J. Food. Stab (2023) 6 (5): 16-26 Journal homepage: www.foodstability.com

Received: 16/10/2023/ Revised: 01/11/2023/ Accepted 03/11/2023 / Available online: 05/12/2023

DOI: 10.36400/J.Food.Stab.6.5.2023-054

Journal of Food Stability

https://www.ajol.info/index.php/jfs

ORIGINAL ARTICLE

The Effect of Forage Substitution with Concentrate Feed on the Growth Performance of New Zealand White Rabbits

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Funding source

None

Abstract

Local rabbit farmers use natural forage in feeding their rabbits and with forage becoming increasingly scarce in the dry season, this becomes a major problem. This study aimed at evaluating the influence of substituting forage with concentrate feed on the growth performance of rabbits. A total of twenty-one rabbits were grouped into three treatments; T1, T2 and T3 with each treatment group having seven rabbits. The rabbits in T1 were fed entirely (100%) on forage, those of T2 were fed entirely (100%) on concentrate feed while those of T3 were fed with 50% forage and 50% concentrate feed. The average daily weight gain and the weekly average weights were measured from week 6 to week 14. Two-way ANOVA was used to assess differences between the treatments means while the Tukey's multiple comparisons test was used to identify the difference between the treatment pairs. The results showed that the weekly average weight for T3 was significantly higher than that of T2 and T1 while that of T2 was significantly higher than that of T1. The average daily weight gain was significantly higher in T3 compared to T2 and T1 while that of T2 was significantly higher than T1.

Practical application

When rearing animals, the desire is to get healthy animals and a substantial weight gain within the shortest time possible especially for farmers rearing the animals for economic purposes. This study has shown that, local rabbit farmers who are mostly using entirely natural forage for feeding their rabbits will get an even better growth performance for their rabbits if they substitute a portion of the natural forage given to the animals with concentrate feed. This is more relevant in the heart of the dry season when there is a general scarcity of natural forage to feed animals.

Keywords: Forage, concentrate feed, rabbit, growth performance, substitution

1. Introduction

Food insecurity and low animal protein intake is a major problem in the world today and even more seriously in developing countries. This usually results in the development of certain protein deficiency diseases (Ume *et al.*, 2016). Animal protein is a better source of protein to animals compared to plant protein sources due to the presence of certain essential amino acids such as tryptophan and lysine which are either absent or present in inadequate amounts in plant protein sources (Adeyemo *et al.*, 2013). The minimum per capita daily protein intake for humans as recommended by the Food and Agriculture

Organization (FAO) is 53.8g while the global value stands at 64g (Protein Challenge, 2020), but in many developing countries, this value is usually far lesser. For instance, the daily per capita protein intake in Nigeria stood at 45.4g as of 2019, (Protein Challenge, 2020). This gap can be closed by looking for more innovative ways to boost animal protein production and consumption through encouraging animal production.

Previous studies have made mention of the idea that an easier approach to close this gap will be to encourage the production of short gestation unconventional livestock, especially monogastric animals such as Pigs, Poultry and Rabbits, of which rabbit is the most favoured (Akintola, 2009). The advantage that rabbits have over the others is the fact that, they can easily be managed within a small space, having shorter gestation time with high rate of reproduction. Rabbits have a relatively low cost of production compared to other monogastrics. Their ability to also feed on forage and their practice of caecotrophy enhances their performance, with a rapid growth rate compared to broiler chicken (Ironkwe, 2004; Amata & Bratt, 2008). Rabbits can also survive on food wastes and agricultural by-products, are potential income generators and have limited competition with humans for similar foods (Ensminger, 1991; Egbo *et al*, 2001). Rabbit meat is very healthy for human consumption and has a high nutritional value with high protein (56%), low fat (9%), low in cholesterol, sodium and calories (8%) and contain 28% phosphorus, 13% iron, 16% zinc, 14% riboflavin, 6% thiamin, 35% of vitamin B12 and 48% niacin. Rabbit urine and manure are both used to increase soil fertility (Ezea, 2004).

