Chemical composition and physical characteristics of standing hay and foggage along the pasture field in Morogoro sub-urban, Tanzania

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Abstract
In-situ forage conservation in the form of standing hay is the commonest and cheapest form of natural pasture conservation by most agro-pastoral and pastoral communities in Sub-Saharan Africa. Standing hay is over matured and un-harvested pasture (mainly annual grasses). On the other hands, excessively overstays standing hay in the field until the first rain a shower of the next season is referred as foggage. The objective of this study was to evaluate the nutritive value of the standing hay and foggage of natural pastures plot rested for entire wet (growing) and dry periods for nine months until the first rains. Standing hay samples were taken three months before the rains while those of foggage were obtained three weeks after the first rains. Ten samples were taken at random from a standing hay and foggage for determination of botanical and nutritive composition. Standing hay and foggage did not differ significantly ($P \geq 0.05$) in terms of dry matter (DM) content (85.9 % vs 83.1 %), Crude protein (3.8 % vs 3.3%), in vitro dry matter digestibility (34 % vs 32 %), metabolizable energy (5.3 vs 5.2 MJ/kg DM). However, standing hay had significantly ($P \leq 0.05$) less Neutral Detergent Fiber (80 vs 82 %) and more leaf:stem ratio (2:1 vs 1.4:1) than

foggage. In terms of organoleptic test scores standing hay and foggage were not significantly (P ≥ 0.05) in touch and pollution but foggage had significantly ((P≤ 0.05) mouldy appearance and bad smell than standing hay. It can be concluded that tropical natural pastures standing hay and foggage have low nutritive value yet the foggage is very fibrous which can reduce the productivity of ***grazing animals.***

Key words*: Forage conservation, natural pasture, mouldy hay, leaf:stem ratio*

Introduction

The primary aim of forage conservation is to maintain its quantity and quality with minimum loss during harvesting and storage (Rotz and Muck, 1994). Three common forms of forage conservation include hay, standing hay and silage. Forage conservation as hay and standing hay is dependent on weather while silage making can be done even in the rain season. Standing hay can however, be useful before the rains otherwise after the rains may just be soaked and become rather mouldy and turned to foggage (Raymond and Pitman, 2000). Good quality hay is rather leafy, fine-stemmed with bright green color indicating proper curing, free from foreign material, free from mould and dust and smells good enough to eat (Alemu and Mengistu, 2007). Conservation of natural pasture hay can be done in two different forms. This includes conservation in the form of baled or loose hay and standing hay (*in situ* conservation).

Forage conservation in the form of standing hay is the commonest and cheapest form of natural pasture conservation in Tanzania (Mtengeti *et al*., 1989). However the major limitation is the decline in nutritive value as the pasture become over matured and also vulnerable to the risk of fire (Comakli *et al.,* 2000). When cutting is delayed, hay dry matter yield is generally increased, but quality characteristics like crude protein content and digestibility decreases (Reece *et al*., 1994). Over mature pasture that has excessively over stayed in the field until the first rain

showers of the next season is referred to as foggage. Foggage is of poor nutritive value when compared with standing hay (Kirkman and Moore 1995). Deterioration of the nutritive value of the natural pasture is caused by the rapid growth rate and therefore maturation, leading to low leaf to stem ratio and declining nutritive value with maturity (Caddel and Allen, 2010). The objective of the study was to assess the quality of natural pasture hay conserved in form of standing hay and foggage.

Material and Methods

The experiment was carried out at Magadu dairy farm in Sokoine University of Agriculture (SUA), Morogoro Tanzania from November, 2011 to June, 2012. SUA is situated about 2.5 km south of Morogoro municipality between 6 and 7°S and between 37 and 38°E at an altitude of 550 meters above sea level. The area receives a mean annual rainfall of 880 mm. The rainfall pattern is bimodal with the short rain beginning sometimes in October ending in mid-January while the long rain begins towards the end of February and end in mid-May. For most parts of the year temperatures vary between 27° and 31° C. The dominant soil type at Magadu dairy farm is clay loam.

