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Nutrient Composition of Pastures in Kayunga District, Uganda: A Preliminary Investigation with Implications for Seasonal Supplementation in Grazing Ruminants

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Abstract

Proximate nutrient composition (crude protein, non-fiber carbohydrates, crude fiber, and ash), fiber fractions (neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin), and both macro- (calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), and sulfur (S)) and trace (copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn)) mineral profiles were quantified in mixed pasture samples collected during the wet (n = 8) and dry (n = 15) seasons in north central Uganda. Metabolizable and Net Energy values for dairy production were estimated based on standard calculations, and samples were compared seasonally. Crude fat (p = 0.05) and lignin (p = 0.01) values were lower in the dry season compared with the wet season, linked with reduced plant growth. Crude protein (13.0% of dry matter (DM)), fiber fractions, and calculated energy content did not vary seasonally in this data set, and reflected chemical components of a grass-dominated system that appeared energetically limiting for production livestock. Mineral constituents varied more dramatically by season, with Ca, Mg, Cu, and Mn lower (all < 0.05) and K higher in the dry season. Sodium was deficient in these pastures, whereas Ca, P, Mg, S, Cu, and Zn concentrations may have been only marginally sufficient, particularly to meet needs for lactation, dependent on season. These limited data suggest that a high-energy mineral supplement may prove beneficial in meeting nutritional and production needs of multiple grazing ruminant species in this region, particularly during dry seasons.

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Keywords

Cattle; Forage; Minerals; Nutrition

1. Introduction

Carrying capacity of rangelands utilized in the Ankole grazing system in Uganda has been previously modeled [1], and has been found to be highly dependent on rainfall patterns, thus subject to strong seasonality. Pasture nutrient resources (sampled in approximately 2-mo intervals corresponding to wet/dry seasons)—measured as either average dry matter production [1] or crude protein content [2]—were also highly variable; cattle body condition and productivity decline with the dry season and recover during wet seasons. Although animals can respond to lower available forage in the dry season behaviorally through selective feeding and browsing, pasture nonetheless provides primary nutrition year-round. Both quantity and quality characteristics must be considered in order to optimize nutritional strategies, including the need for supplementation. This study provides baseline information on proximal nutrient and mineral constituents of pastures utilized by grazing livestock during dry season compared to wet season in the Bbale district of central Uganda.

2. Materials and Methods

Pasture samples (n = 8 wet season; n = 15 dry season) were randomly sampled from open rangelands grazed by Ankole cattle in Kayunga District, Bbale County, Uganda by hand-clipping all ground cover encircled in a 1 m^2 open frame. Wet season samples were taken April/May 2011, whereas dry season samples were collected from the same locale in November/December 2010. Samples were weighed, air-dried in the field, and then oven-dried at 60˚C in the Department of Animal Sciences, Makerere University, Kampala. Samples were ground through a 1 mm screen, and analyzed using standard laboratory methods (http://dairyone.com/wp-content/uploads/2014/02/Forage-Lab-Analytical-Procedures.pdf); minerals were analyzed on a Thermo ICAP 6300 Inductively Coupled Plasma(ICP) Radial Spectrometer (Thermo Fisher Scientific, Inc., Waltham, MA 02454, USA). Seasonal comparisons in nutrient content were evaluated using unpaired t-tests, with significance set at $P < 0.05$.

3. Results and Discussion

Proximate (crude protein, crude fat, non-fiber carbohydrates (NFC), ash), cell wall constituents (acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin), energy estimates, and mineral concentrations in pasture samples are reported in **Table 1**, whereas dietary nutrient recommendation summary ranges for various livestock species are in **Table 2**. Higher nutrient densities in the reported ranges of **Table 2** correspond to higher production stages (growth, late reproduction, lactation). Although mean crude protein did not differ seasonally between samples, percent soluble protein was higher ($P = 0.03$) in samples collected from the dry vs. the wet season. Protein content measured in this study (with one exception) was similar to mean protein recorded in 10 major grasses (mixed) sampled in 4 regions of Uganda (12.2% Acholilango area, 12.7% Eastern region, 15.7% Bugana-Busoga Lake shore, 5.97% Ankole zone; [3], reported by [4]. Nonetheless, crude protein in native pastures (~13% of dry matter (DM)) appeared adequate to meet basal requirements for all species, except perhaps at highest stages of production.

Overall fiber (NDF and ADF) concentrations did not vary seasonally in these samples, but the lignin content of samples collected in the dry season was lower than that of wet season samples, likely due to lower degree of maturity in pasture sampled during the dry season. Due to lower lignification as a proportion of plant cell walls (lignin/NDF or lignin/ADF), dry season pasture had a potentially higher fermentation value compared to wet season forages; this difference, however, was not seen in estimated energy values of the samples. Sabiiti and Mugerwa [4], using *in vitro* digestibility techniques, reported 3% to 15% higher digestibility of wet vs. dry season forages (*Panicum* in pure stand or with 4 different legumes) in Uganda, with digestibility values ranging from 43% to 61%. Certainly ruminant species with healthy rumen function should be able to utilize native pastures for energy production. The metabolizable energy concentrations in these forages (1.7 MKcal/kg), as well

Table 1. Nutrient profile of mixed pasture samples from Kayunga District, Bbale County, Uganda collected 2010-11. All nutrients (except Dry Matter (DM) on a DM basis.

