Effect of incorporation of fermented Prosopis pods in rabbit diets on feed intake, feed conversion ratio, weight gain and growth rate

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Abstract

Rabbit feed for commercial use is primarily made up of cereals that are also used for human food. Often, there is a scarcity of quality cereals available for livestock feed production which makes feed expensive and rabbit production not sustainable. It is proposed that incorporating Prosopis juliflora pods meal, a locally available substitute for cereals, in rabbit feed production will reduce the cost of feed and make rabbit production sustainable. This will improve food and nutritional security and contribute to economic development. This study examined the effects of incorporating Prosopis pods fermented with Aspergillus Niger in the grower rabbit diet on performance. Mature pods were collected from Marigat, Baringo County, ground using a hammer mill with a sieve size of 5mm. The pods were fermented with Aspergillus Niger (FGMPP) for 24, 48, and 72 hours. After running a series of fermentations at different durations, 72 hours duration of fermenting the Prosopis pods was the best in reducing the anti-nutritive factors (condensed tannin, Pectin, and Phytate). A feeding trial using FGMPP-based diet was conducted at Tatton Agriculture Park using 60 New Zealand White grower rabbits (30 bucks and 30 does), 42 days old. Four dietary treatments containing 0, 20, 40, and 60% FGMPP were formulated. The effect of incorporating FGMPP in the diets on feed intake, feed conversion ratio, weight gain, and growth rate was determined. In a randomised complete block design (RCBD), forty-eight rabbits (48) were used. The feed intake, conversion ratio, weight gain, and growth rate data were analysed using the GLM (General Linear Model) procedure of the Statistical Analysis System (SAS) 2009 software. The initial weight was a covariate. Overall data were analysed using a one-way ANOVA test. Mean separation was done using Tukey’s HSD test at p<0.05 significance level. From the result of the study, the diet with the 60% FGMPP had the highest Average daily feed intake (ADFI), while there was no significant difference between 40 and 20%, while the diet with 0% had the lowest. There was an improvement in ADG with the diet with 60% FGMPP. The results on weight gain showed that the diet with 60% FGMPP had the highest, while the lowest was recorded in the one with 0%. For the Feed conversion ratio, the diet containing 60% FGMPP had the lowest; there was no significant difference between the diet with 40 and 20%, while the diet with 0% had the highest. There was no significant difference in the growth rate between the diet with 60 and 40% FGMPP, while the one with 60% differed from the 0% diet. The growth rate did not differ in the rabbits fed the diets containing 0 and 20% FGMPP. It was therefore concluded that including 60% FGMPP in the grower rabbit diet improved performance. The pods should be harvested, fermented and incorporated at 60% in rabbit diet to improve performance. This will also conserve the grazing lands, create employment and enhance the economic contribution of the Prosopis trees in the ASALs.

Keywords: Nutrients, performance, Prosopis juliflora, utilisation

Introduction

Raising rabbits for meat is a rapidly expanding livestock industry worldwide (Borter & Mwanza 2011) [8]. Currently, there hasn’t been any research conducted to identify the reasons behind it, but it is believed that the decrease in land-size ownership has prompted farmers to select livestock businesses such as rabbit farming, which require less land and feed resources (Borter & Mwanza, 2011) [8].
This is why rabbit farming is particularly suitable for peri-urban farmers who may want to raise their rabbits without worrying about disturbing their neighbours since they are quiet (Omole, 1988) [34]. Also, the growing awareness of the benefits of rabbit farming is likely to contribute to its increasing popularity. Some of these advantages include high productivity, early maturity, and fast growth rate. Rabbits are known for their efficient feed conversion. They can convert low-cost high-fibre into high-quality meat, making them a cost-effective choice for meat production. Livestock farming can provide multiple revenue streams such as the sale of meat, fur, or breeding stock, which can significantly contribute to the overall income of the farmers. Their meat is lean, low in cholesterol, and high in protein, making it an appealing option for health-conscious (Lukefahr et al., 2004) [27].

