PRINT: ISSN 0970-9274 ONLINE: 2456-6608
J. Hum. Ecol., 12(3): 171-175 (2001)
DOI: 10.31901/24566608.2001/12.03.02

Nutritional Characteristics of Selected Grass and Browse Species From Kenya's Pastoral Ecosystems

Wellington N. Ekaya

INTRODUCTION

The arid and semi-arid ecosystems have resources that offer the pastoralist communities a very restricted range of enterprise options. The climatic, biological and economic factors virtually restrict production to the conversion of natural forages to meat, milk and fibre by ruminant livestock.

In Africa, by far the largest proportion of the livestock (85-90%) and especially those of the nomadic and transhumant communities, is entirely dependent on natural grasslands and the browse of trees and shrubs over vast communally used grazing lands. In these communities, livestock provide essential items of food through out the year to the majority of the people and are an important element of food security to millions of nomads and transhumants. Livestock also play an important role in their contribution to employment, to family income and to government revenue and foreign exchange. Yet, the potential of animal production in these ecosystems is restricted by the very nature of their environment, which determines the feed quantity and quality.

In Kenya, animal production remains the most profitable use of the arid and semi-arid areas, which constitute over 80% of the country (GoK, 1989). However, the efficiency of animal production in these vast areas is closely related to the nutritional value of the forage grazed. In tropical rangelands generally, forage is usually adequate in quality and quantity during and immediately after the rains. Thereafter there is a rapid decline quantitatively and qualitatively, often to levels unable to meet animal requirements (Karue, 1974, 1975; Leng, 1990). This necessitates animal supplementation where resources warrant. However, supplementation is only possible and effective where *'when'* and *'what'* nutrients deficient in the animal diets, are known to the managers. Information on the nutrient content and characteristics of forage plants at different stages of growth in their life cycle is thus essential for proper animal management. For most of Kenya's range forage plants such information remains scarce or unpublished. The scanty extant literature gives levels of nutrient content without specifying at what age and/or stage of growth of the plant the information was collected, and from which plants part(s). This reduces the usefulness of the information for management purposes.

The purpose of this study therefore was to document quantitative data on the nutritional characteristics of some common range grasses and browse plants that form the bulk of animal diets in Kenyan rangelands, and at specified stages of growth.

MATERIALS AND METHODS

Study Site

This study was conducted at the Kiboko National Range Research Station, located 164 km southeast of Nairobi, along the Nairobi-Mombasa highway. The study site has been classified as an inter-phase between ecological zones IV and V (Pratt et al., 1966). Due to its position along the equator, the area experiences a bimodal pattern of rainfall. Long rains are expected from April through June and short rains from October through December. Dry seasons are usually experienced from January to March and July to September.

Based on fifty-two years' data, the mean annual rainfall was 532.2 mm. The average minimum and maximum temperatures based on the same period were 16.7°C and 28.8°C respectively. During the year which this study was conducted, the total rainfall recorded was 735.9 mm, which was above the long-term annual mean. The minimum and maximum temperatures were 16.5°C and 28.9° C respectively.

Plant Material Collection

Ten grass and browse species dominant at the study site and which are a common and major source of forage for range livestock in Kenya, were identified. Samples from grass species were collected at three stages of growth, i.e.;

(i) *Vegetative stage;* new growth before stem elongation,
(ii) *Milk stage;* stems had elongated, seeds had formed but still soft and immature,
(iii) *Dormant stage;* plants had cured on stems and seeds had been cast.

The samples were cut 5 cm from the ground and consisted of leaves, stems and seeds depending on the stage of growth.

Samples from browse species were collected at two stages of growth, i.e.;

(i) *Early leaf stage,* when plants had produced new leaf growth,
(ii) *Leaf-shed stage,* when deciduous plants were shedding their leaves. Samples consisted of leaves and their petioles.

All the samples were dried at 80°C, ground through a Willey mill with 1 mm size sieve and stored awaiting analyses.

