Pertanika J. Trop. Agric. Sci. 44 (3): 685 - 695 (2021)

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Effects of Cutting Process and Drying Period using Sunlight on Hay Quality of Dwarf Napier Grass (*Pennisetum purpureum*) and *Asystasia gangetica*

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ABSTRACT

This study aims to determine the effect of the cutting process and drying period using sunlight on the hay quality of dwarf Napier grass (*Pennisetum purpureum*) and *Asystasia gangetica*. Hay quality of both species was evaluated in a completely randomised design corresponding to five drying periods (one to five days), with or without cutting process, with three replicates. Both plants were harvested at a vegetative stage and then divided into two portions: unchopped and chopped. Plants were dried using sunlight for the respective drying period, and hay quality was examined in physical and chemical analyses. Each sample was analysed for dry matter (DM) content. The *A. gangetica* at four days drying period and Napier grass at five days drying period were selected for chemical analysis. Results showed that the physical characteristics of hays for both plants were not affected by the drying periods and cutting process. *Asystasia gangetica* achieved higher DM content than Napier grass for almost all drying periods. For Napier grass, the three days were drying periods that achieved the desirable DM content (> 85.0%), while two days were drying periods for *A. gangetica*. Napier grass contained higher crude fibre and ether extract contents than *A. gangetica*, while crude protein content appeared *vice versa*. The nutritive values of both plants were not affected by the cutting process. In conclusion, Napier grass's three days drying

ARTICLE INFO

Article history:
Received: 24 June 2021
Accepted: 19 July 2021
Published: 20 August 2021

DOI: https://doi.org/10.47836/pjtas.44.3.11

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ISSN: 1511-3701
e-ISSN: 2231-8542

periods and a two days drying period of *A. gangetica* can achieve the desirable DM content under sunny conditions.

Keywords: *Asystasia gangetica*, drying period, dwarf Napier grass, hay quality, *Pennisetum purpureum*, sunlight

INTRODUCTION

There are many tropical and sub-tropical forage grasses in the country, some examples being Napier grass (*Penniseutm puprpureum*), Guinea grass (*Panicum maximum*), and setaria (*Setaria sphacelata*). Therefore, it is possible to get a surplus amount of biomass during the rainy season, which farmers cannot finish by supplying to their animals. Moreover, farmers cannot keep the grasses in their fields for a long time because the nutritive quality of plants deteriorates with the advancement of maturity (Shewfelt, 1990). In this circumstance, it is better to preserve their surplus production as silage or hay. Moreover, by preserving the surplus amount of grass, farmers can use the preserved grass for feeding their animals during dry periods or feed scarcity (Tripathi, 1995).

Napier grass is gaining popularity among farmers among the forage grasses because of its high dry matter (DM) yield, moderate nutritive value, ease of propagation, drought tolerance, and low management. Napier grass has two main varieties: tall and dwarf. Halim et al. (2013) reported that tall Napier grass varieties showed higher DM yield and lower nutritive value than dwarf varieties. Due to the lower leaf-stem ratio in tall varieties compared to dwarf varieties, farmers preserve them as silage. Therefore, it is not considered to preserve it by making hay. However, dwarf varieties of Napier grass show a high leaf-stem ratio and may be preserved as hay.

Since there is a longer duration of sunlight in Malaysia, it is possible to make hay using natural sunlight. However, for silage it takes more time, labour, and equipment than haymaking. Hay quality can significantly differ even within one species grown in the same locality. The variation occurs primarily because of an absence of understanding of good haymaking fundamentals and the tendency of farmers to offer less attention to hay crops than to soybeans, corn, small grains, and other crops. Farmers can cut their feed-spending cost by making their hay with good-quality hay rather than buy poor-quality hay from the supplier. Higher quality hay can provide essential nutrients that forage cannot supply because it contains high nutritive content, including crude protein (CP) and digestible energy. The objective of this study was to investigate the effects of ‘cutting into pieces’ and ‘drying period using sunlight’ on physical characteristics and nutritive quality of dwarf Napier grass and *A. gangetica* hay.

