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Yield and Nutritive Value of Palmyrah *(Borassus flabellifer)* Leaves at Different Stages of Maturity

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Abstract: Present study was conducted to evaluate the yield and nutritive value of palmyrah (*Borassus flabellifer*) leaves at different growth stages to find out its forage nutritive value. Palmyrah leaf samples were collected from three male and female palms at seven growth stages (5, 10, 15, 20, 25, 30 and 35 months). Fresh and dry matter weights of the leaves were measured. Dried leaves were ground into 1 mm particles and analyzed for their nutrient composition using standard procedures. There was no significant difference (p>0.05) between male and female palms for most of the parameters studied (dry matter (DM), crude protein (CP), crude fiber (CF), ash and gross energy (GE). Leaf weight varied from 0.91 to 1.22 kg/leaf and 0.91 to 1.30 kg/leaf (DM basis) in male and female palms, respectively. The range of values of nutrient composition of leaves from male and female palms were: CP 10.1-14.4% and 10.1-14.4%; CF 35.5 - 48.1% and 35.7 - 49.3%; calcium (Ca) 1.34 - 4.30% and 1.52 - 4.53% and phosphorous (P) 0.24 - 0.44% and 0.20 - 0.4 0%, respectively. *In vitro* dry matter digestibility (IVDMD) and GE were ranged between 39.72 – 53.99% and 38.06 – 51.28% and 4.35 - 4.55 Mcal/kg and 4.37 - 4.61 Mcal/kg for leaves of male and female palms, respectively. The CP, IVDMD, GE and phosphorus contents were decreased with advancing maturity, whereas, CF and Ca were increased. Accordingly, leaves harvested from both male and female palms at 10 to 30 months of age have a good forage value in terms of CP, IVDMD and fodder yield to be used as ruminant feed.

Keywords: forage-value, growth-stages, leaf weight, nutrient composition

Introduction

The agro-climatic condition of the Northern region is suitable for growing good quality tropical forages (Houwers *et al*., 2015). Palmyrah (*Borassus flabellifer*) is growing naturally in forest, waste lands, plantations and home gardens of the Northern and Eastern Provinces of Sri Lanka (Theivendirarajah, 2008). Fodder production shows a seasonal pattern in Sri Lanka due to the non-uniform

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rainfall pattern. By virtue of the extensive deep rooting system, palmyrah palms are able to withstand severe drought conditions and provide quality green fodder during dry periods in the Northern and Eastern parts of Sri Lanka. Palmyrah palms are dioecious and the leaves (lamina) of palmyrah are a good source of forage for ruminants (Theivendirarajah, 2008). According to Mohanajeyaluxmi (1986), the nutrient compositions of palmyrah leaf lamina after removing the petioles and midribs were superior in quality, especially in crude protein.

A palm starts to sprout a fully developed leaf at the age of two years and it continuously produces a new leaf every month, thereafter. Therefore, the terminal crown of mature palms at the age of 5 years and above have about 30 to 40 fan-shaped green leaves (Theivendirarajah, 2008). Since the number of leaves present in a mature palm varies with maturity, the yield and nutrient composition of leaves present in a palm varies. According to Oelberg (1956), the stage of growth seems to be the most important factor affecting the chemical composition and digestibility of range forage. Therefore, the study aimed to evaluate the yield and nutritive value of palmyrah leaves at different stages of maturity in order to find out the forage value.

Materials and Methods

Collection and preparation of samples

The leaves of three male and female palmyrah palms (10 to 15 years of age) of variety black skin fruit at different growth stages were collected from Kilinochchi district. Basic data regarding the height, girth and leaf number were measured. The leaves were manually harvested at seven stages of growth (5, 10, 15, 20, 25, 30 and 35 months of age) from male and female palms. Fully sprout top leave was considered as one month age and the age of the subsequent leaves was calculated from top to bottom. Fresh matter (FM) and dry matter (DM) yields of harvested leaves were measured. The leaves were cut from the petiole and all the midribs were removed, leaving the strips of the leaf blade and these were again split into smaller strips and dried in an oven at 60 °C until a constant weight is reached. All the samples were ground to 1 mm particles using a laboratory grinder and stored at room temperature for the chemical analysis.

Chemical analysis

Dry matter (DM), ash, crude protein (CP), crude fiber (CF) and ether extract (EE) of the samples were determined according to the AOAC (2005) procedure. *In vitro* dry matter digestibility (IVDMD) was determined according to Tilley and Terry method (1963) as modified by Van Soest and Robertson (1985). Gross Energy (GE) content was measured using a Bomb calorimeter (AOAC, 2005). Calcium content was measured using atomic absorption spectrophotometer and phosphorus content was measured using spectrophotometer (AOAC, 2005).

