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RESEARCH ARTICLE

EVALUATION OF THE NUTRITIONAL VALUE OF FIELD LEGUMES USING THE RABBIT (*ORYCTALOGUS CUNNICULUS)* AS THE ANIMAL FOR BIOASSAY

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ABSTRACT

Rabbit farming (cunniculture) is not yet a popular livestock business enterprise in Kenya due to high feeding and lack of ready market for rabbit products. Cunniculture can be a profitable enterprise, but there is lack of knowledge on rabbits nutrition that is based on locally available forage germplasms. This has led to slow growth and low weight gain of rabbits. This experiment was carried out to determine the nutritional value of locally available field legumes using growing rabbits as the animal for bioassay. Thirty Newzealand White one (1) month old rabbits were randomly placed in rabbit cages in pairs. There were 5 treatments representing the legumes i.e. Lucerne, Desmodium, Vetch and Beans and a control of Rhodes grass hay and each treatment was replicated thrice. Feed and water was given *adlibitum.* From the five treatments, samples were taken in duplicate for proximate analysis to evaluate their nutrient composition. Data on daily feed intake was used to assess the growth rate and feed conversion efficiency. Daily rectal temperature were taken from the 2nd week of experiment. This was done randomly on three rabbits in each treatment for a period of 2 weeks, this was to monitor possible clinical signs of toxicity, especially hypothermia. At the end of the experiment, two rabbits from each treatment were sacrificed and their gastro-intestinal organs weighed and examined for any toxic effects of the legumes. The results demonstrated that beans had the highest CP of 28.98% while Vetch, Desmodium and Lucerne had % CP of 25.90, 21.05, and 20.66 respectively. However Desmodium had the best average daily gain (ADG) of 12.72gm, and feed conversion efficiency of 0.097. Toxicity investigation revealed that Desmodium had the least toxicity score while the beans had the highest. The research design was a CRD and data analysis was done using ANOVA and SPSS, while mean separation was done using Fischers Least Significant difference (LSD), ($P<0.05$). From these results it can be concluded that Desmodium is the best legume as a protein source for growing rabbits.

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1. INTRODUCTION

The global food security is one of the biggest challenges of the 21st century and demographic experts estimate the world needs a food requirement increase of 50-70% to feed an additional 2 billion people by the year 2050. FAO (2014). FAO (2014) latest estimate indicate that global hunger reduction continues and about 795 million people are estimated to be chronically under nourished and malnutrition has fallen from 18.7% to 11.3 Percent globally and from 23.4% to 13.5% for the developing countries. The same FAO reports demonstrate that the hunger target of millennium development goal of halving the proportion of under-nourished people in developing countries by 2015 is within reach.

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The escalating population in most developing countries and the attendant pressure on the meagre natural resources calls for a paradigm shift in livestock nutritional regimes and a shift to semi-intensive or intensive production systems. Katunga (2004). Forage crops to feed rabbits are rarely used in this regions in spite of their states of food insecurity and protein malnutrition. Maass (2012).

2. MATERIALS AND METHODS

2.1 Study site

This study was done in Christian Intermediate Training College (CITC) Kapsabet College situated in Nandi County and in Nandi Central District, Kenya.

2.2 Materials

A rabbit hutch housing 30 rabbits was constructed with good ventilation and divided into five cages to house six rabbits per cage.

2.3 Methodology

500 gms sample from each of the four legumes and from the Rhodes grass control sample were collected after drying at 105C to remove excess moisture and the samples were taken to KALRO Naivasha for proximate analysis to evaluate their nutrient composition in terms of DM, CP, CF, Mineral, NDF, ADF, and ME (Kcal).

The analytical methods for each nutrient was as follows.

Nutrient Method

- Moisture content – oven drying at 105^{o}C
- Crude protein (%CP) – Kjelsahl procedure.
- Ether extract (EE)-Soxhelet extraction.
- Crude fibre (CF) Vansoest fractionation method
- Minerals(ash) Atomic absorption
- (Spectrophotometry) method
- The data set as used to compare their nutritional values.

