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Short communication



Effects of Different Harvesting Ages on Chemical Composition of Five Napier Grass (Pennisetum Purpureum) Varieties

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Abstract

The objective of this study is to determine the effects of the different harvesting ages (45 days, 60 days and 75 days) on the chemical composition of five Napier grass varieties. This research was conducted at Universiti Sultan Zainal Abidin (UniSZA) Farm in Pasir Akar, Besut, Terengganu. The proximate analysis was used to analyze the chemical compositions of moisture, ash, crude fiber, crude protein and fat, while the mineral compositions of magnesium, potassium, aluminium, phosphorus, and calcium were analyzed and measured using the dry ashing method and Induced Couple Plasma Optical Emission Spectrometry (ICP-OES). The findings of this study showed that most chemical compositions of five Napier varieties were decreased ($p < 0.05$) as harvesting age increased. The proximate compositions of all varieties show significantly decreased ($p < 0.05$) as age increased which is the moisture, ash, crude fiber, crude protein, and fat were decreased at age 75 days. Among the five varieties, Dwarf Napier shows the highest of crude protein (25.51%) followed by India Napier (22.44%), Uganda Napier (18.45%), Red Napier (18.26%) and Zanzibar Napier (16.78%), respectively. The mineral compositions of potassium and phosphorus of five varieties were decreased as age harvesting increased. Thus, this study showed that the harvesting ages affect to the chemical composition of the Napier grass and day 45 is the optimum age for harvesting which is providing high nutritive value of animal feed.

Keywords: *Animal feed; harvesting ages; high productivity; Napier grass varieties; nutritive value.*

1. Introduction

An understanding of chemical composition requirement is important to provide diets that appropriately meet the animal's needs, especially for growth and milk production. The chemical compositions such as crude protein, crude fiber, potassium, nitrogen, phosphorus, calcium, and magnesium are the most mineral needed for the animal growth, which can obtained from the animal feed such as a forage [1, 2, 3, 4]. The forage is plant material eaten by livestock, and it continues to constitute the single most important livestock's feed resource in developed and developing countries [5].

A Napier grass or scientifically *Pennisetum purpureum* is the well-known forage used in dairy and feedlot production system due to high yield capability and good nutritive value [3, 4, 6, 7, 8, 9, 10]. The Napier grass is a species of perennial grass which is native to subtropical Africa. It has been fed using a cut and carry system to the livestock. The Napier grass is easy to grow, more adaptable and productive grass which is very suitable for any tropical country conditions [8, 11]. It was introduced to Malaysia in the 1920s and currently used widely as a livestock's feed [3].

Selecting the right forage species is important for cultivation and have to consider the yield, digestibility and chemical composition of the grass. There are several Napier grass varieties such as Indian Napier, Red Napier, Zanzibar Napier, Uganda Napier and Dwarf Napier which are potentially to be main livestock feed. Every variety has different nutritive value, agronomic characteristics and also in the morphology [3, 10]. Other factors such as the maturity of growth stage and soil condition also affect to the nutritive value as well as to the chemical composition [7]. According to Lounglawan et al. [7], a young plant (30-45) days is characterized by their high protein content, ether extract, and ash, while the maturing plant (60 days) has high of crude fiber content. This study also suggested that the cutting interval for the young plant has a high nutrient content compared to the matured plant.

Therefore, this study is conducted to determine and compare the chemical composition of five Napier grass varieties at different harvesting ages. Furthermore, it is essential to recognize the best harvesting age of Napier grass varieties to optimize the nutritive value and chemical compositions. Then, it was hypothesized that harvesting time can affect the nutritive value and chemical composition of Napier grass. In this study, the harvesting ages of Napier were cut at three cutting intervals which are 45 days, 60 days and 75 days respectively.

2. Materials and methods

2.1. Study site

Plant establishment and harvesting were conducted at Universiti Sultan Zainal Abidin Farm in Pasir Akar Besut, Terengganu (5°38'32.05"N, 102°28'25.57"E) and plant chemical analysis were done in Nutrition Laboratory, Faculty of Bioresources and Food

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Industry, Universiti Sultan Zainal Abidin, Besut Campus, Terengganu, Malaysia.

2.2. Source of plant material

The stem cutting of five Napier grass varieties (Red Napier, Dwarf Napier, Zanzibar Napier, India Napier and Uganda Napier) was collected from Inforternak Farm, Sungai Siput, Perak and were transferred to Universiti Sultan Zainal Abidin Farm in Pasir Akar, Besut, Terengganu.

2.3. Plot layout, design and treatment

A 3×5 factorial in a Completely Randomized Design (CRD) was used in this study. The main factors were different harvesting ages (45 days, 60 days and 75 days) and Napier grass varieties (Red Napier, Dwarf Napier, Zanzibar Napier, India Napier and Uganda Napier). Each treatment had three replicates. In all, a total of fifteen (15) plots with each measuring 36 m^2 were used for the planting.

