LACTATION PERFORMANCE OF NEW ZEALAND WHITE RABBITS FED FERMENTED GROUND MATURE *PROSOPIS JULIFLORA* PODS REPLACING MAIZE

[1,2]ODERO-WAITITUH, Jane Atieno, [1]KING'ORI, Anthony Macharia and [1]AMBULA, Mary Kivali
[1]Department of Animal Sciences, Egerton University, P. O. Box 536-20115 Njoro, Kenya.
[2]Ministry of Livestock Development, P. O. Box 1791-20100, Nakuru, Kenya.

Corresponding Author: Odero-Waitituh, J. A. Ministry of Livestock Development, Nakuru County, P. O. Box 1791-20100, Nakuru, Kenya. **Email:** atiwaitts@gmail.com **Phone:** +254 723485424

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ABSTRACT

Rabbit production is one of the enterprises expected to ensure food and nutrition security in developing countries. However the availability of feed ingredients especially energy sources is a challenge. There is therefore, the need to evaluate non-conventional feed resources such as mature Prosopis juliflora pods that are available throughout the year. Fluctuation in the weight of does during lactation is an indication of energy changes in the body of the doe and therefore energy content of the feeds offered. A study was conducted at Egerton University to investigate the effect of replacing maize with fermented ground mature P. juliflora pods (FGMPP) in lactating doe diets on lactation performance and energy balance. The study investigated kits weight gain and doe weight changes during the four week lactation period. Fifteen primiparous does weighing 3.05 ± 0.47 kg with a litter of six kits each, weighing 0.61 ± 0.05 kg were individually housed in cages measuring 75 x 55 x 40 cm^3. In a completely randomized design (CRD) of 5 diets; control (formulated standard breeder diet), 15 % unfermented ground mature pods of P. juliflora (UGMPP), 30 % UGMPP, 15 % FGMPP and 30 % FGMPP replacing maize in standard breeder diets were offered in three replicates per treatment. The nutritional value of mature Prosopis pods improved (p<0.05) on fermentation. There was no treatment (p>0.05) effect in weight of kits and does. Up to 30 % maize in lactating doe diets can be replaced by FGMPP.

Keywords: Anti-nutrients, Fermented *Prosopis juliflora* pods, Non-conventional feed resource, Rabbit

INTRODUCTION

Energy deficit caused by milk production demands in lactating rabbit does may lower receptivity, conception and ovulation rates, embryonic and foetal survival as well as foetal growth in primiparous rabbit does with a consequence of poor reproductive and lactation performance (Fortun-Lamothe and Prunier, 1999; Olotunmogun *et al.,* 2017). According to Fortun-Lamothe (1998), this can be prevented by increased energy intake with a positive effect on conception rate, reproductive and lactation performances. Breeding does; both lactating and pregnant have high nutrient requirements due to extra physiological demands that production and reproduction put on their bodies (Latu *et al.,* 2017). Also, physiological state (pregnancy verses non-pregnancy) concurrent with lactation significantly influences the weight and performance of does (Xiccato *et al.,* 1995; Xiccato *et al.,* 2004). The energy in the lactating doe's diet must be adequate to support lactation in terms of quantity and quality, with the desired balance of protein and energy (Olotunmogun *et al.,* 2017) and therefore

support fast kits growth. Energy balance is calculated from the difference between the energy supply from the feed and the various energy requirements of the animal (Fortun-Lamothe, 2006). There is high energy output associated with milk production in lactating does which is not entirely compensated for by feed intake, therefore does meet this energy deficit by increasing the mobilization of body reserves leading to loss of body energy and therefore, loss of condition and weight (Xiccato *et al.,* 1999). Especially in the first three weeks of lactation when litter weight gain is highly correlated with milk production with a correlation coefficient of r = 0.91 (Fernández-Carmona *et al.,* 2005).

Lactating does offered cereal starch-enriched diets, exhibited higher feed intake to balance for energy. This energy supplement is mainly utilized to increase their milk energy production (higher milk yield with higher energy content) for the kits have high energy requirements (Maertens *et al.,* 2006). Intake of energy that supports milk production without compromising body reserves is possible by the use of rearing technologies that stimulate feed intake (Rommers *et al.,* 1999) and provision of diets with a high energy content that results in better litter performance with lower body reserve depletion (Xiccato, 1995; Pascual *et al.,* 2003). High milk yield of these does is usually related to a greater negative energy balance and lower fertility values affecting subsequent litter size (Pascual *et al.,* 2003). Pascual *et al.* (2000) studied the effect of high-energy diets on the improvement of milk production and body condition of does and reported that a reduction in depletion of body reserves can be realized when dietary energy sources are from starch sources rather than fat sources. This resulted in increment of lipid body reserves and therefore improvement of subsequent reproductive and productive efficiency of breeding does (Fortun-Lamothe and Lebas, 1996).

