BILINGUAL PUBLISHING GROUP

Journal of Botanical Research

https://journals.bilpubgroup.com/index.php/jbr

ARTICLE

Nutrient Composition and Acceptability of Rabbit Fed Silage from Guinea Grass (*Panicum maximum*) and Calopogonium (*Calopogonium mucunoides*)

***Nkemdirim Annabel Chukwu* [1], *Emmanuel Bakpo* [1*], *Keayiabarido Jude* [1], *Sobomate Chuku* [1], *Miracle Uzoma* [1], *Aroloye Numbere* [1,2]**

[1] *Department of Biology and Biotechnology, School of Laboratory Science and Technology, University of Port Harcourt, Port Harcourt P.M.B. 5323, Nigeria*

[2] *Department of Animal and Environmental Biology, University of Port Harcourt, Port Harcourt P.M.B. 5323, Nigeria*

ABSTRACT

The study was conducted to determine the nutrient composition and acceptability of silage produced from guinea grass (*Panicum maximum*) and calopogonium (*Calopogonium mucunoides*) fed to rabbits. Treatment 1 was fresh guinea grass and Calopogonium. Treatment 2 was ensiled 20% guinea grass +20% ensiled calopogonium, Treatment 3 was 25% ensiled guinea grass +25% ensiled calopogonium. Treatment 4 was 30% ensiled guinea grass +30% ensiled calopogonium. Treatment 5 was 35% ensiled guinea grass +35% calopogonium. Treatment 6 was 40% ensiled guinea grass +40% calopogonium. After 30 days of ensiling the silage physical characteristic, acceptability and macro mineral were assessed and the product were presented to fifteen New Zealand rabbits (*Oryctolagus cunuculus*) at 24 weeks of age in a cafeteria experiment to determine their acceptability. Based on the result, the physical characteristic of the silages were within the recommended characteristic for good silage, they were with Olive green color, firm texture in all the treatment group. The acceptability and preference of the silages by the rabbits were significantly ($p > 0.05$) different with treatment 6, 40% ensiled guinea grass +40% calopogonium and treatment 1 (Fresh guinea grass and calopogonium) being the most accepted and preferred and the result of the macro mineral profile of the silages showed significant difference in sodium, calcium,

*CORRESPONDING AUTHOR:

Emmanuel Bakpo, Department of Biology and Biotechnology, School of Laboratory Science and Technology, University of Port Harcourt, Port Harcourt P.M.B. 5323, Nigeria; Email: bakpoemma@gmail.com

ARTICLE INFO

Received: 17 October 2025 | Revised: 25 October 2025 | Accepted: 28 October 2025 | Published Online: 19 November 2025

DOI: https://doi.org/10.30564/jbr.v7i1.12492

CITATION

Chukwu, N.A., Bakpo, E., Jude, K., et al., 2025. Nutrient Composition and Acceptability of Rabbit Fed Silage from Guinea Grass (*Panicum maximum*) and Calopogonium (*Calopogonium mucunoides*). Journal of Botanical Research. 7(1): 1–10. DOI: https://doi.org/10.30564/jbr.v7i1.12492

magnesium and phosphorous content, with treatment 6 having the highest value of all the macro minerals. The study concludes and recommend the use of treatment 6, 40% ensiled guinea grass with 40% ensiled calopogonium for ruminant production because this treatment showed good physical characteristics indicating proper ensiling and preservation of nutrients and high acceptability and preference by rabbits, indicating palatability and reasonable macro mineral content, particularly calcium, sodium and magnesium, which are essential mineral for animal health.

Keywords: Calapogonium; Guinea Grass; Nutrient Composition; Mineral; Rabbit; Silage

1. Introduction

Guinea grass (*Panicum maximum*) originate in Africa, guinea grass has been cultivated for centuries as valuable forage crop and it also serves as a nutritious feed option for most live stocks and offers numerous benefits, it provides essential nutrient for growth and health, including high nutritional value, rich fiber, vitamins and minerals which support healthy digestion and growth among livestock[1]. Guinea grass has the ability to thrive under a variety of environmental conditions, including low-fertility soils, and has made it a valuable species for livestock grazing, especially in regions where forage availability is seasonal[2]. Grazing on guinea grass enables livestock to exhibit natural foraging behavior, promoting physical and mental health while providing essential nutrients, fiber and vitamins that support growth and overall wellbeing of animals. Guinea grass has undergone several breeding programs to improve traits such as nutritive value, seed production, and tolerance to pests and diseases[3]. Guinea grass can also be used for silage production[2]. Rabbit are non-ruminant herbivores. They have a monogastric digestive system with a large cecum, where microbes break down and extract nutrients from plant based foods. Rabbits digestive system is specialized to break down and extract nutrients from plant based foods, particularly high fiber feeds like guinea grass through re-ingestion to maximize nutrient absorption[4].

