International Journal of Veterinary Sciences and Animal Husbandry

ISSN: 2456-2912
VET 2023; SP-8(5): 236-241

www.veterinarypaper.com
Received: 20-07-2023
Accepted: 25-08-2023

Maud Boakyewaa Acheampong
Egerton University, Faculty of Agriculture, Department of Animal Sciences; P.O. Box 536-20115, Egerton, Kenya

Anthony M Kingori
Egerton University, Faculty of Agriculture, Department of Animal Sciences; P.O. Box 536-20115, Egerton, Kenya

Joseph W Matofari
Department of Dairy and Food Science and Technology Egerton University Kenya

Corresponding Author:
Maud Boakyewaa Acheampong
Egerton University, Faculty of Agriculture, Department of Animal Sciences; P.O. Box 536-20115, Egerton, Kenya

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

Maud Boakyewaa Acheampong, Anthony M Kingori and Joseph W Matofari

DOI: https://doi.org/10.22271/veterinary.2023.v8.i5Sd.757

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 this 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, discolouration, or attack by insects were sorted out (Choge *et al*., 2007) [12]. Marigat is located at latitude 0º28'10.1"N, longitude 35º58'59.79"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, discolouration, 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.

Table 1: Composition of experimental diets

Ingredients kg	T_1	T_2	T_3	T_4
Maise grain	44.0	39.0	29.0	21.9
Wheat bran	42.0	23.5	12.5	0.0
Vegetable oil	0.0	2.5	4.5	6.5
FGMPP	0.0	20.0	40.0	60.0
Fish meal	3.0	4.9	4.9	8.5
Cotton seed meal	9.9	9.0	8.0	2.0
Iodised salt	0.5	0.5	0.5	0.5
Vitamin premix	0.5	0.5	0.5	0.5
Binder	0.1	0.1	0.1	0.1
Total	100.0	100.0	100.0	100.0
Calculated analysis CP%	16.5	16.5	16.3	16.1
ME (MJ/Kg)	12.8	12.5	12.0	11.7
CF%	7.5	10.4	14.1	16.9

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;

$Yijk = \mu + \alpha i + \beta j + Sk + \varepsilon ijk$ where;

Y_{ijk}= response variable of interest μ= overall mean
α_i=effect due to the i^{th} treatment, fermented Prosopis juliflora (diet 1, 2, 3, and 4…. i^{th})
β_j=fixed effect of the block (sex)
$S_{k\,=}$ fixed effect of initial weight to be used as a covariate
ε_{ijk}= random error term.

Results

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

Nutrients	Diets			
	T_1	T_2	T_3	T_4
MC	10.711	11.527	11.818	11.753
ASH	8.087	7.844	7.911	11.570
EE	6.266	4.595	7.788	8.388
CF	12.462	13.993	17.982	21.613
CP	16.329	16.410	16.511	16.538

T_1 0% *Prosopis juliflora* pods, T_2 20% *Prosopis juliflora* pods, T3 40% *Prosopis juliflora* pods T_4 60% *Prosopis juliflora* pods, MC (moisture), E.E. (ether Extract) C.F. (crude fibre), C.P. (crude protein).

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

	Treatments				
Parameters	T_1	T_2	T_3	T_4	P-Value
ADFI (g)	109.90^c±3.60	115.42^b±2.03	116.96^b±2.31	124.73^a±2.34	<.0001
Weight gain (kg)	0.100^d±0.009	0.100^c±0.010	0.103^b±0.008	0.105^a±0.007	<.0001
FCR (g)	3.65^a±0.13	3.01^b±0.21	2.56^b±0.18	1.55^c±0.15	<.0001
Growth rate (kg)	1.06^b±0.01	1.25^b±0.02	1.59^a±0.05	1.70^a±0.08	0.0003