According to King'ori *et al.* (2011) *Prosopis juliflora* (Sw.) DC) plants are found and readily available in semi-arid lands of Kenya which comprise about 75 % of Kenya's landmass. They produce pods throughout the year and there is also no competition between man and livestock for their mature pods. They can, therefore, be used as livestock feed ingredient resource. Evaluation of *P. juliflora* nutritional value by Odero-Waitituh *et al.* (2016) reported satisfactory metabolizable energy of 12.8 MJ/Kg, which was comparable to maize. However, it was noted that the pods exhibited high levels of anti-nutrients such as tannins (8 %) and crude fibre (17 %), which interfered with performance when fed to livestock. It was reported that treatment could reduce the effects of these anti-nutrients. For instance, Aremu *et al.* (2015) reported that fermentation significantly reduced the anti-nutrients in Prosopis pods. This, therefore, creates an opportunity of using fermented mature *P. juliflora* pods as an energy source in lactating doe diets. This study, therefore, investigated the effect of replacing maize with fermented ground mature *P. juliflora* pods in breeder doe diets on weight changes of lactating does and weight gain of their kits.

MATERIALS AND METHODS

Prosopis Harvesting, Drying, Storage and Grinding: Mature pods of *P. juliflora* used were obtained from Baringo County, Marigat Sub County. Distance between Marigat and Egerton University (study site) is about 130 km. Marigat is situated in the semi-arid lands at an altitude of 1067 meters above the sea level. It is within longitude 35° 30' East and 36° 30' West and the latitude 0°10' South and 1° 40' North (Ezenwa *et al.,* 2018). The mean temperature is 32.8°C ± 1.6°C. Average annual rainfall is in two seasons: March to August and November to December at 706.07 ± 178.13 mm (Muriithi *et al.,* 2018). *Prosopis juliflora* is a thorny shrub 3-5 m or tree growing up to 15 m height. The fruit of *P. juliflora* is a cylindrical or slightly irregularly curved green pod which turns yellow upon ripening. It is 10 – 20 cm long, sweet to taste and contains 10 – 20 hard oval or elliptic seeds (2.5 – 7.0 mm long) that are difficult to extract (BioNET-EAFRINET, 2020). Prosopis trees were shaken and the fallen dry ripened brownish-yellow mature pods collected from the ground. A taxonomist from Botany Department, Egerton

University, identified and authenticated the plant, where voucher specimen (number PJ-EU/012018) was deposited. The selection of the pods was done to separate whole pods which were used in the experiment. Use of whole pods was done to prevent infection with aflatoxin (Choge *et al.,* 2007). They were put in gunny bags and transported to Egerton University for grinding and fermentation. Pods were dried in the sun until a constant weight was achieved. First grinding of whole pods was done without passing through a sieve. The procedure by Choge *et al.* (2006) was used in the second grinding; the flour was passed through a 5 mm sieve. The ground pods were kept in airtight containers to prevent moisture entry.

Amino acid analysis of UGMPP, FGMPP and maize was conducted at Nanjing Agricultural University, at the laboratories of National Centre for International Research on Animal Gut Nutrition, 210095, Peoples Republic of China, China in November 2018. Proximate analysis, anti-nutrients and feeding experiment were done at the rabbit unit, Tatton Agricultural Park (TAP), Egerton University.

Study Site: The study was conducted in the rabbit unit, Tatton Agricultural Park (TAP), Egerton University. Precipitation is experienced in the months of March to May and June to September ranging between 900 – 1,020 mm per annum. Egerton is within latitude 0º 23'S and longitude 35º 57'E. It is 2,238 m above sea level. It has temperature of 21 ± 4.4^{o}C. There is a bimodal rainfall pattern (Egerton University Meteorological Station, 2019).

