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Short Communication

Variations in chemical composition associated with tissue aging in palatable and unpalatable grasses native to central Argentina

R.A. Distel*, N.G. Didoné, A.S. Moretto[1]

Departamento de Agronomía, CERZOS/CONICET, Universidad Nacional del Sur, San Andrés 800, 8000 Bahía Blanca, Argentina

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Abstract

Tissue aging in unpalatable grasses appears to be associated with a rapid decay in nutritional value because grazers usually start to avoid them at early stages of maturity. The objective of the present study was to determine and compare seasonal variations in fiber, lignin, crude protein and minerals (P, Ca, Mg, K and Na) in a palatable (*Stipa clarazii*) and in an unpalatable (*Stipa eriostachya*; syn: *S. gynerioides*) grass species, following a summer burning in central Argentina. Fiber and lignin contents were higher in the unpalatable grass than in the palatable grass, whereas crude protein and mineral contents were lower in the former than in the latter species. In both species, fiber and lignin increased over time, whereas crude protein and mineral contents declined with time. However, temporal changes were more pronounced and faster in the unpalatable grass than in the palatable grass. Our results suggest that the relatively high nutritive value of the unpalatable species at early plant growth stages following burning may create a window of time, in which it may be more readily grazed by livestock.

Keywords: *Stipa clarazii*; *Stipa eryostachia*; Palatable grasses; Unpalatable grasses; Forage quality

*Corresponding author. Tel.: +54 91 861 124; fax: +54 291 486 1527.
E-mail address: cedistel@criba.edu.ar (R.A. Distel).
[1]Present address: Centro Austral de Investigaciones Científicas, CONICET, CC 92, 9410 Ushuaia, Argentina.

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1. Introduction

Plant palatability is typically associated to pleasant or acceptable taste (Heady, 1964), although it is best understood as the inter-relationship between senses and postingestive consequences (Provenza et al., 1998). When macronutrients and toxin concentration vary in foods, herbivores prefer foods high in macronutrients and low in toxins, regardless of the flavor (Wang and Provenza, 1997) or physical characteristics (Villalba and Provenza, 1999). In the Poaceae family (Graminae), unpalatable grasses avoid grazing because the relatively high contents of structural carbohydrates (particularly lignin) and the relatively low contents of elemental constituents (particularly nitrogen) (Grace, 1983; Moore and Jung, 2001). Moreover, the avoidance of unpalatable grasses enables them to accumulate senescent biomass, which decomposes slowly and further reduces nutritional value to grazers. A common practice to enhance utilization of unpalatable grasses is burning to eliminate senescent biomass and to improve quality of live biomass produced in the regrowth (DeBano et al., 1998). However, tissue maturity in unpalatable grasses appears to be associated with a rapid decay in nutritional value because it is a common observation that grazers start to avoid them soon after burning.

In rangelands of central Argentina, changes in species composition induced by grazing of domestic livestock include the replacement of palatable grass species by unpalatable grass species (Llorens, 1995; Distel and Bóo, 1996). On average, the palatable species are higher in protein and lower in structural carbohydrates than the unpalatable species (Moretto and Distel, 1997; Cerqueira et al., 2004). These differences in plant chemistry result in a marked livestock preference for palatable grasses and in a marked avoidance of unpalatable grasses (Bóo et al., 1993; Bontti et al., 1999; Pisani et al., 2000). However, there is no information for both groups of grasses on the magnitude and speed of temporal changes in quality of the live tissue following disturbances. The objective of the present study was to determine seasonal variations in fiber, lignin, crude protein and mineral (P, Ca, Mg, K and Na) contents in a palatable (*Stipa clarazii*) and in an unpalatable (*Stipa eriostachya*; syn: *S. gynerioides*) grass species after a controlled summer burning.

2. Materials and methods

2.1. Site description

Plant samples were collected from an upland site of a native grassland in central Argentina (38°45′S; 63°45′W). The study site comprised an ungrazed area of 2 ha, that had been burned in February 1999. Prior to burning, the site has been continuously grazed by yearling heifers (8 ha/heifer^{-1}). The climate of the region is temperate, semi-arid. Mean monthly air temperature range from 7 °C in July to 24 °C in January, with an annual mean of 15 °C. Mean annual rainfall is 400 mm, with peaks in March and October. The more severe droughts occur in summer. In the year of sampling (1999), precipitation was 665 mm. The monthly distribution of

precipitation was comparable to the long-term mean, except for March, April, November and December, when precipitation was above average. Dominant soils are coarse-textured Calciustolls, with a petrocalcic horizon at 60–80 cm deep.