Data analysis

Data were subjected to Analysis of Variance Procedures (ANOVA) using Statistical Analysis Software version 9.1.3 (SAS, 2009) to determine the statistical significance between the palmyrah leaves at various growth stages. Mean comparisons were done using Duncan's multiple range test (DMRT).

Results and Discussion

Growth parameters of male and female palms at the time of harvesting

The data regarding the height, girth and leaf number of male and female palmyrah palms at the time of sample collection are given in Table 1. Even though the values were not significantly differed ($p>0.05$), male palms had more number of leaves than the female palms.

Fresh and dry weight of palmyrah leaves

Fresh and dry weight of palmyrah leaves at different growth stages are presented in Table 2. There was no significant difference ($p>0.05$) between male and female palms for dry weight in all stages of growth except for 35 months of age (L 35). However, dry weight observed after 10 months of maturity was significantly higher ($p<0.05$) than the weight observed before 10 months of maturity. The average fresh weight of lamina of a single leaf was 2 kg, whereas a palm had an average of 36 to 38 leaves. Therefore, about 20 leaves can be harvested from a mature palm and the total weight of green matter available from a palm is around 40 kg. Palms (n=1110) can be grown in one hectare of land (3m×3m) (E-agriculture, 2015). Therefore, an average of 44,400 kg of fresh matter/ha can be harvested from a mature palm at a growth of 5 years. Subsequently, an average of 12 leaves can be harvested every year with a fresh weight of 2 kg. Thus, an annual fresh yield of 26,640 kg/ha can be harvested for about 70 years. Accordingly, a palmyrah palm will provide 1680 kg of green forage on average for ruminant in its lifetime.

Nutrient content of palmyrah leaves

The nutrient content of male and female palmyrah leaves (DM basis) at different growth stages is presented in Table 3. The respective DM, CF and Ca contents of palmyrah leaves increased ($p<0.05$) with the advancement of leaf growth (Table 3). The DM content of 46% and ash content of 4.5% reported by Mohanajeyaluxmi (1986), and ash content of 6.8% reported by Perera (1992) for a mixture of leaves were within the range of current results. The greater value obtained for ash indicates that most leaves may be considered as a satisfactory source of minerals (Oelberg, 1956). The Ca content of leaves was observed to increase uniformly from early stage to maturity. This observation can be attributed to the increased amount of cellular material which is the principal element of Ca (Oelberg, 1956). Further, Cook and Harris (1950) stated that the Ca was found to increase with growth in all plants and plant parts. When a plant matures, it becomes more fibrous, which may be the cause of an increase in CF content. This finding was in agreement with the finding of Oelberg (1956), who stated that the trend in CF content in regard to stage of maturity is normally the reverse of protein.

Table 1: Height, girth and leaf number of male and female palms at the time of sampling†

Type	Height (m)	Girth (m)	Number of leaves
Male Palm	11.2±0.5	1.12±0.1	38.0±2.3
Female Palm	11.5±0.3	1.30±0.1	36.0±1.4

† Means ± Standard error

Table 2: Fresh and dry weight of palmyrah leaves at different growth stages†

Leaf number (Maturity)	Type	Fresh weight, kg	Dry weight, kg
L5	M	2.01^{bc}±0.01	0.91^{d}±0.01
	FM	1.92^{c}±0.02	0.91^{d}±0.02
L10	M	2.03^{bc}±0.03	1.10^{c} ±0.02
	FM	1.96^{c}±0.02	1.05^{c}±0.02
L15	M	2.06^{bc}±0.03	1.18^{b}±0.03
	FM	2.17^{a}±0.03	1.20^{b}±0.01
L20	M	2.09^{b}±0.03	1.22^{b}±0.01
	FM	2.19^{a}±0.01	1.26^{ab}±0.01
L25	M	2.05^{bc}±0.06	1.22^{b}±0.01
	FM	2.17^{a}±0.02	1.27^{ab}±0.01
L30	M	1.97^{c}±0.01	1.23^{b}±0.01
	FM	2.15^{ab}±0.02	1.27^{ab}±0.02
L35	M	1.91^{c}±0.01	1.23^{b}±0.01
	FM	2.15^{ab}±0.03	1.30^{a}±0.04

†Means ± Standard error

^{a,b,c} Means with different superscripts within a column are significantly different ($p<0.05$)

L 5- Leaves at five months age, L 10- Leaves at ten months age, L 15- Leaves at fifteen months age, L 20- Leaves at twenty months age, L 25- Leaves at twenty five months age, L 30- Leaves at thirty months age, L 35- Leaves at thirty five months age

