Rothacher *et al.*, 2023).

Table 2. Feed intake of rabbits under various dietary regimens throughout the experimental duration

Experimental period	Treatment 1 (Mean ± SD)	Treatment 2 (Mean ± SD)	Treatment 3 (Mean ± SD)	*p*-value
Day 1–21	2489 ± 38.03	2450 ± 75.00	2380 ± 147.73	0.440^{NS}
Day 22–42	2716 ± 7.25	2383 ± 289.71	2533 ± 160.91	0.183^{NS}
Day 1–42	5204 ± 44.90	4832 ± 330.39	4913 ± 302.91	0.248^{NS}

Superscript letters (NS) designate no significant difference at the 95% confidence level ($p < 0.05$). Abbreviations: Treatment 1 (CSU-formulated Rabbit Grower Feed), Treatment 2 (All-Stage Rabbit Commercial Feed Brand A), Treatment 3 (All-Stage Rabbit Commercial Feed Brand B)

Table 3. Average daily gain (ADG) of rabbits under various dietary regimens throughout the experimental duration

Experimental period	Treatment 1 (Mean ± SD)	Treatment 2 (Mean ± SD)	Treatment 3 (Mean ± SD)	*p*-value
Day 1–21	12.88 ± 4.92	10.98 ± 4.33	11.76 ± 5.64	0.897^{NS}
Day 22–42	9.32 ± 3.18	13.22 ± 3.81	16.06 ± 1.27	0.081^{NS}
Day 1–42	10.02 ± 0.00	12.10 ± 0.00	13.91 ± 0.00±	0.397^{NS}

Superscript letters (NS) designate no significant difference at the 95% confidence level ($p< 0.05$). Abbreviations: Treatment 1 (CSU-formulated Rabbit Grower Feed), Treatment 2 (All-Stage Rabbit Commercial Feed Brand A), Treatment 3 (All-Stage Rabbit Commercial Feed Brand B)

Average daily gain (Table 3) is a key measure of how animals are growing. In the period from Days 1 to 21, Treatment 1 (CSU-formulated rabbit grower feed) exhibited the highest average daily gain (ADG) at 12.89 g/day, followed by Treatment 3 at 11.76 g/day and Treatment 2 at 10.98 g/day. From Days 22 to 42, Treatment 3 was superior (16.06 g/day), but the differences were still not statistically significant (F = 3.932, p = 0.081). Treatment 3 had the highest total ADG (13.91 g/day), but all of the diets supported similar growth (F = 1.082, p = 0.397). No significant differences were observed (F = 0.110, p = 0.897). Treatment 3 exhibited the highest total average daily gain (13.91 g/day), yet all diets facilitated comparable growth (F = 1.082, p = 0.397). These findings indicate that all diets were nutritionally sufficient, probably facilitated by the rabbit's effective hindgut fermentation (Carabaño *et al.*, 2020).

The differences in FCR (Table 4) were not significant (F = 0.108, p = 0.900) from Days 1 to 21, suggesting comparable feed efficiency among the diets. During Days 22–42, Treatments 2 and 3 exhibited significantly superior FCRs compared to Treatment 1

(F = 6.098, p = 0.036). The results indicate that as rabbits age, their feed utilization improves, enhancing feed efficiency. This is due to the age at which they reach slaughter readiness, necessitating tailored nutritional plans to enhance the development of their digestive system (Chen *et al.*, 1978; Knudsen *et al.*, 2014). For the entire period, no significant FCR differences were found (F = 1.060, p = 0.404).

