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Chemical composition and *in vitro* dry matter digestibility of indigenous finger millet (*Eleusine coracana*) in Botswana

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Abstract

Samples of three finger millet landraces NPGRC 3001, NPGRC 3002 and NPGRC 3003 were obtained during the vegetative stage (80 days growth) and from straw. They were analysed for ash, CP, NDF, ADF, ADL, NDF-N, Ca, P, Zn, Mn, Cu and IVDMD.

NPGRC 3001 had the highest IVDMD (62.6% DM), while NPGRC 3002 had the highest ash (15.1% DM), NDF (72.6% DM) and ADF (41.3% DM) content. CP was positively correlated to NDF-N ($r = 0.57$; $P<0.001$) and to IVDMD ($r = 0.40$; $P<0.01$). There was a significant negative correlation between IVDMD and ADF ($r = -0.69$; $P<0.001$) consistent with the negative effect of ADF on energy content of forages. The amount of protein in straw was lower than that of the vegetative form, but was well above what would be expected in natural grass harvested at full maturity.

Key words; Composition, crude protein, finger millet, In vitro dry matter digestibility

Introduction

Finger millet is believed to be the cultivated form of *Eleusine indica* (L.) Gaerta. The plant is an annual, tufted grass and varies in height from as little as 25cm up to more than 120cm. It tillers at a population of less than 10 plants per square meter (Johnson 1968). Finger millet is a traditional African crop grown for food grain and for brewing beer. According to Johnson (1968) the straw is given to livestock. In Botswana the use of finger millet is dying out and it is becoming a marginalized crop. Finger millet used to be utilised in the north east of the country. But nowadays pearl millet is the only millet type prominently cultivated by farmers. In order to revive the popularity of marginalised traditional crops, it is important to find other ways of utilising them such as using them as livestock feed. There are two possible potential ways in which this resource can be used as animal feed. Finger millet can be grown solely as forage and harvested at vegetative stage for making hay or silage. The second option is for an integrated approach in which the grain is used for food and for beer brewing with the straw being a feed resource for livestock. However there is little or no research on the chemical attributes of local finger millet. The results presented here are preliminary data on the chemical composition and dry matter in vitro digestibility of forage (80 days growth) and straw derived from indigenous finger millet in Botswana.

Materials and methods

The trial was carried out on clay soil of Boro Experimental Site in Maun in the 1999/2000 planting season. The experimental site is located at a latitude of 19° 59' S, longitude 23° 25'E and at an altitude of 945 masl. Mean rainfall for the area is 428 mm per year but for the 1999/2000 planting season it was 694mm. The trial was a randomised complete block design with three replications. Three finger millet landraces (NPGRC 3001, NPGRC 3002 and NPGRC 3003) were planted on 14/12/99. The seeds had been sourced from smallholder farmers in North East of Botswana. The plants were planted in plots of size 5m x 3m and each landrace was planted in 6 rows of 0.5 metres spacing. Samples were taken randomly from the three replicates at the vegetative stage on 03/04/2000, dried and stored until analysed. At grain harvesting, straw was sampled from three replicates. Samples from the vegetative stage and the straw were placed in a forced draught oven at 60°C for 48h. The dried samples were ground to pass through a 2 mm screen and analysed for ash, neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), NDF-N, nitrogen (Kjeldahl method) and minerals (wet digestion for macro- and dry digestion for micro-minerals), following the methods of (AOAC 1996). Calcium, Cu, Mn, and Zn were determined with an atomic absorption spectrophotometer and phosphorous with a ultra-violet spectrophotometer. In vitro dry matter digestibility was estimated according to Tilley and Terry (1963), incubating the samples in a thermostatically controlled circulating water bath. Rumen liquor was taken from a Tswana steer fed a mixture of *Cenchrus ciliaris* and *Lablab purpureus* (ratio of 1:1 DM basis at a rate of 8kg/day. The diet contained (g/kg DM) 76.8 crude protein, 7.8 calcium, 1.2 phosphorous, 776 NDF, 547 ADF and 904 organic matter.