2.4 Objective (2) Determination growth rate and feed conversion efficiency (FCE)

Each Rabbit in each treatment was weighed weekly and recorded for the period of 1 month. Data set was used to evaluate the growth rate of rabbits in each treatment and to determine the best legume in growth performance. The daily feed intake was known by weighing each feed in each treatment before feeding adlib during the evening and first weighing the left-overs in the next morning before feeding fresh feed again. The difference gave the daily feed intake in grams which was recorded and the data set was used to compute the feed conversion efficiency using the formula:

$$F.C.E = \frac{AV.\ Weight\ gained\ (gm)}{Feed\ intake\ (gm)}$$

2.5 Objective 3 checking for any toxic effect on legume fed to growing rabbits

Daily rectal temperatures were taken randomly from three rabbits from each treatment. At the end of the experiment (1 month) two rabbits from each treatment were sacrificed and their gastro-intestinal organs, liver and kidneys examined for any patho-physiological abnormalities and the organs were weighed and the data set was used to compare with those of the controls.

2.6 Experimental design

The experimental designs are all CRD. This design is appropriate since the treatments are structured and no external variations are expected other than from the treatments.

2.7 Model equation

The model equation is a linear model i.e.
$Yij = \mu + ai + eij$

Where:

1 = Toxicity signs on live rabbit e.g. alopecia, fur licking, etc and post-mortem signs were observed in all the three organs i.e. liver, lungs, kidney.
2 = Toxicity signs on live rabbits observed ante-mortem and at post-mortem only on any two of the three organs e.g. liver and lungs only.
3.= Toxicity signs on live rabbits observed ante-mortem and at post-mortem only on only one of the three organs e.g. kidney only.
4.=Toxicity signs only observed at post-morterm on only one of the organs e.g. lungs only.
5. = No toxicity sign observed ante-morterm and post-morterm.

2.8 Data Analysis

The data was subjected to ANOVA and tested at 5% level of significance ($p<0.05$), Software and mean separation was done using LSD (Least Significant Difference) at 0.05.

3. RESULTS

3.1 Objective 1- Nutritional composition as per proximate analysis

The results of proximate analysis for nutritional composition of the field forage fed to grower ration (% DM Basis) are as shown in Table 4.1.

Table 1. Nutrient composition as per proximate analysis

	Desmodium (T 1)	Lucerne (T 2)	Vetch (T 3)	Bean (T 4)	Rhodes (T 5)	Total
% CP	21.05	20.66	25.90	28.98	6.70	103.24
% DM	88.06	87.62	86.9	86.69	87.53	436.8
% ASH	7.63	10.13	10.8	10.99	8.68	48.23
% EE	1.33	1.51	0.4	2.16	0.84	6.24
% NDF	53.38	38.36	36.85	54.86	80.39	263.84
% MCAL	1.0977	1.196	1.1631	1.1147	0.8654	5.4369
TOTAL	172.4977	159.476	162.0131	184.7947	185.0054	863.7869

The crude protein (%) was as follows; 28.98, 25.90, 21.05, 20.66 and 6.70 i.e. beans, vetch, green lead desmodium, Lucerne and Rhodes grass respectively. The dry matter content (DM) in all the forage was about 88% and ME (MCAL); was almost same for all the treatments. Also Ash (mineral content); Ether Extract (E.E.) & NDF. (Neutral Detergent Fibre) had almost same values.