2.4. Land preparation, planting and maintenance

Before planting, the tillage process was conducted to loose and fine the soil for the Napier grass establishment. The plot was plowed and harrowed with a tractor. The stem of five Napier grass varieties was cut with a minimum of three nodes per cutting for planting were planted 15-20 cm deep at angle 30°-40°. Weeding was carried out 40 days after planting.

2.5. Plant harvesting and collection

The plant samples for each variety were harvested at three different harvesting ages (45 days, 60 days and 75 days). The plant samples were selected randomly and were cut using the sickle. Then, the plant samples were placed in the paper bags and were transported to the Nutrition Laboratory at Universiti Sultan Zainal Abidin, Besut Campus. The plant samples were removed from the bag, and the dust was brushed off. Then, the plant samples were rinsed shortly for 15 minutes under the tap water to avoid leaching of chemical elements.

2.6. Plant sample preparation for chemical analysis

The plant's samples were chopped into half-inch pieces using the chopper and dried at 80°C for 12-24 hours, then ground using a homogenous grinder (Waring Blender Laboratory 8010S/8010G) for laboratory analysis.

2.7. Chemical composition analysis

The chemical compositions of crude fiber, crude protein, ash, fat and dry matter were analyzed using the proximate analysis according to AOAC [12] procedure. In determining the dry matter, 200 g of each sample of Napier grass varieties were taken and chopped into short length (2-5 cm). The plant samples were then placed in an oven at 105°C for 6 hours. The weight after drying is the dry matter. The Kjeldahl method was used in determined of crude protein. While, the ash component was determined by igniting 5 gm of Napier grass sample in the muffle furnace at 500°C for 5 hours. The residue after burning in the furnace is the ash. The mineral compositions of aluminium, potassium, magnesium, calcium and phosphorus were determined using the dry ashing method according to AOAC [12] procedures and were analyzed using the ICP-OE Spectrometry.

2.8. Data analysis

Data for every harvesting age for five Napier grass were averaged. The Generalized Linear Model with 2-factor ANOVA was used to compare the mean differences between varieties subjected to the three different harvesting ages.Tukey's LSD was used to test the differences between means. The differences between means were considered significant if $p < 0.05$. The data were analyzed using SPSS version 25.

3. Results and discussion

3.1. Proximate compositions

Table 1 presents the results of proximate composition of Napier grass varieties at different harvesting ages. The different harvesting ages have a significant effect ($p < 0.05$) on the percentage of all the components of the proximate analysis.

Table 1: Mean values of proximate composition of Napier grass varieties.

Parameters (%)	Varieties	Harvesting Ages		
		45 days	60 days	75 days
Moisture	Red Napier	74.78^{b}	87.71^{a}	86.13^{a}
	Zanzibar Napier	88.40^{a}	87.68^{b}	84.49^{c}
	Uganda Napier	92.05^{a}	85.27^{b}	80.76^{c}
	Dwarf Napier	91.17^{a}	88.29^{b}	85.14^{c}
	India Napier	93.84^{a}	86.67^{b}	84.67^{b}
Ash	Red Napier	13.81^{a}	10.37^{a}	10.20^{b}
	Zanzibar Napier	12.23^{a}	7.86^{b}	7.40^{b}
	Uganda Napier	12.02^{a}	8.59^{b}	7.15^{c}
	Dwarf Napier	15.90^{a}	13.42^{b}	10.62^{c}
	India Napier	13.03^{a}	10.55^{b}	9.80^{c}
Crude Protein	Red Napier	18.26^{a}	12.83^{b}	7.28^{c}
	Zanzibar Napier	16.78^{a}	9.12^{b}	5.70^{c}
	Uganda Napier	18.45^{a}	8.78^{b}	6.73^{c}
	Dwarf Napier	25.51^{a}	18.70^{b}	11.50^{c}
	India Napier	22.44^{a}	12.75^{b}	11.17^{c}
Fat	Red Napier	2.67^{a}	3.18^{a}	2.70^{a}
	Zanzibar Napier	3.12^{a}	2.12^{b}	1.91^{b}
	Uganda Napier	2.56^{a}	2.37^{a}	1.69^{b}
	Dwarf Napier	4.06^{a}	3.77^{a}	2.88^{b}
	India Napier	4.41^{a}	3.18^{b}	2.60^{c}
Crude Fiber	Red Napier	26.23^{a}	28.98^{b}	30.01^{c}
	Zanzibar Napier	28.15^{a}	31.28^{a}	34.08^{a}
	Uganda Napier	24.86^{a}	28.77^{ab}	31.24^{c}
	Dwarf Napier	20.12^{a}	22.59^{ab}	25.62^{b}
	India Napier	22.36^{a}	26.99^{b}	29.02^{b}

Note : Means within the same column followed by the different letters differ significantly according to Turkey's test at $p < 0.05$.

