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Short Note [Nota Corta]

THE EFFECT OF STAGE OF GROWTH AND METHOD OF DRYING FRESH HERBAGE ON CHEMICAL COMPOSITION OF THREE TROPICAL HERBACEOUS FORAGE LEGUMES

[EFECTO DE LA ETAPA DE CRECIMIENTO Y EL MÉTODO DE SECADO SOBRE LA COMPOSICIÓN QUÍMICA DE TRES ESPECIES HERBACEAS DE LEGUMINOSAS FORRAJERAS TROPICALES]

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SUMMARY

The objective of this study was to assess the effect of stage of growth and method of drying fresh herbage on the chemical composition of herbaceous forage legumes namely *Cassia rotundifolia (*Cassia*)*, *Lablab purpureus* (Lablab) and *Macroptilium atropurpureum* (Siratro). The interactions of legume species, drying method and stage of growth influenced the crude protein content and nitrogen degradation of the legumes. Siratro maintained a greater protein content ranging from 191 to 282 g/kg DM, at all stages of growth and drying methods than either cassia or lablab which had values ranging from, respectively, 173 to 246 and 162 to 254 g/kg DM, but were also different. Drying the forages at 60 ^{0}C caused an increase in the acid detergent insoluble nitrogen content of the legumes. The neutral detergent fibre, acid detergent fibre and lignin content of cassia and siratro harvested at 8 or 14 weeks of growth were greater than in lablab. While the protein content declines with fibre increasing with advancing plant maturity, the legumes tend to maintain a high CP content, which makes them acceptable protein supplementary feeds to low quality roughages. Among the three legumes, siratro showed a higher sustained CP content followed by cassia, and lablab was the least. To ensure high quality forage more emphasis should be placed on drying methods and harvest management as this affects the extent of leaf loss from the forage legumes and hence the quality of the final feed given to animals.

Key words: Forage, legumes, stage of growth, chemical composition.

RESUMEN

El objetivo del presente trabajo fue evaluar el efecto de la edad y el método de secado sobre la composición química de las leguminosas forrajeras herbaceas *Cassia rotundifolia* (Cassia), *Lablab purpureus* (Lablab) y *Macroptilium atropurpureum* (Siratro). Se encontró una interacción entre especie de leguminosa, método de secado y etapa de crecimiento sobre el contenido y degradación de la proteína cruda de las leguminosas. Siratro tuvo un mayor contenido de proteína (de 191 a 282 g/kg MS), durante todas las etapas de crecimiento y en todos los métodos de secado comparado con cassia o lablab (de 173 a 246 y de 162 a 254 g/kg MS respectivamente). El secado de los forajes a 60 ºC causó un incremento en el contenido de nitrógeno ligado a la fibra detergente ácida. El contenido de fibra detergente neutra y ácida, y lignina de cassia y siratro de 8 o 14 semanas de crecimiento fueron mayores que en lablab. Las leguminosas tendieron a mantener un alto contenido de proteína en todas las etapas de crecimiento, lo que las hace aceptables como suplemento proteínico para dietas fibrosas de baja calidad. Entre las tres leguminosas, el siratro mostró el mayor contenido sostenido de proteína seguido por cassia y lablab. Para asegurar un forraje de alta calidad más enfásis debe ser puesto en los métodos de secado y el manejo durante la cosecha dado que influye sobre la pérdida de hojas y por ende en la calidad final del alimento a ser proporcionado a los animales.

Palabras clave: Leguminosas forrajeras, etapas de crecimiento, composición química, métodos de secado.

INTRODUCTION

The introduction of protein rich forage legumes into tropical farming systems has improved livestock production systems (Norton and Poppi, 1995). As a consequence, a range of tropical legumes has been tested for agronomic performance in tropical environments. The protein content of legumes ranges from 150 to 300 g/kg DM, with an average around 170 g/kg DM during the growing season, declining to as low as 110 g/kg DM in the dry season (Topps and Oliver, 1993).