Fermentation of *P. juliflora* pods: The ground pods were subjected to solid-state fermentation in airtight containers. Five (5) kg of ground *P. juliflora* floor was mixed with distilled water (1:1 W/V) according to a modified procedure described by Sarasvati *et al.* (2014). The substrate was then left to undergo anaerobic fermentation for 72 hours. The fermented substrate was then solar dried between 9.00 and 15.00 hours daily until a constant weight was achieved. The solar drier used was fabricated locally at Agricultural Technology Development Centre (ATDC) Nakuru, Kenya.

Proximate Analysis: Proximate composition analysis of dried samples of FGMPP, UGMPP and feed ingredients was done using the standard procedures of AOAC (1990). Crude protein (CP) was determined by Kjedhal's method. The CP values were gotten by multiplying the assayed N values by 6.25. Ether Extract content was determined following the Soxhlet extraction procedure. Nitrogen free extract (NFE) was calculated by subtracting 100 from the sum of % crude ether extract (EE), % crude protein (CP), % ash and % crude fibre (CF).

Amino Acid (AA) Analysis of the Feed Ingredients: FGMPP and UGMPP samples were precipitated at pH 4.5 and then hydrolyzed by constant boiling in a mixture of 1 ml HCl at 110 °C for 24 hours. The phenylthiocarbamyl derivatives gotten from the amino acids were separated by reversed-phase HPLC using a dual pump system and a Bondpak C-18 reversed-phase column and detected using a spectral UV detector. Amino acids were detected by use of a standard mixture of phenylthiocarbamyl derivatives (Marangoni and Alli, 1988).

Anti-Nutrients Determination: FGMPP and FGMPP samples were analyzed for phytic acid, total tannins and aflatoxins. The phytic acid determination was done according to the procedure of Raboy *et al*. (2000). Total tannin determination was done according to the procedure of Abdulrazak and Fujihara (1999) and aflatoxin determination was carried out according to the Vicam AflaTest® procedure for corn, grains and feeds (VST, 2000). *P. juliflora* pods exhibited LD_{50} greater than 5000 mg/Kg and can be used by animals and humans with a degree of safety and tolerance (Kimani *et al*., 2014; Wamburu *et al*., 2015).

Experimental Animals and Management: The study was conducted at Tatton Agriculture Park, Egerton University. The unit observes measures for maintenance of biosecurity and prevention of disease transmission by preventing unnecessary entry to the unit and

provision of a foot bath with Kerol® if individuals must enter the unit. Ethical approval to use live animals for experiment was obtained from the Institute of Primate Research, Kenya and was in compliance with the international code of animal ethics in research (Schnaider and Souza, 2003). Continuous clinical observation of the rabbits was done to ensure that the animals were free from any stress and disease. Regular observation of the rabbits was done by staff from the Faculty of Veterinary Medicine, Egerton University.

Twenty (20) New Zealand primiparous rabbits full or half-siblings were housed in individual cages (75 x 55 x 40 cm^3) and reared on formulated standard breeder diet (Deblas and Mateo, 2010) for one week. During this period, the rabbits were dewormed with ascarex and dusted with Sevin dust for control of internal and external parasites respectively. Before introducing the rabbits to the experimental cages, watering and feeding troughs were thoroughly cleaned, disinfected with kupacide® and dusted with Sevin against external parasites. Feed and water were supplied *ad-libitum* using manual feeders and drinkers throughout the experimental period. After one week, the rabbits were mated around the same time, with a mating interval of 2 ± 1 day. The pregnancy test was done (by palpation of the lower abdomen for presence of the fetuses) on the 14th and confirmed on the 21st day post-service after which kindling nests were provided on the 24th day post service. On kindling, 15 rabbits with similar body weights were selected. Their litter sizes were adjusted to six kits on the day of kindling by cross-fostering. The 15 experimental does plus their six kits were randomly assigned to experimental cages (75 x 55 x 40 cm^3) individually and reared on standard breeder diet (Deblas and Mateo, 2010) for 2 days. The dietary treatments were then randomly assigned to the cages such that there were 3 lactating does per treatment.

Experimental Design and Dietary Formulations: Each cage had one doe plus 6 kits representing one experimental unit. The diets were randomly allocated to 15 experimental units (cages). The five dietary treatments were then randomly allocated to the experimental units such that there were 3 lactating doe plus 6 kits in each experimental unit and 3 does plus 18 kits for each treatment (3 does plus kits/ treatment) in a completely randomized design (CRD).