Calopo (*Calopogonium mucunoides*) is a tropical legume native to Central and South America and it is widely used as forage due to its high nutritional value[5]. Calopo belongs to the family *Fabaceae* and is widely used in agriculture to support livestock production[6]. Its growth habit allows it to form a dense ground cover, making it suitable for livestock grazing and it serve as high quality forage rich in protein and nutrients, enhancing digestibility, nutrient absorption and overall animal health, making it a valuable feed component for livestock such as cattle, goat sheep and rabbits[7]. Studies have shown that Calopogonium provides essential protein and nutrients for growth and maintenance, supports optimal digestive health, and enhances nutrient absorption, ultimately contributing to improved animal performance, health and productivity[8]. Calopogonium has been used in mixed pastures to improve the protein content of grass-based fodders. Its incorporation with Guinea grass has shown synergetic effects, especially in improving the overall acceptability and palatability of forage for ruminant and, more recently, in experimental trials for monogastric animals[9]. Calopo is generally well accepted by rabbits and is considered a suitable forage. Studies have shown that rabbits readily consume fresh Calopo, often displaying a preference for VA legumes like Calopogonium over grasses. While Calopo can be a good source of protein and fiber for rabbits, its important to ensure its part of a balanced diet and to avoid overfeeding due to its potential for high fiber content.

Guinea grass (*Panicum maximum*) and Calopo (*Calopogonium mucunoides*) can be used to make high quality silage for livestock feed. The combination of these two forages can provide a nutritious and palatable feed option for animals. Silage made from Guinea grass and Calopo can offer several benefits including improved nutrient preservation, enhanced palatability and increased feed efficiency. Silage is the technique used for the storage of forage based on the transformation of water soluble carbohydrates into organic acids by the action of lactic acid bacteria that limit the pH and maintain the fresh forage[10]. The quality of silage depends on factors like the forage mixture, moisture content and ensiling process and proper management of silage can result in a nutritious feed that supports animal health and productivity. Ensiling is the process of conserving large amount of forage for some period of time without any dependence on weather condition. Although, ensiling has negative influence on feed

intake and it contribute to reduction in feed intake among livestock[11]. The main factors that boost the performance of livestock are silage quality and availability of nutrients in forage[12]. Nevertheless, feeding value of silage depends on intake and digestibility[13]. Silage intake value is low when compared with fresh forage, based on the toxic substances generated during the process of fermentation[10]. Younger plants typically have a higher concentration of minerals than older, more mature plants. As plants mature, their mineral concentrations tend to decrease, particularly for trace elements like zinc and copper.

Silage quality influences the intake and performance of livestock[14]. The major limitation of livestock production in Nigeria is unavailability of quality forage to livestock throughout the year[15]. Firm texture of silage is considered the standard texture of quality silage[16]. pH of silage at the final stage of production is recommended to be within the range of 3.5–4.3[17]. Increasing the dry matter content of ensiling material reduces the loss of nutrient in the ensiled material[18]. Propionic acid has been used to determine the value of feed intake among livestock, while the major pointer of feed quality is voluntary feed intake, which contributes to effective animal performance[19,20]. Similarly, smell, texture and pH level of feed are the major factors that influence the animals feeding behavior[21]. While palatability is influenced by the health of the animal, hunger, and differential preference for forage species[22]. Acceptability is influenced by factors such as chemical composition of plant, plant maturity, nutrient composition of plant, seasonal availability of plant[23]. Acceptability and utilization of feed by animals is influenced by the behavioral pattern of the animals[24].

Protein is made up of nitrogen component[25]. Therefore, developing rabbits need 16% crude protein whereas nursing and pregnant doe require 18% and 16% crude protein respectively[26]. Minerals are very important and are required in the right quantity for the maintenance and productivity of animals[27]. Minerals such as potassium, sulfur, calcium, and phosphorous, play essential role in the system of an animal and are directly involved in reproduction and growth of most animal[27]. Minerals are essential in animal feed to improve their health and avoid animal disease[8]. The essential amount of macro minerals that comprises of Calcium (Ca), Phosphorous (P), Sodium (Na), Potassium (K), Magnesium (Mg) and Sulphur (S) which are needed in amount higher than 100mg/day for animal. The essential amount of micro minerals that comprises of Iron (Fe), Copper (Cu), Cobalt (Co), Chlorine (Cl) are also required below 100mg/day[28]. The building of structural composition in organ and tissue of animal is based on both calcium (Ca) and Phosphorus (P) are important to create the structural composition of organs and tissue of animals[29]. Animal body is made up of Calcium (Ca), which is vital macro mineral that is responsible for the development of bone and teeth. Similarly, inadequate amount of calcium in mature animals result to disease such as osteomalacia that result to weak bone[30]. Phosphorus has crucial function in the development of urine and the production of glucose, and glycerol EL[31]. Lack of inadequate phosphorous leads to rickets disease[28].

Rabbit production is a vital component of sustainable livestock farming, providing a valuable source of protein for human consumption[32]. However, the availability and quality of feed resources remain significant challenges. Guinea grass and *Calopogonium mucunoides* are promising forage crop for rabbit production due to their high nutritional value and adaptability. Silage production can help address feed scarcity and improve rabbit production[32]. Ensiling is the process of preserving plant material through anaerobic fermentation, which involves harvesting, chopping and packing crops tightly to exclude air, allowing natural bacteria to ferment and preserve the feed materials for animal[33]. Among the forage crops being explored, Calopogonium, a tropical legume, has been identified as a valuable forage crop with potential as a protein-rich feed supplement for monogastric animals[34]. Studies have shown that Calopogonium legumes and Guinea grass are rich in minerals[34]. Rabbit feed intake and acceptability are influenced by various factors, including palatability, texture, and nutrient content of the feed as well as environmental factors like temperature, humidity and lighting and animal factors such as age, health status and genetics and management factors like feeding frequency, feed availability and water quality[35].