Although there is extensive literature on the chemical composition of tropical legumes, much of this information is of limited value (Norton and Poppi, 1995). The available literature reports proximate compositions such as crude fibre and nitrogen free extracts that bear little relation to nutrient content and availability (Norton and Poppi, 1995). In addition, there are few reports on the assessment of chemical composition of herbaceous forage legumes harvested at similar stages of growth and dried at different temperatures. The objective of this study was, therefore, to examine the effect of stage of growth and method of drying fresh herbage on chemical composition of three tropical herbaceous forage legumes *C. rotundifolia*, *L. purpureus* and *M. atropurpureum*.

MATERIAL AND METHODS

Forage production procedure

The forage legumes, *C. rotundifolia* cv Wynn, *L. purpureus* cv Highworth and *M. atropurpureum* cv Siratro, were each grown during the 1994/95 season. Each legume was established in rows 0.45 m apart in plots measuring 15 x 50 m at a small scale commercial farm located in the Marirangwe Small Scale Commercial farming area near Harare, Zimbabwe, on sandy soils (pH 5.5 on $CaCl_2$ scale). Each of the plots was fertilized with single super phosphate at 200 kg/ha as recommended by soil analysis results. Marirangwe is in Agro-ecological Region IIa, with an altitude of 1 500m and receives a rainfall of 750-1000 mm per year.

Experimental procedure

The experiment was a 2 x 3 x 3 factorial experiment in a completely randomized design examining the effects of drying method (sun and oven drying), legume species (cassia, lablab and siratro) and stage of growth (8, 14 and 20 weeks after germination). Legume samples were cut in six randomly selected rows to 10 cm stubble height. At each harvesting stage different rows were harvested. The harvested legumes were each divided into two portions, approximately 2 kg with three replicates each, for either sun drying in the field or oven drying at 60 ^{0}C for 48 hours. During sun drying in the field the hay was turned twice a day for four days to ensure even drying.

Chemical Analysis

The dried legume samples were milled through a 2 mm screen. Duplicate samples of each legume per row either sun or oven dried were analyzed for crude protein (CP) using the Kjeldahl procedure (AOAC, 1984). Neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and acid detergent insoluble nitrogen (ADIN) were all determined according to the procedure of Goering and Van Soest (1970). Total ash was obtained by igniting a dried sample in a muffle furnace at 500 ^{o}C for 24 hours and calcium (Ca) and phosphorus (P) concentrations determined using an Inductively Coupled Plasma (ICP) emission spectrometer.

Statistical Analysis

Analysis of variance was used to determine the effects of legume species, drying method, stage of growth and their interactions on the contents of CP, NDF, ADF, ADL, Ca and P using the General Linear Models procedure of SAS (SAS, 1990). The analytical model was as follows:

$$Y_{ijk} = \mu + L_i + D_j + W_k + (LD)_{ij} + (LW)_{ik} + (DW)_{jk} + (LDW)_{ijk} + e_{ijk}$$

where Y_{ijk} is the dependent variable (e.g. CP, NDF), μ is the overall mean, L is legume species effect (i =1,2,3), D is effect of drying method (j = 1, 2), W effect of stage of growth (k = 1, 2, 3), $(LD)_{ij}$ is the interaction between legume species and drying method, $(LW)_{ik}$ is the interaction between legume species and stage of growth, $(DW)_{jk}$ being the interaction between drying method and stage of growth, $(LDW)_{ijk}$ being the interaction of legume species, drying method and stage of growth and e_{ijk} is the residual error, assumed to be normal and independently distributed. The differences between means were assessed using the Tukey Studentized Range Test of SAS (SAS, 1990).

RESULTS

The chemical composition of either sun or oven dried lablab, cassia and siratro harvested at three stages of growth is presented in Table 1. There was a significant ($P < 0.001$) three-way interaction among legume species, drying method and stage of growth on the CP, NDF, ADF, ADL, ADIN, ash and Ca content of the legumes. The CP content of the three legumes ranged from 162 to 282 g/kg DM. In forages harvested at 8 weeks of growth, sun and oven dried siratro had a higher ($P < 0.001$) CP content than that of either cassia or lablab that received similar drying treatments. Similarly, sun and oven dried cassia had a greater ($P < 0.01$) CP content compared to that of lablab. At 14 weeks of growth, sun dried siratro maintained a higher ($P < 0.001$) CP content than the other two legumes. There were no significant ($P > 0.05$) differences in CP content between sun dried cassia and lablab. When the forages were oven dried, cassia and siratro had similar

($P > 0.05$) CP values that were higher ($P < 0.01$) than that of lablab.