The dietary treatments offered to the rabbits were; control/standard diet, 15 % FGMPP inclusion, 15 % UGMPP inclusion, 30 % FGMPP inclusion and 30 % UGMPP inclusion (Table 1), formulated to meet the nutrient content of 10.8 MJ/kg feed ME and 18 % CP (Deblas and Mateos, 2010).

Data Collection and Statistical Analysis: The difference between feed offered and feed that was left in each experimental unit at the end of each day was calculated as the daily feed intake (DFI). The average intake from each cage represented one experimental unit. Average live weight gain or loss for each experimental unit was represented by the average cage weight gain or loss. Weights for does were taken independently from the kits. Cage doe weight and average kit weight represented one experimental unit for each measurement taken. Weight measurements were taken weekly throughout the experimental period and the final weight taken at the end of 4 weeks feeding period.

Using SPSS Statistics 25.0.0 software, data from the proximate, amino acid, gross energy (GE), and anti-nutrient content analysis of FGMPP, UGMPP, maize, total feed intake (TFI) and weekly weights (WWts) were subjected to normality and homogeneity of variance tests. The data from amino acid analysis of FGMPP, UGMPP and maize and TFI, WWts were then subjected to one-way analysis of variance (ANOVA) using the general linear model (GLM) of Statistical Analysis Systems (SAS, 9.1.3) computer package. The data from the proximate analysis, anti-nutrients and GE of UGMPP and FGMPP were subjected to paired t-tests using SPSS Statistics 25.0.0 software. Where significant differences were observed in the initial body weights, they were used as covariates. Tukey's range test was used to determine differences among treatment means at probability values of ($p<0.05$).

Table 1: Composition of unfermented and fermented *Prosopis juliflora* pods based experimental diets fed to lactating rabbits

Ingredient	Treatments				
	30 % UGMPP	15 % UGMPP	30 % FGMPP	15 % FGMPP	Control
Maize	5	20	5	20	35
Wheat bran	10	9.5	10	10	10.0
Maize germ	25	24	24	25	22.0
Rice husks	10	10.5	10.2	9.3	11.5
UGMPP	30	15	-	-	-
FGMPP	-	-	30	15	-
SFC	18.0	18.0	17.8	17.7	18.5
Bone meal	2.0	2.0	2.0	2.0	2.0
Iodized salt	0.5	0.5	0.5	0.5	0.5
Vitamin premix *	0.5	0.5	0.5	0.5	0.5
Totals	100	100	100	100	100
Calculated CP (%)	17	18.2	18.2	18.4	18.4
Calculated ME	10.9	10.8	10.8	10.7	10.7
Calculated CF (%)	15	15.3	15.3	15.4	15.3

*UGMPP = unfermented ground mature pods of Prosopis juliflora; FGMPP = fermented ground mature pods of Prosopis juliflora; SFC = Sunflower cake; CF = Crude Fibre; CP = Crude protein, ME = Metabolizable Energy mega joules/kg; * To provide per Kg diet: vitamin A(10,000 i. u; vitamin E (5 i.u.), vitamin K (2.5 mg),), vitamin D (20,000 i. u), choline (350 mg), folic acid (1 mg), manganese (56 mg), iron (20 mg), copper (10 mg), zinc (50 mg), cobalt (1.25 mg), iodine (1 mg)*

RESULTS

Fermentation of UGMPP resulted in significant enrichment ($p<0.05$) of limiting amino acid in rabbit nutrition; arginine from 4.95 ± 0.03 to 6.95 ± 0.03 mg/gDM and lysine from 3.65 ± 0.03 to 4.84 ± 0.03 mg/g DM. Arginine and lysine content of UGMPP and FGMPP were significantly higher ($p<0.05$) than for maize. TEAAs for FGMPP 30 mg/g DM and maize 29.2 mg/g DM were similar ($p>0.05$) (Table 2). Also, there was improvement ($p<0.05$) of GE MJ/Kg sample from 14.05 ± 0.06 to 15.56 ± 0.06; % CP from 14.79 ± 0.12 to 16.8 ± 0.12 and % ash from 4.94 ± 0.02 to 5.03 ± 0.02. Tannin content mg/gDM and % CF reduced ($p<0.05$) from 74.6 ± 0.23 to 22.4 ± 0.23 and from 22.67 ± 0.12 to 21.8 ± 0.12 on fermentation respectively.