Statistical analysis

The General Linear Model (GLM) procedure (SAS 1990) was used to test the effects of landrace and feed source on chemical composition and in vitro dry matter digestibility. Interactions between landrace and feed source were also tested. Differences between specific landraces and between plants parts were tested for significance using least significance difference (LSD). Correlations between some chemical attributes were examined. Means are reported as least square means.

Results

Landraces

NPGRC 3001 had the highest IVDMD level while NPGRC 3002 had the highest ash, NDF and ADF content (Table 1).

Table 1. Chemical composition and *in vitro* dry matter digestibility of different finger millet landraces[1]

Parameter	NPGRC3003	NPGRC3001	NPGRC3002	SEM[2]	Prob.
Ash	12.1[b]	11.3[b]	15.1[a]	0.95	<0.05
CP	8.29	8.21	7.98	0.43	NS
NDF	70.1[b]	68.9[b]	72.6[a]	0.79	<0.01
ADF	37.4[b]	37.7[b]	41.3[a]	0.61	<0.001
ADL	5.51[a]	4.68[b]	5.18[ab]	0.28	NS
NDF-N	0.59	0.53	0.52	0.032	NS
Ca	0.75	0.74	0.65	0.039	NS
P	0.07	0.07	0.08	0.01	NS
Zn	25.9	25.2	23.2	2.00	NS
Mn	229.	187	208	16.9	NS
Cu	5.39	5.28	5.11	0.53	NS
IVDMD	62.6[b]	64.3[a]	58.1[b]	1.00	<0.001

[1]Units are expressed as % DM except for Zn, Mn and Cu, which are in ppm.
[2]SEM = Standard error of the mean.
Values within a row among Landraces without letter in common are different (P<0.05)

Forage versus straw

Most of the nutritional criteria indicated that, as expected, the forage had a higher feeding value than the straw (Table 2).

Table 2. Chemical composition and *in vitro* dry matter digestibility of forage and straw of finger millet[1]

Parameter	Feed source		SEM	Prob.
	Forage	Straw		
Ash	8.83	16.9	0.78	<0.001
Crude protein	8.87	7.45	0.35	<0.01
Neutral detergent fibre	71.4	69.7	0.60	NS
Acid detergent fibre	36.7	40.9	0.50	<0.001
Acid detergent lignin	5.49	4.76	0.23	<0.05
NDF-N	0.69	0.40	0.03	<0.001
Calcium	0.55	0.88	0.032	<0.001
Phosphorous	0.11	0.03	0.01	<0.001
Zinc	20.5	29.1	1.60	<0.001
Manganese	183	233	13.8	<0.05
Copper	5.85	4.67	0.43	NS
IVDMD	73.2	50.1	0.80	<0.001

[1]Units are expressed as % DM except for Zinc, Manganese and Copper, which are in ppm

Relationships

Crude protein was positively correlated to NDF-N (r=0.57, P<0.001) and to IVDMD (r= 0.40, P<0.01). CP was however negatively correlated to ADF (r= -0.31, P<0.05). There was a high negative correlation between IVDMD and ADF (r= -0.69, P<0.001) (Table 3).

Table 3. Correlation among the chemical attributes and IVDMD

	ADF	**NDF-N**	**IVDMD**
Crude protein	-0.31*	0.57***	0.40**
IVDMD	-0.69***		

*NS = P>0.05   * = P<0.05   ** = P<0.01   *** = P<0.001*

Discussion

The crude protein contents of the three landraces were similar and comparable with values reported by Aganga et al (1996) and were higher than would be expected of natural grass in Botswana (4.4% in natural grass harvested at full maturity according to APRU [1975]). The mean crude protein in the present study was higher than those of grain sorghum stover tested by Youngquist et al (1990) in Botswana. It was also higher than the mean of 6.2% for grain sorghum residue reported by Snyman and Joubert (1995) in South Africa. Kamalamma Krishnamoorthy et al (1996) recorded low amounts of CP for finger millet straw than was observed in the present study. Crude protein in the present study is in the level permissible for optimal feed intake and rumen function considering the IVDMD of 61% DM.