Rabbit production is a significant aspect of livestock farming in many tropical countries, including Nigeria. One of the major challenges facing rabbit producers is the high cost and inconsistent availability of conventional feed ingredients. Apart from the mentioned problems, other challenges in rabbit feeding include seasonal competition for feed resources with other livestock and seasonal variation of forage

during the dry season, there is surplus forage during the raining season and the surplus forage during the wet season is squandered as they grow to become extremely fibrous, loses nutrients and dries before it is required. This surplus can be ensiled and used during the dry season at the peak of forage scarcity. To address this problem, researchers have been exploring alternative feed sources, such as silage made from locally available forages like Guinea grass and Calopo.

It will be justifiable to study the nutrient profile of silage made from Guinea grass (*Panicum Maximum*) and Calopo (*Calopogonium Mucunoides*) and their acceptability by rabbits fed the silage. The finding could assist to resolve the lack of feed for rabbits during the off season. It may also assist in preserving the excess forage materials accessible for usage in rabbits during the rainy season when forage is abundant. However, biotechnology ensiling techniques could offer a promising solution to improve the nutritional quality of the ensile plant materials (Guinea grass and Calopo).

The research is aimed at investigating the nutrient quality and acceptability of rabbit fed silage from Guinea grass (*Panicum maximum*) and Calopo (*Calopogonium Mucunoides*) and their acceptability by rabbits.

The objectives of the study are:

a. To examine the physical characteristic of the silages
b. To determine the most preferred silage by rabbits
c. To investigate the mineral content of the silages

2. Materials and Method

2.1. Experimental Site

The study was conducted at the Unit of the Biology and Biotechnology Laboratory, of the School of Science Laboratory Technology (SSLT), University of Port Harcourt, Abuja Campus, Choba, Obio/Akpor Local Government Area of Rivers State in South—South Zone of Nigeria. The samples, fresh Guinea grass (*Panicum maximum*) and Calopo (*Calopogonium mucunoides*) leaves were sourced from the University of Port Harcourt Botanical Garden, Abuja Campus, ChobaCommunity in Obio/Akpor Local Government Area of Rivers State.

2.2. Preparation of Silage and Experimental Treatment

The harvested fresh *Penicum maximum* grass and *Calopogonium mucunoides* leaf were wilted for 24 hours in order to reduce the moisture content after which they were chopped to a particle size of 2–3cm using scissors. The chopped experimental materials (*Penicum maximum* and *Calopogonium mucunoides*) were weighed and ensiled in different treatments. Bama bottles (960ml) were used as silo and the silos were tightly cocked and covered to avoid air penetration. Each treatment has three (3) replicate and the ensiling materials were kept in room temperature at 28–°C for one month (13^{th} May–13^{th} June, 2025).

The six treatments are:

T1 20% Guinea grass + 20% Calopogonium.
T2 25% Guinea grass + 25% Calopogonium.
T3 30% Guinea grass + 30% Calopogonium.
T4 35% Guinea grass + 35% Calopogonium.
T5 40% Guinea grass + 40% Calopogonium.

2.3. Experimental Animal, House and Procedure

A total of fifteen (15) mature rabbits weighing 1 to 1.5 kg and aged 24 weeks (six months) were used for the experiment. The rabbits were hire from Nkem's livestock farm in Bende Local Government Area of Abia State, Nigeria. The rabbits were randomly assigned to five treatments and three (3) rabbits per treatments. The rabbits were properly housed in an animal house. The 15 rabbits were acclimatized for 1 day before acceptability test. The rabbits were subjected to the same management condition during the experiment, they were fed twice daily (Morning and evening) 8am and 4pm. The silage was weighed daily before feeding and the quality given daily was based on 3% of the body weight of the rabbits. Water was provided *ad-libitum.* Routine management practice such as cleaning of feeding troughs, washing of watering trough, disinfecting the foot dip and environmental sanitation were carried out throughout the experimental period.

The trial lasted for 34 days (1 days for acclimatization of rabbits, 30 days for silage production, 2 days for silage characteristics evaluation and 1 day acceptability testing period). Cafeteria design was used for this experiment.

2.4. Determination of Physical and Chemical Characteristics of Silage

After 30 days, the silos were opened and examined using the following parameters such as appearance, Odour,

Texture, Temperature, pH.

Appearance: Appearance assessment was done using the visual observation with the aid of a colour chart

Odour: The odour of the silage was assessed to known whether it was pleasant, pungent and unpleasant by five (5) person

Texture: The silage was checked to know the level of wetness by pressing the silage with hands

Temperature: Clinical thermometer was used to check the temperature of the silage

pH: The pH meter was used to measure the pH of the silage

For chemical analysis, samples of Guinea grass and Calopo leafs silage (T1–T5) were analyzed for macro mineral content using the Vanillin-Hel described by Price et al.[36]. The macro mineral in the samples were analyzed using the Vanillin-Hel method described by Price et al.[36].