A plot of natural pasture of one hectare was used in this study. The pasture was rested for the entire growing and dry periods for 9 months until the first showers of short rains of 2011. Therefore the natural pasture plot was over mature with low nutritive value herbage and could be termed as foggage. ''Foggage'' as used in this study refers to excessively overstayed standing hay. The plot consisted of a mixed stand of natural pastures species dominated by *Heteropogon contortus*, *Bothriochloa* species, *Brachiaria* species, *Hyperrhenia* species, *Chloris gayana* and some legumes i.e. *Rynchocia* species, *Neonotonia wightii* and *Macroptilium atropurpureum.* The contribution of leguminous pasture species to the total stand was very little and was regarded as a trace. Among the prominent weeds were *Vernonia glabra.* The nutritive value of foggage was compared to the standing hay harvested in the adjacent area of the same species after resting the area for 6 months.

The weeds from an over mature natural pasture plot were removed by using bush knives and hand hoes. Mowing was done towards the end of October, 2011. Scythes were used for harvesting of the forage materials. Ten forage samples were taken at random from the mowed material for determination of botanical fractions. Botanical fractions were established based on the proportion of the whole leaf (i.e. leaves, leaf sheath) and stems from a given weight of hay sample.

Organoleptic test score (OTS) was done to evaluate foggage quality in terms of appearance, smell, touch and pollution according to Stahlin (1973). Assessment was done by a panel of ten individuals and each marked a score grade on a sheet of paper for each treatment (hay type).

Key for hay grading is outlined below;

Appearance	0 = Grey, strongly bleached hay.
	5= Colour somewhat changed or slightly bleached.
	10=Hay with natural colour.
Smell	0= Hay with no smell at all.
	5= Hay with a good smell of original plant.
Touch	5= somewhat hard.
	10= Soft and pliable hay.
Pollution	0= Hay with many traces of foreign materials and mouldy dust.
	5= Hay free from foreign bodies, only traces of foreign materials.

Ten representative samples each 500 g were taken randomly to the laboratory to determine the dry matter (% DM) content as well as for proximate analysis to determine the Crude Protein content (% CP), *In vitro* dry matter digestibility (% IVDMD) and *in vitro* organic dry matter digestibility (% IVODMD) as well. Crude protein content was determined by using macro Kjedahal method i.e. the procedures of Association of Official Analytical Chemists (AOAC, 1995), whereas

IVDMD was determined according to two stages method of Tilley and Terry (1963) procedures. Metabolizable energy (ME) contents (MJ/kg DM) was calculated according to MAFF (1976) as follows:

DOMD % = 0.98 DMD % -4.8. ME (MJ/kg DM) = 0.15 DOMD % for concentrate feeds or 0.16 DOMD % for forages /hay.

In addition the determination of Neutral Detergent Fiber (NDF)) was done according to Van Soest *et al*. (1991). The same procedures were repeated for standing hay produced on the adjacent area with the same species.

Data Analysis

Data on chemical composition such as %DM, %CP, %NDF and %IVDMD, %IVODMD, ME as well as data on botanical fraction were subjected to statistical analysis. Data were analyzed using the following statistical models:In the first trial the statistical model for data analysis was as follows; $Y_i = \mu + A_i + ei$

Where:-

Y_i = Quality of hay.

μ = overall mean.

A_i = Effects of resting period of the sward

e_i = random error effects.

Means and standard error was calculated and then t-test was used for comparison of the two means with significance at 0.05.

Results

Short rain season mean monthly rainfall was (80.40 mm) ranging from 23.2mm in October to 191.1 mm in December (Table 1).The mean monthly maximum temperatures ranged from 31.6 in Oct to 34 in December while mean minimum temperatures (20.60 and 20.70 mm) did not differ very much. Also the mean monthly solar radiation in short rain was higher (23.70 MJm^2) than that of the long rain season (17.30

MJm^2). In addition short rain season had lower mean monthly relative humidity (73.50%) than those of long rain season (77.00%).