The final weight of kits and the final weight of does were similar ($p>0.05$) across all treatments (Table 3). However, does offered diets with 30%FGMPP were heavier at the end of the 4 weeks lactation period compared to their weights at parturition (Figure 1).

DISCUSSIONS

Fermentation positively affected the proximate fractions and amino acid profile of ground mature pods of *P. juliflora*. Improvement in CP content was in line with results reported by Yusuf *et al.* (2008), Aremu *et al.* (2015), Sarasvati *et al.* (2014) and Thi Huyen *et al.* (2019) for spontaneous and microbial fermentations. Several researchers have reported high enzyme activity in fermenting substrates. For instance, Bairagi *et al.* (2004) reported production of α amylase and cellulases in fermenting substrates of *Leucena* inoculated with intestinal contents of fish. Also, various enzymes were produced during spontaneous fermentation of *Prosopis africana* seeds. For example, α amylase was produced by *Bacillus* species (Achi, 1992; Souza, 2010), xylaneses were produced by *Saccharomyces cerevisiae* (Haltrich *et al.,* 1996), and pectinases were produced by *Bacillus subtilis* (Ahlawat *et al.,* 2009). These microorganisms and the microbial enzymes are proteins (Haltrich *et al.,* 1996) which are composed of amino acids as the building blocks. In the current study, these microorganisms and enzymes could be responsible for the higher CP and amino acid values in fermented substrates (Igwe *et al.,* 2012).

Table 2: Essential amino acid profile, proximate composition, anti-nutrients and gross energy values of maize, UGMPP and FGMPP in mg/g DM

Parameter	Maize	UGMPP	FGMPP
Essential Amino Acids			
Arginine*	3.94 ± 0.03[a]	4.95 ± 0.03[b]	6.94 ± 0.03[c]
Lysine*	2.98 ± 0.03[a]	3.65 ± 0.03[b]	4.84 ± 0.03[c]
Methionine*	4.56 ± 0.11[a]	4.57 ± 0.11[a]	4.1 ± 0.11[a]
Leucine	2.83 ± 0.02[b]	0.36 ± 0.02[a]	0.3 ± 0.02[a]
Phenylanine	2.11 ± 0.04[c]	1.38 ± 0.04[a]	1.89 ± 0.04[b]
Tyrosine	6.87 ± 0.01[b]	5.84 ± 0.01[a]	7.31 ± 0.01[c]
Threonine	3.38 ± 0.01[b]	0.01 ± 0.01[a]	0.01 ± 0.01[a]
Tryptophan	4.27 ± 0.01[b]	0.05 ± 0.01[a]	4.42 ± 0.01[c]
Valine	4.27 ± 0.15[a]	4.44 ± 0.15[a]	5.12 ± 0.15[b]
Histidine	1.66 ± 0.05[b]	1.2 ± 0.05[a]	1.57 ± 0.05[b]
TAAs	57.6 ± 0.4[c]	47.6 ± 0.4[a]	54 ± 0.4[b]
TEAAs	30 ± 0.41[b]	20.7 ± 0.41[a]	29.2 ± 0.41[b]
Proximate Composition			
DM	87.27 ± 0.09[$]	90.04 ± 0.06[a]	92.3 ± 0.06[b]
CP	6.29 ± 0.17[$]	14.79 ± 0.12[a]	16.8 ± 0.12[b]
CF	0.76 ± 0.1[$]	22.67 ± 0.12[b]	21.8 ± 0.12[a]
Ash	0.55 ± 0.05[$]	4.94 ± 0.02[a]	5.03 ± 0.02[b]
EE	1.92 ± 0.27[$]	4.35 ± 0.02[b]	4.26 ± 0.01[a]
GE	16.91[#]	14.05 ± 0.06[a]	15.56 ± 0.32[b]
Anti-nutrients Composition			
Tannins (mg/g)	0.0012[@]	74.6 ± 0.23[b]	22.4 ± 0.16[a]
Phytic acid (ppb)	0.012[@]	48.4 ± 0.12[a]	48 ± 0.12[a]
Aflatoxin (ppb)	0.66[@]	6.7 ± 0.05[a]	6.6 ± 0.23[a]