Crude protein, EE, IVDMD and P contents of the leaves decreased ($p>0.05$) as the leaves advanced in growth (Table 3). The CP content of the leaves at all stages of maturity was above 10%. However, the CP content of the leaves after 25 months of age was lower ($p<0.05$) than the value obtained before 25 months of age. Crude protein levels below 8.0% on dry matter basis are considered insufficient to meet the maintenance requirements of ruminants (Ibrahim, 1988). Van Soest (1994) suggested that CP content of browse species should be higher than the minimum level of 7-8% of DM for optimum rumen function and feed intake in ruminant animals. The CP content of palmyrah leaves at all stages of harvest of the present results is sufficient to meet the minimum level of CP requirement. The CP content of 13-15% reported by Mohanajeyaluxmi (1986), and 12% reported by Perera (1992) for the mixture of leaves were within the range reported in the present study.

IVDMD of the harvested leaves at all stages of growth was below 55% (Table 3). Further, IVDMD values were (below 45%) lower ($p<0.05$) after 30 months of age compared to the leaves harvested before 30 months of age (Table 3). The lower IVDMD values were closely related to the higher lignin content (Ibrahim, 1988). According to Jayawardena and Perera (1991), the digestibility content below 45% of most fodders is considered a limiting factor for feeding livestock.

Table 3. Nutrient content of palmyrah leaves at different growth stages †

LN	Type	Chemical composition (g/100 g DM)							
		DM	CP	EE	CF	Ash	NFE	Ca	IVDMD
L5	M	$0.3^{j}\pm0.13$	$14.4^{a}\pm0.05$	$4.58^{a}\pm0.06$	$35.5^{g}\pm0.15$	$4.5^{fg}\pm0.03$	$41.1^{a}\pm0.07$	$1.34^{j}\pm0.14$	$53.9^{a}\pm3.05$
	FM	$47.4^{i}\pm0.23$	$14.4^{a}\pm0.06$	$4.54^{a}\pm0.06$	$35.6^{g}\pm0.19$	$3.81^{g}\pm0.23$	$41.6^{a}\pm0.14$	$1.52^{i}\pm0.31$	$51.3^{b}\pm1.57$
L10	M	$54.2^{g}\pm0.15$	$13.9^{ab}\pm0.09$	$4.51^{a}\pm0.05$	$38.1^{f}\pm0.21$	$4.84^{e}\pm0.31$	$38.7^{b}\pm0.17$	$2.99^{g}\pm0.12$	$51.7^{b}\pm1.64$
	FM	$53.4^{h}\pm0.26$	$13.9^{ab}\pm0.05$	$4.46^{a}\pm0.06$	$37.0^{f}\pm0.17$	$5.32^{cde}\pm0.04$	$39.3^{ab}\pm0.08$	$1.69^{h}\pm0.15$	$50.1^{bc}\pm2.15$
L15	M	$57.4^{f}\pm0.18$	$13.7^{ab}\pm0.15$	$4.39^{b}\pm0.09$	$39.1^{e}\pm0.34$	$5.27^{de}\pm0.09$	$37.5^{b}\pm0.17$	$3.66^{e}\pm0.14$	$49.1^{cd}\pm2.01$
	FM	$55.4^{g}\pm0.28$	$13.8^{ab}\pm0.09$	$4.38^{b}\pm0.04$	$40.8^{e}\pm0.38$	$6.39^{c}\pm0.12$	$34.6^{c}\pm0.16$	$2.94^{h}\pm0.31$	$49.1^{cd}\pm2.78$
L20	M	$58.3^{e}\pm0.15$	$13.4^{bc}\pm0.16$	$4.32^{b}\pm0.05$	$40.7^{d}\pm0.07$	$5.59^{cde}\pm0.24$	$36.0^{b}\pm0.13$	$3.81^{d}\pm0.14$	$47.5^{d}\pm3.10$
	FM	$57.5^{f}\pm0.13$	$13.7^{ab}\pm0.03$	$4.37^{b}\pm0.06$	$41.5^{d}\pm0.26$	$6.48^{c}\pm0.15$	$33.9^{c}\pm0.13$	$3.31^{f}\pm0.12$	$45.4^{e}\pm 2.15$
L25	M	$59.6^{d}\pm0.13$	$12.9^{d}\pm0.12$	$4.32^{b}\pm0.06$	$41.4^{c}\pm0.18$	$6.24^{cd}\pm0.16$	$35.1^{b}\pm0.13$	$3.82^{c}\pm0.14$	$45.4^{e}\pm1.92$
	FM	$58.4^{e}\pm0.16$	$12.4^{d}\pm0.09$	$4.34^{b}\pm0.04$	$43.3^{c}\pm0.46$	$7.90^{b}\pm0.13$	$32.1^{d}\pm0.18$	$3.82^{d}\pm0.17$	$43.7^{e}\pm2.41$
L30	M	$62.4^{b}\pm0.29$	$11.1^{e}\pm0.06$	$4.26^{b}c\pm0.09$	$43.6^{b}\pm0.32$	$8.20^{b}\pm0.12$	$32.8^{d}\pm0.15$	$4.27^{b}\pm0.29$	$40.0^{f}\pm1.85$
	FM	$59.1^{d}\pm0.09$	$11.3^{e}\pm0.17$	$4.29^{b}c\pm0.04$	$43.8^{b}\pm0.14$	$8.12^{b}\pm0.14$	$32.4^{d}\pm0.12$	$4.18^{c}\pm0.13$	$41.7^{f}\pm1.92$
L35	M	$64.5^{a}\pm0.18$	$10.1^{f}\pm0.15$	$4.20^{c}\pm0.06$	$48.1^{a}\pm0.51$	$9.22^{a}\pm0.23$	$28.5^{e}\pm0.06$	$4.30^{b}\pm0.11$	$39.7^{g}\pm3.01$
	FM	$60.5^{c}\pm0.17$	$10.1^{f}\pm0.13$	$4.26^{b}c\pm0.06$	$49.3^{a}\pm0.38$	$8.69^{b}\pm0.09$	$27.7^{e}\pm0.17$	$4.53^{a}\pm0.08$	$38.1^{g}\pm2.41$