In Cameroon, livestock production remains an important part of the economy, contributing about 125 billion XAF to the Gross Domestic Product (INS, 2015). Cameroon is home to important animal genetic resources composed of cattle (9,857,361 heads), small ruminants (10,895,621 heads), poultry (53,630,641 subjects), pigs (3,936,636 subjects), etc. (MINEPIA, 2020). Rabbits are small mammals and their production plays an important role in the provision of meat, their hair used as materials for the production of clothes, and dropping for agricultural purposes. However, the limited knowledge on the feeding of rabbits, poor management procedures, poor funding, lack of treatment measures for health promotion, limited knowledge of the nutritional content of their meat, lack of sensitization are some of the factors plaguing the production of rabbits in Cameroon. Rabbits feeding only on green leaves might not be enough for proper growth performance and need other energy supplement sources usually given in the form of concentrate feed. Feeding rabbits solely on some forage species in the tropics has negatively resulted in weight loss (Adegbola *et al.* 1985; Bamikole & Ezenwa, 1999). The use of compounded concentrate alone has not also given optimum results (Adegbola *et al.*, 1985; Bamikole & Ezenwa, 1999). However, there is paucity of information on the appropriate combination of forage to concentrate for optimum performance of rabbit because concentrate alone fed to rabbits do not give 100% performance. In rural areas local rabbit farmers mostly use natural forage which is scarcely available throughout the year especially in the dry season which results to relatively smaller weight gains during this period (Ironkwe, 2004), while in urban areas, the scarcity of natural forage necessitates the use of compounded feed. With the above problem there is therefore need to evaluate the performance of rabbits when fed with compounded feed only, forage only or when fed

with both compounded feed and forage. This study was therefore designed to assess the effect of substituting both grass and legume forages with concentrate feed on the growth performance of rabbits.

2. Materials and Methods

2.1. Description of experimental site

This study was conducted at the Nazareth Agro-pastoral training and production center (NAPTPC) mile 4 Nkwen Bamenda. NAPTPC is located in Menteh quarter in Nkwen village, Bamenda III Sub-division in the Mezam division of the North West region of Cameroon. NAPTPC has an undulating relief with steep slopes and plain surfaces, covering an area of about 11 hectares. Activities carried out here are mainly done on gentle slopes with houses constructed mainly on levelled land.

Nkwen village falls within the climate area of Guinea savanna type characterized by two seasons, the dry and the rainy seasons. The rainy season usually runs from March to October. The rainfall ranges between 2000 to 3000mm per annum. The dry season runs from November to February and is characterized by strong, dry, dusty winds and heavy sunshine during the day. The annual average temperature hardly exceeds 19°C. The soils are ferralitic and low-lying. The term low lying is used because Nkwen is being surrounded by mountains and hills and the top soils are being washed away and sent to the low land or valleys forming rich zones of fertile soil lying at these valleys. The soils are made up of sand, silt and silt clay, while the soil texture is coarse in nature with medium to small particle size.

The vegetation around is typical savanna type characterized by grasses of different species, crops and little forest, trees are mostly fruit trees such as mangoes, avocadoes, guavas etc., Cypress and eucalyptus.

2.2. Feeding of rabbits

The rabbits were fed with either concentrate feed or forage or both in wooden feeders. They were fed twice a day in the morning at 7 am and in the afternoon at 3 pm per the treatment. The concentrate feed given to the rabbits covered the needs for energy, proteins, minerals, vitamins and essential amino acids. The composition and the nutritional value of the concentrate feed used are listed in Table 1 and 2 respectively.

Forage was harvested and dried for a week to reduce the moisture content and to ensure the elimination of harmful nematodes and insects. The rabbits were fed with a mixture of the following forages in equal proportions (1/8 portion for each forage type per 100g of forage mixture); Elephant grass (*Pennisetum purpureum*), Bracharia (*Urockloa brizantha*), Rabbit ear (*Emilia sonchifolia*), Timothy grass (*Phleum pretense*), I love you grass (*Desmodium intortum*), Sweet potatoes leaves (*Ipomoea batatas*), Plantain leaves (*Musa x paradisiacal*), Lablab grass (*Lablab purpureus*)

