



Growth and Reproductive Performance of Rabbit Does Fed Replacement Levels of Fermented *Jatropha* (*Jatropha curcas*) seed meal

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Abstract

*This study was designed to evaluate the growth and reproductive performance of rabbit does fed fermented *Jatropha* seed meal (FJSM) as a replacement for soya bean meal at 0, 25, 50, 75 and 100%. A total of 30, twelve weeks old crossbred rabbits (American chinchilla × New Zealand white) were used for the experiment. The rabbits were randomly assigned to five dietary treatments. Each treatment was replicated thrice with two rabbits per replicate in a completely randomised design (CRD) and each dietary treatment had a buck for mating. The results from the study showed that growth performance was significantly ($P < 0.05$) affected by the replacement levels of FJSM. Final body weights and total weight gain decreased progressively as the level of FJSM increased in the diets. Rabbits fed T1 (0% FJSM) diet recorded significantly higher ($P < 0.05$) final and total body weights (2555.58 g and 1330.58 g, respectively). Feed conversion ratio also differed significantly ($P < 0.05$) across dietary treatments. Rabbits fed T1 (0% FJSM) recorded superior feed conversion ratio followed by T2 (25% FJSM) and the inferior values were recorded in T3 (50% FJSM), T4 (75% FJSM) and T5 (100% FJSM). The reproductive performance of does fed replacement levels of *Jatropha* seed meal was highly significant ($P < 0.001$). Average litter size at kindling and average weight of kits at weaning were influenced. The average kit weight at kindling for does fed T1 diet (72.14 g) was significantly higher than those fed T2 (60.12 g). Does on T3, T4 and T5 diets had stillbirths of between 3 and 4 kits. Average weight of kits at weaning were within the range of 500.11 g and 540.75 g for T2 and T1, respectively. It was therefore, concluded that fermented *Jatropha* seed meal can be incorporated in the diet of does up to 25% without adverse effect on their growth and reproductive performance.*

Keywords: Fermentation, Growth, *Jatropha*, Rabbits, Reproductive Performance

Introduction

Rabbit production has been proven as an alternative source of animal protein for man due to the short fall in production of animal protein from other conventional sources such as poultry, cattle, sheep and goats (Ghosh *et al.* 2008; Yakubu and Wafar, 2014). They are animals of small sizes, short generation interval, highly prolific, rapid growth rate, and genetic diversity (Bassuny *et al.*, 2005). The profitability of rabbit production as an enterprise depends on the number of rabbits kindled per doe per year and the postnatal survival of the kids.

Nutrition is one of the factors that could limit the productivity of rabbits (Odeyinka *et al.*, 2008). The use of concentrates in rabbit rabbits' diet is vital, but high cost of feed and feedstuff are the impeding factor owing to the competition between man and livestock for conventional sources (Agunbiade *et al.*, 2002). Considering the cost implication in feeding rabbits, recently, animal nutritionist and physiologist have been focusing on alternative feedstuffs that will provide adequate nutrition promote growth and reproduction (Owen *et al.*, 2010; Wafar and Tarimbuka, 2016). One of the

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non-conventional feedstuffs focused in this study is *Jatropha curcas* seed.

Jatrophas are oil plants belonging to the *Euphorbiaceae* family. The seed has been reported to contain 16-18% crude protein and 34-37% oil (Makkar *et al.*, 2009). *Jatropha* oil is composed mainly of unsaturated fatty acids, notably oleic acid (35-41% of the fatty acids) and linoleic acid (35-43% of the fatty acid) (Makkar *et al.*, 2011). *Jatropha* seed meal also contains anti-nutritional factors; such as lectin, trypsin inhibitor, saponin, phytate, and phorbolsters (Makkar *et al.*, 1998 and Antevy *et al.*, 2017). Phorbolsters considered as the most toxic anti-nutritional factor. The use of *Jatropha* in animal nutrition is however limited due to these anti-nutrients (Makkar and Becker, 1999). A study conducted by Antevy *et al.* (2017) to evaluate the performance of broiler chickens fed differently processed *Jatropha curcas* seed meal showed that broiler chickens fed fermented *Jatropha curcas* seed meal recorded higher feed intake, final body weight gain and superior feed conversion ratio.