†Means ± Standard error

^{a,b,c,d,e,f,g,h,i,j}Means with different superscripts within a column are significantly different ($p<0.05$)

LN- Leaf Number, M – Leaves from male palms, FM – Leaves from female palms, DM- Dry matter, CP – Crude Protein, EE- Ether extract, CF – Crude fiber, NFE- Nitrogen Free Extract, IVDMD- *In vitro* dry matter digestibility

L 5- Leaves at five months age - L 10- Leaves at ten months age, L 15- Leaves at fifteen month age, L 20- Leaves at twenty months age, L 25- Leaves at twenty five months age, L 30- Leaves at thirty months age, L 35- Leaves at thirty five months age

Table 4: Gross energy contents of male and female palmyrah leaves (DM basis) at various growth stages†

Item	Type	L 5	L 10	L 15	L 20	L 25	L 30	L 35
GE (Mcal/ kg)	M	$4.55^{a}\pm0.06$	$4.48^{ab}\pm0.08$	$4.45^{ab}\pm0.20$	$4.40^{b}\pm0.25$	$4.39^{b}\pm0.03$	$4.36^{bc}\pm0.99$	$4.35^{bc}\pm0.03$
	FM	$4.61^{a}\pm0.02$	$4.52^{ab}\pm0.01$	$4.45^{ab}\pm0.23$	$4.42^{ab}\pm0.01$	$4.39^{b}\pm0.01$	$4.38^{b}\pm0.01$	$4.37^{bc}\pm0.01$

†Means ± Standard error

^{a,b,c}Means with different superscripts within a raw are significantly different ($p<0.05$)

M – Leaves from male palms, FM – Leaves from female palms, GE- Gross energy content

L 5- Leaves at five months age - L 10- Leaves at ten months age, L 15- Leaves at fifteen months age, L 20- Leaves at twenty months age, L 25- Leaves at twenty five months age, L 30- Leaves at thirty months age, L 35- Leaves at thirty five months age

GE contents were reduced from 4.55 to 4.35 Mcal/kg in leaves of male palms and 4.61 to 4.37 Mcal/kg in leaves of female palms with the advancement of growth (Table 4). The ME content was calculated and it reduced from 1.45 to 0.73 Mcal/kg and 1.37 to 0.79 Mcal/kg in leaves of male and female palms, respectively with growth. Maturity had no significant effect ($p<0.05$) on the GE and ME content of palmyrah leaves.

Study of Oelberg (1956) explained that the ME of leaves decreased with advancement of growth due to increase in cell wall contents. A study of Khanum *et al*. (2007) stated that the ME values were very low in feedstuffs (included various grasses, crop residues and some tree leaves) having high fiber and low protein contents. This may be the reason for the low ME values observed in leaves harvested after 30 months of growth.

Leaves harvested before 10 months of age had lower weight in comparison to after 10 months of age due to leaf immaturity, whereas leaves harvested after 30 months of age had lower IVDMD due to higher indigestible materials.

Conclusion

Harvesting of leaves at an early stage will affect the growth of the palms. Crude protein, CF, IVDMD and ME content of the leaves harvested between 10 and 30 months of the mature stage showed acceptable values for feeding ruminants. Therefore, it could be concluded that, leaves harvested between 10 and 30 months of growth stages could have a forage value.

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