2.5. Silage Acceptability Trial

Guinea grass and Calopo leafs were ensiled in Treatment 1 and 5. The acceptability test was carried out in the experimental animal house, Unit of Biology and Biotechnology for a period of 7 days. The five feeding troughs used were, randomly, distributed at four locations within the open space in each of the small animal house according to the methods of Olabanji et al.[37] giving each animal have free access to each of the trough. The animals were exposed to the treatments (Silages) for 1 hour daily between 08.00 and 9.00 am. The result of the silage acceptability trial is shown in **Table 1**.

Table 1. Physical characteristic rating of silage.

Scale	Mouldness	Odour	Appearance	Texture
1	Not mouldy	Pleasant	Olive green	Firm
2	Slightly moldy	Fairy Pleasant	Greenish	Slightly moist
3	Average moldy	Slightly Pungent	Dark Brownish Green	Moist
4	Highly moldy	Slightly Pungent	Brown	Heavily moist

Source: Littledike and Goff[38].

2.6. Statistical Analysis

Since there are multiple data, analysis of variance (ANOVA) was used to determine whether there is a significant difference at $p = 0.05$. All data collected were subjected to a one-way analysis of variance (ANOVA) using SAS (2002).

3. Results and Discussion

3.1. Physical Characteristic of the Silages

The result on the physical characteristics of the silages include colour, odour, texture, temperature, pH, and moldiness of ensiled guinea grass with calopogonium shown in **Table 2**.

Table 2. Physical characteristics of ensiled mixture of guinea grass and calopo leaf.

Parameters	T1	T2	T3	T4	T5
Colour	Olive green	Olive green	Olive green	Olive green	Olive green
Odour	Pleasant	Not pleasant	Not pleasant	Not pleasant	Not pleasant
Texture	Firm	Firm	Firm	Firm	Firm
Temperature	27.4 °C	26.2 °C	22.8 °C	28.7 °C	28.3 °C
pH	4.2	4.1	3.8	4.0	3.8
Moldiness	Not moldy	Slightly moldy	Not moldy	Not moldy	Not moldy

Note: Where, T= treatment; 1 = 20% Guinea grass + 20% Calopogonium ; T2 = 25% Guinea grass + 25% Calopogonium; T3 = 30% Guinea grass + 30% Calopogonium; T4 = 35 Guinea grass + 35% Calopogonium and T5 = 40% Guinea grass + 40% Calopogonium.

The colour of the ensiled Guinea grass with Calopogonium in all treatments had similar appearance that appear to be olive green colour.

However, the colour observed was close to the original colour of the experimental materials before ensiling which was an indication of a good quality silages that was well pre-

served according to Ojo et al.[39]. The odour of the silages was observe to be pleasant in treatment 1, (20% ensiled guinea grass + 20% ensiled calopo). Except in treatments 2, 3, 4 and 5 (25% ensiled guinea grass + 25% ensiled calopo, 30% ensiled guinea grass + 30% ensiled calopo, 35% ensiled guinea grass + 35% ensiled calopo, and 40% ensiled guinea grass + 40% ensiled calopo) that were slightly not pleasant. However, the pleasant and slightly not pleasant odor observed in the experimental materials indicate proper fermentation, which helps preserve the feed.

The temperature of the silages was within the range of 26.2 °C to 28.3 °C which is within the normal range of temperature and the colour obtain and the value of temperature recorded in all the treatments is in accordance with the finding of McWilliams[40] who stated that temperature of silages above 30 °C result to dark colour because of caramelization of sugars in the content of the plant. Monitoring temperature can help identify potential issues with silage quality and silage with excessive heat can be detrimental to animal health. The stable temperature rate in this study indicate that the silages are well preserved and stable as notice in the texture.

The texture of the silage was firm across all the treatments. The firm texture of the silage indicate that the silage was good. This finding is in accordance with the finding of Kung and Shaver[16] who stated that silage with firm texture is good. However, monitoring the temperature of silage can help identify potential issues with silage quality and silage with excessive heat can be detrimental to animal health.

The pH value was highest in treatment 1, (20% ensiled guinea grass + 20% ensiled calopogonium), treatment 2, (25% ensiled guinea grass + 25% ensiled calopogonium) and treatment 4, (35% ensiled guinea grass + 35% ensiled calopogonium), followed by treatment 5, (40% ensiled guinea grass + 40% ensiled calopo) and treatment 3 (30% ensiled guinea grass + 30% ensiled calopogonium) were of the same range. The p H range (3.8–4.5) recorded in this study indicates proper fermentation and preservation of the silages. The result of this finding support the finding of NRC[27] who state that silage with optimal p H range of 3.8–4.5 support animal health and productivity. The silages was slightly not moldy in all the treatments indicating the possibility of film texture.

