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Comparative Study on Nutritional Quality of Napier Grass (*Pennisetum Purpureum*) Cultivars

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Napier grass or elephant grass (*Pennisetum purpureum* Schum.) shows great potential as ruminant fodder due to consisting of the high potential of dry-matter-yield. There are several Napier grass cultivars has been introduced as a ruminant fodder such as Dwarf, Zanzibar and Uganda Napier. Still, yet no studies show which is the best of Napier grass in term of high nutritive quality. Thus, the objectives of this study were to measure the nutritional quality in Napier grass cultivars (Dwarf, India, Red, Uganda, and Zanzibar Napier) through proximate analysis and mineral analysis and to determine the best part in the selected superior Napier grass cultivar in terms of crude protein. Three different parts of selected superior Napier grass were selected, which were Napier Grass Leaf (NGL), Napier Grass Stem (NGS) and Napier Grass Total (NGT; leaf and stem). The proximate analysis was measured by the nutritional components of moisture, ash, crude protein (CP), fat, and crude fibre (CF). The mineral analysis was measured for calcium (Ca) and cuprum (Cu) contents through Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) standard methods. The results showed that the Dwarf Napier had the highest overall nutritional quality of moisture, ash, CP, and fat compared to the other cultivars mainly because it is leafier than others and it was significantly different ($p < 0.05$). Meanwhile, there were no significantly different ($p > 0.05$) of Napier cultivars in both analyzed of mineral composition as the sample was taken from a single site. Based on the results obtained, Dwarf Napier was selected as a superior cultivar in terms of CP. The best part of Dwarf Napier shows NGL the most nutritious attributes as higher CP content compared to NGS and NGT.

Keywords: Nutritional quality, Napier cultivars, ruminant, proximate analysis, mineral composition

INTRODUCTION

In the tropical region, poor-quality of natural pastures and supply limitation of the animal feed resources, especially during the dry season are the main problems to the smallholder. Fodder conservation seems to be an option to ensure feed availability during periods of feed limitation (Gitau et al. 1994). Therefore, the conservation forages to feed the ruminants has become a principal feeding approach, since it could be made available all over the year. Besides, the nutritive values of the feed would be more compatible for daily feeding.

The common forage eaten by ruminant includes Napier grass (*Pennisetum purpureum*) or also known as Elephant grass. According to Halim et al. (2013), the Napier grass has been used widely as a fodder grass in dairy and feedlot production system in Malaysia. Various Napier grass cultivars such as Dwarf Napier, Uganda Napier, Zanzibar Napier, Red Napier and India Napier have been introduced. The differences among the cultivars could be differentiated according to the difference morphology characters (Chakaredza et al. 2007, Muia et al. 2001, Tassema et al. 2004). Zewdu, (2005) reported that morphological and agronomic characters could be a principal for classifying the various Napier grass cultivars.

This information very important to make a recommendation to the smallholder for selection of Napier cultivars. The smallholder has to make sure that the forage eaten by their livestock has enough nutritive value, especially in protein content which is needed by the ruminant. At the present, smallholder is preferred to use the Napier grass for their livestock feeding due to high productivity and high of nutritive values (Ansah et al., 2010; Halim et al., 2013).

Considering these points of view, this study has been made to access the superior Napier grass cultivar information in terms of highly potential Napier grass as green fresh fodder dry matter yield along with optimum nutritional quality ultimately.

The plant samples were used are Dwarf Napier, India Napier, Red Napier, Uganda Napier, and Zanzibar Napier. Then, the experiment underwent into different parts by which Napier grass leaf (NGL), Napier grass stem (NGS), and Napier grass total, NGT (stem and leaf).

MATERIALS AND METHODS

Plant samples collection

The established of Napier grass (*Pennisetum purpureum)* with five different cultivars (Dwarf Napier, India Napier, Red Napier, Uganda Napier, and Zanzibar Napier) as shown in Figure 1 were harvested manually using a sickle at Universiti Sultan Zainal Abidin's (UniSZA) Pasir Akar Farm (5˚38'56''N, 102˚28'19''E), Jerteh, Terengganu, Malaysia.