*[a, b, c] different superscript within same raw indicates significant difference at p<0.05; * = Limiting amino acid in rabbit nutrition; TAAs = Total amino acids; TEAAs = Total essential amino acids; UGMPP = Unfermented ground mature pods of Prosopis juliflora; FGMPP = Fermented ground mature Prosopis juliflora pods; GE = Gross energy in Mega joules/Kg sample; [$] = Kamotho et al., (2017); [#] = Asiedu et al., 1993; [@] = Maseta et al. (2016)*

Table 3: Mean values for feed intake and weight changes of kits and does offered breeder diets with FGMPP and UGMPP

Parameters	Treatments				
	30 % UGMPP	15 % UGMPP	30 % FGMPP	15 % FGMPP	Control
Kits weights					
Initial weight(Kg)	0.62 ± 0.03	0.62 ± 0.03	0.59 ± 0.03	0.6 ± 0.03	0.62 ± 0.03
Final weight(Kg)	2.02 ± 0.17	1.79 ± 0.17	2.23 ± 0.17	2.1 ± 0.17	1.85 ± 0.17
Weight gain(Kg)	1.4 ± 0.16	1.3 ± 0.16	1.7 ± 0.16	1.46 ± 0.16	1.23 ± 0.16
Does					
Initial weight(Kg)	3.09 ± 0.24	2.88 ± 0.24	2.83 ± 0.24	3.14 ± 0.24	3.28 ± 0.24
Final weight(Kg)	2.98 ± 0.05	2.83 ± 0.05	2.98 ± 0.05	2.88 ± 0.05	2.9 ± 0.05
Cage TFI (Kg)	7.1 ± 0.47	6.43 ± 0.47	7.19 ± 0.47	7.0 ± 0.47	7.0 ± 0.47

UGMPP = Unfermented ground mature pods of Prosopis juliflora; FGMPP = Fermented ground mature Prosopis juliflora pods; TFI = Total feed intake; means values on arrow were similar (p>0.05)

The observed reduction in CF content of ground mature *P. juliflora* pods on fermentation could be due to activity of cellulolytic enzymes that break down cellulose, produced during fermentation. During spontaneous fermentation, pectinases are produced by *B. subtilis* (Ahlawat *et al.,* 2009); xylaneses are produced by *S. cerevisiae* (Haltrich *et al.,* 1996) which act together with cellulases in a synergy relationship exhibiting an additive effect on cellulose breakdown (Hu *et al.,* 2011).

Out of the anti-nutrients investigated, tannins recorded significant reduction on fermentation. Aflatoxins concentration for both UGMPP and FGMPP were below 20 parts per billion (ppb) recommendations by Allen (2003) for rabbit's feeds. However, aflatoxin content of UGMPP was higher than values (5.8 ppb) reported by Choge *et al.* (2007).

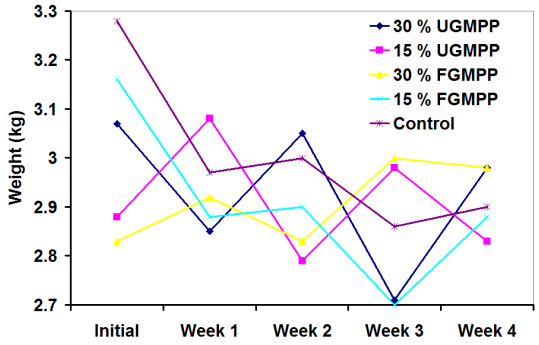

Figure 1: Effect of unfermented and fermented *Prosopis juliflora* pods based experimental diets on weekly doe weights

This difference could be due to differences in harvesting and storage conditions (Assi, 2019). Odero-Waitituh *et al.* (2016) reported that the hygroscopic nature of ground mature *P. juliflora* pods predisposed them to moisture attraction and aflatoxin infestation. Reduction in total tannin content is in agreement with results from studies by Sarasvati *et al.* (2014) when investigating the effects of microbial fermentation on the nutritional quality of *P. juliflora* pods as alternative fish feed. Fermentation of mature pods of *P. juliflora* exhibited total tannin reduction by 69.96 %. The tannin content for 30% UGMPP diets was 2.21 % and for FGMPP diets was 0.68%. These tannin levels were below the dietary inclusion of 2.3 % that did not affect growth, haematological and carcass characteristics in rabbits (Adamu *et al.,* 2010). This was in line with studies by Olagunju *et al.* (2018) where there were reports of 75 % tannin reduction when tamarind seeds (*Tamarindus indica L.*) were naturally fermented. Phytic acid content in the diets were 0.048 g/100 g for 30 % UGMPP and 0.042 g/100g for 30 % FGMPP inclusions. In earlier studies, rabbits fed up to 0.74g/100g exhibited normal growth, an indication that the level was well tolerated. Therefore, the phytic content was below levels considered toxic (Marounek *et al.,* 2003). Also, Kuo *et al.* (2006) reported that β-glucosidase enzymes from *Lactobacillus plantarum* and *B. subtilis* do break the glucoside bonds between the sugars and the phytochemicals and inactivate plant toxins. In this study, it is probable that β-glucosidase enzymes were produced in the fermenting substrates and were responsible for the breakdown of the bonds and therefore a reduction in tannin content of the fermented substrates.