Nutritional Characterization

The samples were analyzed for crude protein (CP), neutral detergent fibre (NDF) and acid detergent lignin (ADL). CP was determined by the Kjeldahl method (A.O.A.C., 1980). The other components were determined by procedures described by Goering and Van Soest (1970). *In-vivo* dry matter digestibility (IVDMD) was determined by the nylon bag technique (Orskov et al., 1980) using rumen-fistulated bovine castrates.

RESULTS AND DISCUSSION

Nutritional Characteristics

Tables 1 and 2 show the nutritional characteristics of the identified plant species at specified stages of growth.

Grasses

Crude protein content at the vegetative stage had a wide range, falling between 11% and 20%

Table 1: Nutritional characteristics of grass species at vegetative (V), milk (M), and dormancy (D) stages of growth

Grass species	*CP(%)*			*NDF(%)*			*ADL(%)*			*IVDMD(%)*		
	V	*M*	*D*	*V*	*M*	*D*	*V*	*M*	*D*	*V*	*M*	*D*
1. *Themeda triandra*	14	7	4	78	79	83	5	7	9	76	53	37
2. *Cymbopogon caesius*	11	7	5	71	73	78	6	7	8	72	58	45
3. *Digitaria macroblephara*	19	7	4	68	72	76	6	7	7	81	64	41
4. *Panicum maximum*	20	7	5	62	72	76	6	7	7	85	55	45
5. *Chloris roxburghiana*	14	8	6	72	78	80	4	7	9	72	57	47
6. *Aristida adoensis*	13	7	3	68	74	78	5	6	8	75	58	34
7. *Sehima nervosum*	11	6	4	70	78	81	5	7	9	66	52	38
8. *Enteropogon spp.*	12	6	4	72	74	76	5	7	9	71	64	39
9. *Eragrostis caespitosa*	18	9	4	71	73	76	5	7	8	88	60	35
10. *Eragrostis superba*	13	7	5	74	74	77	4	6	8	78	51	47

Nutritional element spans all nutrient columns.

Table 2: Nutritional characteristics of browse species at early leaf (EL) and leaf-shed (LS) stages of growth

Browse species	*CP (%)*		*NDF (%)*		*ADL (%)*		*IVDMD*	
	EL	*LS*	*EL*	*LS*	*EL*	*LS*	*EL*	*LS*
1. *Acacia brevispica*	26	18	46	51	11	16	67	56
2. *Balanites aegyptiaca*	11	10	41	57	12	14	79	49
3. *Acacia tortilis*	17	15	51	58	13	23	61	49
4. *Acacia mellifera*	20	19	48	58	10	14	69	54
5. *Grewia similis*	18	12	45	56	8	11	81	70
6. *Acacia senegal*	17	16	51	57	15	16	54	52
7. *Grewia bicolor*	18	13	59	62	13	24	78	65
8. *Grewia villosa*	19	14	57	59	15	16	80	71
9. *Maerua edulis*	29	26	31	56	6	13	89	75
10. *Hermania alhiensis*	19	11	50	62	15	19	69	47

with a mean of 15%. Species on the lower end of the range included *Cymbopogon caesius* (11%) and *Enteropogon machrostachyus* (12%). High values were recorded for *Panicum maximum* (20%), *digitaria macroblephara* (19%) and *Eragrostis caespitosa* (18%).

There was an approximate 50% decline in crude protein content from the vegetative to the milk stage. The mean crude protein content at the milk stage was 7%, with values showing a narrow range and lying between 9% and 6%. The mean crude protein content at the milk stage was significantly lower ($P<0.05$) than that at the vegetative stage.

From the milk stage to the dormancy stage, there was an attenuated decline in crude protein content of about 40%. The mean crude protein content was 4%. *Aristida adoensis* (3%) fell below the mean whereas *Chloris roxburghiana* had the highest value (6%). A significant difference ($P<0.05$) was observed between crude protein contents at milk and dormancy stages.