The samples with age 45 days were selected randomly with 3 replications by quadrates (1x1 m^2) and measured by 1 m height as standard. The plant samples were chopped into smaller pieces (2-5 cm) using the chopping machine. Then, the plant samples were placed into plastic bags and transferred to the Plant Physiology Laboratory of University Sultan Zainal Abidin (UniSZA), Besut Campus for providing materials for this study.

Plant sample preparation for nutrient analysis

The plant samples were removed from plastic bags and washed with deionized water to remove soil and dust particles. The samples were washed and rinsed for about 15 seconds to avoid the danger of nutrients leaching from the tissue (Kalra, 1998). Then, samples stored refrigerated under 4 ℃ for one week (Jones et al. 1991).

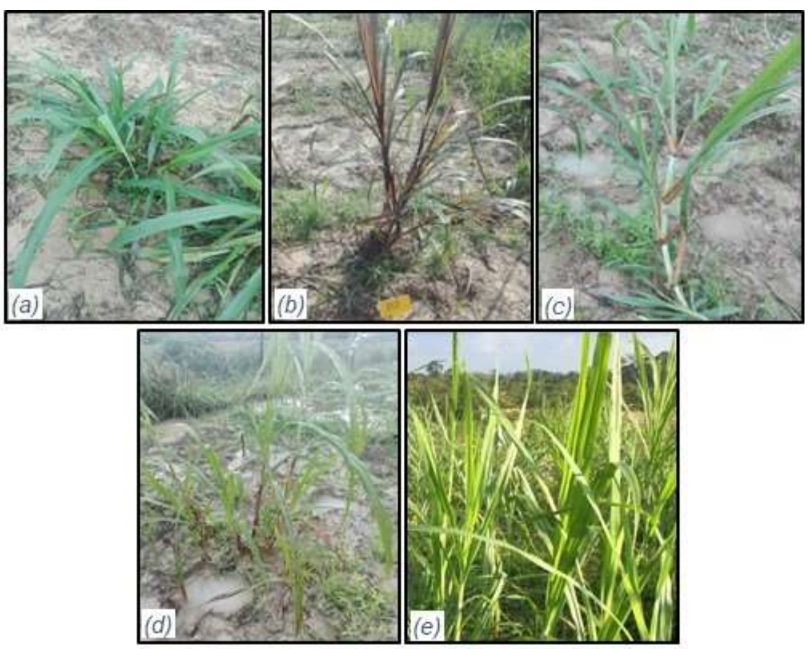


Figure1: Napier grass cultivars of (a) Dwarf Napier, (b) India Napier, (c) Red Napier, (d) Uganda Napier, (e) Zanzibar Napier

Plant chemical composition

The homogenized ground samples were used to determine the chemical composition of the grass. The chemical compositions of dry matter, CP, CF, fat, and ash were analyzed using the proximate analysis according to AOAC (1990) procedure. In determining the dry matter, 5 gm of the Napier grass sample was taken and chopped into short length (2-5 cm). The plant samples were then placed in an oven at 105 °C for 6 h (AOAC, 1990). The weight after drying is the dry matter.

The CP content (N × 6.25) was determined after digestion in sulfuric acid by the Kjeldahl method using Kjeltec™ methods (FOSS™). CF was measured after being treated with boiling dilute sulfuric acid and boiling sodium hydroxide solution using Fibertec™ methods (FOSS™). The ash component was determined by igniting 5 gm of Napier grass sample in a muffle furnace at 550 °C for overnight (AOAC, 1990). The debris after burning in the furnace is the ash.

The mineral compositions of Ca and Cu were determined using the dry ashing method according to AOAC (1990) procedures and were analyzed using the Inductively Coupled Plasma Optical Emission Spectrometry (ICPOES) according to USEPA (1996).

Data analysis

All the data were analyzed using statistics of One-Way Analysis of Variance (ANOVA) to compare the nutritional quality of Napier grass in different cultivars by apply the Minitab version 18 statistical software. The p value ($p < 0.05$) is considered a significant difference.