2.3. Experimental design

This study was executed in the rainy season from the beginning of the month of April to the end of July 2020. The rabbit breed used in this study was the New Zealand white rabbits. A total of 21 rabbits (n = 21) aged 6 weeks were shared into three groups constituted of 7 rabbits (3 males, 4 females) per group. The rabbits were sorted to ensure the differences in the sexes and initial average weights between the different groups were not significant. The animals were housed in a well-ventilated room in metal cages, with seven rabbits per cell (the males separated from the females to avoid copulation). Three experimental

Table 1: Composition of the concentrate feed

Ingredients	Percentage incorporation (%)
Maize	32
Wheat bran	32
Palm kennel cake	22
Soya beans seed cake	3
Fish meal	5
Broiler concentrate 5%	5
Bone meal	1

treatments were applied; Treatment 1 (TI) forage only, Treatment 2 (T2) concentrate feed only, Treatment 3 (T3) forage plus concentrate feed. These treatments are summarized in table 3. The rabbits were fed in the order of 100g/rabbit/day for both forage and concentrate throughout the experiment. The weights were taken every day and the average daily weight gain and the weekly average weight per treatment were calculated.

2.4. Field operations and data collection

The weights of the rabbits were taken every morning at 6 am before feeding them. The rabbits were weighed individually and the results were summed up and divided by the number of rabbits per treatment to obtain the average weight of each treatment. The results obtained were used to calculate the average daily weight gain per treatment. The average weekly weights were taken every Friday at same time in the morning.

Table 2: Nutritive value of the concentrate feed

Nutrient	Value
Crude oil	16%
Energy	2200KcalKg
Cellulose	26%
Calcium	1%
Phosphorus	0.7%
Methionine	0.4%
lysine	0.7%

The animals were given water and restricted feeding and the rabbitory was cleaned after every two days to avoid infections. Observations were made to check for any signs and symptoms of disease condition within the study period such as diarrhea, dysentery, decreased activity, and development of dermatosis. Figure 1 shows rabbits under experimental conditions being fed in wooden feeders.

Figure 1: Rabbits under experimental conditions

Table 3: Experimental layout

	Forage (F)	Concentrate (C)
T1	100%	0%
T2	0%	100%
T3	50%	50%

2.5. Data analysis

Graphpad prism version 6.0 was used as the statistical package. Two-way analysis of variance (ANOVA) was used to assess differences between treatments means while the Tukey's multiple comparisons test was used to identify the treatment pairs which were significantly different. A difference was considered significant when p was less than 0.05, at 95% confident interval (CI). Values were reported as Mean±SEM where SEM is standard error on mean.

3. Results and discussion

3.1. Results

3.1.1. The weekly average weight

There was a general increase in the weekly average weight for all the treatments beginning from the initiation of the study at week 6 to the end at week 14 (Table 4 and Figure 2). There was a significant difference ($p < 0.05$) between the three treatment groups T1, T2 and T3. The total weekly average weight gains throughout the study period of eight weeks were; 1194g for T1, 1398g for T2 and 1503 g for T3 (Table 4). The weekly average weight was significantly higher for T3 compared to T2 and T1 ($p < 0.0001$ in both cases). While that of T2 was significantly higher compared to that of T1 ($p < 0.0001$). This results indicate that the animals which were fed with both forage and concentrate feed (T3) gained more weight and therefore had a better growth performance compared to the two other treatments which were either fed with concentrate feed only (T2) or with forage only (T1). While those fed with concentrate feed only (T2) performed better than those fed with forage only (T1).

Table 4: Weekly average weight for each treatment

Age	Weekly average weight (g)		
	T1	T2	T3
Initial weight at week 6	1249.00±12.22^{a}	1240.02±09.10^{a}	1244.00±22.02^{a}
Week 7	1327.01±26.15^{a}	1431.00±13.20^{b}	1522.11±10.10^{c}
Week 8	1542.10±32.30^{a}	1712.00±10.01^{b}	1821.02±16.22^{c}
Week 9	1786.02±33.10^{a}	1911.02±09.23^{b}	2033.23±11.14^{c}
Week 10	1952.03±12.01^{a}	2126.01±07.22^{b}	2228.05±20.11^{c}
Week 11	2120.10±40.13^{a}	2289.12±17.00^{b}	2408.01±17.21^{c}
Week 12	2287.04±13.23^{a}	2480.00±24.10^{b}	2592.02±47.11^{c}
Week 13	2428.02±10.03^{a}	2600.01±29.00^{b}	2707.00±32.22^{c}
Week 14	2443.21±21.33^{a}	2638.15±18.00^{b}	2747.02±42.23^{c}

$^{a-c}$Different letter of means ± SD of the same rows are significantly different at $p<0.05$.