Fermentation is one of the oldest forms of feed processing and preservation Ross *et al.* 2002), and also has the capacity to improve nutritional and functional properties of the feed stuff (Frias *et al.* 2008). Fermentation has been widely used to increase the bioavailability of nutrients (Hotz and Gibson, 2007), improve the digestibility, flavour and reduce the levels of anti-nutrients in tropical seed meals (Egounlety and Aworh, 2003). Several studies conducted by Kishida *et al.* (2000), Frias *et al.* (2008) and Song *et al.* (2008) have also confirmed the ability of fermentation process in degrading anti-nutritive and allergenic compounds of some selected seed meals thereby increasing the possibilities of its utilization. However, there is paucity of information on the use of fermented *Jatropha* seed meal on the growth

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and reproductive parameter of rabbit does. This study therefore evaluated the effects of fermented *Jatropha* seed meal on growth and reproductive performance of rabbit does.

Materials and methods

Study Area

This study was conducted at the Rabbitry Unit of the Department of Animal Science and Range Management, Modibbo Adama University of Technology, Yola. Yola is **between** latitude 7° 11' North and Longitude 11° 14' East and at an elevation of 364m above sea level in the north eastern part of Nigeria. The mean relative humidity ranges from 30 - 50% with a minimum in February to March when it drops to as low as 10% and a maximum of about 90% in August. The maximum temperature can reach 38°C particularly in April, while minimum temperature can be as low as 18°C (Adebayo, 1999).

Collection and Processing of *Jatropha curcas* Seeds

Jatropha curcas fruits were purchased from Yola market. The fruits were cracked mechanically to remove the seeds and processed according to modified method of Wafar *et al.* (2019). Five kg of the seeds was packaged in a jute bag and placed in a pot containing 20 litres of water then cooked for 45 minutes. The use of jute bag is to control leaching and possibility of hydrolysis of some nitrate. The pot was placed on a tripod stand having firewood as a source of heat. The cooked seeds were packed in a polythene bag to allow natural fermentation to take place. The fermentation process lasted for 120 hours (5 days). The fermented *Jatropha* seeds were sundried and milled using hammer milling machine to produce fermented *Jatropha* seed meal (FJSM).

Experimental Animals, Management, Design and Diets

Thirty (30) doe rabbits (American chinchilla × New Zealand white) were sourced within the study area. The rabbits were assigned to five dietary treatments. Each treatment was replicated three times with two rabbits per replicate in a completely randomised design (CRD) while each dietary treatment has a buck for mating. Each rabbit was housed in a cage measuring 150cm x100cm x120cm fitted with

aluminium feeder and drinker to prevent spillage and feed wastage. The experimental animals were given prophylactic treatment against endo and ecto-parasites using 0.3ml/kg Ivomec®. Five diets were compounded using fermented *Jatropha* seed meal (FJSM) to replace soya bean meal at 0, 25, 50, 75 and 100% designated as treatment 1, 2, 3, 4 and 5 respectively as shown in Table 1. The experiment lasted for 12 weeks.

Table 1. Ingredients and Percentage Composition of the Experimental Diets

Ingredients	Replacement levels of fermented <i>Jatropha</i> seed meal				
	T1 (0 %)	T2 (25%)	T3 (50 %)	T4 (75%)	T5 (100 %)
Maize	52.00	52.00	52.00	52.00	52.00
SBM*	18.00	13.50	9.00	4.50	0.00
FJSM**	0.00	4.50	9.00	13.50	18.00
Groundnut haulms	10.00	10.00	10.00	10.00	10.00
Maize offal	13.00	13.00	13.00	13.00	13.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Premix*	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated analysis					
Crude protein	16.83	16.64	16.73	16.65	16.70
Crude fibre	8.84	8.76	8.70	8.63	8.69
Ca	1.23	1.22	1.20	1.23	1.24
P	0.90	0.90	0.91	0.89	0.83
Lysine	0.91	1.89	0.88	0.97	0.89
Methionine	0.58	0.63	0.61	0.59	0.60
***ME Kcal/kg	2978.14	2998.13	2990.14	2992.88	2991.34