Equalization of litter sizes could have resulted in similar ($p>0.05$) weight gains and final weights in kits across all the treatments. Earlier report by Ajayi *et al.* (2018) indicated that litter size affected kits growth rate with smaller litter sizes growing faster than larger litters. Maertens *et al.* (2006) reviewed quantity, quality and non-dietary factors affecting rabbit milk production and reported that this anomaly can be corrected by the practice of equalizing litter size at parturition in commercial rabbit strains. The does having the capability to express their maximal yield aptitude would, therefore, have similar weight gains in kits. Xiccato *et al.* (2004) investigated the effect of parity order and litter weaning age on the performance and body energy balance of rabbit does, reported that early weaning in does permit reduction in body energy deficit indicating that kits nutrient requirements are met either from does feed intake or from doe mobilizing its body reserves for milk production. According to Maertens *et al.* (2006), kits energy requirement during the first three weeks when lactation is highest; does, therefore, have to produce high-quality milk in terms of energy content to sustain the fast kit growth. Otherwise, the doe mobilizes its body reserves to produce milk for the kits (Xiccato *et al.,* 1999). Similar weight gain of kits across all treatments in the current study was therefore an indication of comparable milk quality and production by the lactating does.

Does' offered diets with 30 % FGMPP were heavier at the end of four week lactation period compared to the time of parturition. This was an indication of positive weight change and therefore positive energy balance. This was contrary to the expectation that all does from all the experimental units could have exhibited a negative energy balance. 30 % FGMPP inclusion in the diets possibly provided enough energy for lactation preventing mobilization of body reserves for milk production (Fortun-Lamothe and Lebas 1996). Fortun-Lamothe (2006) reported that lactation management in does is

very costly in terms of energy and the doe's energy requirement is highest during lactation. Also, Partridge *et al.* (1983) in an experiment to investigate energy and protein metabolism in lactating does reported that higher energy diets resulted in heavier does at the end of the lactation period. According to Partridge *et al.* (1983), the energy requirements for lactation, especially during peak lactation, are higher than can be realized with normal energy provisions in commercial diets. They recommended that high starch and energy diets in lactating does increased lipid reserves and protected the does from weight loss (Fortun-Lamothe and Lebas 1996). Nutrient enrichment and therefore higher energy values during fermentation could have caused an increment in total energy intake and resulted in the lactating does producing without mobilizing the body reserves and exhibiting positive energy balance. It is also probable that due to reduction in anti-nutrients, the energy in 30 % FGMPP diets could have been efficiently used by the does than the other treatments offered. This dietary inclusion was able to prevent depletion of body energy reserves in the does and at the same time meet energy demands of lactation and therefore positive energy balance. However, the weight loss exhibited by the does in all other treatments except 30 % FGMPP inclusion was an indication of mobilization of body reserves for milk production at the expense of their body weight, therefore, weight loss (Xiccato *et al.,* 1999).

Conclusions: Kit's weight gains were similar across all treatments. Doe weight changes during the four week lactation period were similar across all treatments. However, does' offered 30 % FGMPP exhibited a positive energy balance. Also, there was an improvement in nutritional value and GE and reduction of tannin levels of the pods on fermentation. It is recommended that up to 30 % maize in breeder does' diets can be replaced by FGMPP. Due to the availability of mature *Prosopis* pods in ASALs areas and no competition with man, the pods' use will ensure a constant supply of commercial feeds for rabbits, in quality and quantity. This will mitigate occurrences of negative energy balance experienced during post-partum lactation periods, improve kits growth and improve subsequent reproductive and productive efficiencies at the same time reducing doe deaths and culling incidences.

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