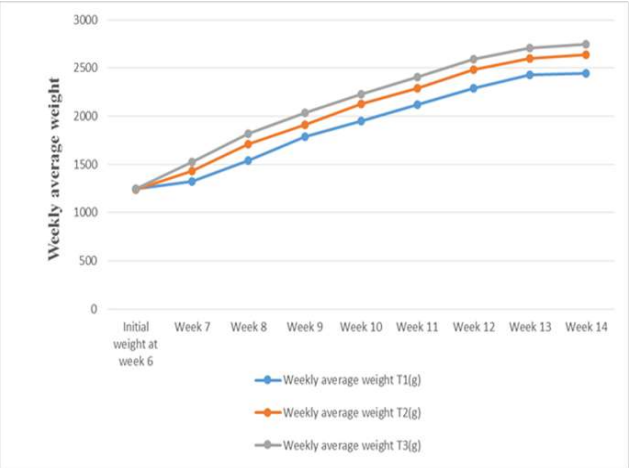

Figure 2: Weekly average weight of each rabbit group. T1: rabbits fed with 100% forage; T2: rabbits fed with 100% concentrate feed and T3: rabbits fed with 50% forage and 50% concentrate feed.

Table 5: Average daily weight gain for each treatment

Age	Average daily weight gain (g)		
	T1	T2	T3
Week 7	25.42±01.20^{a}	32.85±02.01^{b}	39.71±04.01^{c}
Week 8	30.71±03.22^{a}	37.42±05.11^{b}	42.71±06.45^{c}
Week 9	34.85±04.00^{a}	35.57±03.70^{a}	37.28±00.81^{b}
Week 10	23.71±02.33^{a}	23.71±01.65^{a}	27.85±03.55^{b}
Week 11	24.00±04.32^{a}	24.85±02.11^{a}	25.71±04.26^{a}
Week 12	23.85±00.95^{a}	23.00±02.44^{a}	26.28±03.65^{a}
Week 13	20.14±01.11^{a}	19.14±02.48^{a}	16.42±0.89^{a}
Week 14	02.12±00.07^{a}	03.14±00.03^{a}	05.71±00.10^{a}

$^{a-c}$Different letter of means ± SD of the same rows are significantly different at p<0.05.

3.1.2. Average daily weight gain

The average daily weight gain for each treatment increased from week 7 to week 8 then steadily decreased thereafter (Table 5 and Figure 3). This results show that the average daily weight gain for T3 was significantly higher compared to that of T2 and T1 ($p = 0.0363$ and $p < 0.0001$ respectively) while that of T2 was significantly higher compared to that of T1 ($p = 0.0381$). This results indicate that the animals which were fed with both forage and concentrate feed (T3) had a better weight gain and thus a better growth performance compared to the two other treatments which were either fed with concentrate feed only (T2) or with forage only (T1). While those fed with concentrate feed only (T2) performed better than those fed with forage only (T1).

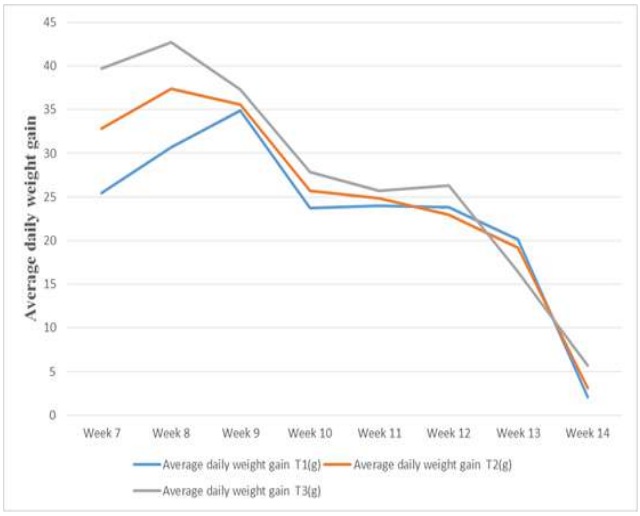

Figure 3: Average daily weight gain for each rabbit group. T1: rabbits fed with 100% forage; T2: rabbits fed with 100% concentrate feed and T3: rabbits fed with 50% forage and 50% concentrate feed.