Kenya's rabbit production is dominated by small-scale producers who invest minimally in housing, feeding, and management practices (Borter & Mwanza, 2011) [8]. The high cost of feed resources in livestock production is a major obstacle to meeting the demand for animal protein, especially in developing nations. *Prosopis juliflora* pods meal has been identified as the feed resource in livestock. Mature Prosopis pods, whether they contain seeds or not, are highly appetizing. These plants produce pods twice a year, resulting in an annual yield of 10-50 kg per plant as noted by Sawal et al. (2004) [36]. Due to the widespread presence of mesquite plants in tropical and subtropical regions and their fruiting cycle, harvesting large quantities of pods from forested areas and roadsides is feasible, and this can provide a source of income for impoverished individuals. The pods can be used as an affordable feed alternative by substituting up to 50% of the grain component and bran in rabbits' diets with no adverse effects on their health, as reported by Sawal et al. (2004) [36]. *Prosopis juliflora* pods have a high protein content and are rich in essential amino acids, including lysine, tyrosine, phenylalanine, and isoleucine are necessary to maintain rabbit production (Zhong et al., 2022) [44]. *Prosopis juliflora* pods contain high levels of Sodium, Potassium, Calcium, Magnesium, Phosphorus, Iron, Copper, Zinc, and Manganese. *Prosopis juliflora* is a highly versatile plant that has been used in rabbit production for many years. This plant is an excellent source of protein for rabbits due to its high nutritional value (Bhat & Karim, 2009) [7]. It is also a good energy source and contains essential vitamins that are vital for rabbits' overall health and well-being. Therefore, Prosopis pods can be used as a feed ingredient for rabbits to promote their health and meet their nutrient requirements.

**Materials and Methods**

**Study site:** The study was conducted at Egerton University Kenya's Rabbit Research Unit, Tatton Agriculture Park (TAP). The University is in Nakuru County, Njoro sub-county. 0°22'11.0" S, 35°55'58.0" E (Latitude:0.369734; Longitude: 35.932779), 1,800 m above sea level with an average temperature between 17-22 °C but can drop to 11 °C during the cold season (July-August). The average annual rainfall in two short and long seasons is 1,200±100 mm. The long rain starts in March and ends in July, while the short rain starts in October and ends in December (Egerton University Meteorological Station, 2019) [16].

**Pod Collection:** Prosopis pods were obtained from Marigat Sub County in Baringo County, which is located about 130 km away from Egerton University. The dry-matured Prosopis pods without spots, discouloration, or attack by insects were sorted out (Choge et al., 2007) [12]. Marigat is located at latitude 0°28'10.1"N, longitude 35°58'59.79"E. The region has a moderate temperature of approximately 32.8 °C ± 1.6 °C and experiences an average rainfall of 512 mm in two distinct seasons - March to August and November to December. The area is semi-arid and situated 1067 metres above sea level.

**Substrate preparation:** The pods without spots, discouloration, or attack by insects were dried under shade to reduce the moisture content to about 11%. After drying, pods were first ground without sieving; The second round of grinding was carried out following the procedure outlined by Choge et al. (2006) [11]. Proximate analysis and analysis for phytate, pectin and condensed tannins were also determined. Thereafter, a sample of the ground material was subjected to fermentation at different temperatures (30 °C, 35 °C, and 40 °C), pH (4.0, 5.0, and 6.0) and time (24hrs, 48hrs, and 72 hours). Analysis for phytate, pectin and condensed tannins content was determined after fermentation. The fermentation temperature, pH and time that resulted in the highest reduction of the anti-nutritive factors (phytate, pectin and condensed tannins) using Box-Behnken Design (BBD) for optimisation was adopted to ferment the Prosopis pod flour for compounding of the experimental diets for the rabbits.

**Experimental animals and management:** Sixty (60) 42-day-old New Zealand White grower rabbits: 30 bucks and 30 does. Wire mesh cages (75×55×40 cm) provided ventilation, and rabbits adapted on a standard diet for 3 days (Deblas & Mateo, 2010) [15]. They were dewormed with ascarex® (2gm into 50mls of water) and dusted with Sevin® (425 mg/kg) to control internal and external parasites, respectively, as the manufacturer prescribes. All drugs were handled as prescribed by the veterinary Officer. Before introducing the rabbits to the rabbit house and experimental cages, the watering and feeding troughs were thoroughly cleaned and disinfected with kupacide®, (5mls into 10 litres of water), and dusted with Sevin® to control external parasites.

**Experimental diets:** Ingredients for formulating the experimental diets were ground and mixed at the Tatton Agriculture Park feed mill, Egerton University. Four dietary treatments comprised 0, 20, 40, and 60% FGMPP (Table 1). The diets were iso-caloric and iso-nitrogenous, formulated to meet the nutrient requirement for grower rabbits (Deblas & Mateo, 2010) [15].