Nutrient	Unit	Wet Season (n = 8)		Dry Season (n = 15)		Seasonal Comparison
		Mean	SD	Mean	SD	P value
Dry Matter	%	90.76	0.45	89.70	1.9	0.03
Crude Protein	%	12.80	3.49	13.15	7.4	0.44
Soluble Protein	%	44.25	4.57	57.21	21.5	0.03
ADF	%	38.70	4.40	34.31	12.3	0.09
NDF	%	62.41	3.30	57.39	16.6	0.14
Lignin	%	7.10	1.58	4.71	3.2	0.01
NFC	%	7.33	3.55	8.64	3.6	0.22
Fat	%	1.95	0.65	1.41	0.8	0.05
Ash	%	11.43	2.04	17.69	18.3	0.11
Digestible Energy	Mcal/kg	2.2	0.3	2.2	0.6	0.46
Metab Energy	Mcal/kg	1.7	0.3	1.7	0.7	0.48
NE Lactation	Mcal/kg	0.9	0.2	0.9	0.4	0.49
NE Maintenance	Mcal/kg	0.9	0.2	0.9	0.5	0.45
NE Gain	Mcal/kg	0.4	0.2	0.5	0.3	0.23
Minerals						
Ca	%	0.44	0.08	0.31	0.1	<0.01
P	%	0.23	0.07	0.34	0.5	0.18
Mg	%	0.24	0.07	0.18	0.1	0.03
K	%	1.60	0.42	2.29	1.3	0.04
Na	%	0.01	0.01	0.02	0.1	0.19
Fe	ppm	1068.88	790.19	814.53	843.5	0.24
Zn	ppm	33.38	15.59	24.67	8.1	0.09
Cu	ppm	9.63	2.00	6.00	2.4	<0.01
Mn	ppm	194.75	89.52	107.60	26.4	0.01
S	%	0.17	0.06	0.18	0.1	0.34
Mo	ppm	1.20	0.77	1.03	0.5	0.30

ADF = acid detergent fiber; NDF = neutral detergent fiber; NFC = non-fiber carbohydrates; NE = net energy; Minerals: calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), sulfur (S), molybdenum (Mo).

as net energy (NE) lactation values (0.9 Mcal/kg), however, suggest that energy may be a limiting nutrient in native pastures.

Total ash was numerically, but not statistically, higher in dry season compared to wet season samples, probably due to a greater proportion of soil contamination. Of the macrominerals analyzed, Ca and Mg were higher in wet season samples compared to dry season; the opposite was seen with K (the latter observation suggesting a less mature, perhaps slower growth stage of plant). Trace elements differed seasonally for Cu and Mn, with wet season samples containing higher concentrations of these nutrients. As with most forages, all pastures sampled were grossly deficient in sodium relative to the dietary needs of ruminants, highlighting the essentially of providing a salt lick for grazing animals. Relative to animal requirements, both Ca and P needs, particularly of lactating cows (either dairy or beef) could be limiting in native pastures, depending upon the season and bioavailability (form) of macrominerals in the forages. Similarly, Mg and S supplied by pastures may prove marginal for dairy cows (and goats) in heavy lactation. Fe and Mn were found in relative excess, whereas Cu appears to be a limiting trace mineral across species and physiologic stages. It is also possible that high dietary Fe levels may limit or interfere with other mineral metabolism, most notably Cu, as has been previously suggested [5]. Zn nutrition may be marginal, depending upon species, season, and stage of production—in general, Zn needs of lactating dairy cows were not met by native pastures in this study. Selenium (Se) and iodine (I) were not measured in these samples, but are known to be limiting in many regions of Sub-Saharan Africa [6]; livestock status should be evaluated to determine the need for supplementation in this region.

Table 2. Target dietary nutrient concentrations for various grazing ruminants (DM basis). Ranges indicate varying levels associated with different stages of production.

Nutrient	Unit	Lactating Cow Reqt [7]	Beef Reqt [8]	Sheep Reqt [9]	Goat Reqt [9]
Crude Protein	%	9.2 - 15.1	7.4 - 16.6	6.2 - 30	
ADF	%	17 - 21			
NDF	%	25 - 33	20 - 57	8.9 - 72.4	
NFC	%	36 - 44			
Metab Energy	Mcal/kg		1.84 - 2.58	1.63 - 3.17	2.39
NE Lactation	Mcal/kg	1.37 - 1.8+			
NE Maintenance	Mcal/kg		1 - 2.29		
NE Gain	Mcal/kg		0.45 - 1.59		
Minerals					
Ca	%	0.3 - 0.48	0.14 - 0.71		
P	%	0.33 - 0.44	0.13 - 0.29		
Mg	%	0.18 - 0.29	0.1 - 0.2	0.12 - 0.18	
K	%	1.0 - 1.2	0.6 - 0.7		0.5 - 0.8
Na	%	0.2	0.06 - 0.1		1.7
Fe	ppm	12 - 22	50	30	35 - 95
Zn	ppm	43 - 73	30	20 - 51	20 - 80
Cu	ppm	9 - 16	10	7 - 11	15 - 25
Mn	ppm	12 - 21	20 - 40	10 - 25	20 - 120
S	%	0.2	0.15	0.18	0.16 - 0.36
Mo	ppm			0.5	0.1 - 1
Se	ppm		0.1	0.3	0.3
I	ppm	0.3	0.5	0.5 - 0.8	0.5 - 0.8

ADF = acid detergent fiber; NDF = neutral detergent fiber; NFC = non-fiber carbohydrates; NE = net energy; Minerals: calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), sulfur (S), molybdenum (Mo), selenium (Se), iodine (I).

4. Conclusion

Based on this limited sample, a high energy supplement with targeted minerals (both macro and trace) may improve overall animal nutrition, health, and productivity of grazing ruminant livestock in this region of Uganda, particularly during the dry season(s). A molasses-based block with added Ca, P, Mg, S, Cu and Zn—and possibly I and Se—may prove beneficial across multiple species.

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