3.1.3. Health condition of rabbits

Rabbits were monitored throughout the study period and no sign of diarrhea, dysentery, decreased activity, nor appearance of dermatosis

was found on rabbit skin. These are signs and symptoms that could indicate a disease condition.

3.2. Discussion

Rabbits are herbivores that feed by grazing on grass, forbs and leafy weeds. Thus their diet contains large amounts of cellulose which is hard to digest. Proper feeding is very necessary in rabbit keeping because it influences their growth, fertility and health. Some foodstuffs contain a lot of protein especially when fresh and green such as lablab and alfalfa and some are sources of energy like maize, sorghum, tubers etc. Both protein and energy sources like carbohydrates are good growth nutrients while minerals, vitamins and common salt are also required. Rabbits need variety in their diet. Grass or green leaves may not be enough for lactating and growing animals. It is best to add something starchy (that contains a lot of energy) to the feed of rabbits. Good candidates for this are rice bran (cassava) tuber, corn and rice left-over from the kitchen. The amount of feed to give a rabbit depends very much on the state of production. A lactating doe needs a lot of concentrate feed for example grains like corn, miles, rice, tubers in addition to the greens, to maintain her body weight and produce milk. Young rabbits also need concentrate supplement which in addition to fodder will improve performance like growth and survival. According to Sandford, the correct nutrition of the rabbit is certainly one of the most important aspects of rabbit keeping. There is no rabbit so good that poor nutrition will not ruin it nor any so bad that good feeding will not improve it (Sandford, 1996). Any rabbit which is not well fed cannot give its best, the greatest cost of producing rabbits lies in feed.

Many studies have investigated the diets and nutrition of rabbits. Iyeghe-Erakpotobor & Muhammad (2007) found out that forages, especially legumes, with their high protein content, have the potential of meeting the needs for cheaper feed sources for rabbits while Omole *et al.* (2007) reported that, rabbits can be maintained on green leaves alone, but for best growth to be achieved, the forage has to be supplemented with concentrate. Bello *et al.* (2001) found out that, the *Moringa oleifera* leaf meal is a good protein source that can be conveniently used to replace soya beans in adult rabbit diet and it does not impair the growth performance of rabbits. Various leaves and seeds of some forest or savannah trees had been tested, evaluated and found to be good replacements for some conventional feed stuff in rabbit production. Dairo (2008) revealed that addition of Loofah gourd (*Luffa Cylindrica*) seed meal serves as a source of vegetable protein not completed for as food when compared with soya beans, groundnut, cowpea, coconut or any other conventional plant eaten by human. As rabbit, fed 5% Loofah gourd seed meal exhibited the optimum performance indices, and showed good nutrient and most profitable and acceptable ways of utilizing other industrial by-products.

We noticed that, the average daily weight gain increased from week 7 to week 8 and then decreased steadily thereafter to the end of the study period (week 14) for all treatment groups. Rabbits of different weights, ages and physiological conditions have different requirement for nutrients. The growth of the rabbit is extremely rapid and therefore, its nutritive requirement is high during the early periods of its life. The total digestible nutrient requirement for any unit of growth increases with increasing weight (Sandford, 1986). Since the rabbits in this study were given same quantity of feed every day from week 6 to week 14 irrespective of their weight and age, this might have caused the steady decrease in average daily

weight gain from week 8 to week 14 for all the treatment groups.

