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Abstract

This study evaluated the potential of Job's tears or adlai (*Coix lacryma-jobi* L.*)* seeds as an alternative feed ingredient for rabbit production. Using a 2x3 factorial in a Randomized Complete Block Design (RCBD), 54 male rabbits aged eight weeks from two breeds (Californian and New Zealand) were fed commercial feeds every morning in a 30-day feeding trial with varying amounts of adlai seeds (0%, 10%, and 20%), and fixed amount of 150 g napier grass in the afternoon. The nutritional analysis of the different feed formulation showed that the levels of moisture, crude protein, ash, fat, nitrogen-free extract, calcium, and phosphorus were either within or closely aligned with the recommended nutritional standards for growing rabbits. Growth performance was assessed through final body weight at 12 weeks old, average weight gain (AWG), average daily gain (ADG), feed intake (FI), and feed conversion ratio (FCR). Results showed no significant differences (P>0.05) in all the performance parameters across treatments, indicating that adlai seed inclusion did not adversely affect rabbit performance. These findings suggest that adlai seeds can be a sustainable component of rabbit diets. Its potential to enhance growth of rabbits may be explored in future studies by varying the percentage of adlai seeds in the feed formulation for various breeds and growth stages.

Keywords: *adlai, alternative feed, feeding trial, Job's tears, nutritional analysis, rabbit, sustainable livestock feed*

Introduction

Livestock farming in the Philippines commonly integrates production of forage crops, wherein locally-available forage crops can greatly affect the overall cost of production by lowering feed cost. Feed quality is also important in terms of the nutritional content of ingredients that are crucial to the growth and developments of animals, especially during times of low availability, high market demand, and high cost of feed ingredients. Among these farm animal species affected by feed concerns is rabbit, a small livestock that can sustainably supply a household's need for white meat or protein. In a year, one female rabbit or doe can give birth to enough offspring that could produce almost fifty kilograms of meat (Ugosor et al., 2016). Rabbits are highly adaptable to varying environmental conditions; they require minimal space, produce little waste, and can be easily cared for by women, children, elderly, or even persons with disability (Owen & Amakiri, 2010). They convert fodder efficiently into high-protein, low-calorie meat, and they are prolific breeders (Opoku, 2010; Mokoro et al., 2015). Rabbit farming is a sustainable and

affordable source of protein that can be tapped by communities being challenged by climate change, rising population, and evolving meat consumption patterns (Mutsami & Karl, 2020; Molina-Flores et al., 2020). Rabbit farming is a promising livestock enterprise in the Philippines, but rabbit raisers need a lot of support to make this venture successful (Dionisio et al., 2023).

A grain that has potential as alternative animal feed, and is considered to be an alternative for rice and corn, is adlai or Job's tears (*Coix lacryma-jobi* L.). It belongs to the Poaceae family and got its name from its tear-shaped seeds that are 8–12 mm long, with a hard shell of varying colors (Aradilla, 2018; Magpantay et al., 2021). Adlai can thrive in marginal soils and needs minimal cultivation, irrigation, or pest control efforts (Monteroyo & Aradilla, 2014; Dela Torre, 2018). It can be grown in the Philippines's three main island groups - Luzon, Visayas and Mindanao (De Jesus et al, 2015; Tangpos, 2022; Magallon & Cabahug, 2022). Adlai seeds contain 16.2% protein, 4.65% fat, and 79.17% carbohydrates (Kim et al., 2004; Yang et al., 2013). They are also sources of beneficial compounds, including amino acids, vitamins (notably B1), anti-inflammatory agents, antioxidants, and anti-cancer properties (Yu et al., 2008; Chen et al., 2012; Li et al., 2013; Lu et al., 2013).

Feed is the highest cost in livestock and poultry farming. In extensive rabbit production systems relying on local forages, alternative strategies are essential (Oseni & Lukefahr, 2014). Hence, this study consisted of a feeding trial to assess the effects of incorporating adlai seeds into rabbit diets by analyzing the nutritional composition of the formulated feeds and observing the rabbits' growth performance and overall health. Through this research, the aim was to determine whether adlai can serve as a sustainable potential feedstuff ingredient, thus contributing to the development of more resilient rabbit production systems.

Objectives of the Study

This study evaluated the potential of adlai seeds as feedstuff for rabbit production. Specifically, this study aimed to (a) assess the nutritional composition of crumbled rabbit pellets mixed with varying amount of adlai seeds, and (b) determine the final weight, average weight gain, feed intake, and feed conversion ratio of rabbits.