MATERIALS AND METHODS

Plant Materials and Sample Preparation

Dwarf Napier grass at about two months of plant maturity was collected from Susu Kambing Mache Klate, Machang, Kelantan. In contrast, *Asystasia gangetica* was collected at the vegetative stage from Agro Techno Park, Universiti Malaysia Kelantan, Jeli Campus, Kelantan. About half of the grasses for each species of plants were cut manually into two, termed as chopped. The remaining grasses for each species of plant were termed as unchopped. Dwarf Napier grass and *A. gangetica* were evaluated for hay quality. Treatments consisted of five drying periods: one day, two days, three days, four days, and five days. Each drying period was evaluated with unchopped and chopped plant materials. A completely randomised design with three replications was adopted. Based on a good weather forecast, about 1.0 kg grass for each replication was dried on a plastic sheet (1 m × 1 m) under the sun for respective treatment. The drying period consisted of eight hours in one day, from 9:00 a.m. to 5:00 p.m. The grass was turned over at 1:00 p.m. daily to speed up the drying process. The maximum, minimum and average temperatures during October 2020 were 30.6°C, 24.0°C, and 27.3°C, respectively, while the average rainfall and humidity were 323 mm and 90%, respectively.

Physical and Chemical Analyses

Physical analysis was performed by evaluating the hays of dwarf Napier grass and *A. gangetica* on the following: stage of maturity, leafiness, colour, odour and conditions, and foreign materials, as shown in Table 1. The percentage of leaves (old and brown) was observed by visual inspection, and the score was given (Table 1). Samples of all hays were analysed for DM following the Association of Official Analytical Chemists (AOAC) (2000). However, samples of *A. gangetica* at four days drying period and Napier grass at five days drying period were analysed for determination of CP, crude fibre (CF), ether extract (EE), and ash contents following the method of AOAC (2000).

Table 1
Standard scores for measuring the physical quality of hay (Vough, 2000)

	Characteristics	Score
Maturity		
i)	0-5% of leaves are old and brown	27-30
ii)	6-15% of leaves are old and brown	22-26
iii)	16-30% of leaves are old and brown	17-21
iv)	>30% of leaves are old and brown	11-16

Table 1 *(Continued)*

	Characteristics	Score
Leafiness		
i)	Very leafy	17-20
ii)	Leafy	12-16
iii)	Few leaves	7-11
iv)	Not leafy	1-6
Colour		
i)	The bright green colour of the crop	15-20
ii)	Golden yellow to yellow hays 5-15	5-15
iii)	Brown or black	0-5
Odour and conditions		
i)	The smell of new-mown hay	15-20
ii)	Musty or off-odours	5-15
iii)	Dusty	0-5
Foreign materials		
Hay with non-harmful foreign material should receive a lower score than that without. Hay with harmful foreign material should not be fed to animals.		1-10

Statistical Analysis

The results for different drying periods were subjected to analysis of variance. Differences among means were tested using Duncan Multiple Range Test (DMRT) or *F* test, with significance at $p<0.05$, by Statistical Package for the Social Sciences (SPSS) software (Version 22.0). In addition, the student's *t*-test was used to compare the means between two groups (Napier grass *vs* *A. gangetica* and unchopped *vs* chopped) at $p<0.05$.

RESULTS AND DISCUSSION

Physical Characteristics

Maturity was observed at the time when the grass was being harvested. Table 2 shows that scores for maturity were above 22 among all the treatments, which indicated that 6% to 15% of leaves from the collected samples were old and brown. Leafiness plays a critical role in getting high-quality hay because more vitamins and minerals can be found in the leaves. As shown in Table 2, the leafiness score for each treatment was more than 11.0%, which indicated that both experimental plants represented leafy characters. Leafiness percentage can be lost due to improper handling and leaves becoming too dry (thus causing them to fall off from the stem). The low percentage of leafiness in hay reduces feed value (Vough, 2000).

Table 2
Scores (mean ± standard deviation) for physical characteristics for dwarf Napier grass and Asystasia gangetica *hays regardless of drying periods*

Characteristics	Dwarf Napier grass		*Asystasia gangetica*		*p*-value
	Unchopped	Chopped	Unchopped	Chopped	
Maturity	24.2 ± 0.84	25 ± 1.0	23.8 ± 0.45	24.8 ± 0.84	0.113
Leafiness	16.0 ± 1.87	15.4 ± 2.07	16.2 ± 2.05	15.2 ± 2.05	0.839
Colour	16.6 ± 1.82	16.2 ± 2.39	16.6 ± 1.82	16.6 ± 2.41	0.987
Odour and conditions	16.0 ± 1.87	16.8 ± 1.92	16.2 ± 1.92	16.8 ± 1.92	0.872
Foreign materials	10.0 ± 0.00	10.0 ± 0.00	10.0 ± 0.00	10.0 ± 0.00	1.000