When harvested at 20 weeks of growth, sun dried cassia had a greater ($P < 0.01$) CP content compared to that of lablab. The CP content of siratro was higher ($P < 0.001$) than that of either cassia or lablab. However, when oven dried there were no significant ($P > 0.05$) differences in the CP content between cassia and lablab, lablab and siratro forages while that of cassia was lower ($P < 0.01$) than that of siratro.

Table 1: Chemical composition (g/kg DM) of either sun or oven dried cassia, lablab and siratro harvested at three stages of growth

Legume (L)	Growth Stage (W)	Drying (D)	CP	NDF	ADF	ADL	ADIN	Ash	Ca	P
Cassia	8	Sun	225	343	282	84.4	53.3	110	7.5	1.4
		Oven	242	426	288	76.0	70.2	128	7.3	1.3
	14	Sun	221	507	368	73.7	16.1	133	20.3	1.9
		Oven	246	506	408	74.2	21.5	131	20.4	1.6
	20	Sun	184	545	323	70.3	6.5	111	20.9	1.4
		Oven	173	547	357	106	10.0	79.7	21.1	1.1
Lablab	8	Sun	252	375	294	89.3	35.3	93.9	7.2	1.1
		Oven	254	328	282	95.8	60.0	114	7.6	1.2
	14	Sun	221	455	331	76.2	35.5	96.2	19.0	1.4
		Oven	216	473	405	62.5	20.5	119	20.2	1.4
	20	Sun	162	522	386	78.3	9.0	77.4	16.5	1.0
		Oven	183	566	353	58.5	11.0	68.0	19.0	1.2
Siratro	8	Sun	282	351	323	101	59.9	108	6.0	0.9
		Oven	279	413	322	91.7	72.9	173	8.2	1.1
	14	Sun	238	546	433	56.1	15.2	125	19.8	2.1
		Oven	252	534	472	72.7	20.6	157	21.0	1.4
	20	Sun	229	465	334	143	12.0	131	22.0	1.3
		Oven	191	509	418	114	8.00	105	21.9	1.0
	SED	LxD	5.21	4.60	3.53	1.10	0.29	0.87	0.33	0.09
		LxDxW	5.94	5.05	4.68	0.90	0.39	1.49	0.27	0.15
	Significance	L	***	***	***	***	***	***	***	**
		W	***	*	***	***	***	*	***	*
		D	NS	***	***	***	***	***	***	***
		LxW	***	***	***	***	***	***	***	NS
		LxD	**	***	***	***	***	***	***	*
		WxD	**	***	***	***	***	***	NS	NS
		LxDxW	***	***	***	***	***	***	***	NS

Means within the same column are significantly different at *= $P < 0.05$, **= $P < 0.01$,***= $P < 0.001$, NS= not significant

The neutral detergent fibre (NDF) values, which constitute the cell walls, of the legumes were influenced by the interactions of legume species, drying method and stage of growth (L x D x W). The NDF values ranged between 328 and 566 g/kg DM. At 8 weeks of growth, sun dried cassia and siratro had similar ($P > 0.05$) NDF values that were higher ($P < 0.001$) than that of lablab. In oven-dried forages, cassia had greater ($P < 0.001$) content of NDF compared to either lablab or siratro that also differed between themselves, with lablab having a lower ($P < 0.01$) NDF content than that of siratro. When harvested at 14 weeks of growth, sun and oven dried siratro had greater ($P < 0.001$) NDF content than that of either cassia or lablab. Similarly, cassia forage had higher ($P < 0.01$) NDF content compared to lablab on both drying methods. At 20 weeks of growth, sun dried cassia had a higher ($P < 0.001$) NDF content than that of the other two legumes which also differed between themselves. However, oven drying resulted in cassia having a lower ($P < 0.01$) NDF value compared to that of lablab but higher ($P < 0.05$) than that of siratro. The NDF content of lablab was also greater ($P < 0.01$) than that of siratro.