RESULTS AND DISCUSSION

Proximate composition

The Analysis of Variance (ANOVA) for proximate composition indicated significant differences ($p < 0.05$) among five different Napier grass cultivars (Dwarf Napier, India Napier, Red Napier, Uganda Napier, and Zanzibar Napier) which are shown in the Table 1 and Figure 2.

Table 1: Proximate compositions of five different Napier grass cultivars.

Proximate Composition	Napier Cultivars Mean ± Standard Error Mean (SEM)				
	Dwarf	India	Red	Uganda	Zanzibar
Moisture (%)	86.37± 0.09	82.03± 0.59	79.00^{c}± 0.95	80.28^{bc}± 0.79	81.05^{bc}± 0.11
Dry Matter (%)	13.63^{c}± 0.09	17.97^{b}± 0.59	21.00^{a}± 0.95	19.72^{ab}± 0.79	18.95^{ab}± 0.11
Ash (%)	7.78^{a}± 0.04	7.30^{b}± 0.04	6.59^{c}± 0.04	5.72^{e}± 0.07	6.29^{d}± 0.10
Crude Protein (%)	9.82^{a}± 0.06	9.43^{b}± 0.05	9.68^{ab}± 0.10	8.97^{c}± 0.02	8.67^{d}± 0.01
Fat (%)	2.85^{a}± 0.09	0.46^{d}± 0.03	2.03^{b}± 0.15	0.90^{cd}± 0.12	1.05^{c}± 0.12
Crude Fibre (%)	26.74^{c}± 0.72	30.92^{b}± 0.31	32.54^{b}± 0.94	33.98^{ab}± 0.13	35.73^{a}± 0.92
Nitrogen Free Extract (%)	52.8^{a}± 0.58	51.88^{b}± 0.37	49.16^{bc}±0.91	50.43^{bc}± 0.19	48.24^{c}± 0.92

Different letters in superscript (^{abcde}) within the same row indicate a significant difference ($p<0.05$) among Napier grass cultivars

Meanwhile, there are no significant differences ($p > 0.05$) for the mineral composition (Figure 3). The direct segregation of the cultivars into two distinct groups, where four cultivars grouped as tall type (> 130 cm) cultivars (India Napier, Red Napier, Uganda Napier, and Zanzibar Grass) and a short types cultivar (< 90 cm) (Dwarf Napier) (Halim et al. 2013). According to Rodrigues et al. (1986) the length of internodes could differentiate the height of Napier cultivars and the differentiation of cells apical meristems could differentiate the pattern of internodes.

There were significant differences among the five cultivars of Napier grass in their nutritional quality parameters ($p < 0.05$) (Table 1). However, there're non-significant difference among the four tall cultivars of Napier grass (India Napier, Red Napier, Uganda Napier, and

Zanzibar Napier) either in terms of nutritive quality. In this study, the nutritional quality of Napier grass is essential as they influence the production of ruminant livestock. Schut et al. (2010) proved that determining the nutritive value of grass forage was crucial in livestock nutrition, related to effective livestock production.

The moisture content indicated had significant differences ($p < 0.05$) through the mean value of Dwarf Napier grass showed as the highest value, 86.37 % compared to other tall cultivars which are India Napier 82.03 %, Zanzibar Napier 81.05 %, Uganda Napier 80.28% and Red Napier 79.00%, respectively as shown in Table 1. The result of moisture analysis obtained from this study, nearly similar to the findings by Halim et al. (2013) which is 86.25 %, as the moisture content represents the index quantity of water contained in the plants and significantly being used as a scientific parameter (Frazier et al. 1978).

Meanwhile, the mean value of ash for the Napier grass cultivars show there were significant differences ($p < 0.05$). The mean value of ash for Dwarf Napier was higher (7.78 %) compared to other tall cultivars as shown in the Table 1. Ash is considered as the total mineral or inorganic content of the samples. According to McClements and Decker (2009), the ash content represents the mineral contents consisting of the plant's body, therefore, the determination for ash analysis is vital for assessment of nutrient labelling, material quality, microbiology stability, and food processing standard operational procedure.

