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An investigation of the effect of drying methods on the nutritive value of forage grasses

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ABSTRACT

Drying methods have been identified as a critical factor in forage evaluation because there are changes in their chemical components that are affected by different drying temperatures. The study evaluated the effect of three drying methods (sun-drying, shade-drying and oven-drying (60°C) on the chemical components of three local grass species (*Pennisetum purpureum*, *Brachiaria ruziziensis* and *Brachiaria arrecta*) grown under tropical conditions. The objective was to determine how drying methods influence the nutritive value of forage grasses to optimize feeding practices. The harvested grass samples were dried to a constant weight under the three drying methods before being milled and then subjected to chemical analysis. Dry matter (DM), organic matter (OM), ash, ether extract (EE), crude fibre (CF), and nitrogen free extracts (NFE) were determined. Across drying methods, the DM content was highest ($p<0.05$) in *B. ruziziensis* (908 g/kg DM). The OM of the oven dried species was significantly higher in *B. ruziziensis* (885 g/kg DM) when compared to the species of *B. arrecta* (867 g/kg DM) and *P. purpureum* (859 g/kg DM). The CP content was highest ($p<0.05$) in *B. ruziziensis* (123 g/kg DM) (shade dried) and lowest ($p<0.05$) in *B. arrecta* (87.6 g/kg DM) (sun-dried). Across drying methods, the CF content was highest ($p<0.05$) in *B. arrecta* (367 g/kg DM) (oven dried) and lowest ($p<0.05$) in *P. purpureum* (264 g/kg DM) (shade dried). Species demonstrated higher levels of OM, CP, and lowest CF levels under shade-drying when compared to other drying methods. It was concluded that drying methods do influence the chemical components of grass species with shade-drying, indicating a greater potential for laboratory analyses and field processing.

Keywords: Chemical composition, drying temperatures, fibre, forages, sun-drying, shade-drying.

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INTRODUCTION

Small ruminant livestock production in Trinidad and Tobago can be sustained by maximizing the use of well-adapted and productive forage grass species. While several grass species have shown promise over the years, variation in seasons has had a negative impact on their availability and quality (McDonald et al., 2002). This can be addressed by increasing the production of grass species and by applying adequate conservation techniques during periods of abundance. To effectively incorporate these grasses in diets formulated for small ruminant feeding, an evaluation of their chemical constituents is imperative. The adequacy of the formulated feeds would depend on the accurate chemical analyses of these grass species that can be influenced by the drying techniques utilized during the analysis process. Drying temperatures and techniques can affect the chemical composition of forages and therefore are imperative factors in forage assessment (Ramsumair et al. 2014). Water loss, respiration, loss of volatile organic substances, and protein degradation are among several processes that occur during forage drying. These processes, except for water loss to some extent, can have a negative impact on the chemical composition of samples and should be minimized (Deinum and

Maassen, 1994). Drying is influenced by the levels of heat applied and can result in loss of water-soluble sugars which can be attributed to decomposition and respiration (Deinum and Maassen, 1994) and Maillard reaction (Van Soest, 1982). The solubles that remain are not very soluble in acid and neutral detergents (Van Soest, 1982) and their formation results in increased heat input during the drying period. Feeds are preserved as enzymatic and microbial reactions are inhibited by the reduction of moisture due to drying (McDonald et al., 2002). Enzymatic degradation of sugars and subsequent loss of carbon and dry matter can occur if the forages are dried below 30 °C. These losses can be attributed to the water content of the forages and it is a result of continued enzymatic respiration during the drying process (Collins and Coblentz, 2007). Additionally, degradation and volatilization of cellular constituents can result in loss of dry matter losses at higher temperatures. Some of the commonly used drying methods alter some chemical constituents of legumes. Burrit et al. (1988) and Papachristou and Nastis (1994) demonstrated that oven-drying increases the neutral detergent fibre (NDF) and lignin concentrations and depresses the *in vitro* dry matter digestion (IVDMD). Van Soest (1982) indicated that drying methods can influence nitrogen solubility, thus lowering the nutritive value of feed. Freeze-drying (equipment unavailable for this study) is recognized as the most appropriate method for drying forages as it preserves the labile metabolites, including non-structural carbohydrates (NSC) in fresh forages (Raguse and Smith, 1965; Heberer et al., 1985). However, such equipment may be unavailable in most local laboratories and to resource-poor farmers due to its high cost and the challenge of applying it to large samples under field conditions. A forced-draught oven may be more applicable to dry forage samples but there is the risk of fluctuating readings. Drying in a microwave oven has also been suggested because it provides very rapid low temperature pre-drying (Hofman, 1965).