*Vitamin-mineral premix provided the following per kg of feed: Vit. A 1500 IU; Vit.D₃ 3000 IU; Vit.E 30 IU; Vit.K 2.5mg; Thiamine B₁ 3mg; Riboflavin B₂ 6 mg; Pyroxidine B₆ 4 mg; Niacin 40 mg; Vit. B₁₂ 0.0 mg; Pantothenic acid 10 mg; Folic acid 1mg; Biotin 0.08 mg; Chloride 0.125mg; Mn 0.0956 g; Antioxidant 0.125 g; Fe 0.024 g; Cu 0.006 g; Se 0.24 g; Co 0.24.

SBM *= Soya bean meal, FJSM** = Fermented *Jatropha* seed meal, ME***= Metabolizable energy

**Data Collection
Growth performance**

During the experiment, data on feed intake, final body weight, body weight gain, feed conversion ratio and mortality were recorded

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Feed intake

Daily feed intake was determined by subtracting the refusals from the amount of feed offered per animal per day.

Weight gain

Animals were weighed at the beginning of the experiment (initial weight) and subsequently once per week using a sensitive electronic weighing balance.

Feed conversion ratio (FCR)

This was calculated from the records of feed intake and weight gain by dividing the feed intake of the rabbits by the weight gain.

Doe Reproductive Measurement

Rabbit buck from each dietary treatment was used to service the does using natural mating. After successful mating, the following parameters were evaluated:

Gestation length (in days) = from the day of mating to kindle

Litter size at birth (g) = number of kits at birth

Litter size at weaning = number of kits at weaning;

Litter weight at birth (g);

Litter weight at weaning (g) and

No of stillbirth

Chemical Analysis

Proximate composition of the experimental diets and anti-nutritional composition of raw and fermented *Jatropha* seed meal were determined (dry matter (DM), crude protein (CP), crude fibre (CF), ether extracts (EE) and Ash content) as described by AOAC (2010). The extraction of phorbol ester was carried out using modified method of Makkar *et al.* (1997).

Statistical Analysis.

All data obtained were subjected to analysis of variance (ANOVA) using JMP SAS (2013)

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software where significant differences exist, Duncan's Multiple Range Test (DMRT) option of same software were used to separate means.

Results and Discussion

Proximate and antinutritional composition of raw and fermented *Jatropha* Seed meal.

The proximate and antinutritional compositions of the raw and fermented *jatropha* seed meal are presented in Table 3. The results showed higher values of crude Protein (CP) 43.67%, ash (9.13%) and lower values of crude fibre (2.41%), ether extracts (20.18%), nitrogen free extracts (NFE) (14.52%) and metabolizable energy (3765.83Kcal/kg) on the fermented *Jatropha* seed meal than the raw seed. The crude fibre (CF) and ether extracts (EE) values of raw seed were 4.06% and 32.13%, while the fermented seed recorded 20.18% EE and 2.41% CF respectively. Nitrogen free extract for raw and fermented *jatropha* meal were 48.61 and 48.14% respectively. The higher crude protein (CP) content observed in fermented *Jatropha* seed meal could possibly be due to the modification effect of the fermentation process that leads to crude protein improvement. The CP values of both raw and fermented *Jatropha* seed meal were within the range of 35-50% crude protein reported by Aslani *et al.* (2007). In comparison, soya bean meal contains lower CP than *Jatropha* seed meal. The ash content of the fermented *Jatropha* seed meal in this study is higher than that of soya bean meal (6.4%). This indicates that fermented *Jatropha* seed meal may be comparable to soybean meal in its usefulness in rabbit diets (Makkar *et al.*, 1998). The crude fibre (CF) content of the raw and fermented *Jatropha* seed meal is lower than 9.10% reported by Sumaiti *et al.* (2012). The variation in the crude fibre composition when compared to other studies could be attributed to the differences in agronomic practices,

laboratory analysis and edaphic factors (Taiwo *et al.*, 2005).