Table 2. Means average daily feed intake/rabbit in grams (gm)

	T1	T2	T3	T4	T5	SEM
R1	112.47	95.23	92.46	118.16	106.19	
R2	139.34	113.91	111.49	83.39	123.66	
R3	125.60	106.13	100.14	105.27	104.91	
R4	144.81	110.95	169.46	171.91	126.13	
MEAN	130.56a	106.56a	118.39a	119.68a	115.22a	11.032

Table 3. Showing feed conversion efficiency

	DESMODIUM	LUCERNE	VETCH	BEAN	RHODES	SEM
R 1	0.096	0.084	0.083	0.054	0.042	
R 2	0.08	0.074	0.075	0.091	0.045	
R 3	0.104	0.069	0.075	0.063	0.066	
R 4	0.108	0.053	0.045	0.037	0.648	
MEAN	0.097a	0.070a	0.070a	0.061a	0.200a	0.060

Table 4. The weight gain and feed conversion efficiency at 4th Week of study

Feed conversion and weight gain (gm) in the 4th	DESMODIUM (T 1)	LUCERNE (T 2)	VETCH (T 3)	BEAN (T 4)	RHODES (T 5)
W4	15.67	5.96	7.56	6.50	8.18
FCE	0.108	0.053	0.045	0.037	0.648

Table 5. Anova table of daily weight gain of rabbits in (gm) over a period of 4 weeks

	DESMODIUM (T 1)	LUCERNE (T 2)	VETCH (T 3)	BEAN (T 4)	RHODES (T 5)	SEM
R 1	10.81	8	7.7	6.41	4.43	
R 2	11.25	8.5	8.46	7.65	5.65	
R 3	13.13	7.38	7.58	6.68	6.95	
R 4	15.67	5.96	7.56	6.5	8.18	
MEAN	12.72a	7.5b	7.83b	6.81b	6.3b	4.305

Table 6. Average daily rectal temperature on every 4 day basis

	Treatments				
Day	T 1	T 2	T 3	T 4	T 5
0	37.2	36.2	36.4	36.7	36.6
4	36.2	36.3	35.1	35.2	36.8
8	36.5	35.8	34.7	34.7	36.8
12	37.1	36.2	36.4	35.8	37.0
			Temperature (°C)		

Table 7. Organ system weights

	T1	T2	T3	T4	T5	MEAN	STD
GIT	250	191.4	198.4	162.75	268	214.11	±19.48
Liver	94.03	75.03	74.17	59.05	101.03	80.662	±7.53
Kidney	25.05	27.05	17.75	11.1	27.05	21.6	±3.13

Table 8. Toxicity scores on live rabbits, observations/rectal temperatures /organs- systems parameters

Organs	T 1	T 2	T 3	T 4	T 5
Score	4	3	2	1	5

Table 4.2. Objective Ii table I- feed intake-means of daily feed intake / rabbit in grams

TREATMENTS ⟹

REPLICATE ⇩

	DESMODIUM (T 1)	LUCERNE (T 2)	VETCH (T 3)	BEAN (T 4)	RHODES (T 5)
W 1	112.47	95.23	92.46	118.16	106.19
W 2	139.34	113.91	111.49	83.39	123.66
W 3	125.6	106.13	100.14	105.27	104.91
W 4	144.81	110.95	167.46	171.91	126.13
OVERALL MEAN	130.81	106.56	117.89	119.68	115.23

Table 2. The weight gain and feed conversion efficiency at 4th Week of study

Feed conversion and weight gain (gm) in the 4th	Desmodium (T 1)	Lucerne (T 2)	Vetch (T 3)	Bean (T 4)	Rhodes (T 5)
W4	15.67	5.96	7.56	6.50	8.18
FCE	0.108	0.053	0.045	0.037	0.648

Table 4.5 weight gains-means of daily weight gains/rabbit in grams
Objective ii table ii - weight gains-means of daily weight gains/rabbit in grams

TREATMENTS ⟹

REPLICATES ⇩

	DESMODIUM (T1)	LUCERNE (T2)	VETCH (T3)	BEAN (T4)	RHODES (T5)
W1	10.81	8.00	7.70	6.41	4.43
W2	11.25	8.5	8.46	7.65	5.65
W3	13.13	7.38	7.58	6.68	6.95
W4	15.67	5.96	7.56	6.50	8.18
OVERALL MEAN	12.72	7.5	7.83	6.81	6.30

3.2 Objective II Table I- feed intake-means of average daily feed intake / rabbit in grams treatments ⟹

The feed intake was almost similar In all the diets. Table 4.2 indicates an average daily feed intake of 130.81 (gm); 106.56 (gm). 117,89 (gm), 119.68(gm) and 115.23 (gm) for green leaf desmodium intortum, lucerne, common vetch, beans and Rhodes grass respectively.