Means within a row with different subscripts letter ^{abdc} are statically different $p\leq0.05$ T_1 Contains 0% Prosopis T_2 contain 20% Prosopis T_3 contains 40% Prosopis T_4 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 feeds 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 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. Gutierrez *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) [36]. Rabbits that consume Prosopis pods regularly tend to gain weight faster than the ones on conventional feed (Waitituh, 2021) [39]. Including Prosopis pods in a rabbit's diet is an excellent way to maintain a maximum weight. According to Ruiz-Nieto *et al*. (2020), rabbits that were fed Prosopis juliflora pods exhibited better weight gain and feed conversion ratio compared to those that were not fed the same. Jiwuba *et al*. (2020) [24] found that rabbits fed with Prosopis juliflora pods did not experience any negative effects on their haematological and serum indices even with a 30% inclusion rate. Based on this, the researchers suggested that it is safe to include Prosopis juliflora pods up to 30% in rabbit diets without any harmful consequences. Whereas, in this study, Prosopis pods were included up to 60% without negatively affecting the health of the rabbits. The feed conversion ratio measures how efficiently the rabbits convert their feed into meat or other desired products. The results for the feed conversion ratio showed that 60% FGMPP had the lowest because the rabbit utilised their feed efficiently and was able to produce more meat per unit of feed consumed, which agrees with a study by Adamu *et al.* (2013) [2] reported that feed conversion ratio (FCR) was lower with increasing levels of Prosopis pods, where lowest value was recorded in 40% Prosopis pods inclusion in diets. Monitoring and improving the feed conversion ratio can also help prevent overfeeding (Knudsen *et al.,* 2014) [26]. The growth rate of grower rabbits did not significantly differ between the diet with 60% and 40% FGMPP. However, 60% differed from 0%. The increased growth rate may be attributed to the plant materials in *Prosopis juliflora* which have growth-promoting activities such as 1-aminocyclopropane-1-carboxylate (ACC) deaminase, siderophore, and indole acetic acid (IAA) and produce compounds that can potentially act as manipulators of hindgut fermentation. These compounds exhibit antibacterial, antioxidant, antifungal, anthelminthic, and antitumor activity. (William & Jafri, 2015) [41]. These activities result in optimized propionate production, decreased deamination of dietary amino acids, reduced methanogenic bacteria, increased protein flow to the small intestine, and improved diet digestibility, according to Tapia *et al*. (2000) [38]. It has been reported that Prosopis pods possess several medicinal properties, including anti-inflammatory and anti-microbial effects, which might have contributed to improving the health of rabbits and subsequently, increasing their body weight. Adequate dietary fibre intake is known to reduce 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) [2] 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%.

Acknowledgment
The authors are grateful to TAGDEV for sponsoring this study. I sincerely thank the Department of Animal Science and Department of Dairy and Food Science Technology, Egerton University, for their support during my study period. I am also grateful to Tatton Farm and its management for their support throughout my field experiment.

References

1. Abebe H, Tamir B. Effects of supplementation with pigeon pea (*Cajanus Cajun*), cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) on feed intake, body weight gain and carcass characteristics in Wollo sheep fed grass hay. Inter. J of Adv. Research in Biological Sciences. 2016; 3(2):280-295. http://s-o-i.org/1.15/ijarbs-2016-3-2-39
2. Adamu L, Igwebuike JU, Kwari ID, Aliyu J. Using Prosopis africana pulp for rabbit feeding: 1. Effects on growth and economic performance. Global Journal of Pure and Applied Sciences. 2013;19(1):1-7.
3. Attia YA, Hassan RA, Attia KM, El-Gabrey H, Assar MH, Nagadi SA, *et al*. Productive Performance of Growing Rabbits Fed Diets Containing Corn Cobs and Supplemented with Enzymes. Journal of King Abdulaziz University: Meteorology, Environment & Arid Land Agriculture Sciences. 2021;30:1.
4. Attia YA, Al-Khalaifah HS, Abd El-Hamid HE, AlHarthi MA, El-Shafey AS. Effect of different levels of multienzymes on immune response, blood haematology and biochemistry, antioxidants status and organs histology of broiler chicks fed standard and low-density diets. Front. Vet. Sci. 2020c;6:510.