The result of the anti-nutritional factors (ANFs) composition (Table 3) shows that raw *Jatropha* seed contained 3.32mg/100g phorbolster, 20.45mg/100g trypsin inhibitors, 191.56mg/100g saponnin, 278.67mg/100g tannin, 94.67mg/100g oxalates and 234.56mg/100g phytates, while the fermented *Jatropha* seed recorded 2.11mg/100g phorbolster, 8.67mg/100g trypsin inhibitors, 78.96mg/100g saponnin, 87.89mg/100g tannins 56.45mg/100g oxalates and 58.11mg/100g phytates. It results showed decrease in antinutrients as a result of

fermentation. Presences of anti-nutrients in the raw *jatropha* seed meal confirm the earlier report of Makkar and Becker, (1999) that *jatropha* seed meal contained high concentration of anti-nutritional factors. The use of fermentation as a method of detoxification however, reduced the concentration of ANFs and increased the nutrient composition of *Jatropha* seed meal, but did not completely remove the ANFs in the seed. The finding is in line with the report of Makkar *et al.* (1998), Wafar (2013) and Yakubu *et al.* (2017) when they subjected tropical legume seeds to different processing methods and recorded partial reduction of ANFs in the seeds

Table 3 Proximate Composition of Raw and Fermented *Jatropha* Seed Meal

Parameter (%)	Raw	Fermented	
Dry matter	91.11	89.91	
Crude Protein	30.11	43.67	
Ether extracts	32.13	20.18	
Crude fibre	4.06	2.41	
Ash	7.13	9.13	
NFE	17.68	14.52	
*Metabolizable Energy	4344.24	3765.83	
<i>Antinutritional factor (mg/100g)</i>			<i>% Reduction</i>
Phorbolsters	3.32	2.11	63.55
Trypsin inhibitors	20.45	8.67	42.39
Saponin	191.56	78.98	41.22
Tannins	278.67	87.89	31.53
Oxalates	94.67	56.45	59.62
Phytates	234.56	58.11	24.77

*Metabolizable Energy = ME (kcal/kg) = 37 x % CP + 81 x % EE + 35.5 x % NFE. Calculated according to the formula of Pausenga, (1985). CP= Crude protein EE = Ether extracts NFE = Nitrogen free extracts

Growth performance of Doe rabbits fed graded levels of fermented *Jatropha* Seed meal

Table 4 shows the growth performance of rabbit does fed fermented *Jatropha* seed meal. The final body weights and total weight gain

decreased progressively as the level of fermented *Jatropha* seed meal increased in the diets. Rabbits fed T1 (0% FJSM) diet recorded significant higher (P<0.05) higher final body weight and total body weights (2555.83 g and 1330.55 g respectively). Among fermented

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Jatropha seed meal-based diets, rabbit fed T2 (25%) recorded significant higher ($P<0.05$) final body weight (2011.10 g) and total body weight (815.76 g) than the other groups on FJSM. Total feed intake varied from 1206.51 g in T5 (100% FJSM) to 4325.70 g in T1 (0% FJSM). It was observed from the study that rabbits fed recorded T3 (50% FJSM), T4 (75% FJSM) and T5 (100% FJSM) diets recorded lower feed intake. This could be attributed to the residual effect of anti-nutritional factors in the fermented Jatropha seed meal which resulted to low palatability of the diets. Ogbu *et al.* (2015) reported that anti-nutritional factors such as tannins and saponins decrease feed intake as a result of its astringent properties. Weaver and Kanna (2002) also reported that phytates reduce the bioavailability of divalent cations due to insoluble complexes formation during digestion and absorption of minerals. This suggests that rabbit does fed diets containing 50, 75 and 100% replacement levels of Jatropha seed meal could not efficiently absorb the dietary nutrients available in the gastro-intestinal tract as a result of high concentration of antinutritional factors.