Minerals, calcium (Ca) and phosphorus (P) form a major mineral supplementation intervention in Botswana in the form of licks containing dicalcium phosphate (Madibela et al 2002). The level of these minerals was the same among the finger millet landraces and the ratio of Ca to P was 10:1. Calcium is associated with phosphorous metabolism in animals. According to Abdulrazak et al (2000) a ratio of 2:1 is recommended for physiological function of phosphorous metabolism of bones. The high ratio of Ca to P observed in the present study indicates a potential imbalance supply of these minerals by finger millet. Calcium and phosphorous content of finger millet straw in the present study was lower than of finger millet used by Kamalamma Krishnamoorthy et al (1996) in a feeding study of crossbred dairy cows. It was found that copper levels did not differ between landraces and was within the normal range of 4 to 8ppm for pasture (McDonald et al 1988). However, according to Smith and Akinbamijo (2000), the susceptibility of Cu to form biological unavailable complexes (i.e. copper-molybdenum-sulphur, copper-iron, copper-zinc, copper-phytate) is partly responsible for high incidence of copper deficiency syndromes with grazing ruminants. The significance of this unavailability may be felt in reproduction of grazing ruminants since copper deficiency is associated with reproductive disorders. It is not apparent, however, if copper in finger millet would be available to ruminants or not. Zinc is an important constituent of several enzymes. The level of zinc in the present study was higher than that reported by Aganga et al (1996) for E. coracana. The mean level of Manganese (209 ppm DM) in the present study was within the range of 40-200ppm for pasture (McDonald et al 1988). Ash was different between landraces, with NPGRC 3002 having the highest value. It was found that straw had high level of ash than the vegetative form probably due to contamination during harvesting. There was also a landrace x feed source interaction for ash indicating that specific difference in landrace did not have similar effects on the two feed sources.

Neutral detergent fibre differed between the landraces, with NPGRC 3002 having the highest (72.6% DM) and NPGRC 3001 the least (68.97% DM) amount. Acid detergent fibre constituted about half the portion of NDF. Acid detergent lignin was not affected by difference in landrace but by the utilization form, with the vegetative-form having a high value than straw. This is unexpected since when plants mature the structural components are suppose to increase. Aganga et al (1996) found an increasing lignin values as the finger millet crop matures. Kamalamma Krishnamoorthy et al (1996) recorded fibre components contents of finger millet straw, which were similar to those observed in the present study. Neutral detergent bound nitrogen was found in the present study to be similar between landraces. The vegetative form had high value of NDF-n than straw. The overall NDF-n level was however less than what was observed for sweet sorghum forage harvested at 16 weeks (Madibela et al 2002). In vitro dry matter digestibility differed between landraces, NPGRC 3001 with the highest value and NPGRC 3002 having the least level. The overall mean of IVDMD was lower than 78% recorded for sweet sorghum in Botswana (Madibela et al 2002). The vegetative form was found to have high IVDMD than straw. As the plant mature IVDMD declines (Aganga et al 1996). This implies that better forage quality would be obtained if finger millet were harvested at 80 days after planting, as was the case in this study. In vitro dry matter digestibility for finger millet at approximately 80 days after planting was higher than the value reported by Aganga et al (1996) at similar growth stage. A positive correlation between IVDMD and CP indicate that as the crude protein increase, there was an improvement in IVDMD. Acid detergent fibre has a negative effect on energy content of forages and this was consistent with a highly negative correlation observed between ADF and IVDMD.

The results of the present study show differences between finger millets on ash, NDF, ADF and IVDMD. An interaction between landrace and feed resource was only observed for ash and IVDMD. Feed resource had an effect on all parameters investigated except NDF and copper, indicating that it would be advisable to harvest finger millet at vegetative stage to ensure forage quality.

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