Nutritional and morpho-anatomical characterization of *Phyllostachys aurea* (Poaceae, Bambusoideae, Bambuseae) foliage for Argentine livestock systems

Caracterización nutricional y morfo-anatómica del follaje de *Phyllostachys aurea* (Poaceae, Bambusoideae, Bambuseae) para sistemas ganaderos en Argentina

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Abstract

Bamboo cultivation in Argentina could represent a major economic activity if its various applications were revealed. This study characterized the anatomy and micromorphology of leaf blades by optical and scanning electron microscopes. Foliage leaves presented predominant parenchyma and scarce sclerenchyma. Foliage chemical and biological composition were analyzed in 3 populations of *P. aurea* sampled in two contrasting seasons of the year. The six samples evaluated showed 13% protein, adequate for ruminant feed. Neutral detergent fiber (aNDFom) was approximately 60% DM, a probable limiting factor for consumption. Significant differences in ADFom (acid detergent fiber) and ADLom (acid detergent lignin) favored spring results, with lower values than winter results. The presence of silica in different cell types could limit digestion. Fermentation kinetics indicated that dry matter digestibility is close to 50%, and higher in spring given lower amounts of indigestible components. In addition, all samples analyzed had a low content of immediately soluble material and a high content of potentially fermentable insoluble material. Anatomy and chemical-nutritional characterization allow *P. aurea* foliage to be considered in ruminant feeding.

Keywords
woody bamboo • nutritional value • leaf anatomy and morphology • ruminant feed

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Resumen

El cultivo de los bambúes en la Argentina no ha alcanzado la relevancia merecida, pudiendo representar un valor económico más importante si se hicieran conocer sus diversas aplicaciones. En el presente trabajo, se caracterizó la anatomía y micromorfología de las láminas mediante microscopio óptico y microscopio electrónico de barrido. Se analizó la composición química y biológica del follaje en 3 poblaciones de *P. aurea* muestreadas en dos estaciones contrastantes del año. Las hojas del follaje presentaron una predominancia de tejido parenquimático sobre el esclerénquima, el cual fue escaso. La presencia de sílice en diferentes tipos celulares podría limitar la digestión. El promedio de proteína bruta fue 13% para las seis muestras analizadas y resulta aceptable para alimentación de rumiantes en mantenimiento. A su vez, se observó un contenido de aFDNmo (Fibra en detergente neutro) del 60%bs, lo cual puede ser limitante para el consumo. Se identificó una diferencia significativa en FDAmo (Fibra en detergente ácido) y LDA mo (Lignina en detergente ácido) entre invierno y primavera, favorable a la primavera con menores valores de dichos analitos. La cinética de fermentación indicó que la digestibilidad de la materia seca es cercana al 50%, siendo mayor en primavera dada la menor cantidad de componentes indigestibles. Además, para todas las muestras analizadas, el contenido de material inmediatamente soluble fue bajo, mientras que el material insoluble potencialmente fermentable fue elevado. Los resultados del análisis anatómico, complementado con la caracterización químico nutricional, permiten considerar al follaje de *P. aurea* en la alimentación de rumiantes.

Palabras clave

bambú leñoso • valor nutricional • anatomía y morfología de las hojas • alimentación para rumiantes

Introduction

The millennial cultivation of woody bamboo in Southeast Asia has recently gained attention in some tropical and subtropical countries of America (*e.g.* Colombia, Ecuador, Bolivia, Brazil and Chile (Londoño, 2009). Parodi (1943) stated that bamboo cultivation in Argentina had not reached its productive and economic potential. Its development should be encouraged by revealing its various applications. Woody bamboo provides human feed (24), and materials for utensils, cosmetic products, and crafts (22, 28, 30). Other uses are related to forage, paper pulp, fibers, biochar and pyrolysis compounds (1, 2, 3, 10).

Woody bamboo has rapid vegetative growth from vigorous rhizomes (27). Clumps can be used after 3 to 4 years of implantation. In addition to high biomass production, wide adaptability and evergreen leaves make them potential candidates in forage production (40). After rational culm cutting, bamboo gives annual harvests for 30 to 120 years, depending on the species (17, 18). The vegetative growth phase of *Phyllostachys aurea* Carrière ex Rivière & C. Rivière lasts 15 to 30 years, followed by flowering (30, 37) with no clump death. In Argentina, this exotic species is cultivated for ornamental purposes and its culms are used in construction and crafts, while shoots are edible (39, 48). Bamboo foliage is an alternative forage for domestic cattle. However, information on its chemical-nutritional composition as feed for ruminants is scarce (29). Other countries have identified several genotypes, growing sites, and seasons for forage variability (6, 34, 40, 47). Biomass production occurs in the temperate and rainy season, with growth impeded in winter, under 10°C (19).