Very few comparisons have been made in an effort to identify the best drying procedure for local forage species in the climate of Trinidad and Tobago. The objective of this study was to provide resource-constrained farmers in Trinidad and Tobago with an optimal drying technique that is adaptable to the local climate and on-farm conditions, along with an assessment of its cost-effectiveness, would be beneficial.

MATERIALS AND METHODS

The study followed a factorial treatment arrangement 3 species *Pennisetum purpureum* (elephant grass), *Brachiaria ruziziensis* (mulato grass), *Brachiaria arrecta* (tanner grass) x 3 drying methods (sun-drying, shade-drying and oven-drying (60°C) with three replicates in a completely randomized experimental design.

Study site

The experiment was conducted at the University of Trinidad and Tobago, ECIAF Campus Farm, Caroni North Bank RD, Centeno. The soil of the experimental site has a silt loam texture and contains 0.08 % nitrogen (N). The land is flat, moderately drained, and above flood levels.

Sample Collection

The leaves of three grass species, distributed throughout the same 2-acre block, were harvested five inches from the soil level and stored separately into brown paper bags. The samples were collected during the morning period, following a zigzag pattern. Samples per species were then bulked and subdivided into three replicates. Samples for oven-drying were transported immediately to the laboratory and dried in an oven at a constant weight at 65 °C. The samples for shade-drying were placed in the green house, which was at an average temperature; ranging from 28 to 31 °C. The samples for sun-drying were placed on a brown paper bag and placed outdoors in full sunlight. The dried samples were then milled by passing them through a 1mm sieve using a Wiley Mill (Glen Creston Ltd, Middlesex, UK) and kept in separate brown paper bags pending chemical analysis.

Chemical Analyses

The DM content was measured by placing 1 g of sample in a pre–weighed porcelain crucible in an oven set at 100°C overnight. The weight loss was used as a measure of the moisture content, while organic matter was determined by igniting 1 g of sample in a muffle furnace at 550 ºC and estimated as the loss in sample weight. The nitrogen content was determined using the Kjeldahl method (AOAC 2005 method no.990.03) and was converted to crude protein by multiplying the percentage N content by 6.25 (AOAC 2005 method no.990.03). Crude fat was determined in accordance with the Soxhlet extract method using petroleum ether as the extract agent (60–80 °C) (AOAC 2005). The ash content was assayed by incinerating the samples in a muffle furnace at 550 °C (AOAC 2005). The nitrogen-free extract (NFE) values were derived from the following: NFE = (DM (g/kg DM)−(ether extract (g/kg DM) + crude protein (g/kg DM) + ash (g/kg DM) + crude fiber (g/kg DM)).

Statistical Analysis

The drying method and the effect of species on chemical composition were analyzed using the General Linear Models (GLM) procedure of MINITAB (MINITAB Version

16) for a factorial treatment arrangement of 3 species x 3 drying methods in a completely randomised experimental design to account for effect of grass species and drying methods effects. The difference in mean was conducted by Tukey's test. The linear method used was as follows:

$$Yijk = \mu + Ti + Dj + Eijk$$

where
Yijk = dependent variable *ijk*;
μ = population mean for the variable;
Ti = effect of the species (*i* = 3; *P. purpureum, B. ruziziensis,* and *B. arrecta*);
Dj = effect of drying method (*j* = 3; shade-drying, sun-drying, shade-drying at 65°C);
Eijk = random error associated with observation *ijk*.