The ADF contents of the legumes were influenced by the interaction of legume species, drying method and stage of harvesting the forages. Among the legumes harvested at 8 weeks of growth, sun or oven dried siratro forage had greater ($P < 0.001$) ADF contents compared to that of either cassia or lablab that were dried similarly. The ADF value of sun-dried cassia was lower ($P < 0.01$) than that of sun dried lablab but the two legumes had similar ($P > 0.05$) ADF contents in oven dried forages. At 14 weeks of growth, siratro maintained a higher ($P < 0.01$) ADF content in both sun and oven dried forages compared to values of either cassia or lablab. The ADF content of sun-dried cassia was greater ($P < 0.05$) than that of lablab but the two legumes had similar ($P > 0.05$) ADF values in oven dried forages. When harvested at 20 weeks of growth, sun drying resulted in higher ($P < 0.01$) ADF value for lablab compared to cassia and siratro. The ADF content of cassia was also lower ($P < 0.001$) than that of siratro. In oven dried forages, cassia and lablab had similar ($P > 0.05$) ADF values that were lower ($P < 0.01$) than that of siratro.

An interaction of legume species, drying method and stage of growth affected the ADL content of the legumes. Sun drying of the forages harvested at 8 weeks of growth resulted in cassia having a lower ($P < 0.001$) ADL content compared to that of lablab and siratro. The ADL content of lablab was also significantly lower ($P < 0.01$) than that of siratro. When the forages were oven dried, cassia maintained a lower ($P < 0.01$) ADL content than that of either lablab or siratro. However, the ADL content of lablab was greater ($P < 0.01$) than that of siratro. At 14 weeks of growth, cassia had a lower ($P < 0.001$) ADL content compared to that of lablab but both legumes had ADL contents that were higher ($P < 0.01$) than that of siratro. In oven dried forages, cassia and siratro had similar ($P > 0.05$) ADL values that were greater than that of lablab. When the forages were harvested at 20 weeks of growth, sun drying resulted in siratro having a higher ($P < 0.001$) ADL content compared to values of cassia and lablab. Similarly, lablab had a greater ($P < 0.01$) ADL content than cassia. When the forages were oven dried siratro maintained a higher ($P < 0.001$) ADL content compared to that of either cassia or lablab whilst that of cassia was greater ($P < 0.05$) than that of lablab.

The ADIN content of the three legumes was influenced by the interaction of legume species, drying method and stage of growth. At 8 weeks of growth, sun and oven dried cassia had higher ($P < 0.001$) ADIN contents compared to that of lablab and the ADIN contents of the two legumes were lower ($P < 0.01$) than that of siratro on both drying methods. The ADIN content of sun-dried cassia harvested at 14 weeks of growth was lower ($P < 0.001$) than that of lablab whilst siratro had a greater ($P < 0.01$) ADIN content compared to that of either cassia or lablab. Oven drying the fresh forages resulted in similar ($P > 0.05$) ADIN contents between lablab and siratro while that of cassia was lower ($P < 0.01$). At 20 weeks of growth, sun dried lablab and siratro had greater ($P < 0.01$) ADIN contents compared to that of cassia. The ADIN content of lablab was also lower ($P < 0.05$) than that of siratro. When the forages were oven dried, siratro had a lower ($P < 0.01$) ADIN content compared to that of cassia and lablab that also differed ($P < 0.05$) between themselves.

The interaction of legume species, drying method and stage of growth of the forages influenced the ash content of the three legumes. Cassia and siratro forage harvested at 8 weeks of growth and sun dried had similar ($P > 0.05$) ash contents that were higher ($P < 0.001$) than that of lablab. However, in oven dried forages, cassia had a lower ash content than siratro but the ash contents of the two legumes were greater ($P < 0.001$) compared to that of lablab. At 14 weeks of growth, sun dried cassia and siratro maintained greater ($P < 0.01$) quantities of ash compared to lablab while that of cassia was also higher ($P < 0.05$) than that of siratro. A similar trend was observed in oven-dried forages except that of cassia that was lower ($P < 0.01$) than that of siratro. When the forages were harvested at 20 weeks of growth, sun and oven dried cassia and siratro had higher ($P < 0.01$) ash contents compared to that of lablab while cassia had a lower ($P < 0.05$) ash content than that of siratro.