The results showed that, rabbits fed with forage only (T1) had the least growth performance. The poor performance of rabbits fed only on forage could be due to relatively low supply or inadequate amounts of growth components such as digestible carbohydrates (energy source), proteins and certain essential amino acids needed by animals which are absent in grass and legume forages. Humans and other monogastric species have limited ability to digest plant cell wall components such as cellulose and hemicellulose. Forage eaters, however, have microbial populations in their digestive tracts that can ferment these components into usable nutrients. Forages tend to have a large loss of energy due to fermentation in the rumen of the animal (Schroeder, 2006). This results tallies with the works of Adegbola *et al.* (1985) and that of Bamikole & Ezenwa (1999) who reported feeding rabbits solely on some forage species in the tropics has negatively resulted in weight loss. Also, Raharjo *et al.* (1988) concluded from a review of rabbit production on tropical feed resources that tropical grasses were unsuitable as the sole feed for rabbits due to their low digestibility (less than 10 %). However, rabbits can successfully be raised on diets that are low in grains and high in roughage (Cheeke, 1986).

Results also showed that animals fed with concentrate feed only (T2) had a better growth performance compared to those that were fed with forage only (T1). This is because concentrate feed may be more balanced compared to forage which is richer in vitamins, fibers (roughage) and sometimes taken in unbalanced proportions. Concentrate feed is more balanced in nutrients than forage but it doesn't give optimal performance when rabbits are fed on concentrate feed only. This points to the fact that rabbits, as natural herbivores need forage in their food for proper performance. This result is in agreement with the works of Bamikole & Ezenwa (1999), Adegbola *et al.* (1985) who reported that the use of compounded concentrate alone does not yield optimum results.

The rabbits that were fed with 50% forage and 50% concentrate feed (T3) gave optimal and best growth performance compared to the other treatments proving the point above. Concentrate feed may have a higher nutritive value compared to forage but it doesn't give an optimum growth performance when used alone because rabbits are herbivores and so still need forage which is rich in components such as vitamins, fibers (roughage) to enhance feed intake and digestibility. Forage therefore complements concentrate feed for optimal growth performance. This result tallies with that of Adeyemo *et al.* (2013) who found that for optimum performance of rabbits, they should be fed 50% of concentrate and 50% of forage because it is this percentage that gives highest weight gain and highest average weight gain. According to Ojewola *et al.* (2005), rabbit perform better when fed with mixture of forage and concentrate.

Previous studies have looked at the effect of altering the proportion of concentrate feed and forage on haematological parameters but found no association. Adeyemo *et al.* (2013) reported that varying the amount of forage added to concentrate feed fed to rabbits had no significant difference on haematological parameters (Neutrophils, Basophils, monocytes, Lymphocytes, RBC, WBC, Hb, Eosinophils and total protein) between groups.

4. Conclusion

This study which was aimed at assessing the effect of substituting forages with concentrate feed on the growth performance of rabbits showed that a mixture of concentrate feed (50%) and forage (50%) produce better growth performance compared to those fed with forage only or those fed with concentrate feed only. The poor and unbalanced quality of grasses is a major constraint in rabbit production. Rabbit farmers are therefore called upon to use both forage and concentrate feed for optimal growth performance.

Conflict of interest

The authors declare that they have no competing interests.

Acknowledgement

The authors will like to thank the Nazareth Agro-pastoral training and production center (NAPTPC) mile 4 Nkwen, Bamenda for providing the working environment for the realization of this study.

Ethics

Animals were housed under favourable conditions and treated in the fairest of ways to avoid any infringements on animal rights.

Funding source

None

Authors' Contributions

ENN; conception, study design, data analysis, manuscript writing and revision. LPM; conception, study design, data collection, manuscript writing. NGA, MHF, GCTT, DFW, ASN, NCN, MMFN; manuscript writing, correction, revision, approval and literature search. TFT, NHN; Statistical analysis, graphics, manuscript revision and approval.

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Cite this paper as: Ndzi, N.E., Muhnyuy, L.P., Adzemye, N.G., Fanadzenyuy, M.H., Taboue, T.C.G., Wauffo, F.D., Nsangou, S.A., Nguetoum, N.C., Ndebé, F.M.M., Tchouangueu, T.F & Ndzi, N.H. (2023). The Effect of Forage Substitution with Concentrate Feed on the Growth Performance of New Zealand White Rabbits. *Journal of Food Stability*, 6 (5), 16-26.
DOI: 10.36400/J.Food.Stab.6.5.2023-054