The most favourable colour in haymaking is bright green. However, the colour of hay is not the decisive factor in deciding the quality of hay because it cannot honestly decide its nutritive value (Rocateli & Zhang, 2017). Slight discolourations from sun bleaching, dew, or moderate fermentation are not as severe as the loss of green colour from maturity, rain damage, and excessive fermentation or heating. Colour was not significantly different (p>0.05) among the treatments (Table 2). The smell of hay plays a vital role in acceptance as feed by animals since the smell acts as an appetiser before eating. The smell of new-mown hay indicates high-quality hay, while hay emitting off-odours indicates low-quality hay (Rocateli & Zhang, 2017). There were no differences in odour scores among the treatments. Foreign materials can be easily observed in hay because the different materials from the hay are apparent (Rocateli & Zhang, 2017; Vough, 2000). There are two types of foreign materials: injurious and non-injurious materials. Non-injurious materials are usually not harmful to animals because they are usually waste from the surroundings attached to the hay. Meanwhile, harmful materials are dangerous to animals because they can injure them and, in the worst case, cause death. Based on Table 2, the scores for the foreign materials were all ten among the treatments, which indicate that there were no foreign materials in the hay of this study. This condition is probably caused because the study used a low quantity of hay.

Chemical Composition

Dry Matter. Dry matter content is crucial in haymaking. It is an essential factor in the long-term preservation of hay, which avoids the undesirable growth of fungus and mould. Typically, hay should contain at least 85% DM (Lemus, 2020). Table 3 shows that the DM contents of Napier grass and *A. gangetica* were significantly (p<0.05) affected by drying periods irrespective of whether they are chopped or not. *Asystasia gangetica* achieved significantly higher DM content than dwarf Napier grass for each drying period (except at day three). The highest DM value of Napier grass (87.3%) was recorded on day five, while the lowest DM value (67.7%) was recorded on day one. Although Napier grass hay on days two and three did not achieve the desired DM content, Napier grass hay achieved the desired DM content on days three, four, and five, which was 86.5% or more. Results indicated that it is possible to make hay from dwarf Napier grass within three days, whether chopped or not if dwarf Napier grass is dried using the scorching heat usually found in Malaysia. The DM contents of dwarf Napier grass hay that was dried for three to five days are in line with the findings of Mapato and Wanapat (2018). They reported that dwarf Napier grass contained 85.7% DM that was dried for three to five days by sun-drying.

Table 3

Differences of dry matter content (%) (mean ± standard deviation) in dwarf Napier grass and Asystasia gangetica *hays (irrespective of whether they are chopped or not)*

Drying period	Dwarf Napier grass	*Asystasia gangetica*	*p*-value
One day	67.7 ± 11.3^{aA}	79.8 ± 3.5^{bA}	0.015
Two days	82.4 ± 3.1^{aB}	92.5 ± 2.0^{bC}	0.000
Three days	87.2 ± 1.9^{B}	86.4 ± 0.8^{B}	0.157
Four days	86.5 ± 1.3^{aB}	91.1 ± 0.3^{bC}	0.000
Five days	87.3 ± 1.3^{aB}	83.9 ± 1.5^{bB}	0.001
Overall	82.2 ± 9.1^{a}	86.7 ± 5.1^{b}	0.010
p-value	0.000	0.000	

Note. Means within rows followed by different lower case letters and within columns followed by different upper case letters differ ($p<0.05$)

As shown in Table 4 (irrespective of the species), the DM content was not affected by each drying period between unchopped and chopped hays. As expected, for both unchopped and chopped hays, the DM content of hay at a one day drying period was significantly lower DM than the other drying periods. However, the DM values were not affected by each drying period (except at two days) between unchopped and chopped hays of Napier grass (Table 5). At two days drying period, chopped hay achieved significantly ($p<0.05$) lower DM content (79.6 vs 85.3%) than the unchopped hay, respectively. It is also shown that unchopped hay of Napier grass achieved the desired DM content (85% or more) at a minimum of two days drying period. In contrast, it was achieved at three days drying period for chopped hay of Napier grass.