3.2. Acceptability, and Preference of Fresh Guinea Grass and Calopogonium and Silages

The acceptability and preference values of fresh guinea grass and calopogonium and the silage are shown in **Table 3**. The results showed significant ($p < 0.05$) difference among fresh guinea grass and calopogonium and the silages. The rabbits feeding behavioral patterns were such that number of visits (NV) number of bites (NB), the time spent feeding (TS) (Sec), and number of bites per visit (BV) were affected significantly ($p < 0.05$). The number (29.43 and 29.43) of visits was highest in treatment 1 and 6, followed (23.33 and 22.00) by treatment 2 and 3 while treatment 4 and 5 had the least number of (17.00 and 21.31) visits by the rabbits. Treatment 1 and 6 recorded the highest number (20.00) of bites, followed (19.33 and 17.00) by treatment 3 and 4 while treatment 5 and 2 had the least number of (15.65 and 15.00) number of bites on the experimental feed (Silage) by the rabbits. However based on the result the highest number of visits and bites recorded in treatment 1 and 6 indicate that fresh guinea grass and calopogonium and the silages were palatable and appealing for the rabbits. Thus, the highest number of bites by the rabbits in treatment 1 and 6 showed the rabbit's preference for treatment 1 and 6 diet. The time spent by the rabbit on the experimental material was highest in treatment 1, (38.00 seconds) and 6, (38.00 seconds), followed by treatment 2, (33.00 seconds) while the lowest number of time spent on the experimental material was recorded in treatment 4, 3 and 5 (26.33 seconds, 23.33 seconds and 28.34 seconds). Thus the highest number of times spent in treatment 1 and 6 clearly indicates that the rabbits were satisfied feeding on the diets.

The bites per visit recorded the highest value (24.33 and 24.33) in treatment 1 and 6, followed by (19.33, 19.00 and 18.01) in treatment 2, 3 and 5 while treatment 4 recorded the lowest number of (15.00) bites per visits. Thus the highest number of bites per visit recorded in treatment 1 and 6 suggest that the rabbits find the fresh guinea grass and calopogonium and the silages highly palatable and were eager to consume them. The result also indicates that the rabbits visits all the experimental materials which suggest that the experimental animal made their choice based on preference suggest that the rabbits find the fresh guinea grass and calopogonium and the silages highly palatable and were eager to consume them.

Table 3. Acceptability and preference of fresh guinea grass, Calopogonium and silage.

Parameters	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Number of visit	29.43 [a]	23.33 [b]	22.00 [b]	17.00 [d]	21.31 [c]	29.43 [a]	1.47
Number of bite	20.00 [a]	15.00 [d]	19.33 [b]	17.00 [b]	15.65 [c]	20.00 [a]	1.13
Time spent	38.00 [a]	33.00 [b]	23.33 [c]	26.33 [d]	28.34 [c]	38.00 [a]	3.17
Bite per visit	24.33 [a]	19.33 [b]	19.00 [b]	15.00 [d]	18. 01 [b]	24.33 [a]	1.23

Note: [abcd] Mean of the same row with different superscript differ significantly ($p < 0.05$). NV = Number of visits, NB = Number of bites, TS = Time spent, BV = Bites per visit. T = Treatment. T1 = fresh guinea grass and calopogonium, Treatment 2 = 20% Guinea grass + 20% calopogonium, Treatment 3 = 25% Guinea grass + 25% calopogonium, Treatment 4 = 30% Guinea grass + 30% calopogonium, Treatment 5 = 35% Guinea grass + 35% calopogonium, Treatment 6 = 40% Guinea grass + 40% calopogonium.

3.3. Macro Mineral Profile of Fresh Guinea Grass and Calopogonium and the Silages

The macro mineral profile of fresh guinea grass and calopogonium and the silages are shown in **Table 4**. There were significant ($p < 0.05$) differences in all the element studied. Sodium (Na) recorded the highest value of (0.143% and 0.140 %) in treatment 5 and 6, followed by (0.139 % and 0.130 %) in treatment 4 and 3 then treatment 2 had the lowest value of (0.110%) while the least value of (0.090 %) was recorded in treatment 1. The result indicate that the fresh guinea grass and calopogonium and the silages contain sufficient sodium which is essential for animal health.

Table 4. Macro mineral profile of fresh guinea grass and calopogonium and the silages.

Elements (%)	T_1	T_2	T_3	T_4	T_5	T_6	SEM
Sodium	0.090 [d]	0.110 [c]	0.130 [b]	0.139 [b]	0.140 [a]	0.143 [a]	0.004
Calcium	20.00 [a]	15.00 [d]	19.33 [b]	17.00 [b]	15.65 [c]	20.00 [a]	1.13
Magnesium	0.140 [a]	0.112 [e]	0.118 [c]	0.120 [c]	0. 137 [b]	0.141 [a]	0.003
Phosphrous	0.096 [d]	0.098 [d]	0.129 [c]	0.150 [b]	0.155 [b]	0.200 [a]	0.005

Note: [abcd] Means on the same row with different superscript differ significantly ($p < 0.05$). T = Treatment. T_1 = fresh elephant grass and calopogonium. T_2 = 20% guinea grass + 20% calopogonium, T_3 = 25% elephant + 25% calopogonium. T_4 = 30% guinea grass + 30% calopogonium. T_5 35% guinea grass + 35% calopopogonium and T_6 40% elephant + 40% calopogonum.