**Data collection**

The following parameters were recorded: feed offered, feed refusal, and live and carcass weights. The following were calculated from the data collected: feed intake, feed conversion ratio (FCR), weight gain (W.G.), growth rate (G.R.), and dressing percentage (D%). Feed offered and refusal was recorded daily, while live weight was recorded weekly. Feed intake was calculated daily, while FCR, W.G. and G.R. were calculated weekly. The dressing percentage was calculated at the end of the feeding trial.
Feed intake: It was calculated by the difference between feed offered and feed refusal (Abebe & Tamir, 2016) [1].

Feed conversion ratio: It was calculated as the average feed intake (g) consumed divided by the average weight gained during each week (Knudsen et al., 2014) [26].

Weight gain was obtained by subtracting the previous week's weight from the current week's weight (Chehade et al. 2022) [10].

Growth rate was determined as the difference between final body weight and initial body weight divided by the period between the weighing (Christiansen et al., 1996).

Experimental design

Design for objective two: A randomised complete block (sex) design (RCBD) with a covariate (initial weight) was used. The model was:

\[ Y_{ijk} = \mu + ai + bj + sk + \varepsilon_{ijk} \]

where:

- \( Y_{ijk} \) = response variable of interest
- \( \mu \) = overall mean
- \( a \) = effect of the treatment, fermented Prosopis juliflora pods, T1 0% Prosopis juliflora pods, T2 20% Prosopis juliflora pods, T3 40% Prosopis juliflora pods, T4 60% Prosopis juliflora pods
- \( b \) = fixed effect of initial weight to be used as a covariate
- \( s \) = fixed effect of initial weight to be used as a covariate
- \( \varepsilon_{ijk} \) = random error term.

Results

Table 1: Composition of experimental diets

<table>
<thead>
<tr>
<th>Ingredients kg</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maise grain</td>
<td>44.0</td>
<td>39.0</td>
<td>29.0</td>
<td>21.9</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>42.0</td>
<td>23.5</td>
<td>12.5</td>
<td>6.0</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>0.0</td>
<td>2.5</td>
<td>4.5</td>
<td>6.5</td>
</tr>
<tr>
<td>FGMPP</td>
<td>0.0</td>
<td>20.0</td>
<td>40.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Fish meal</td>
<td>3.0</td>
<td>4.9</td>
<td>4.9</td>
<td>8.5</td>
</tr>
<tr>
<td>Cotton seed meal</td>
<td>9.9</td>
<td>9.0</td>
<td>8.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Iodised salt</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Vitamin premix</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Binder</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Calculated analysis CP%</td>
<td>16.5</td>
<td>16.5</td>
<td>16.3</td>
<td>16.1</td>
</tr>
<tr>
<td>ME (MJ/Kg)</td>
<td>12.8</td>
<td>12.5</td>
<td>12.0</td>
<td>11.7</td>
</tr>
<tr>
<td>CF%</td>
<td>7.5</td>
<td>10.4</td>
<td>14.1</td>
<td>16.9</td>
</tr>
</tbody>
</table>

Table 2: Analysed chemical composition of the diets (D.M. Basis %)

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC</td>
<td>10.711</td>
<td>11.527</td>
<td>11.818</td>
<td>11.753</td>
</tr>
<tr>
<td>ASH</td>
<td>8.087</td>
<td>7.844</td>
<td>7.911</td>
<td>11.570</td>
</tr>
<tr>
<td>EE</td>
<td>6.266</td>
<td>4.595</td>
<td>7.788</td>
<td>8.388</td>
</tr>
<tr>
<td>CF</td>
<td>12.462</td>
<td>13.993</td>
<td>17.982</td>
<td>21.613</td>
</tr>
</tbody>
</table>

Table 3: Effects of the incorporation of fermented Prosopis pods in diets on feed intake, feed conversion ratio, weight gain and growth rate of rabbit

<table>
<thead>
<tr>
<th>Treatments</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADFI (g)</td>
<td>109.99±2.60</td>
<td>115.42±2.03</td>
<td>116.99±2.31</td>
<td>124.73±2.34</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Weight gain (kg)</td>
<td>0.100±0.009</td>
<td>0.100±0.010</td>
<td>0.103±0.008</td>
<td>0.105±0.007</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>FCR (g)</td>
<td>3.65±0.13</td>
<td>3.01±0.21</td>
<td>2.56±0.18</td>
<td>1.55±0.15</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Growth rate (kg)</td>
<td>1.06±0.01</td>
<td>1.25±0.02</td>
<td>1.59±0.05</td>
<td>1.70±0.08</td>
<td>0.0003</td>
</tr>
</tbody>
</table>

Means within a row with different subscripts letter are statically different (p<0.05). T1 contains 0% Prosopis, T2 contain 20% Prosopis, T3 contains 40% Prosopis, T4 contain 60% Prosopis ADFI average daily feed intake. FCR feed conversion ratio.