4. DISCUSSION

Objective 1 – Parameter- Nutrient composition of field forages. Table 4.1 shows the nutritional composition by proximate analysis and the results shows that the bean plant had the highest crude protein (% CP) of 28.98, among the legumes while the Rhodes grass control diet had the least (% CP) of 6.70. The green lead desmodium had (%CP) 21.05 and this compares well with the findings of D.M.M Katunga *et al* (2015), who reported (% CP) of desmodium intortum at 22.2. This findings however contradicts the findings of Baragahorongye *et al*. (2012) who reported a % (CP) of 18.82 in desmodium. Lucerne had a lesser (% CP) of 20.66 compared to desmodium intortum in contrast to the findings of ILRI (2008-2009) who reported a (% CP) of 23.79. In another experiment the % CP In Lucerne of 13-19 % was reported by martens *et al*, (2012) who suggested that such variation could be due to factors such as soil type where Lucerne is known to be sensitive to low soil Ph and also to weather conditions and time of cutting. Generally all the four legumes had a % CP level of average 24% which is over and above the recommended CP minimum level of 13-17 % CP needed for maintenance and production requirement respectively by rabbits. Aduku *et al* (1990). All the diets except Rhodes grass hay had a CP of over 21% suggesting they can replace the supply of CP in commercial rabbits feeds, this is according to Proximate analysis findings by G.T. Lyeghe –Erakpotobor *et al.* (2006). The (% CP) in Rhodes grass was lowest at 6.70 but in agreement with FAO (1990) report stating that the concentration of crude protein in tropical grasses grown and determined in different parts of the world ranged from 2-27 % of the dry matter. The % dry matter was generally the same for all the 5 diets with an average of 87% DM but in contrast with findings of by ILRI (2008-2009) who recorded a % DM of 97.86, 91.86, and 90.58 for beans, Rhodes grass hay and Lucerne respectively. The mineral content (% Ash) in the forages depicted a similar trend ranging from 7.63, 8.68, 10.8, 10.99 and 10.13 for desmodium, Rhodes grass hay, Vetch, bean, and Lucerne respectively. This results contradicts the findings on ILRI (2008-2009) which recorded the Ash levels for Rhodes grass hay, desmodium and Lucerne at 9%, 9%, and 13% respectively. Desmodium and Rhodes had % Ash of 7.63 and 8.68 respectively which is indicated for rabbits diet as per proximate analysis results done by G.T. Lyeghe –Erakpotobor *et al*, (2006).The Ether Extract in bean was highest at 2.16 (% DM) while Vetch had the lowest % EE of 0.4. Desmodium, Lucerne and Rhodes grass hay had almost same levels of % .E.E. All the legumes and Rhodes grass hay had % E.E. which was far below the recommended levels indicated for commercial rabbit meal of 12.61, G.T. Lyeghe –Erakpotobor *et al*, (2006). The NDF was highest in Rhodes grass at mean of 80.39 %, while desmodium, Lucerne, bean and vetch had almost same levels in NDF but contradicts the findings of ILRI