Furthermore, protein is a nitrogen derivation involves in ruminant physiological growth and development include muscle growth, milk protein yields, boost the disease resistance, reproductive system, and implemented for body functional maintenance (Solaiman, 2006). Previous study described that the range of protein content of Napier grass should vary from 4.4 % to 20.4 % with the value of mean around 12 % (Rusdy, 2016). From the results obtained showed, there were significant differences ($p < 0.05$) as crude protein (CP) content was higher in the Dwarf Napier compared to the taller cultivars with 9.82 % while all the tall varieties showed low crude protein content which are Red Napier 9.68 %, India Napier 9.43 %, Uganda Napier 8.97% and Zanzibar Napier 8.67 %, respectively as shown in the Table 1.

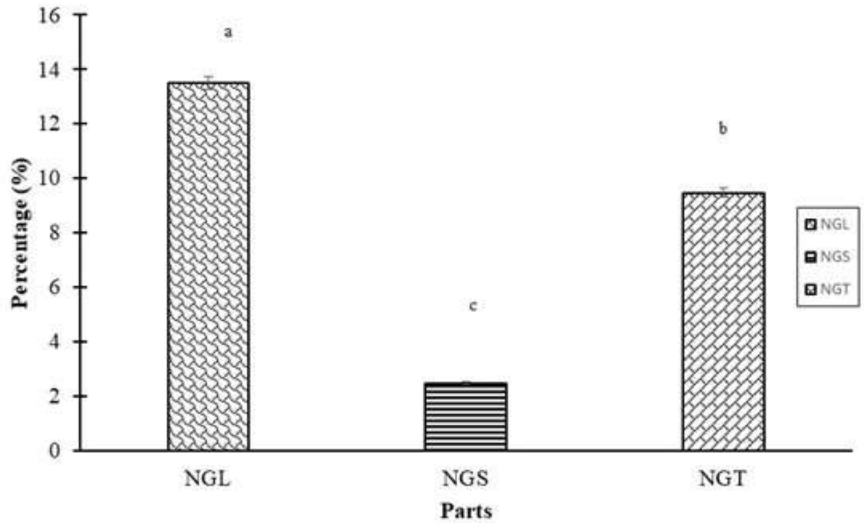
The taller cultivars contributed to have a higher of dry matter yield compared to the short cultivar but the latter was higher in nutritive value. The leafier structure of short cultivar contributed to high nutritive value than tall cultivars (Ansah et al. 2010). Nevertheless, a short type had a lower dry matter yield (DMY) compared to tall cultivars. This was influenced by the major leaf fraction presence in Dwarf Napier than the others (Zailan et al. 2016). In spite of quality changes, the CP content obtained was above the critical level (> 7 % CP) which is necessary for voluntary ruminants feed intake in sustaining the rumen microflora (Minson, 1990, Nori et al. 2009, Rusdy, 2016).

Moreover, the ether extract (EE) or fat content among the cultivars show there were significant differences ($p < 0.05$) although in low amount, by the high fat content was dominated by Dwarf Napier than the tall cultivars as shown in the Table 1. It is vital in a low level of fat content for proper rumen feeding in order to avoid off-feed problems (Grant et al. 2007).

Besides, the relative value of crude fibre (CF) indicates the fraction commonly used in evaluating the carbohydrate content of ruminant feeds. Carbohydrate supplied most of the energy required by ruminant as it makes up 65 % to 75 % of the dry weight of most forage (Guyer et al. 1997).