The calcium (Ca) content of the fresh guinea grass and calopogonium and the silages recorded the highest value in treatment 6, and 1, followed by treatment 3, and 4. While treatment 5, had the lower value, then treatment 2, had the lowest value. Thus, the high calcium content recorded in fresh guinea grass and calopogonim indicate that the ensiling process did not affect the calcium content of the plant rather it made them valuable materials for animal feed based on the similar higher values of calcium recorded in treatment 6, (40% guinea grass and 40% calopogonium) and in treatment 1, (fresh guinea grass and calopogonium). However; the high calcium content in treatment 6 and 1, (40%, guinea grass and 40%, calopogonium) and (fresh guinea grass and calopogonium) could contribute to improve bone health and overall wellbeing in animals. Thus the calcium content found in the experimental materials was between (15.00–20.00 %) which were within the recommended range for maintenance of growing and lactating ruminant animals according to Recter and Robinson.

Treatment 6 and 1 recorded the highest value of magnesium (0.141 and 0.140 %), followed by (0.137%) in treatment 5, then treatment, 3 and 4 had the lower values of (0.118 and 120 %), while treatment 2, recorded the least (0.112%) value of magnesium. However, the magnesium content recorded from all the treatment groups were within the range of (0.112–0.141%). However; the content of magnesium in the fresh guinea grass, calopogonium and the silage made them ideal materials for animal feed, particularly for young or growing animal with high magnesium requirements.

The phosphorous (P) content of the experimental materials was highest in treatment 6, (0.200 %) followed by 5, 4 (0.155 and 0.150) and 3 (0.129 %), while treatment 2 and 1 recorded the least value (0.096 and 0.098 %). The high phosphorous content found in treatment 6, 5 and 4 could reduce the need for additional phosphorous supplements in animal diets.

4. Conclusions

Based on the results ensiling Guinea grass with Calopogonium produced perfect silage based on the physical characteristics observed such as colour, odour, texture, temperature, pH and, moldiness of the silage produced in this study were all good and acceptable by the rabbit during acceptability trial and the result has shown that Guinea grass and Calopogonium can be ensiled for sustainable livestock production in humid tropical area especially Treatment 5 40%Guinea grass +40%Calopogonium). The macro minerals of the fresh and ensiled Calopogonium and Guinea grass show that the ensiling materials are good source of sodium , calcium, magnesium and phosphorus for ruminant and pseudo ruminant animal production. Further study should be carried out on digestability and performance of rabbit fed on the recommended level of silage and above the recommended level.

Recommendation

Treatment 5 and 6 exhibit good silage terms of acceptability and macro mineral such as Calcium and Magnesium. It can be recommended for the management of ruminant and pseudo ruminant animal production.

Author Contributions

N.A.C. conducted the research and compiled manuscript; E.B. supervised the work and edited and revised the work; K.J., M.U. and S.C. reviewed and edited the final copy; A.N. coordinated the project. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Ethical review and approval were waived for this study because it was an acceptability experiment that does not involve the use of blood or the sacrificing of animal.

Informed Consent Statement

Not applicable.

Data Availability Statement

Data will be available on request

Acknowledgments

We would like to thank staff and final year students of Department of Biology and Biotechnology, University of Port Harcourt.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Ong, Y.L., Chung, E.L.T., Nayan, N., et al., 2025. Phytobiotic Effects of Guinea Grass Supplementation on Production and Health Performances of Coloured-Broilers. Italian Journal of Animal Science. 24(1), 149–163. DOI: https://doi.org/10.1080/1828051X.2024.2444457

[2] Food and Agriculture Organization of the United Nations (FAO), 2015. Grassland species profiles: Panicum maximum. Available from: https://www.fao.org/agriculture/crops/thematic-sitemap/theme/biodiversity/weeds/listweeds/pan-max/en/ (cited 15 October 2025).

[3] Napalinga, C.P., 2025. Plant-Based Feed and Forage Research for Livestock: A Bibliometric Review. ASEAN Journal of Scientific and Technological Reports. 28(5), e259394. DOI: https://doi.org/10.55164/ajstr.v28i5.259394

[4] Gidenne, T., Fortun-Lamothe, L., Savietto, D., 2025. Organic Rabbit Farming in Europe: Technical and Economic Performance in French Organic Rabbit Systems. In: Awasthi, L.P. (Ed.). Advances in Organic Farming. CABI: London, UK. pp. 459–468. DOI: https://doi.org/10.1079/9781800626850.0047

[5] Mpairwe, D.R., Sabiiti, E.N., Ummuna, N.N., et al., 2003. Integration of Forage Legumes with Cereal Crops. I. Effects of Supplementation with Graded Levels of Lablab Hay on Voluntary Food Intake, Digestibility, Milk Yield and Milk Composition of Crossbred Cows Fed Maize–Lablab Stover or Oats–Vetch Hay Ad Libitum. Livestock Production Science. 79(2–3), 193–212. DOI: https://doi.org/10.1016/S0301-6226(02)00176-8