Table 1 Monthly rainfall, temperature, relative humidity and solar radiation during the short rain season from October, 2011 to January, 2012

Month	Rain (mm)	Temperature (°c) Min	Max	R.H (%)	Rad(MJm^2)
October	23.20	19.70	31.60	71.00	18.00
November	37.00	21.30	32.40	72.00	19.10
December	191.1	20.20	34.00	75.00	19.20
January	70.30	21.50	33.10	76.00	38.20
Mean	80.40	20.70	32.80	73.50	23.70

R.H-Relative humidity. Max- maximum. Min- minimum

The soil from experimental field was clay loam in texture, low in total N, medium in P and very acidic (Table 2).

Table 2: The soil chemical composition and texture of the study area

S/N0	Depth sampling (cm)	Soil pH (in H_2o)	TN-Kjeld (%)	P (mg/kg) $PBry^{-1}$	K^+ $cmolkg^{-1}$	Texture
1	0-20	4.67	0.13	2.39	0.59	Clay Loam
2	20-40	4.74	0.11	3.39	0.67	

Results for chemical composition of foggage and standing hay are given in Table 3. The DM content of foggage was 85.94 ±0.07% while that of standing hay was 83.07±0.07% and were not significantly (P≥ 0.05) different. Standing hay had slightly higher %CP content (3.80 ±0.08) than the foggage (3.31 ±0.08) but they were not significantly (P≥ 0.05) different. *In vitro* dry matter digestibility of foggage was 34.27±0.67% and was slightly higher than those of standing hay (32.30±0.67%).

Similarly IVODMD were 33.29±0.52% and 32.44±0.52% for foggage and the standing hay respectively. ME energy was 5.33±0.09 MJ/kg DM and 5.20±0.09 MJ/kg DM for foggage and standing hay respectively and were not significantly (P≥ 0.05) different. The NDF content of foggage was significantly higher (P≤ 0.05) than that of the standing hay. The resting period of foggage was significantly (P≤ 0.001) higher than that of standing hay.

Table 3: LSM and SE for chemical composition of foggage and standing hay

	Hay type	**n = 18**			
	Foggage	**Standing hay**	**SE**	**P values**	**SL**
Rest period (Months)	9.00^{A}	6.00^{B}	0.00	<0..0001	***
DM%	85.94 ^{A}	83.70 ^{A}	0.07	0.4963	^{ns}
NDF%	82.4^{A}	80.25^{B}	0.33	0.0309	*
CP%	3.31 ^{A}	3.80 ^{A}	0.08	0.0692	^{ns}
INVDMD%	34.27 ^{A}	32.30 ^{A}	0.67	0.1727	^{ns}
INVOMD%	33.29 ^{A}	32.44 ^{A}	0.52	0.3655	^{ns}
ME(MJ/kgDM)	5.33 ^{A}	5.20 ^{A}	0.09	0.4029	^{ns}

LSM with the same letter are not significantly different. SL= Significant level

LSM-Least square means SE-Standard error SL-Significant level ^{ns} - Not significant * = (P≤ 0.05) * * * = (P≤ 0.001)

Results for botanical fractions of foggage and standing hay are given in Table 4. Standing hay had significantly higher (P≤ 0.05) leaf/stem ratio than the foggage. (The leaf fraction included the leaf sheath).

Table 4: LSM and SE for botanical fractions of foggage and standing hay (leaf/stem ratio)

Botanical fractions	**(n = 20)**
Hay type	**Leaf/Stem ratio mean**
Standing hay	2.04
Foggage	1.40
SE	0.19
P value	0.0256
SL	*

LSM-Least square means * = (P≤ 0.05) SL-Significant level SE-Standard error

Results of organoleptic test scores for the standing hay and foggage with respect to appearance, smell, touch and pollution are shown in Table 5. Standing hay had significantly (P≤ 0.001) higher organoleptic test scores for both appearance and smell than foggage. However the two types of hay were not significantly (P ≥ 0.05) different in terms of touch and pollution.