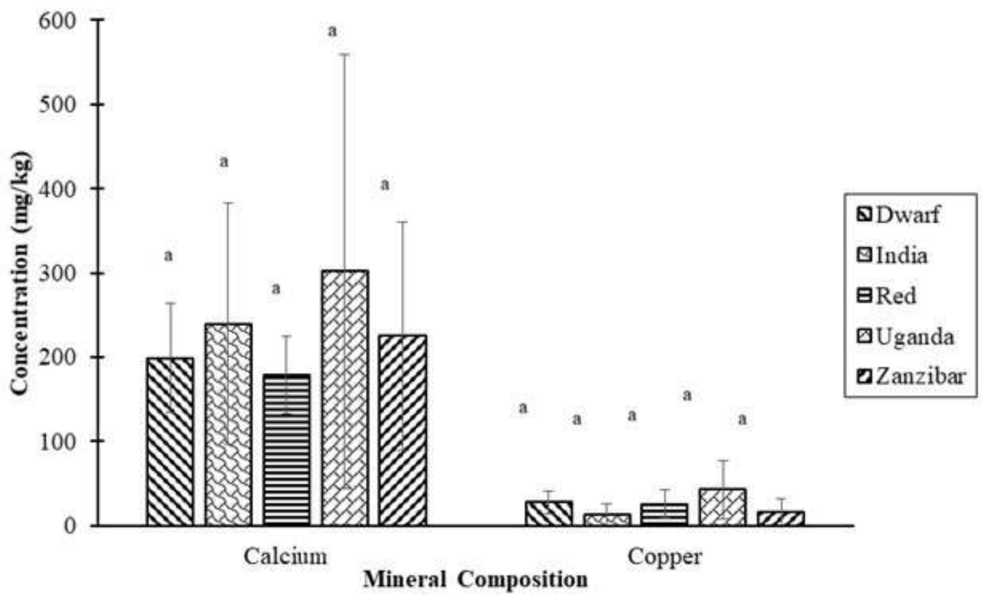
Generally, fibre consisting of hemicelluloses, lignin, oligosaccharides, pectin, gums, and waxes (Thapar, 2011). Crude fibre is a dietary fundamental to ruminant digestion system (Thapar, 2011), thus, affect the body weight of ruminant as livestock production (Hsu et al. 1991). Roughly, gained result shows the crude fibre content of grass tends to vary between tall and short cultivars, although not many differences among the tall cultivars, though its related to the digestibility of roughages and therefore is of some useful value.

Table 1 shows that Zanzibar Napier had a highest of crude fibre (CF) content and Dwarf Napier had the lowest CF content, which is 35.73 % and 26.74 % respectively, compared to the other Napier cultivars. There were significant differences ($p < 0.05$) of CF content for all compared cultivars of Napier. The Zanzibar Napier was more superior in terms of crude fibre due to high morphological lignification as reported by Haryani et al. (2018).



Notes: Error Bars (± SE).
Samples presented with different alphabetic letters are significantly different (*p<0.05*).

Figure 2: Proximate composition (%) of Napier Grass Leaf (NGL), Napier Grass Stem (NGS), Napier Grass Total (NGT) of Dwarf Napier.



Notes: Error Bars (± SE).
Figure 3: Mineral compositions (mg/kg) of different Napier grass cultivars

Determination of proximate composition in crude protein (CP) of Napier Grass Leaf (NGL), Napier Grass Stem (NGS), and Napier Grass Total (NGT) as indicated the combination of leaf and stem has also been carried out from the selected superior cultivar in terms of CP from the result of Table 1 which was Dwarf Napier to correlate nutrient uptake by plants fraction, thus, represented in Figure 2.

Dwarf Napier was morphologically leafier cultivar where the leaf fraction was approximately 4 times heavier than the stem fraction (Zailan et al. 2016). As expected, the short internodes of the Dwarf cultivars recorded higher crude protein percentage (9.82 %) compared to the other tall cultivars (Table 1).

The determination of crude protein being selected among all of the analysis in proximate composition due to CP is the most essential component in animal nutrition. This component is often the critical limiting factor to animal production. As the present study, the CP in the grass was stressed out as the component which was very important for a high-quality diet feed. According to Pinkerton (2005), crude protein is often used as indicators of forage quality.

