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Article type : Short Report

Effects of feeding lambs fresh versus dried *Puccinellia tenuiflora* (Griesb.)
Scribn. & Merr. on water and nutrient intake and apparent digestibility

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This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: [10.1111/GRS.12321](https://doi.org/10.1111/GRS.12321)

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33 **Abstract**

34

35 The objective was to investigate effects of feeding lambs fresh versus dried *Puccinellia*.
36 *tenuiflora* (Griesb.) Scribn. & Merr. on nutrient and water intake and apparent
37 digestibility. Twenty-four lambs were offered fresh or dried (48 h) grass. The dry matter
38 (DM) content of fresh grass was 65% that of dried grass and the aNDFom content of fresh
39 grass was 87% that of dried grass, whereas the metabolizable energy concentration of two
40 forages were similar. Lambs eating fresh grass had higher ($P < 0.05$) DM intake (944 vs
41 837 g DM d⁻¹ sheep⁻¹), metabolizable energy intake (9.1 vs 7.9 MJ d⁻¹ sheep⁻¹), and crude
42 protein intake (86 vs 75 g d⁻¹ sheep⁻¹) than those eating dried grass. However, there was
43 no significant difference between treatments in drinking water intake, fecal nutrient
44 output or nutrient digestibility. In conclusion, feeding lambs fresh *P. tenuiflora* improved
45 voluntary feed intake without depressing nutrient digestibility.

46

47 **KEYWORDS**

48 forage composition; nutrient partitioning; water intake

49 1 | INTRODUCTION

50

51 *Puccinellia tenuiflora* (Griesb.) Scribn. & Merr. has an outstanding tolerance to highly
52 alkaline and saline soil and it is commonly grown for ruminants to graze or eat as
53 conserved forage. Although salt-responsive mechanisms underpinning the growth of *P.*
54 *tenuiflora* in high alkali and saline soil conditions have been reported, there have been
55 few publications evaluating feeding value and digestive characteristics of *P. tenuiflora* in
56 ruminants. Feeding fresh vs dried forage to ruminants has altered feed intake, digestibility
57 and liveweight gain performance (Archimède et al., 1999; Pasha, Prigge, Russel, &
58 Bryan, 1994), but the nature and extent of responses seemed inconsistent (Andrade et al.,
59 2016; Pasha et al., 1994). Furthermore, effects of moisture content of the grass on water

60 intake were not investigated in these studies. Therefore, the aim of this study was to
61 investigate the effects of feeding fresh or dried *P. tenuiflora* on nutrient and water intake
62 and digestibility by sheep.

63

64 2 | MATERIALS AND METHODS

65

66 All procedures involving the use of animals were approved by the Animal Care
67 Committee of the Institute of Geography and Agroecology, Chinese Academy of Sciences
68 (#2016001). *P. tenuiflora* grass was harvested in a six year old paddock with high salinity
69 and alkaline soil, located in a semi-arid region in Changchun, China (44°33'N, 123°31'E).
70 Twenty-four male Ujumqin lambs (mean \pm SD) 120 ± 10.5 d of age and 29 ± 0.8 kg of
71 body weight (BW) were assigned to one of two dietary treatments (fresh vs. dried grass),
72 in a completely randomized design. Both treatments had a 7-d adaptation and a 7-d
73 measurement period. Lambs were kept in individual metabolism cages ($1792 \times 790 \times$
74 1615 mm) and offered the grass and water *ad libitum*. Lambs were fed fresh harvested
75 grass in two equal-sized meals at 0600 and 1800 h, whereas dried grass treatment lambs
76 were offered grass that had been air-dried (at 25–35 °C for 48 h).

77 Daily grass and water intake per lamb were estimated from the difference between
78 supply and refusal. Daily grass sample was collected and stored at -20 °C for chemical
79 analyses. A subsample of grass was dried in a forced air oven at 65 °C for 48 h to
80 determine the DM content and then ground through a 1-mm sieve for organic matter (OM)
81 (AOAC, 1990; 968.06) and nitrogen (N) analysis (AOAC, 1990; 976.05). The content of
82 neutral detergent fiber excluded ash (aNDFom) was determined as described (Van Soest
83 et al. 1991).

84 Total amount of feces and number of defecations were recorded on a daily, with 168
85 fecal samples collected and combined for each lamb. Fecal samples from five lambs per
86 treatment were used for chemical analyses. Fecal samples were dried in a forced air oven
87 at 65 °C for 48 h to determine DM content and then ground to pass a 1-mm screen for N,
88 aNDFom and OM analysis (same methods as described above). Digestibility for DM,
89 OM, aNDFom and N were calculated. Metabolizable energy (ME) concentration of
90 grasses was calculated: ME (MJ/kg DM) = $0.156 \times$ Apparent DMD (%) – 0.535 (AAC,
91 1994).

92 Differences between treatments in DM intake (DMI), water intake, fecal output and
93 digestibility were analyzed by one-way ANOVA, with treatment as the fixed effect, using
94 GenStat 16 (VSN International, 2011). For all analyses, $P < 0.05$ was significant.

96 3 | RESULTS AND DISCUSSION

97
98 The DM content of fresh grass was 65% that of dried grass (570 vs. 871 g DM kg⁻¹ fresh
99 matter), whereas the aNDFom content of fresh grass was 87% that of dried grass (383 vs.
100 438 g kg⁻¹ DM). However, CP (90 vs. 91 g kg⁻¹ DM) and OM (822 vs. 803 g kg⁻¹ DM)
101 content did not differ markedly between the forages.