RESULTS

The effect of drying methods on the chemical composition of three grass species is presented in Table 1. The DM content was highest (p<0.05) in *Brachiaria arrecta* (906 g/kg DM) and lowest (p<0.05) in *P. purpureum* (896 g/kg DM) among the species allotted to sun-drying. In contrast, the dry matter content was highest (p<0.05) in *P. purpureum* (899 g/kg DM) and lowest (p<0.05) in, *B. ruziziensis* (890 g/kg DM) among the species allotted to shade-drying. The DM of oven dried species was significantly higher in *B. ruziziensis* (908 g/kg DM) when compared to the other grass species. In all treatments, DM content was highest (p<0.05) in *B. ruziziensis* (908 g/kg DM). *Pennisetum purpureum* possessed the highest (p<0.05) moisture content (115 g/kg DM) whereas *B. arrecta* (104 g/kg M) had the lowest (p<0.05) among species subjected to sun-drying. Among grass species that were shade dried, the moisture content was significantly higher in *B. ruziziensis* (123 g/kg DM) and lowest (p<0.05) in *P. purpureum* (111 g/kg DM). In contrast, the moisture content was lowest (p<0.05) in *B. ruziziensis* (101 g/kg DM) when compared to the other oven dried grass species (*P. purpureum* 114 g/kg & *B. ruziziensis* 116 g/kg DM) respectively (Table 1).

Table 1: Effect of drying methods on the chemical composition of grass species (g/kg DM).

Treatment	Species	DM (g/kg)	MC (g/kg)	OM (g/kg)	CP (g/kg)	EE (g/kg)	Ash (g/kg)	CF (g/kg)	NFE (g/kg)
Sun dry	*P. purpureum*	896^{aA}	115^{aA}	852^{aA}	101^{aA}	54.1^{aA}	148^{aA}	303^{aA}	605^{aA}
	B. ruziziensis	901^{bA}	109^{bA}	891^{bA}	103^{bA}	46.0^{bA}	109^{bA}	315^{bA}	574^{bA}
	B. arrecta	906^{cA}	104^{cA}	864^{cA}	87.6^{cA}	35.2^{cA}	136^{cA}	336^{cA}	595^{cA}
Shade dry	*P. purpureum*	899^{aB}	111^{aB}	897^{aB}	121^{aB}	49.5^{aB}	103^{aB}	264^{aB}	527^{aB}
	B. ruziziensis	890^{bB}	123^{bB}	872^{bB}	123^{bB}	46.6^{bA}	128^{bB}	282^{bB}	569^{bA}
	B. arrecta	894^{cB}	119^{cB}	877^{cB}	95.7^{cB}	42.5^{cB}	136^{cA}	300^{cB}	561^{cB}
Oven dry	*P. purpureum*	897^{aA}	114^{aA}	859^{aC}	97.9^{aC}	37.8^{aC}	141^{aC}	324^{aC}	601^{Aa}
	B. ruziziensis	908^{bB}	101^{bC}	885^{bC}	92.5^{bC}	33.5^{bC}	115^{bC}	328^{aC}	569^{bA}
	B. arrecta	895^{aB}	116^{aB}	867^{cA}	88.8^{cA}	29.7^{cC}	133^{cA}	367^{bC}	619^{cC}
SEM		2.77	3.38	3.15	0.703	1.28	3.15	6.33	7.68
Main effect (Drying)									
Sun dry		901^{a}	109^{a}	869^{a}	97.2^{a}	45.1^{a}	131^{a}	318^{a}	591^{a}
Shade dry		894^{b}	117^{b}	882^{b}	113^{b}	46.2^{a}	122^{b}	282^{b}	552^{b}
Oven dry		900^{c}	110^{c}	870^{a}	93.1^{c}	33.7^{b}	129^{c}	340^{c}	596^{c}
SEM		0.00	0.00	0.00	0.09	0.03	0.01	0.10	0.02
Main effect (Species)									
P. purpureum		897^{a}	113^{a}	869^{a}	107^{a}	47.1^{a}	131^{a}	297^{a}	578^{a}
B. ruziziensis		900^{b}	100^{b}	882^{b}	106^{a}	42^{b}	117^{b}	308^{b}	571^{b}
B. arrecta		898^{a}	112^{a}	869^{c}	91^{c}	35.8^{c}	135^{c}	334^{c}	592^{c}
SEM		0.01	0.01	0.02	0.03	0.12	0.02	0.22	0.55

$^{abc\ A\text{-}C}$Means in the same column within a parameter with different superscripts differ significantly; p<0.05. s.e.m.: Standard error of mean; DM: dry matter; MC: moisture content; OM: organic matter; CP: crude protein; EE: ether extract; CF: crude fibre; NFE: nitrogen free extractives.