Materials and Methods

Experimental Design and Layout

This institutionally-approved research study was laid out in a 2x3 factorial in a Randomized Complete Block Design (RCBD), with breed as factor A, and the different amounts of feeding as factor B. The experimental treatments for Factor A were: A1 – Californian, and A2 – New Zealand White. Factor B included the different morning rations in a restricted feeding scheme: B1 – control or 0% adlai (50 g Commercial feeds); B2 – 10% adlai seeds (45 g CF:5 g AS); B3 – 20% adlai seeds (40 g CF:10 g AS). In the afternoon, each rabbit from all treatments was given 150 g of Napier grass as part of its daily roughage requirement. There was a total of six (6) treatment combinations (A1B1, A1B2, A1B3, A2B1, A2B2, and A2B3), and each had three (3) replications, for a total of 18 groups, to which the fifty-four (54) heads of eight-week-old male rabbits were randomly assigned. The rabbits were purchased at six weeks old and underwent acclimatization for two weeks prior to the experiment.

Preparation and Nutritional Analysis of Experimental Feeds

Whole adlai seeds were mixed with pelleted feeds, with the pellets crumbled into smaller pieces, about 2–3 per pellet. The variety of adlai was not properly identified by a botanist, so this is a limitation in the study. Feed samples, consisting of crumbled commercial rabbit pellets with or without adlai seeds, were submitted to the Regional Feed Laboratory, City of San Fernando, Pampanga. The nutritional

parameters analyzed were moisture, crude protein, ash, crude fat, calcium, phosphorus, salt, nitrogen-free extract, and metabolizable energy. Moisture was determined using the oven-drying method, crude protein by Kjeldahl method, ash by furnace-ignition method, crude fat and crude fiber by Ankom® filter bag technology, calcium content by titrimetry method, phosphorus content by vanadomolybdate method, salt content by Mohr method, and the nitrogen free extract and metabolizable energy by computation method.

Management of Experimental Rabbits

The experimental animals were purely confined in individual 0.56 m^2 screen-type cages, with individual feed and water bowls made of recycled plastic cups and bottles. Six-week-old rabbits were fed twice daily based on the experimental groupings, and water was made available at all times. The weight of each rabbit was measured before (at 8 wks. old) and after the feeding trial (at 12 wks. old) using a digital weighing scale with a 5 kg capacity and up to 0.01 gram precision. The feed intake was weighed daily within the 30-day feeding period, starting from March 1 to March 31, 2024. The feed allocation of 50 g of concentrates and 150 g of roughage per day is based on the farming practices of local rabbit producers in Bulacan and Nueva Ecija.

Statistical Analysis

The normality and homogeneity of the data were tested prior to determining significant differences among the treatments used in the experimental study. The data gathered were analyzed using Statistical Tool for Agricultural Research (STAR) software version 2.0, following the analysis of variance in a 2-factor factorial Randomized Complete Block Design (RCBD) to determine the effects of the treatments.

Results and Discussion

Nutritional Analysis

Table 1 presents the results of the nutritional analysis of feed formulations with varying amounts of adlai seeds, as determined by the Regional Feed Laboratory of Central Luzon region, located in the City of San Fernando, Pampanga.

Table 1

Nutritional Analysis of Feed Formulations with Varying Amount of Adlai Seeds

Parameters	Feed types with varying amounts of adlai		
	B1 - Control; 50 g Commercial feeds [CF] as AM meal)	B2-10% of adlai seeds [45 g CF:5g AS])	B3-20% of adlai seeds [40 g CF:10g AS]
% Moisture Content	7.7±0.1	8.1±0.1	9.3±0.1
% Crude Protein	15.0±0.5	13.1±0.4	13.3±0.5
% Ash Content	10.4±0.1	10.2±0.3	10.0±0.1
% Crude Fat	4.4±0.1	4.0±0.2	4.5±0.2
% Crude Fiber	17.8±0.7	18.4±0.5	17.1±0.6
% Calcium	1.0±0.2	1.1±0.3	1.4±0.3
% Phosphorus	0.5±0.1	0.5±0.1	0.4±0.1
% Salt	0.6±0.1	0.6±0.1	0.6±0.1
Nitrogen Free Extract, %	44.7	46.2	45.8
Metabolizable Energy, kcal/kg	2463.5	2415.5	2451.0

The moisture content of control or B1 (7.7%) is lower than those with adlai, wherein B2 (10% adlai) had 8.1% moisture, and B3 (20% adlai) had 9.3% moisture. The crude protein contents of B1 (15%), B2

(13.1%), B3 (13.3%) as well as the nitrogen free-extract (NFE) in B1 (44.7%), B2 (46.2%) and B3 (45.8%) is within the recommended range set by Michigan State University Extension (2017) for young rabbits, wherein ration should contain 12–15% crude protein and 43–47% nitrogen-free extract (carbohydrate).