102 Fresh grass treatment had a higher ($P < 0.05$) intake than the dried grass treatment for
103 DM (944 vs 837 g DM d⁻¹ sheep⁻¹), ME (9.1 vs 7.9 MJ d⁻¹ sheep⁻¹) and CP (86 vs 75 g
104 d⁻¹ sheep⁻¹). Feed water intake (712 vs 124 ml d⁻¹ sheep⁻¹) and daily water intake (2791
105 vs 1857 ml d⁻¹ sheep⁻¹) were higher ($P < 0.05$) in lambs eating fresh as compared with
106 dried grass. However, there were no differences ($P > 0.05$) between treatments in OM,
107 aNDFom, drinking water intake, digestibility and fecal output of DM, OM, CP and
108 aNDFom.

109 The DM content of *P. tenuiflora* is relatively higher than that of other grass species
110 (Archimède et al., 1999; Pasha et al., 1994). Dried forage has 53% higher DM and 14%
111 higher aNDFom content than fresh forage, and 11% lower DMI in lamb fed dried forage
112 than fresh forage in the present study were similar to the findings of Archimède et al.
113 (1999), who compared consumption of dried versus fresh *Poa pratensis* and *Digitaria*
114 *decumbens* grass in sheep. In contrast, there was a 12% reduction in DMI when sheep
115 were offered high-moisture forage (220 g DM kg⁻¹ fresh matter) than those which were
116 offered hay (870 g DM kg⁻¹ fresh matter) (Pasha et al., 1994). These inconsistencies have
117 several potential causes: 1) as DMI is limited by maximum rumen fill, the higher water
118 content in fresh grass may lead to the decrease in DMI through a physical regulation.
119 However, such effects can be transitory and subject to increase of water outflow rate from
120 the rumen (Estrada, Delagarde, Faverdin, & Peyraud, 2004). 2) In this study, lamb eating
121 the fresh grass defecated more often ($P = 0.033$) and excreted more water in feces ($P =$
122 0.025) than those eating dried grass. Extra water ingested from fresh grass would have
123 been at least partly excreted via feces, thereby counter-balancing rumen fill (Allison,

124 1985). Future research is needed to explore the actual mechanisms that regulate DMI in
125 consumption of fresh vs dried forage.

126 The increased DMI was associated with an increased daily water intake of lambs in
127 this study, which is consistent with general observations in sheep, goats and cattle studies
128 (AAC, 1994). Higher water intake can reduce DM accumulation in the digestive tract of
129 ruminants (Phillips, 1960), reducing apparent nutrient digestibility (Balch, Balch,
130 Johnson, & Turner, 1953). On the contrary, due to the effect of the ruminal mat, the forage
131 with greater NDF (i.e. dried grass) can cause longer rumen retention time and leading
132 higher apparent digestion coefficients (Schulze, Weisbjerg, Storm, & Nørgaard, 2014).
133 However, in the present study, there was no significant difference between diets in
134 apparent digestibility of nutrients (i.e. DM, OM, aNDFom and CP).

135

136 4 | CONCLUSIONS

137

138 Overall, feeding fresh *P. tenuiflora* improved DM and nutrient intake without altering
139 DM or nutrient digestibility. This finding is useful to guide future use of *P. tenuiflora* in
140 ruminant animal production.

141

142 ACKNOWLEDGMENTS

143

144 This work was financially supported by the National Key Research and Development
145 Program (Grant No. 2016YFC0500606) and the Youth Innovation Promotion
146 Association of the Chinese Academy of Sciences (No. 2015184).

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TABLE 1 Effects of feeding fresh and dried *Puccinellia tenuiflora* grass on intake, fecal output, digestibility and estimated metabolizable energy in sheep.

	Fresh grass	Dried grass	SEM	P-value
DM intake (g DM/d)	944	837	33.2	0.033
ME intake (MJ/d)	9.1	7.9	0.41	0.043
CP intake (g/d)	86	75	3.0	0.021
aNDFom intake (g/d)	361	367	14.3	0.800
OM intake (g/d)	758	688	27.2	0.084
Fecal water output (g/d)	834	673	47.5	0.025
Fecal DM output (g DM/d)	327	303	15.2	0.28
Fecal OM output (g/d)	286	271	19.2	0.583
Fecal aNDFom output (g/d)	136	135	8.9	0.948
Fecal CP output (g/d)	43	42	3.5	0.862
Defecation frequency (times/d)	15.5	13.2	0.48	0.003
Drinking water intake (ml/d)	1579	1733	88.6	0.231
Feed water intake (ml/d)	712	124	9.7	<0.001
Daily water intake (ml/d)	2291	1857	90.5	0.003
DM digestibility (%)	65	64	1.4	0.392
OM digestibility (%)	50	51	1.4	0.695
aNDFom digestibility (%)	63	65	1.5	0.458
CP digestibility (%)	51	47	2.5	0.314
ME† (MJ/kg DM)	9.7	9.4	0.22	0.392

Abbreviations: DM, dry matter; ME, metabolizable energy; CP, crude protein; aNDFom, neutral detergent fiber (exclude ash); OM, organic matter.

† ME (metabolizable energy) concentration: $ME (MJ/kg DM) = 0.156 \times \text{Apparent DMD} (\%) - 0.535$.