A study conducted by Esonu *et al.* (2001) reported that high trypsin inhibitors in the diet reduce protein digestibility resulting in poor utilization of available nutrients. Phorbol esters are toxic to livestock even at very low concentrations (Goel *et al.*, 2007). The findings from this study confirmed the result of Abdel-Shafy *et al.* (2011) who reported significant reduction in feed intake and growth rate of more than 30% as a result of residual phorbol esters in jatropha seed meal.

Feed conversion ratio (FCR) also differed significantly ($P<0.05$) across dietary treatments. Rabbits fed T1 (0% FJSM) recorded superior feed conversion ratio followed by T2 (25% FJSM) and the inferior value in T3 (50% FJSM), T4 (75%) and T5 (100% FJSM) fermented Jatropha seed meal. Rabbit fed T3, T4 and T5 diets recorded high percentage mortality and this could be attributed to residual content of phorbol ester. Agboola and Adenuga (2015) reported high percentage of mortality of birds fed 10% level of Jatropha seed meal

Table 4: Growth performance of Doe rabbits fed graded levels of fermented Jatropha Seed meal

Parameter	Replacement levels of fermented Jatropha seed meal					SEM
	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	
Initial body weight (g)	1225.29	1195.34	1140.41	1205.53	1188.40	21.73 ^{ns}
Final body weight (g)	2555.83 ^a	2011.10 ^b	1624.57 ^c	1549.85 ^d	1405.48 ^d	34.34 [*]
Total weight gain (g)	1330.55 ^a	815.76 ^b	484.11 ^c	344.32 ^{cd}	217.07 ^d	30.86 [*]
Total feed intake (g)	4325.70 ^a	3599.10 ^b	2565.70 ^c	1531.00 ^d	1206.51 ^c	47.00 [*]
Feed conversion ratio	3.25 ^b	4.41 ^{ab}	5.30 ^{ab}	4.57 ^{ab}	5.58 ^a	0.38 [*]
Mortality (%)	0	1.00	1.00	2.00	3.00	

Means in the same row bearing different superscripts differ significantly ($P<0.05$), SEM = Standard error mean; ns = Not significant

Reproductive performance of rabbit doe fed replacement levels of fermented Jatropha Seed meal

The reproductive performance of doe rabbits fed replacement levels of Jatropha seed meal is shown in Table 5. There were significant

differences ($P<0.001$) in average litter size at kindling and average weight of kits at weaning. The average kit weight at kindling for does fed T1 (72.14 g) was significantly higher than those fed T2 (60.12 g). Does on T3, T4 and T5 diets had stillbirth between 3 and 4 kits.

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Average weight of kits at weaning are within the range of 500.11 g and 540.75 g for T2 and T1, respectively. The gestation length falls within the range of 28-31days reported by Nguyen *et al.* (2006). It seems the diets did not affect the gestation period when T1 (0%) and T2 (25%) fermented *Jatropha* seed meal (FJSM) was included in the diet, but the rabbits on T3 (50% FJSM), T4 (75% FJSM) and T5 (100% FJSM) had stillbirths at week three. The result from this study confirmed earlier reports of Makkar *et al.* (1998) that high

concentrations of phorbol esters consumption could cause several symptoms such as giddiness, vomiting, diarrhea and even death. In another study conducted by Abdel Gadir *et al.* (2003), it was demonstrated that in Nubian goat kids (three per treatment group) that even 0.25g treated *Jatropha* kernel meal per kg feed resulted in deaths after 11 days. Litter size at kindling were within the range of 2- 8 reported by Iyeghe-Erakpotobor *et al.* (2000) and 3.5 - 5.09 reported by Ozimba and Lukefahr (1991).