The site is in the southern part of the Caldén District (Cabrera, 1976). The potential physiognomy of the vegetation is grasslands with isolated shrubs (Distel and Bóo, 1996). The more abundant herbaceous species are perennial, cool-season bunchgrasses (Distel and Peláez, 1985). The herbaceous layer is co-dominated by palatable grasses (*S. clarazii*, *Piptochaetium napostaense*, *S. tenuis*) and unpalatable grasses (*S. eriostachya*, *S. brachychaeta*, *S. tenuissima*, *S. ambigua*).

2.2. Plant sampling and chemical analysis

Individuals ($n = 10$) of *S. clarazii* and *S. eriostachya* were randomly sampled in fall (April), winter (July) and spring (November), 1999. Plant samples were oven-dried at 60 °C for 48 h. Green leaf blades were sorted, ground (to pass through a 1-mm sieve), and analysed for neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin by the detergent method (Goering and Van Soest, 1970), N by semi-micro Kjeldahl, and P, Ca, Mg, K and Na by atomic spectrometry (Sequential Plasma Spectrometer Shimadzu ICPS 1000-III). We analysed the 10 samples for fiber, lignin and nitrogen, and a subset of five samples for minerals. Crude protein (CP) was calculated by multiplying $N \times 6.25$.

2.3. Statistical analysis

Data met the assumptions of normality and homogeneity of variance and were analysed by a two-way (species and time) ANOVA.

3. Results

3.1. Seasonal variations in fiber, lignin and protein contents

Species and time significantly ($p < 0.0001$) influenced the contents of NDF, ADF, lignin and CP (Table 1). Fiber and lignin contents were higher in *S. eryostachia* than in *S. clarazii*, whereas CP content was higher in *S. clarazii* than in *S. eryostachia*. In both the species, fiber and lignin increased as the growing season progressed, whereas CP declined as the growing season progressed. There was a significant ($p < 0.0001$) species by time interaction. Temporal increases in NDF, ADF and lignin and temporal reductions in CP were more marked in *S. eryostachia* than in *S. clarazii*.

3.2. Seasonal variations in mineral contents

Mineral contents were influenced ($p < 0.0001$) by species and season, except ($p > 0.05$) for Na (Table 2). P, Ca, Mg and K contents were higher ($p < 0.0001$) in *S. clarazii* than in *S. eryostachia*. In both species the content of minerals declined

Table 1
Contents of crude protein, fiber and lignin in green leaves of *Stipa clarazii* (palatable perennial grass) and *Stipa eryostachia* (unpalatable perennial grass) in fall, winter and spring of 1999

Seasons and species	Crude protein (%)	Neutral detergent fiber (%)	Acid detergent fiber (%)	Lignin (%)
Fall				
S. clarazii	21.9 (0.4)	53.5 (0.9)	23.1 (0.5)	2.9 (0.1)
S. eryostachia	15.6 (0.4)	58.7 (0.6)	29.4 (0.4)	3.7 (0.2)
Winter				
S. clarazii	15.1 (0.2)	53.5 (0.4)	24.5 (0.4)	2.6 (0.1)
S. eryostachia	7.4 (0.1)	69.3 (0.6)	38.0 (0.5)	5.9 (0.2)
Spring				
S. clarazii	10.9 (0.1)	57.0 (0.4)	30.8 (0.2)	5.2 (0.2)
S. eryostachia	6.5 (0.1)	68.6 (0.3)	40.3 (0.5)	8.0 (0.2)

Values represents mean and (SE), $n = 10$. For each parameter, species, seasons and the interaction species × seasons represent significant ($p < 0.0001$) sources of variation.