Panizzo *et al.* (2017) nutritionally evaluated the foliage of the native woody bamboo *Guadua chacoensis* (Rojas Acosta) Londoño & P. M. Peterson and suggested its use as grazing supplement. In southern Argentina, *Chusquea culeou* E. Desv. ("caña colihue") constitutes the main winter forage for bovine diet while other grasses remain covered in snow (25). We aimed to nutritionally and morpho-anatomically characterize *P. aurea* foliage for ruminant feed.

Materials and methods

Selection and collection of material

We used foliage leaves from 3 populations of the woody bamboo *P. aurea*: Lucien Hauman (S: 34°35'; E: 58°28'), Arturo Ragonese (S: 34°36'; E: 58°40') Botanical Gardens and wild bamboo from Buenos Aires Delta (S: 34°24'; E: 58°33'). We sampled in two contrasting production seasons, spring (October 2017) and winter (July 2018). Nine culms were harvested at each location (*i.e.* 3 culms × 3 bamboo sites per harvest). A pool of foliage leaves was used in nutritional characterization of each population. Additionally, segments of the middle portion of blades were selected for anatomical and micromorphological studies.

The climate was humid temperate (figure 1) (20). Monthly rainfall and mean temperature did not restrict clumps growth of *P. aurea*. However, summer in 2018 was drier with rains accumulated in May and June.

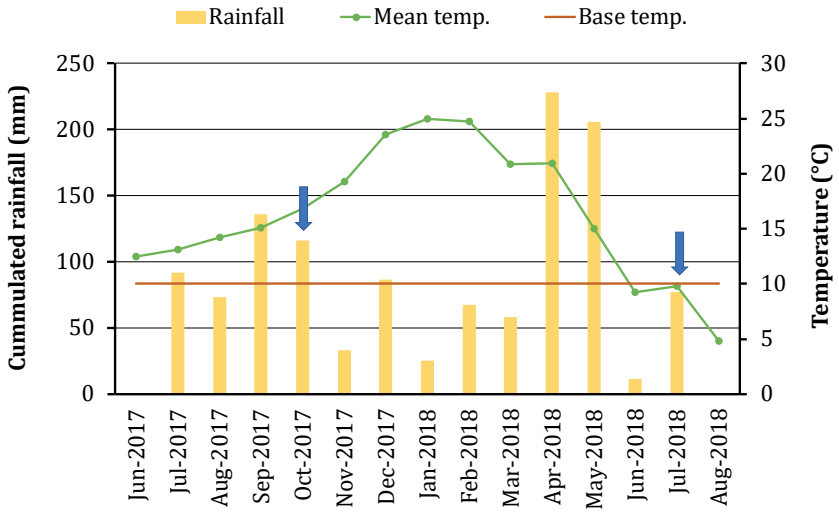


Figure 1. Average temperatures and cumulated rainfall during the months before *Phyllostachys aurea* foliage harvest (20); and growth base temperature of bamboo species according to Halvorson *et al.* (2010).

Figura 1. Temperaturas promedio y precipitaciones acumuladas durante los meses antes de la cosecha del follaje de *Phyllostachys aurea* (20) y temperatura base de crecimiento de especies de bambú según Halvorson *et al.* (2010).

Morphological and anatomical studies

The species' growth habit and leaf size, consistency, and indumentum followed McClure (1966) and Judziewicz *et al*. (1999) terminology. Foliage leaf blades collected in spring were dehydrated in alcohol series and embedded in paraffin following traditional anatomical techniques (12). Twenty µm-thick sections were cut with a rotary microtome and stained with safranine-Fast green. The following anatomical traits were considered: midrib and keel (position, vascular bundles, adaxial and abaxial sclerenchyma), abaxial and adaxial epidermis, bulliform cells, arm cells and intercellular spaces [sometimes referred to as "fusoid cells" (42), described in accordance to Ellis (1976, 1979) and Clark (2005). Observations were made with a Nikon® Microphot FXA optical microscope (Tochigi, Japan). Blade micromorphology was studied with a Scanning Electron Microscope (SEM, Phillips XL 30 Microscope (Phillips, The Netherlands). To describe abaxial and adaxial epidermal traits, small blade fragments were cleaned in xylene for 1.5 h with an ultrasonic cleaner (Cleanson, model CS 1106, Argentina). The material was air-dried, mounted, and coated

with a gold-palladium (40%-60%) alloy by a Thermo VGScientific, then observed using a Phillips XL 30 Scanning Electron Microscope (MACN-CONICET, Argentina). Papillae pattern in long cells follows (49). Foliar anatomy and micromorphology related content of sclerenchyma, silica cells, macro and micro hairs, prickle and hooks, with possible forage acceptability. To quantify phytoliths and describe their association in each period and locality, articulated (*i.e.*, more than two elements) and non-articulated elements (*i.e.*; a single element per morphotype), were considered (15). Morphotype description involved an *ad hoc* classification based on the proposals of Neumann *et al.* (2019).