Across species, the moisture content was both highest (p<0.05) in *B. ruziziensis* (123 g/kg DM) (shade dried) and lowest (p<0.05) in *B. ruziziensis* (101 g/kg DM) (oven dried).

The OM content was highest (p<0.05) in *B. ruziziensis* (891 g/kg DM) and lowest (p<0.05) in *P. purpureum* (852 g/kg DM) among the species allocated to sun-drying. In contrast, the OM content was highest (p<0.05) in *P. purpureum* (897 g/kg DM) and lowest (p<0.05) in *B. ruziziensis* (872 g/kg DM) among species allotted to shade-drying (Table 1). The OM of the oven dried species was significantly higher in *B. ruziziensis* (885 g/kg DM) when compared to the *B. arrecta* (867 g/kg DM) and *P. purpureum* (elephant grass) (859 g/kg DM) species. Across treatments, the OM content was highest (p<0.05) in shade dried *P. purpureum* (897 g/kg DM) and lowest (p<0.05) in sun-dried *P. purpureum* (852 g/kg DM). *Brachiaria ruziziensis* possessed the highest (p<0.05) content of CP (103 g/kg DM) and *B. arrecta* (87.6 g/kg DM) had the lowest (p<0.05) among species subjected to sun-drying. Among grass species that were shade dried, CP content was significantly higher in *B. ruziziensis* (123 g/kg DM) and lowest (p<0.05) in *B. arrecta* (95.7 g/kg DM). The CP content of oven dried species was significantly higher in *P. purpureum* (97.9 g/kg DM) when compared to the other grass species. Across treatments, the CP content was highest (p<0.05) in shade dried *B. ruziziensis* (123 g/kg DM) and lowest (p<0.05) in sun-dried *B. arrecta* (87.6 g/kg DM) (Table 1).

Pennisetum purpureum possessed the highest (p<0.05) content of EE (54.1 g/kg DM), whereas *B. arrecta* (35.2 g/kg DM) had the lowest (p<0.05) among species subjected to sun-drying. Similarly, among grass species that were shade dried, the EE content was significantly higher in *P. purpureum* (49.5 g/kg DM) and lowest (p<0.05) in *B. arrecta* (42.5 g/kg DM). The EE content was lowest (p<0.05) in *B. arrecta* (29.7 g/kg DM) when compared to the other oven dried grass species (*P. purpureum* 37.8 g/kg DM & *B. arrecta* 33.5 g/kg DM) respectively (Table 1). Across species, EE was highest (p<0.05) in sun-dried *P. purpureum* (54.1 g/kg DM) and lowest (p<0.05) in oven dried *B. arrecta* (29.7 g/kg DM). *Pennisetum purpureum* possessed the highest (p<0.05) content ash (148 g/kg DM), and *B. ruziziensis* (109 g/kg M) had the lowest (p<0.05) ash content among species subjected to sun-drying. Among grass species that were shade dried, the ash content was significantly higher in *B. arrecta* (136 g/kg DM) and lowest (p<0.05) in *P. purpureum* (103 g/kg DM). The ash content was lowest (p<0.05) in *B. ruziziensis* (115 g/kg DM) when compared to the other oven dried grass species (*P. purpureum,* 141 g/kg DM & *B. arrecta* 133 g/kg DM, respectively) (Table 1). Across species, the ash content was the highest (p<0.05) in sun-dried *P. purpureum* (148 g/kg DM) and lowest (p<0.05) in shade dried *P. purpureum* (103 g/kg DM).