Discussion

The effect of fermented Prosopis pods meal in diets on average feed intake, feed conversion ratio, weight gain, and growth rate was determined. From the results, rabbits fed on a diet with 60% FGMPP had the highest average daily feed intake, while there was no significant difference between diets with 40 and 20% FGMPP. A diet with 0% FGMPP had the lowest average daily feed intake. The highest ADFI was recorded in the rabbits fed on the diet with 60% FGMPP because it had high fibre content compared to the rest. This result agrees with the findings of Chaudhury et al. (1995) [9], who reported that rabbits given higher fibre consumed more feed and gained more weight than rabbits on lower-fibre diets. Rabbits depend on the bacterial population in their hindgut to help them digest fibre, which is vital for their overall gut health, mobility, caecotrophy, and appetite stimulation. They have a high feed intake, consuming 65-80 g of feed per kg of body weight, and a fast feed transit time of 19 hours. This allows them to consume more foods while still meeting their nutritional requirements (De Blas & Wiseman, 2003) [14]. According to Attia et al. (2021) [3], the digestibility and intake of fibre residues with high lignin content can be enhanced through physical and biological treatment. Several studies have been conducted on using exogenous microorganisms to

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boost nutritional usage ([Falcao-Cunha et al., 2007]) [19], increase growth rate, and improve feed conversion ratio. The treatment of the Prosopis pods with Aspergillus Niger in this study also improved utilisation by the grower rabbits to increase feed intake. According to a study conducted by Gado et al. (2009) [20], the inclusion of Aspergillus Niger in the diet of rabbits resulted in an increase in caecal fermentation. This, in turn, led to improved feed utilisation. Gutiérrez et al. (2002) [21] also observed that supplementing enzymes in a rabbit diet resulted in increased nutrient digestibility and improved feed conversion ratio. From the results, 60% of FGMPP-based diets had the highest weight gain, while the lowest weight gain was recorded in diets with 0%. The diet with 40% resulted in higher weight gain than 20% FGMPP. The improved weight gain in rabbits fed on 60% FGMPP could be a result of the increased efficiency of feed utilisation by the rabbits on 60% FGMPP-based diets due to the improved nutritional value from fermentation, which reduced the anti-nutritive factors (condensed tannins, phytate and pectin) in the diets. Fermentation improves the nutritional quality of non-conventional feed resources (Yao et al., 2018) [43]. Wang et al. (2018) [40] reported the quality and digestibility were noticeably enhanced via solid-state fermentation (SSF) using lactic acid bacteria. These increments in weight gain of rabbits may be attributed to the effect of fibre, which may increase caecal length, decrease pH, NH3-N (mmol/l), and increase the digestible protein (Battaa et al., 2013) [6]. Concentrating on converting ammonia-N into microbial protein benefits rabbits characterized by pseudo-rumination. Also, it may be due to the increase of volatile fatty acids (VFA) in the cecum (Bakr, 2019) [5]. Prosopis pods are high in protein, fibre, and minerals essential (Sawal et al. 2004) [38]. Rabbits that consume Prosopis pods regularly tend to gain weight faster than the ones on conventional feed (Waititu, 2021) [39]. Including Prosopis pods in a rabbit’s diet is an excellent way to maintain digestive issues, enhance intestinal motility, and promote growth in rabbits (Johnson-Delaney, 2006). Rabbits on higher-fibre diets have been reported to gain weight better than those on low fibre. Adamu et al. (2013) [6] reported that better performance was obtained by replacing 50% of the maize with Prosopis juliflora pods (20% inclusion) in the diets of growing rabbits. Therefore, Grower rabbits’ performance is not compromised when fed 60% Prosopis juliflora pods in their diets.

Conclusion
The results concluded that incorporating 60% FGMPP in a grower rabbit diet improved average daily feed intake, weight gain, feed conversion ratio and growth rate.

Recommendation
It was recommended that to reduce the rapid spread of prosopis trees in the ASALs of Kenya, prosopis pods should be harvested, fermented and incorporated in grower rabbit diet at 60%.

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