The interaction of legume species, drying method and stage of growth influenced the Ca content of the legumes. Sun drying forages harvested at 8 weeks of growth resulted in similar ($P > 0.05$) Ca content between cassia and lablab, and cassia and siratro while that of lablab was greater ($P < 0.001$) than that of siratro. When the forages were oven dried, there were no differences ($P > 0.05$) between cassia and lablab, and lablab and siratro. However, the Ca content of cassia was lower ($P < 0.01$) than that of siratro. At 14 weeks of growth sun dried lablab had a lower ($P < 0.01$) Ca content compared to cassia and siratro while the latter legumes did not differ ($P > 0.05$). In oven dried legumes, siratro had a greater ($P < 0.01$) Ca content compared to lablab while no differences ($P > 0.05$) existed between the other legume comparisons. The Ca content of sun-dried cassia harvested at 20 weeks of growth was lower ($P < 0.01$) than that of siratro and both legumes had higher ($P < 0.001$) Ca contents compared to lablab. Similarly, oven dried cassia and siratro had greater ($P < 0.01$) Ca contents than lablab while they themselves were not different ($P > 0.05$).

The phosphorus (P) contents of cassia, lablab and siratro were dependent on the interaction between legume species and drying method, and the main effect of stage of growth. Sun dried cassia and siratro had similar ($P > 0.05$) P contents of 1.57 and 1.43 g/kg DM, respectively, which were higher ($P < 0.05$) than that of lablab, 1.17 g/kg DM. The P content of oven-dried forages was not different ($P > 0.05$) with mean values of 1.33, 1.27 and 1.17 g/kg DM for cassia, lablab and siratro, respectively. Forages harvested at 14 weeks of growth had greater ($P < 0.05$) P content of 1.63 g/kg DM compared to those harvested at 8 and 20 weeks of growth which were not different ($P < 0.05$) and had a mean value of 1.17 g/kg DM.

DISCUSSION

The assessed quality parameters of the legumes were dependent on the interactions of species, method of drying fresh forages and stage of growth. The CP content of the legumes ranged between 162 and 282 g/kg DM and these values fall within the range reported in the literature for tropical herbaceous legumes (Topps and Oliver, 1993; Norton and Poppi, 1995). Cassia in this study had CP content that was higher than values of 138 g/kg DM reported in earlier studies (Ahn et al., 1988). This difference is due to the fact that the cassia used in this study may have been younger and contained more leaf fraction than the cassia used by Ahn et al., (1988) which was harvested after seed collection and might have lost an appreciable amount of the leaf fraction. Sun drying of cassia tended to reduce the CP content of the forage, especially at 8 and 14 weeks of growth. This could have arisen due to loss of the leaf fraction that contains more CP than the stems during field drying. At 8 weeks of growth, lablab in this study had a higher CP content than values of 144 g/kg DM reported by Skerman et al. (1988) at a similar growth stage. The CP content of lablab at 20 weeks of growth was higher than the value of 119 g/kg DM reported by Santana et al. (1988) in lablab harvested at the pod maturation stage of growth.

The CP content of siratro obtained in this study was within the range of 150 to 300 g/kg DM reported previously (Topps and Oliver, 1993; Norton and Poppi, 1995). Siratro maintained a higher CP content than either cassia or lablab at different stages of maturity. This could be due to a high leaf retention capacity of siratro compared to cassia and lablab and the differences in growth habits of the legumes. The leaf fraction of legumes has been reported in earlier studies to have a higher CP content than the stems (Adjei and Fianu, 1985; Cameroon, 1988). However, the protein content of siratro observed in this study at 8 weeks of growth is higher than that reported by Siewerdt and Holt (1975) of 180 g/kg DM at similar stage of growth. With increasing maturity, the CP content of the legumes, irrespective of drying method, declined. This decline was due to an increase in stem growth and leaf senescence and abscission (Albrecht et al., 1987).