The ash contents in BI (10.4%), B2 (10.2%), B3 (10%), and crude fat in B1 (4.4%), B2 (4%), B3 (4.5%) were higher than 4.0-6.5% ash or mineral content and 2–3.5% fat recommended by MSU Extension (2017). However, the crude fiber (CF) of B1 (17. 8%), B2 (18.4%), and B3 (17.1%) was lower than the recommended crude fiber range of 20–27% (MSU Extension, 2017).

The calcium contents of the feed formulations (B1 – 1.0%±0.2; B2 – 1.1%±0.3; and B3 – 1.4%±0.3) and their phosphorus contents (B1,B2 – 0.5%±0.1; B3 - 0.4%±0.1) are within the recommended 1.5: 1 to 2:1 recommended ratio (Halls, 2010). The metabolizable energy of feeds (B1 – 2463.5 kcal/kg; B2 – 2415.5 kcal/kg; and B3 – 2451.0 kcal/kg) are near the recommended ME for fattening rabbits which is 9.8 MJ or 2342.26 kcal/kg (Lukefahr, 2022).

Performance of Rabbits

Table 2

Production Performance of Californian and New Zealand White Rabbits Fed with Commercial Feeds and Varying Amounts of Adlai Seeds

Performance Parameters	Factor A - Breed	Factor B - Feed type with varying levels of adlai seeds B1 (100% Commercial Feed)	B2 (90 % CF, 10% Adlai Seeds)	B3 (80 % CF, 20% Adlai Seeds)	Factor A Mean
Initial wt., 8 wks. old (g)	A1 (Californian)	1,093.89	1,155.11	1,104.78	**1,117.93**
	A2 (NZ White)	1,055.00	1,201.11	1,165.89	**1,140.67**
	Factor B Mean	**1,074.45**	**1,178.11**	**1,135.33**	
Final wt., 12 wks. old (g)	A1 (Californian)	1,626.78	1,455.56	1,551.22	**1,544.52**
	A2 (NZ White)	1,564.67	1,597.32	1,617.00	**1,592.99**
	Factor B Mean	**1,595.72**	**1,526.44**	**1,584.11**	
Average weight gain (g)	A1 (Californian)	532.89	300.44	446.44	**426.59**
	A2 (NZ White)	509.67	396.20	451.11	**452.33**
	Factor B Mean	**521.28**	**348.32**	**448.78**	
Average daily gain (g)	A1 (Californian)	17.76	10.01	14.88	**14.22**
	A2 (NZ White)	16.99	13.20	15.04	**15.08**
	Factor B Mean	**17.37**	**11.61**	**14.96**	
Feed intake (g)	A1 (Californian)	1,496.11	1,487.22	1,495.78	**1,493.04**
	A2 (NZ White)	1,489.22	1,490.44	1,478.78	**1,486.15**
	Factor B Mean	**1,492.67**	**1,488.83**	**1,487.28**	
Feed conversion ratio (FCR)	A1 (Californian)	2.98	5.00	3.40	**3.79**
	A2 (NZ White)	3.06	3.85	3.76	**3.59**
	Factor B Mean	**3.02**	**4.47**	**3.58**	

The initial weight of experimental rabbits, which were eight weeks old before the experiment, was determined before the start of the feeding trial. The results indicate that the rabbits were relatively similar in size and weight at the beginning of the experiment. There was no significant difference in the initial weight results among the six groups from the 2x3 factorial design, ranging from 1,104.78 g to 1,201.11 g.

The final weight was determined after one month of feeding trial, or 10 weeks of age for the rabbits. There were no interaction effects observed between the breed and type of feed. The achieved final weight among the six groups ranged from 1,455.56 g (A1B2 – Californian, 10% adlai) to 1,626.78 g (A1B1 –

Californian, 0% adlai). There was also no significant effect by either of the two factors. The highest mean final weight among feed types was observed in the control group with 1,595.72 g, but has no significant difference to 1,584.11 g of B3 (20% adlai) and 1526.44 g of B2 (10% adlai). The higher mean for breed was for NZ White rabbits at 1592.99 g, but there was no significant difference to the 1,544.52 g of Californian rabbits. The results imply that replacing up to 20% of commercial feeds with adlai seeds has no significant effect on the weight of rabbits.

These results for body weight at 12 weeks of age for meat-type rabbits are close to, but slightly lower than, the two-month-old average weight of 1,640 g for New Zealand White rabbits raised in Bulacan, Philippines (Nicolas et al., 2019). This could be attributed to the hot environmental temperatures during the study, since it was conducted in the month of March, one of the hottest months in the country (Cabrera, 2024). Rabbits are sensitive to high environmental temperatures, and heat stress can reduce their body weight, weight gain and feed intake (Dahmani et al., 2022).