Chemical-nutritional evaluation

Determinations included: dry matter (DM) by oven-drying at 105°C, ashes by incineration at 550°C (Cen; AOAC, 1990, Nº. 942.05), crude protein (CP; AOAC, 1990, Nº. 984.15), neutral and acid detergent fibers (42) using α-amylase and ash free (aNDFom and aADFom, respectively), and ash free acid detergent lignin (ADLom). Silica was determined by calcination technique (Si; Labouriau, 1983).

The *in vitro* evaluation of gas production (GP) followed the recommendations of Wawrzkiewicz *et al.* (2005). Measurements were made at regular intervals (*i.e.* 2, 4, 6, 8, 12, 16, 20, 24, 36, 48, 60, and 72 h). In addition, samples were incubated for up to 48 h to recover undigested residues in ANKOM® F57 filter bags determining DM digestibility (DMD_{iv}) and NDF ($NDFD_{iv}$). Cumulative net gas production (CNGP) and digestibility were corrected for blank (*i.e.* bottles without substrate) and incubated dry matter.

GP kinetics were adjusted to the equation $CNGP = a + b \times (1 - e^{-ct})$ (35). CNGP (ml/g DM) was determined at 12, 24, 48 and 72 h, parameters a, b and c, maximum hourly rate of GP (RGP_{Max}; ml/g DM.h) and the time at which it occurs (T_{RGPmax}; h) and average rate gas production (RGP_{Av}).

Statistical analysis

Comparisons were made between spring and winter considering the three populations as replicates. The data were analyzed with SAS® statistical program. Seasons were compared by a completely randomized one-way design, with no interactions. A Tukey test compared means at $p < 0.05$.

GP rates were compared via a model considering time (T) as a repeated measure and the interaction with season (S × T) with a completely randomized two-way design with interaction. A Tukey test compared means at $p < 0.05$.

Results

Morphological studies

The studied clumps were 2-9 m tall (figure 2A, page 144). Rhizome axillary buds formed edible shoots (figure 2B, page 144) and produced aerial culms. These were woody, hollow, 1-5 cm in diameter, with grooved internodes on the side of the bud, upper nodes spaced apart, and the lower ones asymmetric and proximate (figure 2C and figure 2D, page 144). Bamboos have culm leaves and foliage leaves. The formers have a protective function (figure 2B, page 144) and at maturity are deciduous, constituting abundant litter on the soil surface. Foliage leaves are photosynthetic and have perennial lanceolate leaf blades, 5-16 × 1-2 cm (figure 2D, page 144).

A: habit. B: young shoot. C: nodes and internodes of culm middle portion. D: basal nodes, internodes and foliage leaves. Scale bars: A: 2 m; B: 3 cm; C: 12 cm; D: 1.5 cm.

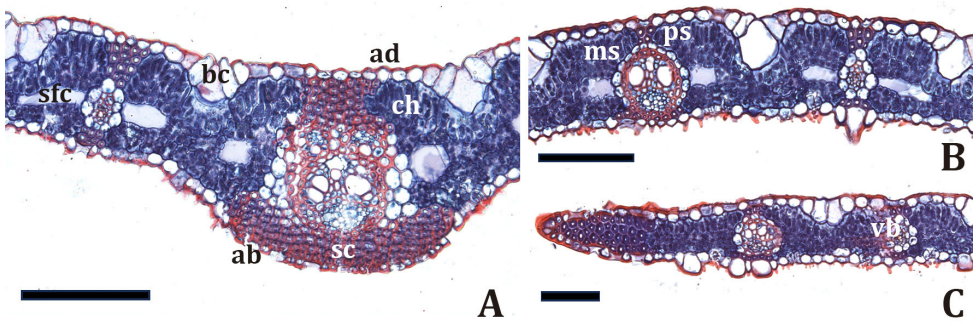
A: hábito. B: turión. C: nudos y entrenudos de la parte media de las cañas. D: nudos, entrenudos basales y hojas del follaje. Escalas: A: 2 m; B: 3 cm; C: 12 cm; D: 1,5 cm.

Figure 2 / Figura 2. *Phyllostachys aurea*.

Anatomical studies

In cross-section, foliage leaf blades present characteristic C_3 anatomy. Well-developed midrib, keel projecting abaxially, with a first-order vascular bundle surrounded by a double sheath consisting of an outer parenchyma sheath and inner mestome sheath, locked towards both surfaces (figure 3A). The adaxial epidermis exhibited a single layer of smooth-walled cells and groups of fan-shaped bulliform cells. The abaxial epidermis was papillose and formed by various cell types (*i.e.*, long cells, suberous cells, silica cells, and hooks, (figure 3A, 3B and 3C).