Table 4

Differences of dry matter content (%) (mean ± standard deviation) in unchopped and chopped hays (irrespective of the species)

Drying period	Unchopped	Chopped	*p*-value
One day	70.3 ± 13.5^{A}	77.2 ± 4.1^{A}	0.128
Two days	89.1 ± 4.3^{B}	85.8 ± 7.0^{B}	0.175
Three days	87.0 ± 1.0^{B}	86.6 ± 1.9^{B}	0.335
Four days	88.8 ± 2.3^{B}	88.7 ± 3.0^{B}	0.474
Five days	85.5 ± 3.0^{B}	85.7 ± 1.4^{B}	0.456
Overall	84.1 ± 9.4	84.8 ± 5.5	0.371
p-value	0.000	0.001	

Note. Means within columns followed by different upper case letters differ ($p<0.05$)

Table 5

Differences of dry matter content (%) (mean ± standard deviation) in unchopped and chopped hays of dwarf Napier grass

Drying period	Unchopped	Chopped	*p*-value
One day	61.1 ± 13.6^{A}	74.3 ± 1.7^{A}	0.085
Two days	85.3 ± 0.9^{bB}	79.6 ± 0.3^{aB}	0.000
Three days	87.7 ± 0.6^{B}	86.8 ± 2.9^{C}	0.317
Four days	86.8 ± 1.1^{B}	86.1 ± 1.6^{C}	0.270
Five days	87.7 ± 1.6^{B}	86.8 ± 0.9^{C}	0.216
Overall	81.7 ± 11.9	82.7 ± 5.4	0.385
p-value	0.001	0.000	

Note. Means within rows followed by different lower case letters and within columns followed by different upper case letters differ ($p<0.05$)

Asystasia gangetica hay achieved the desired DM content on day two, which was more than 85.0%. The highest DM value (92.5%) for *A. gangetica* hay was recorded on day two. In comparison, the lowest DM value (79.8%) was recorded on day one. Meanwhile, the DM values were not affected by the drying periods between unchopped and chopped hays of *A. gangetica* (except on day four) (Table 6). On day four, chopped hay achieved higher DM content (91.3 *vs* 90.8%) than the unchopped hay, respectively. Sobayo et al. (2012) reported that chopped *A. gangetica* sun-dried DM value was 85.5%. However, the drying period was not stated in the Sobayo et al. (2012) study. Therefore, the data in Tables 3, 4, 5, and 6 agree with the findings of Sobayo et al. (2012) because the DM contents in both hays of this current study were more than 85% when it was sun-dried for three days or more.

The temperature during the drying process of this study in October was a suitable temperature to make hay. In addition, the percentage of humidity was relatively high in that month (90.0%). The air moving across the top of the drying hay crop must absorb the water that is evaporating and mix it with the rest of the atmosphere. In this regard, air behaves much like a sponge or a mop (Evans, 1975). The humidity is high, so the hay will absorb the water from the air and increase its moisture. In October, the average wind speed recorded was 4.18 mph (miles per hour) which is deemed relatively low. Since most drying takes place during daylight hours, wind speed is an essential factor. If the wind speed is low, the air next to the crop surface will soon become saturated and be unable to absorb any water.

Table 6

Differences of dry matter content (%) (mean ± standard deviation) in unchopped and chopped hays of Asystasia gangetica

Drying period	Unchopped	Chopped	*p*-value
One day	79.5 ± 4.1^{A}	80.1 ± 3.7^{A}	0.426
Two days	93.0 ± 0.7^{C}	92.0 ± 3.0^{C}	0.312
Three days	86.3 ± 1.0^{B}	86.4 ± 0.7^{B}	0.445
Four days	90.8 ± 0.2^{aC}	91.3 ± 0.0^{bC}	0.005
Five days	83.3 ± 2.1^{B}	84.5 ± 0.6^{B}	0.188
Overall	86.6 ± 5.4	86.9 ± 4.9	0.434
p-value	0.000	0.000	

Note. Means within rows followed by different lower case letters and within columns followed by different upper case letters differ ($p<0.05$)

Nutritive Value. As shown in Table 7 (whether they are chopped or not), the CP content was higher in *A. gangetica* than in Napier grass. In contrast, the CF and EE contents appeared *vice versa*. However, there was no significant difference in ash content between Napier grass and *A. gangetica*. This difference might be attributed due to the use of different species.