The crude fiber percentage of all varieties increased as the age increased which was the highest at 75 days. The results of crude fiber obtained in this study were similar to the findings of Lounglawan et al. [7] which found that the crude fiber was higher at 60 days compared to 45 days and 30 days. Among of the five varieties, Zanzibar Napier has the highest of crude fiber content followed by Uganda Napier, Red Napier, India Napier and Dwarf Napier, which were 34.08%, 31.24%, 30.08%, 29.02% and 25.62%, respectively. Based on previous studies by [13], the intervals between harvests led to the accumulation of fiber and quality reduction due to increase cell wall carbohydrates that increased along maturity which also caused the crude protein to decline [14]. The percentage of crude fiber regarding harvesting ages is the reverse of the protein percentage. The lower percentages of crude fiber in early harvesting ages also mean that the grasses are desirable as an animal feed [15].

In terms of crude protein, it is a vital component to produce a high- quality feed. According to Pinkerton [16], the protein had been used as an indicator of forage quality. In this study, the mean value of crude protein was highest during the 45 days for five Napier grass varieties. The percentages of crude protein were de-

creased with the increasing of ages. The Dwarf Napier has the highest of crude protein content followed by India Napier, Uganda Napier, Red Napier and Zanzibar Napier, which were 25.51%, 22.44%, 18.45%, 18.26%, 16.78%, respectively. There is a significant difference between the mean values of crude protein at level $p < 0.05$.

The high content of crude protein in the Napier grass indicates the rapid growth stages of the grass. This result shows that the protein percentage was decreased along the maturity. The result of this study was similar to the findings of Lounglawan et al. [17], which stated that the crude protein content decreased as the grass age increased. According to Schut [18], the changes in the nutrient composition of plants were influenced by several factors, including climate, season, weather, soil type, and soil fertility.

Ash content is defined as the total inorganic and mineral content in the materials [19]. The findings of this study show that the ash percentage of all varieties were higher in the 45 days which is been decreasing along the maturity. It was similar to the findings of Lounglawan et al. [7] where the ash percentage higher when cutting at 30 days (14.01%) compared to 45 days (11.99%). Among the five varieties, the Dwaft Napier shows the highest percentage of ash content. The grasses have relatively high ash content, and the contents are the true reflection of the ash contained obtained in the grasses [21]. Each Napier varieties showed the highest percentage of moisture content when the grass was harvested at 45 days. The result of moisture analysis of this study was similar to the findings of Lounglawan et al. [7] where the moisture percentage when cutting at days 30 days was higher compared to 45 days which is 88.63% and 82.84%, respectively.

The moisture content represents the amount of water in a material. The India Napier showed the higher moisture content at 45 days followed by Uganda Napier, Dwarf Napier, Zanzibar Napier and Red Napier, which were 93.84%, 92.05%, 91.05%, 88.40% and 74.78%, respectively. Fat is a group of substances that soluble in ether or other organics solvent but insoluble in water [22]. The percentage of fat for each variety was decreased as the harvesting ages increased. The result of this study was similar to the Lounglawan et al. [7] which found that the fat content when cutting at 30 days was higher compared to 45 days and 60 days. Among the five varieties, India Napier shows the higher of the fat percentage which 4.41%.

According to Keba et al. [23], the nutritional quality of the forage is influenced by the management practices and the harvesting ages. Besides, several factors such as climate are also influenced by the quality of the forages [24]. To maximize both yield and nutritional qualities, great care adapts to growing Napier grass. According to Okwori [25], organic matter content of the Napier grass can be enhanced by using the sufficient quantity of fertilizers. This practice can increase the nutritive value of Napier grass as an animal feed.

3.2. Minerals composition

The mineral compositions of Red Napier, Zanzibar Napier, Uganda Napier, Dwarf Napier and India Napier at different harvesting ages were shown in Table 2. The magnesium (Mg) is essential in photosynthesis, as it is the central atom in the chlorophyll molecule. The results of this study show that there is a significant difference ($p < 0.05$) of Mg content among three harvesting ages which for each Napier variety. The Mg content in the Uganda Napier was higher at 75 days compared to 60 days and 45 days, which are 1.12 ppm, 1.10 ppm, and 0.08 ppm, respectively. The findings of this study are similar to the results of Helmut [26] which found that the mineral compositions in plants were decreased along the maturity.