Neutral detergent fibre content was high, with means at 71%, 75% and 78% for vegetative, milk and dormancy stages respectively. There was a significant difference ($P<0.1$) between the neutral detergent fibre at vegetative stage and that at milk stage. However, there was no significant difference ($P>0.1$) in the neutral detergent fibre content between the milk and dormancy stages. Species with high fibre values at vegetative stage included *Themeda triandra* (78%) and *Eragrostis superba* (74%). The lowest fibre content was recorded for *Panicum maximum* (62%).

There was an approximate 6% increase in neutral detergent fibre content, from the vegetative to the milk stage. Values at milk stage ranged between 79% for *Themeda triandra*, and 72% for *Digitaria macroblephara* and *Panicum maximum*. A further 4% increase in fibre was recorded, between milk and dormancy stage, with values ranging between 76% and 83%.

The mean lignin content at vegetative, milk and dormancy stages was 5%, 7% and 8% respectively. Values ranged between 4% and 6%, 6% and 7% and 7% and 9% for vegetative, milk and dormancy respectively. Species with lowest values were *Chloris roxburghiana* and *Eragrostis superba* (4%) at the vegetative stage, *Aristida adoensis* and *Eragrostis superba* (6%) at dormancy stage and *Digitaria macroblephara* and *Panicum maximum* (7) at dormancy stage. Increase in lignin content was more rapid between vegetative and milk stage (40%), than between the milk and the dormancy stages (14%).

Dry matter digestibility at vegetative stage ranged between 66% and 88% with a mean value of 76%. Digestibility values above 80% were recorded for *Digitaria macroblephara* (81%), *Panicum maximum* (85%) and *Eragrostis caespitosa* (88%). *Sehima nervosum* had the lowest value (66%). There was an average 25% decrease in digestibility at the milk stage, during which values ranged between 51% and 64%. The mean digestibility was 57%.

At the dormancy stage, digestibility declined by 28%, to a mean value of 41%. The highest value was recorded for *Eragrostis superba* and *Chloris roxburghiana* (47%), whereas Aristida adoensis had the lowest value (34%).

Browse

Trends in browse nutritional characteristics were similar to those in grasses. Crude protein at the early leaf stage ranged between 11% for *Balanites aegyptiaca* and 29% for *Maerua edulis*. The mean protein content at this stage was 19%. A 21% decline in protein occurred between the early leaf and leaf shed stage. *Hermania alhiensis* had the lowest protein content (11%) whereas *Maerua edulis* maintained the highest (26%). The mean value was 15%.

Fibre content at early leaf stage was highest for *Grewia bicolor* (59%) and lowest for *Maerua edulis* (31%), with a mean of 48%. A 21% increase in fibre content was observed at the leaf-shed stage, which had a mean value of 58%, with values ranging between 62% for *Hermania alhiensis* and *Grewia bicolor* and 51% for *Acacia brevispica*.

Mean lignin contents were 12% and 17% at early leaf and leaf shed stages respectively. Values at early stage ranged between 6% and 15%. At the leaf shade stage, the lignin content ranged between 11% and 24%.

Dry matter digestibility at early leaf stage had a mean value of 73%, with values ranging between 54% for *Acacia Senegal* and 89% for *Maerua edulis*. A 19% decline in digestibility was observed at the leaf-shed stage. Values ranged between 47% for *Hermania alhiensis* and 75% for *Maerua edulis*. The mean digestibility coefficient was 59%.

Mean dry matter digestibility at the early leaf stage was significantly higher ($P<0.05$) than that at leaf shed stage. No significant difference was observed between growth stages for crude protein, neutral detergent fibre and lignin contents.

The quantitative data presented in tables 1(a) and 1(b) above is complementary to that of French (1956), Dougall and Bogdan (1958), Dougall et al., (1964), Karue (1974, 1975) and Tessema (1986). It gives the potential nutritive value of various forage plants common in Kenyan, and indeed East African pastoral livestock production ecosystems, and at specified stages of growth. The actual nutritive value however can only be obtained after making allowances for the inevitable losses during digestion, absorption and metabolism in the animal.