Environmental factors such as rainfall and soil fertility, and extent of leaf loss in the samples analyzed may have caused the differences between results obtained in this study and those reported in literature. The observed decline in CP content of the three legumes with increasing maturity is in agreement with results from other studies (Khorasani et al., 1997). This decline is attributed to an increase in cell wall accumulation while cell contents decline (Buxton, 1989). The protein content of the three legumes is in excess of that proposed as the minimum requirements for lactation (120 g CP/kg DM) and growth (113 g CP/kg DM) in ruminants (ARC, 1984). This makes them good sources of protein when given to ruminants as protein supplements to low quality roughages.

The NDF, which constitutes the cell walls of the legumes, ranged between 328 and 566 g/kg DM and is comparable to values of 339 to 545 g/kg DM reported by Topps (1993) for 13 tropical herbaceous legumes. In all the three legumes the NDF content increased with increasing plant maturity irrespective of the drying method. The greatest increase in NDF between 8 and 20 weeks of growth was observed in lablab, followed by cassia and least in siratro. The difference in NDF content between the three legumes may be associated with species or morphological and anatomical differences (Norton, 1982). Lablab, with an upright growth habit, and cassia having a semi-prostrate growth habit are expected to accumulate more structural carbohydrates, mainly in the stems, in order to support aerial growth compared to a trailing legume such as siratro. Another possible reason is that in both cassia and lablab, as senescence of leaves occurs with advancing maturity, the leaves are lost from the plants, resulting in more stemmy material, remaining while in siratro such leaves may be retained in the trellis. Stem material of forages is higher in cell wall content than leaves and always increases in NDF content with maturity (Balde et al., 1993). However, the leaves do not exhibit the increase in cell walls associated with plant maturation (Jung and Allen, 1995). The observed increase in NDF content of the legumes with advancing plant maturity in this study is in agreement with results reported in earlier studies (Khorasani et al., 1997). Similar results have also been reported for the tropical legume *N. wightii* (Vera et al., 1989) and lucerne (Grenet and Jamot, 1989).

The ADF content of cassia, lablab and siratro in this study ranged from 285 to 388, 288 to 369 and 323 to 425 g/kg DM, respectively, and were within the ranges reported in earlier work (Skerman et al., 1988; Topps, 1993). A similar trend to that of NDF was observed with the ADF content of the three legumes with advancing maturity, although there was a tendency for ADF to decline between 14 and 20 weeks of growth. Similar changes have been reported in *N. wightii* (Vera et al., 1989), *S. hamata* (Wanapat, 1987) and alfalfa

(Grenet and Jamot, 1989; Khorasani et al., 1997). These changes are due to increased secondary thickening in cells associated with plant support and water transport (Buxton, 1989).

The ADL content of siratro was consistently higher than that of either cassia or lablab at similar stages of maturity. The cassia in this study had lower mean ADL content of 88.2 g/kg DM at 20 weeks of growth compared to the value of 109 g/kg DM reported by Ahn et al. (1988) for more mature cassia hay harvested after seed collection. Lablab and siratro had a lignin content that was within published values (Norton and Poppi, 1995). The decline in ADL with increasing maturity observed in this study with lablab does not support the generally accepted concept of increasing lignification of plant cell walls with increasing maturity (Coombe, 1981). However, in a study by Khorasani et al., (1997), the lignin content of alfalfa was observed to increase curvilinearly with advancing maturity, up to the booting growth stage, beyond which there was no change. This possibly, could have occurred in the lablab used in this study but because of less frequent harvests, this trend may not have been clearly observed. However, cassia and siratro showed increases in ADL content with advancing maturity that is in agreement with reported results (Grenet and Jamot, 1989; Vera et al., 1989). Because of the strong effect of maturity on lignin concentration, herbage samples at different maturities provide some information on changes in lignin concentration and possible effects on digestibility (Jung and Allen, 1995). The proportion of ADL in ADF, therefore, declined with increasing maturation of the legumes and this possibly explains the high nutritive value and digestibility of tropical legumes compared to tropical grasses reported in the literature (Minson, 1990).