Table 5: Reproductive Performance of doe rabbit fed graded levels of fermented *Jatropha curcas* seed meal

Parameters	Replacement levels of fermented <i>Jatropha</i> seed meal					SEM
	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	
Gestation length (days)	31.00	30.00	21.00	21.00	21.00	-
No of stillbirth	0.00 ^b	0.00 ^b	4.00 ^a	3.00 ^a	4.00 ^a	1.26 ^{***}
Average litter size at kindling (g)	4.00 ^a	3.00 ^a	0.00 ^b	0.00 ^b	0.00 ^b	1.31 ^{***}
Average kit weights at kindling (g)	72.14 ^a	60.12 ^b	0.00	0.00	0.00	1.95 ^{***}
Average litter size at weaning (g)	4.00 ^a	3.00 ^a	0.00 ^b	0.00 ^b	0.00 ^b	1.31 ^{***}
Average weight of kit at weaning (g)	540.75 ^a	500.11 ^b	0.00	0.00	0.00	8.07 ^{***}

Means in the same row bearing different superscripts differ significantly (P<0.001) ^{***}, NS= not significant different (P>0.05), SEM = Standard error mean

Conclusion and recommendation

The study showed that the fermented *Jatropha* seed meal at 25% replacement levels can be used in rabbit diets. It was therefore, recommended that 25% fermented *Jatropha* seed meal can be incorporated in doe rabbit diet without adverse effect on the growth and reproductive performance. However, adverse effect was observed on the reproductive performance of doe rabbit fed beyond 25% fermented *Jatropha* seed meal.

References

Adebayo, A.A. (1999). Climate II. In: *Adamawa State in Maps*. Edit; (A. A. Adebayo and A. L. Tukur). Paracleate publishers, Yola, Nigeria Pp 58
 Agboola, A.F. and Adenuga, A.A. (2015) Performance and organ histopathology

of growing Japanese quails (*Coturnix coturnix japonica*) fed heat treated *Jatropha* seed cake substituted for soyabean meal. *Tropical Animal Production Investigation 18: 1-8*

Abdel Gadir W.S, Onsa T.O, Ali W.E.M, El-Badwi S.M.A and Adam S.E.I (2003). Comparative toxicity of *Croton macrostachys*, *Jatropha curcas* and *Piper abyssinica* seeds in Nubian goats. *Small Ruminant Research, 48:61-67*

Abdel-Shafy, S., Nasr, S. M., Abdel-Rahman, H. H. and Habeeb, S. M. (2011) Effect of Various Levels of Dietary *Jatropha curcas* seed Meal on Rabbits Infested by the Adult Ticks of *Hyalomma Marginatum Marginatum*