[6] Giller, K.E. (Ed.), 2001. Nitrogen fixation in tropical cropping systems, 2nd ed. CABI Publishing: London, UK. DOI: https://doi.org/10.1079/9780851994178.0000

[7] Goswami, N., Solomon Ahamba, I., Kinkpe, L., et al., 2025. Enhancing Rabbit Farming Efficiency with Integrated Genomics and Nutritional Strategies. Frontiers in Animal Science. 5, 1514923. DOI: https://doi.org/10.3389/fanim.2024.1514923

[8] Mondin, C., Trestini, S., Trocino, A., et al., 2021. The Economics of Rabbit Farming: A Pilot Study on the Impact of Different Housing Systems. Animals. 11(11), 3040. DOI: https://doi.org/10.3390/ani11113040

[9] Ghani, M.U., Kamran, M., Pandey, S.P., et al., 2025. Optimizing Cutting and Mix-Cropping Improves Forage Yield and Quality of Cultivated Grassland in a Semi-Arid Environment. European Journal of Agronomy. 171, 127816. DOI: https://doi.org/10.1016/j.eja.2025.127816

[10] Legendre, H., Goby, J.-P., Duprat, A., et al., 2019. Herbage Intake and Growth of Rabbits Under Different Pasture Type, Herbage Allowance and Quality Conditions in Organic Production. Animal. 13(3), 495–501. DOI: https://doi.org/10.1017/S1751731118001775

[11] Charmley, E., 2001. Towards Improved Silage Quality – A Review. Canadian Journal of Animal Science. 81(2), 157–168. DOI: https://doi.org/10.4141/A00-066

[12] Terry, A., Dele, P., Jethro, D.B., et al., 2025. Silage Production and Livestock Raising in Africa. In: Cai, Y., Ataku, K. (Eds.). Cultural History and Modern Production Technology of Silage. Springer Nature: Singapore. pp. 169–195. DOI: https://doi.org/10.1007/978-981-96-5787-2_11

[13] De Souza, J.M.S., Neto, A.B., Da Rosa, M.A.B., et al., 2025. Nutritional Value and Fermentability of Sorghum Silages Grown in the Amazon Biome. Grassland Science. 71(2), 86–94. DOI: https://doi.org/10.1111/grs.12440

[14] Xue, F., Xu, C., Zhao, Y., et al., 2025. The Impact of Varieties and Growth Stages on the Production Performance and Nutritional Quality of Forage Triticale in the Qaidam Basin. Plants. 14(19), 2942. DOI: https://doi.org/10.3390/plants14192942

[15] Sikiru, A.B., Velayyudhan, S.M., Nair, M.R.R., et al., 2023. Sustaining Livestock Production Under the Changing Climate: Africa Scenario for Nigeria Resilience and Adaptation Actions. In: Egbueri, J.C., Ighalo, J.O., Pande, C.B. (Eds.). Climate Change Impacts on Nigeria, Springer Climate. Springer International Publishing: Cham, Switzerland. pp. 233–259. DOI: https://doi.org/10.1007/978-3-031-21007-5_13

[16] Kung, L., Shaver, R., 2002. Interpretation and use of silage fermentation analysis reports. Focus on Forage. 3(13), 1–5. Available from: https://www.researchgate.net/publication/292458166_Interpretation_and_use_of_silage_fermentation_analysis_reports

[17] Wang, S., 2025. Silage Preparation, Processing and Efficient Utilization. Agriculture. 15(2), 128. DOI: https://doi.org/10.3390/agriculture15020128

[18] Udén, P., 2018. Fresh and Ensiled Forage Plants—Total Composition, Silage Losses and the Prediction of Silage Composition from the Crop. Grass and Forage Science. 73(2), 420–431. DOI: https://doi.org/10.1111/gfs.12328

[19] Prihambodo, T.R., Mulianda, R., Wulandari, W., et al., 2025. Scopus-Based Bibliometric Analysis of Research Trends in Silage Feed and Its Impact on Rumen Fermentation in Ruminants. Veterinary World. 1972–1990. DOI: https://doi.org/10.14202/vetworld.2025.1972-1990

[20] Akdag, A., Bozbay, C.K., Ocak, N., 2018. Voluntary Feed Intake, Grazing Behaviour and Plant Preferences of Ruminants. International Journal of Scientific and Technological Research. 4(9), 127–138. Available from: https://www.researchgate.net/publication/329268569_Voluntary_Feed_Intake_Grazing_Behaviour_and_Plant_Preferences_of_Ruminants

[21] González-Pech, P.G., Torres-Acosta, J.F.D.J., Sandoval-Castro, C.A., et al., 2015. Feeding Behavior of Sheep and Goats in a Deciduous Tropical Forest During the Dry Season: The Same Menu Consumed Differently. Small Ruminant Research. 133, 128–134. DOI: https://doi.org/10.1016/j.smallrumres.2015.08.020

[22] Watson, P.E., Thomas, D.G., Bermingham, E.N., et al., 2023. Drivers of Palatability for Cats and Dogs—What It Means for Pet Food Development. Animals. 13(7), 1134. DOI: https://doi.org/10.3390/ani13071134

[23] Fu, C., Cheema, W.A., Mobashar, M., et al., 2025. Insects as Sustainable Feed: Enhancing Animal Nutrition and Reducing Livestock Environmental Impression. Journal of Animal Physiology and Animal Nutrition. 109(2), 280–290. DOI: https://doi.org/10.1111/jpn.14055

[24] Kahn, C.M., Line, S., Aiello, S.E., 2006. The Merck veterinary manual, 9th ed. Merck & Co: Rahway, NJ, USA.