The ADIN values of the legumes were increased by the drying treatment at all stages of maturity. This is in agreement with results reported earlier in alfalfa (Sanderson and Wedin, 1989). The increase in ADIN content of the legumes may be due to Maillard reactions (Van Soest, 1994) which occurred during oven drying. Heating is reported to promote Maillard reactions between sugar aldehyde groups and the free amino groups of protein to yield an amino-sugar complex (Stern et al., 1994) and cross-linking between and within proteins. Analytically a high nitrogen content of ADF provides evidence of heating and can be related to lower degradability of protein and dry matter in hays (Yang et al., 1993). With increasing stage of growth, the ADIN content of the legumes on both drying methods declined contrary to results reported by Sanderson and Wedin (1989) who reported an increase in ADIN content of alfalfa stems with increasing maturity. The discrepancy between results from this study and those reported by Sanderson and Wedin (1989) could be due to differences in legume species, processing (temperature) or sample preparation (screen size).

The ash content ranged from 68 g/kg DM to 173 g/kg DM and declined with advancing plant maturity, with cassia and siratro having a greater ash content than lablab at similar growth stages. The high ash content of cassia and siratro could possibly be due to soil contamination of the forage as the two legumes have semi-erect and trailing growth habits, respectively, compared to the upright growth habit of lablab. Both siratro and lablab had ash contents that fell within reported ranges of 55 to 147 and 72 to 136 g/kg DM, respectively. Siratro at eight weeks of growth had a mean ash content of 141 g/kg DM, which is higher than the value reported of 72 g/kg DM (Gohl, 1981) at a similar stage of maturity. Mature lablab at 20 weeks of growth had higher ash content than the value of 92 g/kg DM reported for mature lablab hay (Boitumelo and Mahabile, 1991). The mean ash content of 115 g/kg DM of cassia obtained in this study is higher than the value of 46 g/kg DM reported by Ahn et al. (1988). The difference in ash content of legumes in this study and published values may be attributed to differences in environmental factors such as soil fertility, stage of plant growth and, possibly, soil contamination of samples during collection. The decline in ash content in the three legumes with increasing maturity could be due to a natural dilution process as dry matter accumulation outstrips mineral uptake as the forages mature (Bittman et al., 1988).

The Ca content of the legumes ranged between 6.0 and 21.3 g/kg DM. Lablab had Ca values comparable to values reported in earlier studies (Boitumelo and Mahabile, 1991), and were in the range of 9.0-19.8 g/kg DM reported by Gohl (1981) but were higher than the range of 3-9 g/kg DM reported by Skerman et al. (1988). Similarly, Ca content of siratro in this study is in agreement with results published earlier (Skerman et al., 1988). The Ca content of the legumes increased with advancing stage of growth. This increase may be associated with increased Ca accumulation in plant tissues associated with plant support. The values obtained in this study exceed recommended requirements in ruminants of 1.9 to 4.0 g/kg DM, despite varying estimates of availability of 0.58-0.78 (SCARS, 1990). Therefore animals fed on these forages are unlikely to suffer from Ca deficiency.

The P levels in lablab, cassia and siratro ranged from 1.0 to 1.8 g/kg DM and were within the range reported by Skerman et al. (1988) and by Norton and Poppi (1995). However, the P content was lower than the recommended requirements for ruminant animals of 1.8 to 3.2 g/kg DM (ARC, 1984; SCARS, 1990). The availability of phosphorus in ruminants is estimated as 0.70 (SCARS, 1990) of that ingested and, therefore, P deficiency may occur in animals offered these legumes, hence, phosphorus supplementation is necessary.

CONCLUSION

From the results obtained, it is evident that the chemical composition of the three legumes is greatly influenced by differences between species, method of drying fresh forages and stage of growth of the forages. The variation in chemical composition reported in the literature is probably due to these factors among others. While the protein content declines with fibre increasing with advancing plant maturity, the legumes tend to maintain a high CP content, which makes them acceptable protein supplementary feeds to low quality roughages. Among the three legumes, siratro showed a higher sustained CP content followed by cassia, and lablab was the least. To ensure high quality forage, less emphasis should be placed on differences between herbaceous legume species and much more emphasis should be placed on drying methods and harvest management as this affects the extent of leaf loss from the forage and hence the quality of the final feed given to animals.

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