DOI: 10.3389/fvets.2019.00510
5. Bakr AA. Impact of Partial Replacement of Alfalfa Hay with Prickly Pear Peels (PPPS) on Productive Performance of Rabbits. Egyptian Journal of Nutrition and Feeds. 2019;22(3):535-550.
6. Battaa AM, Zeedan KI, Abd EL Lateif AI. The effect of different levels of dietary fiber fractions on performance and immunity of growing rabbits 1–The Effect of using corn cubs as a source of acid detergent fiber on growth performance. Egyptian Poultry Science Journal. 2013;33(1):51-71.
7. Bhat R, Karim AA. Exploring the nutritional potential of wild and underutilised legumes. Comprehensive Reviews in Food Science and Food Safety. 2009;8(4):305-331.
8. Borter DK, Mwanza RN. Rabbit production in Kenya, current status and way forward. In proceedings of annual scientific symposium of the animal production society of Kenya. Driving Livestock Entrepreneurship towards attainment of Food sufficiency and Kenya Vision. 2011;2030:13-19.
9. Chaudhary LC, Singh R, Kamra DN, Pathak NN. Effect of oral administration of yeast (*Saccharomyces cerevisiae*) on digestibility and growth performance of rabbits fed diets of different fibre content. World Rabbit Science. 1995;3(1):15-18.
10. Chehade SB, Green GB, Graham CD, Chakraborti A, Vashai B, Moon A, *et al*. A modified standard American diet induces physiological parameters associated with metabolic syndrome in C57BL/6J mice. Frontiers in Nutrition. 2022;9:929446. https://doi.org/10.3389/fnut.2022.929446.
11. Choge SK, Harvey M, Chesang S, Pasiecnik NM. Cooking with Prosopis Flour. Recipes Tried and Tested in Baringo District, Kenya. KEFRI, Nairobi, Kenya and HDRA, Coventry, United Kingdom; c2006. https:// answers.practicalaction.org/our-resourc es/item/cooking-with-prosopis-flour Accessed February 12, 2020.
12. Choge SK, Pasiecnik NM, Harvey M, Wright J, Awan SJ, Harris PJC. Prosopis pods as human food, with special reference to Kenya; c2007. Retrieved, August 24th, 2022, from http://www.wrc.org.za/.
13. Christensen H, Sienko A, Rayburn W, Gonzalez C, Coleman F. Selection of a clinically relevant dose of corticosteroids to enhance fetal lung maturity and their effect on fetal growth and development. Teratology. 1996;53:98.
14. De Blas C, Wiseman J. The Nutrition of the Rabbit. CABI Publishing, Oxon, U.K; c2003.
15. Deblas C, Mateos GG. Feed formulation. In Deblas, C., Wiseman, J. (Ed), Nutrition of the rabbits. U.K.: CAB International; c2010. p. 222.
16. Egerton University Meteorological Station. Climatic data. Egerton University, Njoro Campus, Kenya; c2019.
17. Mézes CS, Zijártó M, Kustos N, Gódor Surmann K, Erdélyi M. Dose-dependent effect of cellulose supplementation on performance of early-weaned rabbit. In: Proc. 8th World Rabbit Congress, Puebla, México; c2004. p. 799-804.
18. Ezenwa LI, Omondi PA, Nwagbara MO, Gbadebo AM, Bada BS. Climate variability and its effects on gender and coping strategies in Baringo County, Kenya. Journal of Applied Sciences and Environmental Management. 2018;22(5):699-706.
19. Falcao-e-Cunha L, Castro-Solla L, Maertens L, Marounek M, Pinheiro V, Freire J, *et al*. Alternatives to antibiotic growth promoters in rabbit feeding: a review. World Rabbit Sci. 2007;15:127-140.
20. Gado HM, Salem AZM, Robinson PH, Hassan M. Influence of exogenous enzymes on nutrient digestibility, extent of ruminal fermentation as well as milk production and composition in dairy cows. Animal Feed Science and Technology. 2009;154(1-2):36-46.
21. Gutierrez I, Espinosa A, Garcia J, Carabano R, Dgblas JC. Effects of starch and protein sources, heat processing, and exogenous enzymes in starter diets for sorghum based diets. Nigerian J Anim. Prod. 2002;44:279-286.
22. Henciya S, Seturaman P, James AR, Tsai YH, Nikam R, *et al*. Biopharmaceutical potentials of Prosopis spp. (*Mimosaceae*, *Leguminosa*). J Food Drug Anal. 2017;25:187-196.
23. Chukwunomso JPD, Bede OE, Nonye AL. Effect of diets with Iron tree (*Prosopis africana*) pulp on performance and blood characteristics of growing rabbits. Asian J Anim. Sci. 2020;14:61-68.
24. Jiwuba PC. Effect of pawpaw (*Carica papaya*) leaf meal on productive parameters of growing rabbits. Agric. Sci. Technol. 2018;10:102-106.
25. Johnson-Delaney CA. Anatomy and physiology of the rabbit and rodent gastrointestinal system. In Proc. Assoc. Avian Vet. 2006;10:9-17.
26. Knudsen C, Combes S, Briens C, Coutelet G, Duperray J, Rebours G, *et al*. Increasing the digestible energy intake under a restriction strategy improves the feed conversion ratio of the growing rabbit without negatively impacting the health status. Livestock Science. 2014;169:96-105.
27. Lukefahr SD, Cheeke PR, McNitt JI, Patton NM. Limitations of intensive meat rabbit production in North America: A review. Canadian journal of animal science. 2004;84(3):349-360.
28. Mohammed G, Igwebuike JU, Alade NK. Haematological and Serum biochemical indices of growing rabbits fed bovine blood rumen–content mixture (BBRCM). Agric. Biol. JN Am. 2010;2(4):724-728.
29. Mourão JL, Pinheiro V, Alves A, Guedes CM, Pinto L, Saavedra MJ, *et al*. Effect of mannan oligosaccharides on fattening rabbits' performance, intestinal morphology, and cecal fermentation. Animal Feed Science and Technology. 2006;126(1- 2):107-120.
30. Muller L, Cheruiyot E, Ouma L, Osano A, Ogendo J. Evaluation of potential fodder sorghum genotypes for prussic acid, lignin and cellulose content. Journal of Agricultural Science and Technology A. 2020;10:39-43.
31. Naveed M, Mitter B, Yousaf S, Pastar M, Afzal M, Sessitsch A. The endophyte Enterobacter sp. FD17: A maise growth enhancer selected based on rigorous testing of plant beneficial traits and colonisation characteristics. Biol. Fertil. Soils. 2014;50:249-262. DOI: 10.1007/s00374-013-0854-y
32. Nyachoti CM, Zijlstra RT, De Lange CFM, Patience JF. Voluntary feed intake in growing-finishing pigs: A review of the main determining factors and potential approaches for accurate predictions. Canadian Journal of Animal science. 2004;84(4):549-566.
33. Odero-Waitituh JA, Kingori AM, Ambula MK. Bio-economic implications of feeding fermented ground mature Prosopis Juliflora pods to grower rabbits. Journal of Economic Impact. 2020;2(2):43-49.
34. Omole TA. Use of cassava for feeding rabbits. Paper presented at the workshop on the potential of utilising