Table 2
Contents of phosphorous (P), calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) in green leaves of *Stipa clarazii* (palatable perennial grass) and *Stipa eryostachia* (unpalatable perennial grass) in fall, winter and spring of 1999

Seasons and species	P (%)	Ca (%)	Mg (%)	K (%)	Na (%)
Fall					
S. clarazii	0.24 (0.006)	0.64 (0.05)	0.20 (0.01)	1.97 (0.03)	0.21 (0.03)
S. eryostachia	0.14 (0.003)	0.44 (0.02)	0.09 (0.003)	1.33 (0.05)	0.22 (0.01)
Winter					
S. clarazii	0.18 (0.01)	0.69 (0.02)	0.13 (0.01)	1.85 (0.1)	0.24 (0.01)
S. eryostachia	0.09 (0.005)	0.29 (0.02)	0.06 (0.003)	1.00 (0.1)	0.23 (0.02)
Spring					
S. clarazii	0.15 (0.02)	0.68 (0.04)	0.14 (0.008)	1.31 (0.04)	0.26 (0.01)
S. eryostachia	0.08 (0.003)	0.35 (0.01)	0.07 (0.003)	0.70 (0.01)	0.26 (0.01)

Values represents mean and (SE), $n = 5$. For each parameter, species and seasons represent significant ($p < 0.0001$) sources of variation, except for Na. The species × time interaction was significant ($p < 0.01$) for Ca only.

($p < 0.0001$) as the growing season progressed, except ($p > 0.05$) for Ca. The species by time interaction was significant ($p < 0.01$) for Ca only. The declination in Ca content through time progressed faster in *S. eryostachia* than in *S. clarazii*.

4. Discussion

The results on fiber, lignin and crude protein contents (Table 1) were in the range of values reported for a large variety of graminoid species (Jones and Wilson, 1987;

Georgiadis and McNaughton, 1990; Northup and Nichols, 1998; Pérez Corona et al., 1998). Cerqueira et al. (2004) reported also higher levels of CP for *S. clarazii* than for *S. eryostachia* in the northern part of the Caldén District, but the absolute values were lower than the absolute values reported in the present study. Their samples were from unburned plants and composed of a mixture of green and dead material, which may explain the observed differences.

The rapid accumulation of cell wall contents, fast lignification of the cell wall and rapid reduction in CP levels may allow the unpalatable grass to avoid grazing since an early stage of regrowth. Fibrousness reduces intake rate because of the associated reduction in bite size to properly sever forage and the associated increase in chewing time necessary to adequately process the forage (Laca et al., 2001). On the other hand, lignin and CP can interfere with the digestion of structural carbohydrates, the former by acting as a physical barrier to rumen microbial enzymes (Moore and Jung, 2001) and the latter by limiting rumen microbial growth (Orskov, 1982).

Minerals are important components of metabolic process in animals, and they can depress feed intake when levels are low (Grace, 1983; Provenza, 1995). Therefore, the low elemental concentrations in the unpalatable grass can add to its fibrousness nature in reducing forage nutritive value. For example, P and Mg in *S. eryostachia* were below critical values recommended for cattle and sheep nutrition throughout the growing season (Grace, 1983; National Research Council (NRC), 1984).

5. Conclusions

Fiber and lignin contents were higher in the unpalatable grass than in the palatable grass, whereas CP and mineral contents were lower in the former than in the latter species. In both species, fiber and lignin increased over time, whereas CP and mineral contents declined with time. However, temporal changes were more pronounced and proceed faster in the unpalatable grass than in the palatable grass species. The observed changes in plant chemistry help explain herbivores strong preference for *S. clarazii* and their strong avoidance of *S. eryostachia* found in previous studies (Bóo et al., 1993; Bontti et al., 1999; Pisani et al., 2000; Pordomingo and Rucci, 2000).

6. Implications

Rangelands located in the central part of Argentina have a history of about 100 years of grazing by sheep and cattle. Floristic changes associated with grazing include the replacement of palatable perennial grasses by unpalatable perennial grasses (Llorens, 1995; Distel and Bóo, 1996). Selective grazing against palatable species appears to be the dominant mechanism in the process of species replacement (Moretto and Distel, 1999). From a practical point of view, the key problem is that reductions in grazing pressure do not lead to the palatable species recovering dominance over the short term. Our results suggest that the relatively high nutritive

value of unpalatable species during early plant growth stages following burning may create a window of time, in which they may be more readily grazed by livestock. At this time, heavy grazing in short bursts may serve to counteract their competitive advantage, favoring the regeneration capacity of palatable perennials.

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