Generally, the time of high nutritive value in grasses was limited to a short period of rapid growth (3-4 weeks) during and immediately after the vegetative stage. Although CP was as high as 20% at the vegetative stage, this component showed the greatest change per unit of time, declining to as low as 6% within a period of four weeks, and then further to less than 4% by the age of twenty weeks. As grasses age physiologically, their percent content of CP declines as it becomes progressively diluted by an increasing percentage of non-nitrogenous organic matter (Dougall et al., 1964; Van Soest, 1982).

Stem material in grasses increases with advancement in maturity thereby lowering the leaf: stem ratio. The stems being plant support structures rapidly increase in fibre content, which becomes increasingly impregnated with lignin for further structural support (Van Soest, 1982; Jung and Vogel, 1986). This in effect increases the cellwall contents (NDF) as the plants mature. Dry matter digestibility subsequently declines. Lignin is an indigestible non-carbohydrate phenylpropanoid polymer (Kamstra et al., 1955; Allinson and Osbourn, 1969; Van Soest, 1982; Jung and Vogel, 1986), and acts as an encrusting substance (Kamstra et al., 1955) thus preventing intestinal and microbial enzymes from reaching and attacking plant nutrients. This further contributes to the decline in DMD as plants mature.

Leng (1990) classified grasses with DMD values below 55% and CP below 8% as low quality in terms of meeting the nutrient requirements of unsupplemented free-ranging ruminants in arid ecosystems. Using this criterion, past the milk stage, all grasses were unable to meet nutrient requirements of free-range ruminants.

Browse species had higher CP contents than grasses at contemporary stages of growth. This has also been reported by Otsyina and McKell (1985). The decline in the CP content of browse plants was more attenuated than that of grasses. Although some browse plants e.g. *Balanites aegyptiaca* had the lowest CP content at the early leaf stage, there was little decline at the leaf shed stage.

Both grasses and browse showed an increase in ADL with advancement in maturity. However, the browse plants contained 2-3 times more ADL than grasses. Jung and Vogel (1986) attributed this to contamination of ADL by cutin, which occurs in higher amounts in browse species.

It would be expected that due to the higher CP content and lower total fibre (NDF) content, browse species would have high DMD values, probably above 85% at the early leaf stage. However, only modest values were observed in more than 60% of the species. This has been attributed to plant secondary compounds, for example tannins, insoluble phenolics and sappoinins which interfere with digestion mechanisms in the animal due to their toxic effects or through enzyme inhibition and substrate binding in the digestive tract (Mahamadou and Huss, 1982; Van Soest, 1982; Amrik and Menke, 1986; Reed, 1986). Tannins for example, have a protein precipitating action which reduces the level of available nitrogen for rumen micro-organisms. This in effect reduces the microbial populations and subsequently the digestibility of forages. Digestive enzymes, being protein in nature, are also precipitated by the tannins, thus rendering them ineffective for substrate breakdown. This has the effect of reducing the overall digestibility as well as the nutritive value of the forage, which has a direct negative effect on animal production.

The great ephemerality in nutrient content, especially for grasses dictates that the forage be utilized when still nutritious and of high nutritive value to the animals. Otherwise forage nutrient content quickly declines with senescence and even the standing dead plant material will increasingly be lost through death and decomposition.

KEY WORDS Rangeland. Grass. Browse. Growth-stage. Nutrient Content. Management.

ABSTRACT A study was conducted to determine the nutritional characteristics of selected grass and browse species from Kenya'' rangelands. The identified species were analyzed for their chemical composition (CP, NDF, ADL) and *in-vivo* DMD at specified stages of growth whereas browse species were analyzed at early leaf and leaf shed stages of growth. The time of high nutritive value in grasses was limited to a short period of rapid growth during the growing season. Thereafter CP rapidly declined from as high as 19% to less than 7% within a period of four weeks. *In-vivo* DMD declined and total fibre increased, thereby lowering the potential nutritive value. Browse species showed less decline in their potential nutritive value and it is apparent that they are potential supplements to grass-dependent range ruminants during the dry season.