Irrespective of the species, there were no differences ($p<0.05$) on the CP, CF, EE, and ash contents between unchopped and chopped hays (Table 8). The Napier grass's proximate components (except for CF) were not affected by the cutting process (Table 9). The CP, CF, EE, and ash contents of unchopped Napier grass were 15.4%, 22.0%, 0.6%, and 15.7%, while the contents for chopped Napier grass were 15.0%, 24.4%, 0.8%, and 14.6%, respectively. Similarly, the proximate components (except for EE) of *A. gangetica* were not affected by the cutting process. The CP, CF, EE, and ash contents of unchopped *A. gangetica* were 18.1%, 17.6%, 0.1%, and 13.9%. In comparison the contents for chopped *A. gangetica* were 17.6%, 20.8%, 0.3%, and 11.1%, respectively. The above findings indicated that the cutting process might not influence the proximate components. Like the current study, Mapato and Wanapat (2018) reported that dwarf Napier grass contained 15.1% CP. In another study, Sobayo et al. (2012) reported that the CP content of *A. gangetica* leaf meal was 19.38%, slightly higher than the current study. The CF value in this study is within the range of the reported value by Rahman et al. (2020). From the study of Sobayo et al. (2012), the CF content for *A. gangetica* leaf meal was 15.3%, slightly lower than the recorded value in this study. The EE value of dwarf Napier grass in this study was lower than the findings of Rahman et al. (2020); it may have occurred due to the use of plants with different maturities. Maturity is one of the crucial factors in determining hay quality. Sobayo et al. (2012) found 12.7% EE in *A. gangetica*, significantly higher than the EE value found in this study. In the Rahman et al. (2020) study, the reported ash value was slightly lower (10.2%) than the ash content found in this study. In contrast, the ash content recorded in the Sobayo et al. (2012) study was much lower (1.74%) than what was recorded in this study.

Table 7

Composition of proximate components (%) (mean ± standard deviation) in dwarf Napier grass and Asystasia gangetica *hays (irrespective of whether they are chopped or not)*

Parameter	Dwarf Napier grass (sun-drying for 5 days)	*Asystasia gangetica* (sun-drying for 4 days)	*p*-value
Crude protein (%)	15.2 ± 2.0[a]	17.9 ± 1.9[b]	0.018
Crude fibre (%)	23.2 ± 1.7[b]	19.2 ± 3.0[a]	0.009
Ether extract (%)	0.7 ± 0.2[b]	0.2 ± 0.1[a]	0.000
Ash (%)	15.1 ± 2.4	12.5 ± 4.1	0.100

Note. Means within rows followed by different lower case letters differ ($p<0.05$)

Table 8

Composition of proximate components (%) (mean ± standard deviation) in unchopped and chopped hays (irrespective of the species)

Parameter	Unchopped	Chopped	*p*-value
Crude protein (%)	16.8 ± 3.0	16.3 ± 1.5	0.376
Crude fibre (%)	19.8 ± 3.2	22.6 ± 2.6	0.061
Ether extract (%)	0.4 ± 0.3	0.5 ± 0.3	0.152
Ash (%)	14.8 ± 3.1	12.8 ± 3.9	0.178

Table 9

Composition of proximate components (%) (mean ± standard deviation) in unchopped and chopped hays within each species

Species	Parameter	Unchopped	Chopped	*p*-value
Dwarf Napier grass (sun-drying for 5 days)	Crude protein (%)	15.4 ± 3.0	15.0 ± 0.7	0.423
	Crude fibre (%)	22.0 ± 1.1[a]	24.4 ± 1.4[b]	0.037
	Ether extract (%)	0.6 ± 0.2	0.8 ± 0.2	0.117
	Ash (%)	15.7 ± 3.3	14.6 ± 1.7	0.312
Asystasia gangetica (sun-drying for 4 days)	Crude protein (%)	18.1 ± 2.9	17.6 ± 0.4	0.381
	Crude fibre (%)	17.6 ± 3.1	20.8 ± 2.4	0.112
	Ether extract (%)	0.1 ± 0.0[a]	0.3 ± 0.1[b]	0.024
	Ash (%)	13.9 ± 3.2	11.1 ± 5.2	0.236

Note. Means within rows followed by different lower case letters differ ($p<0.05$)

CONCLUSION

Physical analysis of dwarf Napier grass and *Asystasia gangetica* hays was not significantly affected by drying and cutting. For dwarf Napier grass, the three-days drying period achieved the desirable DM content (>85.0%). In contrast, for *A. gangetica*, the two-days drying period achieved the desirable DM content. The nutritive values of dwarf Napier grass and *A. gangetica* were not affected by the cutting process. The CF and EE contents were higher in dwarf Napier grass than *A. gangetica*, while the CP content appeared *vice versa*.

ACKNOWLEDGMENTS

For financial support, the authors acknowledge the Faculty of Agro Based Industry, Universiti Malaysia Kelantan, Jeli Campus, Kelantan, Malaysia (SGJP/A07.00/01597A/001/2018/000448).

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