(2008-2009) which reported NDF levels for Rhodes grass hay and Lucerne at 65% and 44% respectively and 54% for bean. The Desmodium NDF % of 53.38 in this experiment contradict the findings of Maas *et al*, (2015), who reported a value of 64.% NDF. It also contradicts the findings of Ontiti S/M. *et al* KARI – NBRC-Lanet (1999) who reported % NDF of 46.97 for desmodium. The Rhodes grass hay according to Ontiti S.M. *et al* , had the % NDF of 68.34 which is in contrast with the findings of this experiment of % NDF 80.39. This could be attributed to the different agro-ecological zones where the crops were planted for this experiment at Kapsabet Nandi County In Zone III and in Lanet Naivasha – Zone IV. The matabolizable energy (MCAL means) was very similar in all the forages ranging from lowest of 0.8654 fro Rhodes grass to 1.196 for Lucerne. This is more or less in agreement with the findings of ILRI (2008-2009) who recorded MCAL of 1.74 For Lucerne hay and 1.20 MCAL for Rhodes grass hay, 1.14 Mcal for bean. The rabbits requires a Kcal maintenance of 2100 to 2200 Kcal. Per kilo of feed and reproduction and growth needs 300 – 500 Kcal per kilo above maintenance requirements, Deblass (2003). The % ME (Mcal) mean of 1.08 for all the five forages is over and above the mandatory ME requirements of about 240 Kcal of energy of metabolic weight ($W^{o.75}$) and the estimated requirement in a feed is 2200 to 3200 Kcal DE/Kg of feed Lebas (1989). All the diets in this study was short of this requirement. The average daily feed intake for rabbits fed on the five diets were 138.81, 106.56, 117.89. 119.68 and 115.23 gm for Desmodium, Lucerne, Vetch, Bean and Rhodes grass hay respectively. The daily feed intake reduced in the 3rd week due to weather changes and increase in dry matter as the forages approached maturity. There was no significant difference in feed intake ($p>0.05$) M. Fredrick Houndo Nougbo (2012).

Under parameter: Feed Conversion Efficiency (FCE)

The efficiency with which the rabbits in the different diets converted the feed eaten into formation of body tissues. It was calculated using the following formula.

$$FCE = \frac{\text{WEIGHT GAIN (gm)}}{\text{FEED INTAKE (gm)}}$$

The FCE ranged from 0.389, amongst legumes 0.28, 0.278, 0.245, and 0.801 for Desmodium, Lucerne, Vetch, Bean and Rhodes grass respectively. Statistically there was no significant difference ($p>0.05$) which is in agreement with the findings of in FCE, but desmodium had highest FCE of 0.389 and Rhodes grass hay had the least of 0.801.The average daily weight gain (ADG) for a rabbit was achieved by subtracting the previous weeks weight from the current weeks weight and dividing the weekly gain by seven (7) being the number of days per week. The total weight gain was obtained by subtracting the initial weight of a rabbit from its final weight. The Average Daily Gain (ADG) recorded in this study are in agreement with those of Nworgu *et al*. (1999) who reported significant difference in daily weight gain of Weaner rabbits served with different levels of concentrates and grasses. Asuguo (1997) attributed variations in body weight and rate of gain of rabbits to differences in the nutrient composition of the forages served.

The ADG also in this study agrees with the growth rate of 5-10 gms per day reported by G.T. Lyeghe –Erakpotobor *et al*. (2006) during the growing phase where. There was significant difference ($P<0.05$) in average daily weight gain (ADG). The average daily gain in this study is in contrast with the findings of Cheeke *et al*. (1987) who recorded an ADG of between 18.1 – 21.2 gm for rabbits fed on 2 legumes. I.e. Gliricidia and Leucaena sp. The rabbits fed on Lucerne, Vetch and Beans did not show a corresponding increase in weight inspite of the high percentage CP in this legumes. This is unique scenario may be associated with the possible presence of anti-nutritional factors /toxic compounds which retards growth. An obvious observation in this study with respect to weigth gains is that despite varying but more or less adequate protein levels intake from the different diets especially the legumes, the high protein intake by grower rabbits may not be effectively converted to high growth rate.

It would be anticipated that higher protein intake by rabbits should convert to higher weight gain but it appears not to be the case in this study, especially for Lucerne, Vetch and Bean groups of rabbits. This observation tends to agree with those of G.T. Lyeghe –Erakpotobor *et al*, (2006) who alluded that low weight gains obtained could probably be due to genetic ceiling placed on growth during the growth phase as the growing rabbits approach puberty. The low ADG in the same groups may also be associated with the presence of anti-nutritional/toxic factors in the forages. From the 3rd week of study, the growth rate reduced for group fed Lucerne, Vetch and beans. This may be explained by the onset of the long rain and extreme weather conditions or could be due to presence of anti-nutritional factors/toxic compounds which could be in the legumes and have been accumulating in the rabbits body system and starting to exert growth inhibition.