Table 5: LSM and SE for Organoleptic test scores (OTS for standing hay and foggage with respect to appearance, smell, touch and pollution

Hay types n=10	**Appearance(A)**	**Smell(S)**	**Touch(T)**	**Pollution(P)**
Standing hay	5^{A}	5^{A}	5^{A}	5^{A}
Foggage	0^{B}	0^{B}	5^{A}	5^{A}
SE	0.00	0.00	0.00	0.00
P-values	0.0001	0.0001	0.07501	0.0858
SL	* * *	* * *	Ns	Ns

LSM with the same letter are not significantly different. SL= Significant level

LSM-Least square means * * * = (P≤ 0.001) ns- Not significant

OTS key for grading according to Stahlin (1973). A= 0,5,10 S= 0, 5 T= 5, 10 P = 0, 5.

Results for organoleptic test scores of foggage and standing hay regardless of appearance, smell, pollution and touch are given in Table 6. Standing hay had slightly higher organoleptic test scores than the foggage but were not significantly ($P \geq 0.05$) different. High scores for organoleptic test indicate superior quality.

Table 6: LSM and SE for OTS of foggage and standing hay regardless of Appearance, Smell, Touch and Pollution

Hay type n = 8	**Organoleptic test scores**
Sanding hay	5.00
Foggage	2.50
SE	1.02
P value	0.1817
SL	ns

LSM-Least square means ns- Not significant SL-Significant level SE-Standard error

OTS key for grading according to Stahlin (1973). A= 0,5,10 S= 0, 5 T= 5, 10 P = 0, 5.

Discussion

The standing hay had slightly higher CP content (3.80%) than the foggage (3.31%) but the difference was insignificant. Low values of CP contents reported in this study could be due to a decrease in leafiness and an increase in stem to leaf ratio due to advance aging of forage plants (Van Soest, 1982; Teshome, 1987). A decrease of the crude protein content as grasses mature is due to an increase in the proportion of stem, which has lower crude protein content than the leaf fraction (Laredo and Minson, 1973).

The value of in vitro dry matter digestibility of foggage (34.27%) reported in this study was slightly higher than the reported value of standing hay (32.30%). These results were in agreement with Van Soest

(1994) who observed that high NDF content and low CP content with advancing stage of maturity accounts for low IVDMD of the natural grass standing hay due to accelerated lignification of plant cell wall under tropical conditions.

The results of this study revealed that the NDF content of foggage (82.4%) was higher than that of standing hay of (80.25%) These differences could be attributed to the higher proportion of stem in foggage as compared to standing hay. The results of the present study indicate that ME content of the standing hay was slightly higher than that of foggage. The standing hay ME value reported in this study (5.33 MJ/kg DM) was lower than the values reported by Bogale *et al*. (2008) ranging from 7.9 ME (MJ/kg DM) in Sinana sub-district to 6 ME (MJ/kg DM) in Dinsho sub-district in Ethiopia. The difference could be attributed to the variation in pasture species difference, geographical location, environmental condition especially the rainfall and temperatures.

Standing hay had higher leaf to stem ratio than the foggage. The results of leaf to stem ratio of 1.40 for foggage is closely related to those reported by Rautenbach *et al.* (2008) who reported the leaf to stem ratio of 1.30 for grasses in KwaZulu-Natal, South Africa. The higher value of leaf to stem ratio obtained in this study for the standing hay as compared to the foggage are consistent with Van Soest (1982) who advocated that the aging of forage is frequently associated with a decrease in leafiness and thus an increase in stem over leaf fraction.

Standing hay had higher organoleptic test scores for both appearance and smell than foggage. The difference was due to the fact that foggage was strongly bleached in appearance and had no original smell of the plant at all as compared to the standing hay which was slightly grey (Stahlin, 1973).

Conclusion

The current study revealed that the quality of hay is affected by maturity stage. The higher the maturity stage the lower the quality of forage in terms of nutritive value and digestibility. The foggage with extended maturity found to have poor quality compared to standing hay. Further studies are recommended seasonal fluctuation in forage quality over time.

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