The CF content was highest (p<0.05) in *B. arrecta* (336 g/kg DM) and lowest (p<0.05) in *P. purpureum* (303 g/kg DM) among the species allotted to sun-drying. Similarly, the CF was highest (p<0.05) in *B. arrecta* (300 g/kg DM) and lowest (p<0.05) in *P. purpureum* (264 g/kg DM) between species allotted to shade-drying (Table 1). The CF content of the oven dried species was significantly higher in *B. arrecta* (367 g/kg DM) when compared to *B. ruziziensis* (328 g/kg DM) and *P. purpureum* (324 g/kg DM) species. Across treatments, the CF content was highest (p<0.05) in oven dried *B. arrecta* (367 g/kg DM) and lowest (p<0.05) in shade dried *P. purpureum* (264 g/kg DM). *Pennisetum purpureum* possessed the highest (p<0.05) nitrogen free extractives (NFE) content (605 g/kg DM), whereas *B. ruziziensis* (574 g/kg M) had the lowest (*p*<0.05) among species subjected to sun-drying. In contrast, among grass species that were shade dried, the content nitrogen free extractives was significantly higher in *B. ruziziensis* (569 g/kg DM) and lowest (p<0.05) in *P. purpureum* (527 g/kg DM). The NFE value was lowest (p<0.05) in *B. ruziziensis* (29.7 g/kg DM) when compared to the other oven dried grass species (*P. purpureum,* 601 g/kg DM & *B. arrecta,* 619 g/kg DM) respectively) (Table 1). Across species, the NFE were highest (p<0.05) in oven dried *B. arrecta* (619 g/kg DM) and lowest (p<0.05) in shade dried *P. purpureum* (527 g/kg DM). This study has also demonstrated that there is a substantial interaction between species and drying method that affects the chemical composition (g/kg DM); DM, OM, CP, CF, EE and NFE (P<0.05).

DISCUSSION

Drying methods/techniques can significantly influence the results of proximate analyses on feed samples (Parissi et al., 2005). Those methods utilizing heat may alter the nutritive value of feedstuff, including fiber fractions, and may eventually result in the formation of indigestible Maillard products (Purcell et al., 2011). Various drying methods might impact the nutritional content of the forage samples, particularly in terms of the adhesion of nitrogen to NDF and ADF. They may also lead to an inaccurate determination of digestibility. It has long been established that the most efficient means of reporting the chemical components of feed samples is on a dry matter basis, and hence samples should be dried before chemical analysis. The most effective drying techniques are those that rapidly reduce plant metabolic activity and preserve macromolecular structures after harvesting (Alomar et al., 2003; Pelletier et al., 2010).

There were significant differences in chemical composition including; DM, CP, and EE content between species allotted to the sun and air drying. This may be due to leaf components that easily oxidize upon direct

exposure to light such as β-carotene, a precursor of vitamin A, and phenolic compounds (Palmer et al., 2000). All grass species demonstrated higher levels of OM, CP and the lowest CF levels under shade-drying when compared to other drying methods. This is exciting as it suggests that resource-poor farmers that do not have access to sophisticated laboratories for shade-drying can substitute this drying method with shade-drying. However, this does not corroborate the findings of Dzowela et al. (1995), who reported that sun-dried leaves would have had a shorter time in which water is available for respiration to take place, while shade-drying resulted in prolonged plant metabolic activity. In such circumstances, soluble carbohydrates from the forage are consumed by the respiration process producing carbon dioxide and heat, thus reducing the amount of soluble carbohydrates and increasing the fibre proportion (Heberer et al., 1985).

The EE content was lowest among the oven dried species when compared to the species in other drying methods. This does not support the work of Dzowela et al. (1995), who indicated that sun-dried leaves would have had a shorter time in which water is available for respiration to take place, while shade-drying resulted in prolonged plant metabolic activity. Under these conditions, the soluble carbohydrates of the forage are consumed by the respiration process that produces carbon dioxide and heat, thus reducing the amount of soluble carbohydrates and increasing the fibre proportion.

Crude fibre levels were highest among species that were oven dried. This may be due to the higher drying temperature, as high temperatures also result in the formation of indigestible protein-carbohydrate complexes called Maillard products, which are assayed as part of fibre fractions (Coblentz and Hoffman, 2008). In addition, drying forage samples at higher temperatures is likely to increase fibre levels because of the Maillard products and lower soluble carbohydrates. These complexes are poorly soluble in acid and neutral detergent solutions, and their formation increases at higher temperatures during drying processes (Ramsumair et al., 2014). In contrast to work conducted by Ramsumair et al. (2014), fibre concentration was observed to be higher in sun-dried than in shade-dried grasses possibly reflecting the slightly longer period it took to completely dry the leaves under sun. Slower drying rates promote loss of non-structural carbohydrates resulting in higher concentration of cell wall components (Pelletier et al., 2010).