Objective III: Toxicity check

Parameter - Body condition

All the rabbits fed desmodium, Vetch and Rhodes grass hay were in fair body condition but those fed on beans, Vetch and Lucerne exhibited rough fur court, fur-leaking, pica and dermatitis on limbs and ears drooping.

Parameter- rectal temperature

A check on daily rectal body temperature was randomly done on two rabbits per treatment every morning for the period of two weeks. The rabbits on Rhodes grass control and desmodium exhibited near constant normal temperatures of around 37^{o}c, but the other groups had persistent hypothermia.

Lungs

The rabbits on desmodium and lucerne depicted Ecchymotic harmorrhages in the lung parenchyma (tissue) while the rabbits on Vetch and Beans had diffused hemorrhages' and cachexic carcas was observed in the bean group unlike the Rhode grass group which had good lungs.

Abdomen

The stomach was good in the rabbits fed on Rhodes grass hay and on desmodium.

This indicates that the two diets are safe for use as rabbits feeds either singly or in combined diet unlike the other legumes.

Gastro- Intestinal Tract (GIT)

The GIT of rabbits fed on Vetch, Desmodium and Rhodes grass hay had good pelleted stool while those on Lucerne had dark stool full of contents in one rabbit. Pelleted stool in rabbits is a normal condition but the fluidy content in beans is suggestive of a disease condition or toxicity.

Liver

The livers of rabbits fed on Rhodes grass had no lesions and were bright red in colour (normal) while the livers of rabbit fed on lucerne, Vetch and beans had dark coloration with pussy sports indigative of underlying disease condition and or toxicity effects in the respective diets.

Kidneys

The rabbits fed on Rhodes grass hay and desmodium, Lucerne, Vetch and beans had good (normal kidneys, but those on Lucerne, Vetch and beans had haematuria reddish urine. This is abnormal and indicative of haemolysis of cells in the body. The urine of rabbits fed on Rhodes grass hay (control) had straw – coloured urine (normal) which leaves other legumes as containing the legumes as potential toxic agents especially for the rabbits (non-ruminant).

Parameter – Effects on organs /system weights

The the study revealed a wide range in organ/system weigths where Rhodes grass control group of rabbits had the highest weights of 268gm of the GIT and the bean group had the lowest of 162.75 gm. This is also true for weights of liver and kidneys. This is suggestive of patho-physiological effects associated with the legume species o which are not seen in the Rhodes grass control group.

Conclusion

- The results of this study showed that the four legumes i.e. Desmodium, Lucern, Vetch and Beans have 28.98% CP which is over and above the required for maintenance and production by growing rabbits.
- The study also indicated that legumes can support good growth rate and fair feed conversion efficiency in rabbit production.
- The study also has shed light on the possible presence of anti-nutritional /toxic compounds in the named legumes as was observed in the ante-mortem and post mortem observations.
- It is evident from this study that Desmodium seems to have less of anti-nutritional /toxic compounds than other legumes.

Recommendation

As a result of the proximate analysis of the nutrient composition of the legumes in this study, farmers can now access this information and use it to make their Total Mixed Rations (TMR) for rabbits. It is also recommended that rabbit farmers can improve on the growth rates of grower rabbits by making a home made ration of a mixture of the green leaf desmodium (*desmodium intortum*) with Rhodes grass & other concentrates feeds. Nutritionally, desmodium may be the best legume supplying protein to herbivores and ruminants. However, from the toxicity findings, in this study, the green leaf desmodium is good for non-ruminants as a protein supplement since it has lowest toxicity has compared to the other legumes. Also all the four legumes can be used as protein supplements in ruminants since they have higher crude protein levels of over 20% and there is no toxicity risks since the ruminal microbes in the ruminants will detoxify the toxic compounds unlike in the non-ruminants.

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