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- in Animal Performance, Anti-tick feeding and Haemogram. *Tropical Animal Health Production*, 43 (2): 347-357.
- Antyev, M., Yakubu, B., Aliyara, Y.H., and Wafar, R.J. (2017). Effects of Processing Methods of *Jatropha curcas* Seed Meal on Growth Performance and Blood Profile of Broiler Finisher Chickens. *Asian Research Journal of Agriculture*. 4 (4): 1-9
- AOAC (2010). Official Method of Analysis, 14th edition of the Official Analytical Chemist Standard Method Arlingo, U.S.A.
- Aslani, M.R., Maleki, M., Mohri, M., Sharifi, K., Najjar-Nezhad, V. and Afshari, E. (2007) Castor bean (*Ricinus communis*) toxicosis in a sheep flock. *Toxicology* 49: 400-406
- Agunbiade, J.A., Bello, R.A., Adeyemi, O.A. (2002). Performance characteristics of weaner rabbits on cassava peel based balanced diets. *Nigerian Journal of Animal Production* 29:171- 175.
- Bassuny, S.M., Abdel- Aziz., A.A., Abd El-Fattah, H.I., Abdel- Aziz, M.Y.S (2005). Fibrous crop by- product as feed 4. *Egypt Journal of Nutrition and Feeds*, 8:541-554
- Egounlety, M. and Aworh, O. C. (2003). Effect of soaking, dehulling, cooking and fermentation with *Rhizopus oligosporus* on the oligosaccharides, trypsin inhibitor, phytic acid and tannins of soybean (*Glycine max Merr.*), cowpea (*Vigna unguiculata L. Walp*) and ground bean (*Macrotylo mageocarpa Harms*). *Journal of Food Engineering* 56:249-254.
- Esonu B. O., Undedibie A. B. I., Herbert U., Odey J. O. and Odu S. (2011). Comparative Evaluation of Raw and Cooked jack been (*Canavalia insiformis*) on the performance of weaner rabbits. *World Rabbit Science* 4:139 – 141
- Frias, J., Song, Y.S., Martinez- Villaluenga, C., De Mejia, E.G and Vidal-Valverde, C. (2008). Immunoreactivity and amino acid content of fermented soya bean products. *Journal of Agriculture and Food Chemistry*, 56 (1):99 -105
- Ghosh, S.K., Das, A., Bujarbaruah, K.M. Das, A., Dhiman, K.R. and Singh, N.P. (2008). Effect of breed and season on rabbit production under subtropical climate. *World Rabbit Science*. 16: 29-33.
- Goel, G., Makkar, H. P. S., Francis, G., and Becker, K., (2007). Phorbol esters: structure, biological activity, and toxicity in animals. *International Journal Toxicology*, 26 (4): 279-288
- Hotz, C and Gibson, R.S (2007). Traditional food processing and preparation practice to enhance the bio – availability of micronutrient in plant based diets. *Journal of Nutrition*, 134 (40):77 -100
- Iyeghe- Erakpotobor, G.T., Oyedipe, E.O, Eduvie, L.O., Ogwu, D and Olorunju, S.A.S (2000). Effect of flushing on reproductive performance of multiparous rabbits. Proceedings of 25th Annual Conference of Nigerian Society of Animal Production Umudike.332.

- JMP® SAS (2013) Version 10. SAS institute Incorporated, Cary, NC
- Kishida, T., Ataki, H., Takebe, M. and Ebihara, K. (2000). Soybean meal fermented by *Aspergillus awamori* increases the cytochrome p-450 content of the liver microsomes of mice. *Journal of Agriculture and Food Chemistry* 48:1367-1372.
- Makkar, H.P.S., Aderibigbe, A.O. and Becker, K. (1998). Comparative evaluation of non-toxic and toxic varieties of *Jatropha curcas* for chemical composition, digestibility, protein degradability and toxic factors. *Food Chemistry*. 62: 207 – 215.
- Makkar, H.P.S. and Becker, K. (1999). Plant toxins and detoxification methods to improve feed quality of Tropical Seeds Quality of Tropical Seeds. *Asian-Australian Journal Animal Science*. 12 (3):467-480
- Makkar, H.P.S., Maes, J., DeGreyt, W. and Becker, K. (2009). Removal and degradation of Phorbol esters during pre-treatment and transesterification of *Jatropha curcas* oil. *Journal of the American Oil Chemist Society*.86:173 – 181.
- Makkar, H.P.S., Aderibigbe, P.S and Becker, K. (1997). Potential of *Jatropha curcas* seed meal as a Protein supplement to livestock feed, constraints to its utilization and possible strategies to overcome constraints to its utilization. Proceedings of the International Symposium on Biofuels and Industrial Products from *Jatropha curcas* and other. Tropical Oil Seed Plants, Managua, Nicaragua, Mexico, 23-27.
- Makkar, H. P. S., Kumar, V., Oleyele, O. O., Akinleye, A. O., Angulo- Escalante, M and Becker, K. (2011). *Jatropha platyphylla*, a new non-toxic *Jatropha* species, physical properties and chemical constituents including toxic and antinutritional factors of Seeds. *Food Chemistry*. 125 (1); 63-71
- Nguyen T.K.D., Nguyen V.T and Preston T.R. (2006). Effect of dietary protein supply on the reproductive performance of crossbred rabbits. *Workshop-seminar “forages for Pigs and rabbits” MEKARN-CelAgrid, Phnom, Peenh, Cambodia, 22-24.*
- Odeyinka, S.M., Oyedele, O.J., Adeleke, T.O. and Odedire, J.A. (2008). Reproductive performance of rabbits fed *Moringa oleifera* as a replacement for *Centrosema pubescens*. *9th World Rabbit Congress Verona-Italy, June 10-13, pp. 411-416*
- Ogbu N.N., Ogbu C.C. and Okorie A.U. (2015). Growth performance of broiler chickens fed raw and processed pigeon pea (*Cajanus cajan*) Seed Meal. *Journal Animal Science Advances*, 5(7): 1350 1356
- Owen, O. J., Amakiri, A. O. and Ezeano, C. I. (2010). The cost benefit analysis of incorporating bitter leaf (*Vernonia amygdalina*) meal in broiler finisher diet. *Proceeding 35th Annual Conference Nigerian Society for Animal Production (NSAP)*. March 14-17th Ibadan-Nigeria p. 670-674
- Ozimba C.E. and Lukefahr S.D. (1991). Comparison of rabbit breed type of post - weaning litter, growth, feed efficiency and survival performance