CONCLUSION

It is clear that the chemical composition of grass is significantly affected by the drying method employed. The CP content was higher among species that were shade dried when compared to the other drying methods. Furthermore, the CF levels were lower among species that were shade dried. These findings suggest that shade drying is a valuable method for forage evaluation. However, it is important to note that this drying method might require a longer duration.

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Conflict of interest

The authors declare that they have no potential conflict of interest.

REFERENCES

Alomar D, Fuchslocher R, de Pablo M, **2003**. Effect of preparation method on composition and NIR spectra of forage samples. Anim Feed Sci Technol, 107: 191 – 200.

AOAC (Association of Official Analytical Chemists) **2005**. Association of Official Analytical Chemists. Official Methods of Analysis (13th eds). Washington D.C.

Burrit EA, Pfister JA, Malecheck JC, **1988**. Effect of drying method on the nutritive composition of oesophageal fistula forage samples: influence of maturity. J Range Manag, 41: 346-349. file:///C:/Users/andell.edwards/Downloads/8277-8158-2-PB%20(3).pdf

Coblentz WK, **Hoffman** P, **2008**. Heat damaged forages: Effects on forage quality. Focus on Forage**,** 10: 1-4.

Collins M, **Coblentz** WK, **2007**. Postharvest physiology. In: Barnes RF, Nelson CJ, Moore KJ, Collins M, editors. Forages: The Science of Grassland Agriculture. 6th ed., vol. II. p. 583-99.

Deinum B, **Maassen** A, **1994**. Effects of drying temperature on chemical composition and in vitro digestibility of forages. Anim Feed Sci Technol, 46: 75–86. https://doi.org/10.1016/0377-8401(94)90066-3

Dzowela BH, Hove L, Mafongoya PL, **1995**. Effect of drying methods on chemical composition and in vitro digestibility of multi-purpose tree and shrub fodders. Trop Grassl, 29: 263-269.

Heberer JA, Below FE, Hageman RH, **1985**. Drying method effect on leaf chemical constituents of four crop species. Crop Sci, 25: 1117–1119. https://doi.org/10.2135/cropsci1985.0011183X002500060053x

Hofman MAJ, **1965**. Microwave heating as an energy source for the predrying of herbage samples. Plant Soil, 23: 145–148.

McDonald P, **2002**. Animal nutrition. Pearson Education India.

Palmer B, Jones RJ, Wina E, Tangendjaja B, **2000**. The effect of sample drying conditions on estimates of condensed tannin and fibre content, dry matter digestibility, nitrogen digestibility and PEG binding of *Calliandra calothyrsus*. Anim Feed Sci Technol, 87: 29–40. https://doi.org/10.1016/S0377-8401(00)00182-6

Papachristou TG, **Nastis** AS, **1994**. Changes in chemical composition and in vitro digestibility of oesophageal fistula and hand plucked forage samples due to drying method and stage of maturity. Anim

Feed Sci Technol, 46: 87-95.
Parissi ZM, Papachristou TG, Nastis AS, **2005**. Effect of drying method on estimated nutritive value of browse species using an in vitro gas production technique. Anim Feed Sci Technol, 123-124: 119-128. https://doi.org/10.1016/j.anifeedsci.2005.04.046
Pelletier S, Tremblay GF, Bertrand A, Bélanger G, Castonguay Y, Michaud R, **2010**. Drying procedures affect non-structural carbohydrates and other nutritive value attributes in forage samples. Anim Feed Sci Technol, 157: 139-150.
Raguse CA, **Smith** D, **1965**. Carbohydrate content in alfalfa herbage as influenced by methods of drying. J Agric Food Chem, 13: 306–309. https://doi.org/10.1021/jf60140a005
Ramsumair A, Mlambo V, Lallo CHO, **2014**. Effect of drying method on the chemical composition of leaves from four tropical tree species. Trop Agric, 91: 179-85.
Van Soest PJ, **1982**. Analytical systems for evaluation of feeds. In: van Soest PJ, editor. Nutritional ecology of the ruminant. Corvallis, Oregon, USA: O & B Books; 1982. p. 75-94.
Van Vuuren AM, Krol-Kramer F, van der Lee RA, Corbijn H, **1992**. Protein digestion and intestinal amino acids in dairy cows fed fresh Lolium perenne with different nitrogen contents. J Dairy Sci, 75: 2215-22. https://doi.org/10.3168/jds.S0022-0302(92)77982-X

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