Among the varieties, India Napier shows the higher of the Mg content (1.15 ppm) followed by Dwarf Napier (0.96 ppm), Uganda Napier (0.88 ppm), Zanzibar Napier (0.78 ppm), and Red Napier (0.63 ppm), respectively. The Mg content affected by seasonal factors, temperature, soil pH and cation exchange complex (CEC) [27]. Besides, the Mg is important in livestock as it acts as the cofactor for the most enzyme in the body [26]. The results of this study show that the calcium (Ca) content was increased as the ages increased which highest at age 75 days. There is a significant difference ($p < 0.05$) of calcium content among three harvesting ages for Uganda Napier, Dwarf Napier and India Napier. This results also dissimilar to the findings of Rahman et al. [27] which found that the mineral compositions in plants was decreased along the maturity.

Table 2: Mean values of minerals composition of Napier grass varieties

Parameters (ppm)	Varieties	Harvesting Ages		
		45days	60days	75days
Magnesium	Red Napier	0.63^{a}	0.65^{a}	0.66^{a}
	Zanzibar Napier	0.78^{a}	0.90^{a}	0.63^{a}
	Uganda Napier	0.88^{b}	1.10^{a}	1.12^{a}
	Dwarf Napier	0.96^{b}	0.93^{a}	0.95^{a}
	India Napier	1.15^{b}	1.38^{a}	1.20^{b}
Phosphorus	Red Napier	1.39^{a}	1.2^{a}	0.82^{b}
	Zanzibar Napier	1.40^{a}	1.18^{a}	0.49^{b}
	Uganda Napier	1.18^{a}	1.13^{a}	0.67^{b}
	Dwarf Napier	1.53^{a}	1.23^{b}	0.79^{c}
	India Napier	1.52^{a}	1.54^{a}	0.89^{b}
Potassium	Red Napier	107.33^{a}	60.17^{b}	64.48^{b}
	Zanzibar Napier	96.39^{a}	38.35^{c}	54.16^{b}
	Uganda Napier	87.65^{a}	51.27^{b}	51.86^{b}
	Dwarf Napier	95.29^{a}	81.60^{b}	59.34^{c}
	India Napier	93.33^{a}	50.89^{b}	68.16^{b}
Calcium	Red Napier	0.17^{a}	0.18^{a}	0.18^{a}
	Zanzibar Napier	0.18^{a}	0.22^{a}	0.17^{a}
	Uganda Napier	0.15^{b}	0.17^{b}	0.22^{a}
	Dwarf Napier	0.16^{b}	0.21^{a}	0.21^{a}
	India Napier	0.22^{a}	0.26^{a}	0.26^{a}
Aluminium	Red Napier	0.13^{a}	0.08^{a}	0.09^{a}
	Zanzibar Napier	0.12^{ab}	0.19^{c}	0.06^{a}
	Uganda Napier	0.08^{a}	0.12^{a}	0.08^{a}
	Dwarf Napier	0.25^{b}	0.17^{ab}	0.10^{a}
	India Napier	0.14^{a}	0.16^{a}	0.07^{a}

Note : Samples presented with different alphabetic letters are significantly different ($p < 0.05$).

Among the five varieties, India Napier shows the highest of Ca content which is 22%. According to [28], the Napier grass contained a high Ca content compared to other grasses. Furthermore, calcium is the important mineral needed by the livestock for the body which it supports the skeleton structure and function.

The P element is vital by plants which is for the growth and development. The results of this study show that the P content in the Napier grass was decreased as age increased. The highest of P content was recorded on day 45 and the result of this study was similar with the findings of Lounglawan et al. [7] and Helmut [26]. The India Napier and Dwarf Napier were shown the highest P contents compared to other varieties which were 1.53 ppm and 1.52 ppm, respectively. The P element also involved in controlling keys enzyme reactions and in metabolic pathway regulation [29]. The high content of P element in Napier grasses will subsequently supply adequate amount of Mg that is needed by livestock as Mg is involved in many biochemical processes of livestocks such as activation of phosphates and participation in carbohydrate metabolism [1].

Potassium (K) plays a crucial role in plant growth and metabolism. It contributes greatly to plant survivability that is under various biotic and abiotic stresses [30]. The results of this study showed that the K content decreased as age increased. The K element is essential for structural development of the cell wall and membrane of the plant [31]. In addition, the potassium (K) is the most a abundant mineral element in the animal body which needed for proper muscle development [32]. The amount of net energy that is available affected the level of animal production, but the maximum performance only can be achieved when sufficient nutrient and mineral are provided.

4. Conclusion

This study has shown that the different harvesting ages have marked effect on the chemical compositions of the Napier grass varieties. The proximate analysis result showed that at the age increased, the crude fiber percentage increased, whereas moisture content, ash, crude protein and ether extract all showed a decreased. The mineral composition of K and P of five varieties was decreased as age harvesting increased. The results also showed the most chemical compositions were the highest at the early stage which is at 45 days. Therefore, the best harvesting age of Napier grass was the 45 days, which provide the highest nutrition for the animals's need.

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