Table 4. Feed conversion ratio (FCR) of rabbits under various dietary regimens throughout the experimental duration

Experimental period	Treatment 1 (Mean ± SD)	Treatment 2 (Mean ± SD)	Treatment 3 (Mean ± SD)	p-value
Day 1–21	10.08 ± 3.58	11.74 ± 4.44	11.70 ± 6.55	0.900^{NS}
Day 22–42	14.91 ± 4.56	8.85 ± 1.41	7.52 ± 0.31	0.036*
Day 1–42	1.52 ± 0.00	10.07 ±0.00	8.66 ± 0.00	0.404^{NS}

Superscript letters (NS) designate no significant difference at the 95% confidence level (p < 0.05); (*) denotes a significant difference at the 95% confidence level (p < 0.05). Abbreviations: Treatment 1 (CSU-formulated Rabbit Grower Feed), Treatment 2 (All-Stage Rabbit Commercial Feed Brand A), Treatment 3 (All-Stage Rabbit Commercial Feed Brand B)

Table 5. One-way ANOVA and Tukey HSD comparison of economic performance indicators among dietary treatments

Economic parameter	Treatment 1	Treatment 2	Treatment 3	Interpretation
Total Production Cost (₱)	4183.98^{b}	5237.37^{a}	5354.47^{a}	Significant (p < 0.05)
Total Revenue (₱)	4895.00^{a}	5102.50^{a}	5255.00^{a}	Not significant (p > 0.05)
Net Profit (₱)	711.02^{a}	-134.87^{b}	-99.47^{b}	Significant (p < 0.01)
Benefit–Cost Ratio (BCR)	1.17^{a}	0.97^{b}	0.98^{b}	Significant (p < 0.01)
Return on Investment (ROI, %)	16.99^{a}	-2.58^{b}	-1.86^{b}	Significant (p < 0.01)
Gross Ratio	0.85^{b}	1.03^{a}	1.02^{a}	Significant (p < 0.05)
Net Profit Margin (NPM, %)	14.53^{a}	-2.64^{b}	-1.89^{b}	Significant (p < 0.01)

Treatment 1 (CSU-formulated Rabbit Grower Feed), Treatment 2 (All-Stage Rabbit Commercial Feed Brand A), Treatment 3 (All-Stage Rabbit Commercial Feed Brand B)

Overall, dietary impact on FCR was most evident in the later stage, with Treatments 2 and 3 showing improved efficiency during peak growth. Tukey's post hoc test for FCR from Days 22 to 42 denotes that there was a statistically significant difference between Treatment 1 and Treatment 3 at the 0.05 level. This signifies a distinct disparity in the efficacy with which these groups utilized the feed. No significant differences were detected between T1 and T2 or between T2 and T3, as their p-values exceeded 0.05 and confidence intervals included zero.

Table 5 shows that dietary involvement augmented production cost-effectiveness. Treatment 1 constantly outperformed Treatments 2 and 3, with lower operation outlays and higher net profit despite comparable profits. Improving feed cost competence, not output, drove profitability. Feed-related expenditures improved without income growth in Treatments 2 and 3, resulting in negative net profit, ROI, and net profit margin. Unproductive cost-to-revenue conversion is directed by gross ratio values above one, while Treatment 1's condensed gross ratio specifies economic efficacy. Treatments 2 and 3 vary slightly, signifying alike economic inadequacy with equal feed cost bases. These findings prove the significance of feed formulation in maximizing economic returns and support Treatment 1 as an economically feasible nourishing approach that improves productivity through efficient nutrient employment, supplementary feed assessment studies in animal production systems.

CONCLUSION

The CSU-formulated rabbit grower feed statistically and biologically matched the performance of the two commercial feeds based on feed intake, body weight gain, and average daily gain as the primary parameters. This denotes that the CSU-formulated rabbit grower feed enhanced nutrient absorption and promoted optimal growth throughout the feeding duration, similar to commercially prepared rabbit feeds suitable for all stages. The nutritional values obtained from the proximate analysis may differ from the recommended standards; however, the statistical and biological assessments revealed no significant discrepancies in the recorded data, indicating that the formulation can serve as an alternative dietary regimen during the growth phase, as it meets the nutritional needs of the experimental animals without eliciting any notable adverse external reactions. The economic assessment revealed that the CSU-formulated rabbit grower feed is the most cost-effective option, providing practicality, sustainability, and a viable alternative to commercial rabbit feeds.

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