REFERENCES

Allinson, D.W. and Osbourn, D. F.: The cellulose-lignin complex in forages and its relationship to forage nutritive value. *J. Agric. Sci.*, **74**: 23-35 (1969).

Amrik, S.V. and Karl – Heinz Menke: Occurrence and nutritional significance of tannins present in unconventional feeds in India. *Anim. Res. Dev.*, **24**: 7-21 (1986).

A.O.A.C.: *Official Methods of Analysis.* Washington D.C. (1980)

Dougall, H.W. and Bogdan, A.V.: Browse plants of Kenya with special reference to those occurring in South Baringo. *E.A.A. for J.*, **23**: 236-242 (1958).

Dougall, H.W., Drysdale V. M. and Glover P. E.: The chemical composition of Kenya browse and pasture herbage. *E. Afr. Wildl. J.*, **2**: 86-92 (1964).

French, M.H.: The nutritive value of East African hay. *Emp. J. Exp. Agric.*, **24**: 53-60 (1965).

Goering, H.K. and Van Soest P. J.: *Forage Fibre Analysis (Apparatus, Reagents, Procedures and Some Applications).* U.S.D.A. Agric. Handbook 379. Washington D.C. (1970).

Government of Kenya.: *National Development Plan for the Period 1989 – 1993.* Government Printers, Nairobi (1989).

Jung, H.G. and Vogel K.P.: Influence of lignin on the digestibility of forage cellwall materials. *J. Anim. Sci.*, **62**: 1703-1712 (1986).

Kamstra, L.D., Moxon A. L. and Bengley O.G.: The effect of stage of maturity and lignification on the disgetion of cellulose in forage plants by rumen micro-organisms in-vitro. *J. Anim. Sci.*, **17**: 199-207 (1955).

Karue, C.N.: The nutritive value of herbage in semi-arid lands of East Africa. I: Chemical composition. *E.A.A. For J.*, **40**: 89-95 (1974).

Karue, C.N.: The nutritive value of herbage in semi-arid lands of East Africa. II: Seasonal influence on the nutritive value of Themeda. *E.A.A. For J.*, **40**: 372-387 (1975).

Leng, R.A.: Factors affecting the utilization of poor quality forages by ruminants particularly under tropical conditions. *Nutri. Res. Rev.*, **3**: 277-303 (1990).

Mahamadou D. and Huss W.: Tannin contents of African pasture plants: Their effects on analytical data dnd in-vitro digestibility. *Anim. Res. Dev.*, **15**: 79-90 (1982).

Orskov, E.R., De Hovel F. D. and Mould F.: The use of the nylon bag technique for the evaluation of feestuffs. *Trop. Anim. Prod.*, **5**: 195-213 (1980).

Otsyina, R.M. and Mckell C M.: Browse in the nutrition of livestock. *Wld. Anim. Rev.*, **53**: 33-39 (1985).

Pratt, D.J., Greenway P. J. and Gwynne M. D.: A classfication of East African Rangelands. *J. Appl. Ecol.*, **3**: 369-382 (1966).

Reed, J.D.: Relationships among soluble phenolics, insoluble prabthicyanidins and fibre in East African browse species. *J. Range Manage.*, **39**: 5-7 (1986).

Tessema, S.: Chemical composition and in-vitro dry matter digestibility of herbage. In: Hansen, R.M., B.M. Woie and R.D. Child (Eds.): *Range Development and Research in Kenya.* Proceedings of a conference, Agricultural Resources Centre, Egerton University, Kenya (1986).

Van Soest, P.J.: *Nutritional Ecology of the Ruminant.* O & B Books Inc. U.S.A. (1986).

Author's Address: **Wellington N. Ekaya,** Department of Range Management, University of Nairobi, P.O. Box 29053, Nairobi. *E-mail:* <ekaya@net2000ke.com>