Cassava as Livestock Feed in Africa, Ibadan (Nigeria); c1988.

35. Ruiz-Nieto JE, Hernández-Ruiz J, Hernández-Marín J, Mendoza-Carrillo J, Abraham-Juárez M, Isiordia-Lachica PM, *et al*. Mesquite (*Prosopis* spp.) tree as a feed resource for animal growth. Agroforestry Systems. 2020;94(4):1139-1149.
36. Sawal RK, Ratan R, Yadav SBS. Mesquite (*Prosopis juliflora*) pods as a feed resource for livestock-A review. Asian-Australasian Journal of Animal Sciences. 2004;17(5):719-725.
37. Tag El-Din TH. Productive performance of meat rabbits as affected by partial replacement of clover hay by okra and sugar beet processing by-products. J Agric. Sci., Mansoura Univ. 1996;21(12):4339-4350.
38. Tapia A, Feresin GE, Bustos D, Astudillo L, Theoduloz C, Schmeda-Hirschmann G, Biologically active alkaloids and a free radical scavenger from Prosopis species. J Ethnopharmacol. 2000;71:241-246.
39. Waitituh JAO. Reduction of Anti-Nutritive Compounds in Ground Mature Prosopis Juliflora Pods in Rabbit Diets using Fermentation Technology (Doctoral dissertation, Egerton University); c2021.
40. Wang C, Su W, Zhang Y, Hao L, Wang F, Lu Z, *et al*. Solid-state fermentation of distilled dried grain with solubles with probiotics for degrading lignocellulose and upgrading nutrient utilisation. AMB Express. 2018;8:1-13.
41. William K, Jafri L. Mesquite (*Prosopis juliflora*): Livestock grazing, its toxicity and management. Journal of Bioresource Managmente. 2015;2(1):49-58.
42. Xu B, Li Z, Wang C, Fu J, Zhang Y, Wang Y, *et al*. Effects of fermented feed supplementation on pig growth performance: A meta-analysis. Animal Feed Science and Technology. 2020;259:114315. https://doi.org/10.1016/j.anifeedsci.2019.114315.
43. Yao K, Zhang T, Wang H, Liu J. Upgrading of by-products from the beverage industry through solid-state fermentation with Candida utilise and Bacillus subtilis. Letters in Applied Microbiology. 2018;67:557-563. DOI: 10.1111/lam.13078.
44. Zhong J, Lu P, Wu H, Liu Z, Sharifi-Rad J, Setzer WN, *et al*. Current insights into phytochemistry, nutritional, and pharmacological properties of Prosopis plants. Evidence-Based Complementary and Alternative Medicine; c2022.