The average weight gain (AWG), determined by subtracting the initial weight at 8 wks from the final weight at 12 wks, and was likewise not affected by the two factors and their interaction. The achieved AWG after four weeks of feeding ranged from 300.44 g (A2B1 – 10% adlai, Californian) to 532.89 g (A1B1 – control, Californian). The related parameter which is average daily gain (ADG), was computed by dividing the AWG by 30, the number of days spent for the study. The highest mean ADG among feed types was observed in the control group at 17.31 g, but there was no significant difference compared to 14.96 g of B3 (20% adlai) and 11.61 g of B2 (10% adlai). The higher mean for breed was observed in NZ White rabbits at 15.08 g, but there was no significant difference compared to the 14.22 g of Californian rabbits.

The results on AWG and ADG also both imply that replacing up to 20% of commercial feeds with adlai seeds has no significant effect on the weight gain of meat-type rabbit breeds. The 15.08 g ADG obtained in this study for three months old New Zealand White rabbits is comparable to the 15.26 g ADG reported by Nicolas et al. (2019), for the same breed and age of rabbits. Compared to the reported ADG of rabbits raised in other tropical countries, such ADG is comparable to the results of Samkol (2009) with 14.0g ADG, but lower than that of Omer and Badr (2013) who obtained 19.91–23.09 g ADG.

The feed intake (FI), determined by subtracting the weight of all unconsumed feeds from the total daily ration, also show to be unaffected by the breed and feed types. Most daily rations are fully consumed by the rabbits, while on some days, only minimal leftovers or crumbs remain. The observed feed intake after four weeks of feeding ranged from 1,478.78 g (B3A2 – 20% adlai, NZW) to 1,496.11 g (A1B1 – control, Californian). The highest mean feed intake among feed types was observed in the control group at 1,492.67 g, but there was no significant difference compared to 1,488.83 g of B2 (10% adlai) and 1,487.28 g of B3 (20% adlai). The higher mean for breed was observed in Californian rabbits at 1,493.04 g, but there was no significant difference compared to 1,486.15 g of New Zealand White rabbits.

The results also imply that replacing up to 20% of commercial feeds with adlai seeds has no significant effect on the feed intake of both rabbit breeds. Rabbits have a high feed intake and fast metabolism, so they can still meet nutritional needs with forages that are low in energy and protein (de Blas & Wiseman, 2020). According to Sena et al., (2015), newly-weaned meat-type rabbits can consume about 4 to 6 ounces of food per day, according to size.

The feed conversion ratio (FCR) is the means of getting the feed efficiency in producing additional weight, with lower numbers signifying better efficiency. The FCR, which is determined by dividing the feed intake by the weight gain, was also not significantly affected by the rabbit breed and level of adlai on the feeds. The computed FCR ranged from 2.98 g (A1B1 – control, Californian) to 5.00 (A1B2 – 10% adlai,

NZW). The lowest computed FCR among feed types was observed in the control group at 3.02, but there was no significant difference compared to 4.47 of B2 (10% adlai) and 3.58 of B3 (20% adlai). The lower computed FCR for breed was observed in NZ White rabbits at 3.59, but there was no significant difference compared to 3.79 g of Californian rabbits. The results also imply that replacing up to 20% of commercial feeds with adlai seeds has no significant effect on the feed efficiency of both rabbit breeds. Maertens (2009) stressed that the use of diets with accurate nutrient level, coupled with appropriate feeding methods, are necessary for minimum losses and optimum digestive health and FCR. In this study, the obtained FCR of 2.98 to 5.00 from the experimental rabbits was comparable to the FCR reported in the study of Omer and Badr (2013) which ranged from 3.66 to 4.10, and in the 3.4–3.8 FCR observed in European farms as studied by Gidenne et al. (2017).

Conclusion

It was concluded from the findings of this study that incorporating adlai seeds in the diet of growing rabbits, regardless of breed and varying feeding levels, did not negatively affect growth performance. Therefore, Adlai seeds could be considered a potential feedstuff in rabbit diets without adverse effects on the growth performance.

Recommendations

Future studies may explore the use of pelleted adlai seeds with commercial feeds using pellet machine to mix it together for the improvement of feed efficiency. Varying the percentage of adlai seeds as main feeds to rabbit diet may enhance growth performance further, specifically if other breeds and the specific growth stages are also studied. Cultivating adlai locally, if there are available areas before raising rabbits is recommended for cheaper and sustainable feed resource for rabbit raisers. It is further recommended that future studies explore the utilization of adlai (*Coix lacryma-jobi* L.) seeds and other parts of the plant through various feed processing methods such as pelletizing, extrusion, or fermentation to further enhance feed efficiency and nutritional value.

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