Figure 2 shows there were significant differences ($p < 0.05$) among the analyst Dwarf Napier's fractions of Napier Grass Leaf (NGL), Napier Grass Stem (NGS), and Napier Grass Total (NGT), within 13.49 %, 2.49 %, and 9.46 %, respectively. The high crude protein (CP) percentage in Dwarf Napier's NGL fraction had been recorded in Figure 2 means that digestibility was higher in NGL compared to NGS and NGT.

This has significant assumption on the nutritive quality of the grass as the leaves contain higher levels of nutrients and less fibre than stems as described by Zewdu (2005) also found the highest result was from the short cultivar of Napier. Dwarf Napier has higher Leaf-Stem-Ratio and the leafier swards make the whole-plant nutritive quality better than the tall varieties that are stemmier (Halim et al. 2013).

Apart from proximate composition, mineral composition is also necessary for proper ruminant physiologically growth and development. The contents of inorganic elements are very important in the plants (White and Broadley, 2009). It is required for numerous plant growth processes (Cakmak, 2013).

Results in Figure 3 shows there were no significantly different ($p > 0.05$) for both calcium (Ca) and copper (Cu) contents among the compared Napier cultivars. This indicates that the plant samples taken from the same site will contain similar mineral composition in the plant body encouraged by the diffusion rate in between of the soil-plant relation. The calcium element being selected to be analyzed as it is the most essential component of plant macro-element, while, the copper element was chosen to be analyzed as it is the most essential of the plant micro-element.

Calcium is a vital component in the ruminant diet as it is required to be supplemented in the daily feeds in rate of 0.65 % to 4.0 % for the developments of skeleton structure of which made up till 99 % contents, especially bone and tooth, instead, a deficiency of the element may contribute to poor milk production or even worse as death as they exposed towards milk fever (Yusoff, 2010). Meantime, copper is crucial micro-element for ruminant's body functional maintenance, but in a small amount of 5.0 part per million (ppm) or the ruminant may infect with diarrhea, osteoporosis, and loss in body weight that will contribute to low livestock production (Yusoff, 2010).

Level of mineral compounds changes in response towards biotic and abiotic factors as one factor is the soil mineral composition. Apart from genetics, the mineral compositions of forages are influenced by soil nutrition factors (Tessema et al. 2011). Therefore, the application of some fertilizers may enhance the availability of organic matter contents in particular soil mineral composition and subsequently reinforce Napier grass's nutritive value as ruminant feeds (Okwori et al. 2010).

Therefore, great care should be taken to determine the optimum time and height of maturity when planning to harvest even graze Napier grass in order to maximize the herbage yield also both chemical and mineral compositions. Despite many favorable characteristics, Napier grass is naturally considered to be of inferior nutritional quality depends on management, particularly in terms of metabolizable energy, digestion kinetics and percentage of crude protein, also, the palatability for ruminant consumption when compared to other available forage crops (Halim et al. 2013).

Based on the correlation coefficients between agronomic and nutritional quality results, it can be condensed that tall cultivars had a higher dry matter yield, but less tillering and were less leafy than shorter cultivar, thus, tall cultivars out yielded the short cultivar but this was at the expense of nutritional quality (Halim et al. 2013).

Therefore, nutritional quality influenced by the agricultural management practices, but on average, Napier grass consists of 9 % crude protein, 20 % dry matter and 9 % ash (Islam et al. 2003). In general, the highest nutritional requirements are for lactation, followed by growth and body functional maintenance (Little, 1982, Norton, 1982).

CONCLUSION

This study has shown that the selection of suitable cultivars has a marked effect on the chemical compositions of Napier grass. The proximate analysis result showed that Dwarf Napier as superior cultivars along with the leaf fraction as the highest nutritional quality. The mineral analysis showed no differences in those analyzed calcium and copper contents among the cultivars. The Dwarf Napier cultivar could be recommended forage for dairy production due to high crude protein composition compared to the other Napier cultivars.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest

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AUTHOR CONTRIBUTIONS

Nurul Aini Kamaruddin and Muhammad Syawal Kamaruddin were involved in the field sampling, lab analysis and manuscript preparation. Normala Ahmad and Noor Zubaidah Abdul Rahman were involved in the field sampling and lab analysis.

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