[25] Partridge, G.G., 1989. Nutrition of Farmed Rabbits. Proceedings of the Nutrition Society. 48(1), 93–101. DOI: https://doi.org/10.1079/PNS19890013

[26] Lebas, F., Coudert, P., Rouvier, R., et al., 1997. The Rabbit: Husbandry, Health, and Production (Vol. 21). Food and Agriculture Organization of the United Nations: Rome, Italy. Available from: https://www.fao.org/4/t1690e/t1690e.pdf

[27] National Research Council (NRC), 2007. Nutrient requirements of rabbits, 2nd ed. National Academies Press: Washington, DC, USA.

[28] Soetan, K.O., Olaiya, C.O., Oyewole, O.E., 2010. The importance of mineral elements for humans, animals and plants: A review. African Journal of Food Science.

4(5), 200–222. Available from: https://academicjournals.org/article/article1380713863_Soetan%20et%20al.pdf/1000

[29] Suttle, N. (Ed.), 2010. Mineral Nutrition of Livestock, 4th ed. CABI: London, UK. DOI: https://doi.org/10.1079/9781845934729.0000

[30] McDonald, P., Edwards, R.A., Greenhalgh, J.F.D., et al., 2010. Animal Nutrition, 7th ed. Pearson Education: London, UK.

[31] Raja, S., Murugan, M., Lakshmikantan, U., et al., 2021. Importance of Phosphorus in Animal Nutrition. Indian Farmer. 8(12), 542–549. Available from: https://indianfarmer.net/uploads/S%20Raja%20TANUVAS%20Imp%20of%20Phosphorus%20Manuscript%20(Autosaved).pdf

[32] Ayeni, M.D., Adewumi, M.O., Bello, M.A., AdiAdi, K.F., Osungade, A.A., 2023. Effects of rabbit production on income and livelihood of rural households in Nigeria. Heliyon. 9(8). DOI: https://doi.org/10.1016/j.heliyon.2023.e17145

[33] Nave, R.L.G., 2025. Sustainable Forage Production in Crop–Livestock Systems. Agronomy. 15(3), 657. DOI: https://doi.org/10.3390/agronomy15030657

[34] Castro-Montoya, J.M., Dickhoefer, U., 2020. The Nutritional Value of Tropical Legume Forages Fed to Ruminants as Affected by Their Growth Habit and Fed Form: A Systematic Review. Animal Feed Science and Technology. 269, 114641. DOI: https://doi.org/10.1016/j.anifeedsci.2020.114641

[35] Gidenne, T., Combes, S., Fortun-Lamothe, L., 2012. Feed Intake Limitation Strategies for the Growing Rabbit: Effect on Feeding Behaviour, Welfare, Performance, Digestive Physiology and Health: A Review. Animal. 6(9), 1407–1419. DOI: https://doi.org/10.1017/S1751731112000389

[36] Price, M.L., Van Scoyoc, S., Butler, L.G., 1978. A Critical Evaluation of the Vanillin Reaction as an Assay for Tannin in Sorghum Grain. Journal of Agricultural and Food Chemistry. 26(5), 1214–1218. DOI: https://doi.org/10.1021/jf60219a031

[37] Ingweye, J.N., Barikpe, B., Kalio, G.A., 2024. Nutritional Evaluation of Farmer-identified Grasses as Rabbit Feed. Nigerian Journal of Animal Science and Technology (NJAST). 7(1), 47–59. Available from: https://www.njast.com.ng/index.php/home/article/view/312

[38] Littledike, E.T., Goff, J., 1987. Interactions of Calcium, Phosphorus, Magnesium and Vitamin D that Influence their Status in Domestic Meat Animals. Journal of Animal Science. 65(6), 1727–1743. DOI: https://doi.org/10.2527/jas1987.6561727x

[39] Ojo, V.O.A., Akinade, G.A., Adetukubo, G.A., et al., 2017. Silage quality of Pennisetum Purpureum Schumach. Grass mixed with proceed Entrobium cyclocarpum (Jacq) Griseb. Seeds at varying proportion as affected by ensiling period. Tropical Agriculture. 94(4), 362–371. Available from: https://www.researchgate.net/publication/321212181_Silage_quality_of_Pennisetum_purpureum_Schumach_grass_mixed_with_processed_Enterolobium_cyclocarpum_Jacq_Griseb_seeds_at_varying_proportions_as_affected_by_ensiling_periods

[40] Pinheiro, V., Gidenne, T., 2024. Rabbit Nutrition and Feeding. In: Simões, J., Monteiro, J.M. (Eds.). Veterinary Care of Farm Rabbits. Springer International Publishing: Cham, Switzerland. pp. 201–234. DOI: https://doi.org/10.1007/978-3-031-44542-2_10