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- traits. *Journal of Animal Science* 69: 3494-3500
- Pauzenga, U. (1985). Feeding parent stock. *Zootecnia international* Pp 22- 25
- Ross, P. R., Morgan, S. and Hill, C. (2002). Preservation and fermentation: past, present and future. *International Journal of Food Microbiology*.79:3-16.
- Song, Y. S., Frias J., Martinez-Villaluenga, C., Vidal-Valdeverde, C. and De Mejia, E. G. (2008). Immunoreactivity reduction of soybean meal by fermentation, effect on amino acid composition and antigenicity of commercial soy products. *Food Chemistry*. 108:571-581
- Sumiati, F., Hermana, W., Sudarman, A., Istichomah, N. and Setiyono, A. (2012). Broiler performances fed diet contained *Jatropha curcas* L. meal fermented with *Rhizopus oligosporus*. *Journal Animal Science Technology*, 34 (2): 117-125
- Taiwo, A. A., Adejuyigbe, A.D., adeowale, J.A., Osbotan, J.S and David, O.O (2005). Performance and nutrient digestibility of weaned rabbits fed forages supplemented with concentrates. *Nigerian Journal of Animal Production*, 32(1):74-78
- Yakubu, B and Wafar, R.J (2014). Effects of processing methods of *Leptadenia hastata* on growth performance, nutrient digestibility and carcass characteristics of weaner rabbits. *IOSR Journal of Agriculture and Veterinary Science*. 7 (1) 53-58
- Yakubu, B., Aliyara, Y.H., Antyevev M and Mbahi, T.F (2017). Effects of
- fermented *Jatropha (Jatropha curcas)* seed meal on growth performance, carcass and internal organs evaluation of broiler finisher chickens. *Greener Journal of Animal Breeding and Genetics*, 3(1):001-008
- Wafar, R.J., Tarimbuka, L.I., Sini, T and Adi, Z.A (2019). Evaluation of fermented sorrel (*Hibiscus sabdariffa* l.) seed meal on growth performance and carcass characteristics of weaner rabbits. *FUDMA Journal of Agriculture and Agricultural Technology*, 5(1): 9-17
- Wafar, R.J and Tarimbuka L.I. (2016). Effects of substituting groundnut cake with supported by water spinach (*Ipomoea aquatica*) leaf meal on performance, carcass yield and blood profile of weaner rabbit. *FUW Trends in Science & Technology Journal*, 1(1):238-242.
- Wafar, R.J (2013). Effects of replacing toasted sorrel seed (*Hibiscus Sabdariffa*) meal for soybean meal in broiler finisher diet. *Journal of Animal Production Advances*, 3(8): 247-253
- Weaver, C.M. and Kanna, S. (2002). Phytate and mineral bioavailability In: Reddy, N.R. and Sathe, S.K., editors *Food Phytates*. CRC press, Boca Raton., Florida, USA 211-224

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