Chlorenchyma was diffuse and exhibited large intercellular spaces between fusoid cells, and on both sides of the vascular bundles in contact with parenchyma sheath. Arm cells are thin-walled and asymmetrically invaginated on the abaxial side. Scarce sclerenchyma. Girders associated with primary and secondary vascular bundles and strands at blade edges (figure 3C). In superficial view, leaf blades with SEM showed marginal hooks, smooth adaxial surface (figure 4A and 4B page 145) and abaxial epidermis formed by a diversity of cell types among which were long cells with short papillae, stomatal complex slightly sunken with elongated papillae of the long contiguous cells overarching the stomata (subtype IV), silica cells, suberous cells, bicellular microhairs, hooks and prickles (figure 4C and 4D page 145). The phytolytic association of all analyzed materials presented a greater abundance of morphotypes accompanying leaf epidermis: silica cells, suberous cells, microhairs, hooks, prickles, and fan-shaped bulliform cells (figure 5A, 5B and 5C, page 145). To a lesser extent, prismatic morphotypes with wavy edges derived from long cells and short cylindrical elements (figure 5A and 5B, page 145).

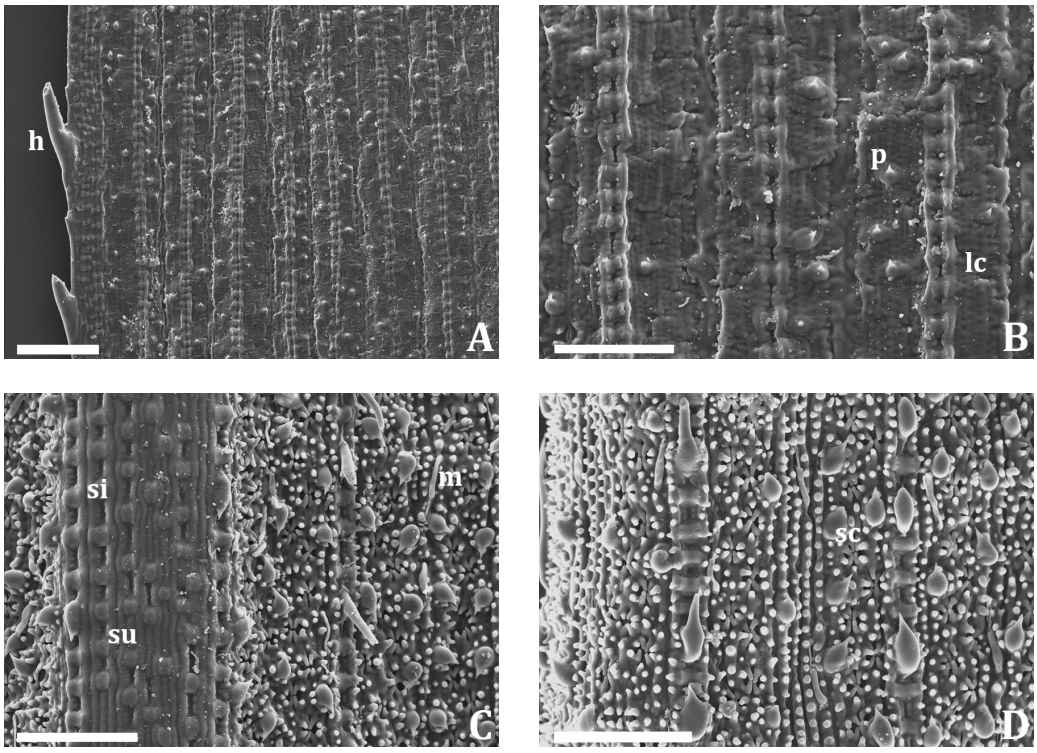


A: keel. B: arm. C: margin. ad: adaxial epidermis; ab: abaxial epidermis; bc: bulliform cells; ch: chlorenchyma; ms: mestome sheath; ps: parenchyma sheath; sc: sclerenchyma; sfc: spaces between fusoid cells; vb: vascular bundle. Scale bars: 100 µm.

A: costilla central. B: ala. C: margen. ad: epidermis adaxial; ab: epidermis abaxial; bc: células buliformes; ch: clorénquima; ms: vaina mestomática; ps: vaina parenquimática; sc: esclerénquima; sfc: espacios entre células fusoides; vb: haz vascular. Escalas: 100 µm.

Figure 3. Foliage leaf blade cross-section in *Phyllostachys aurea*.

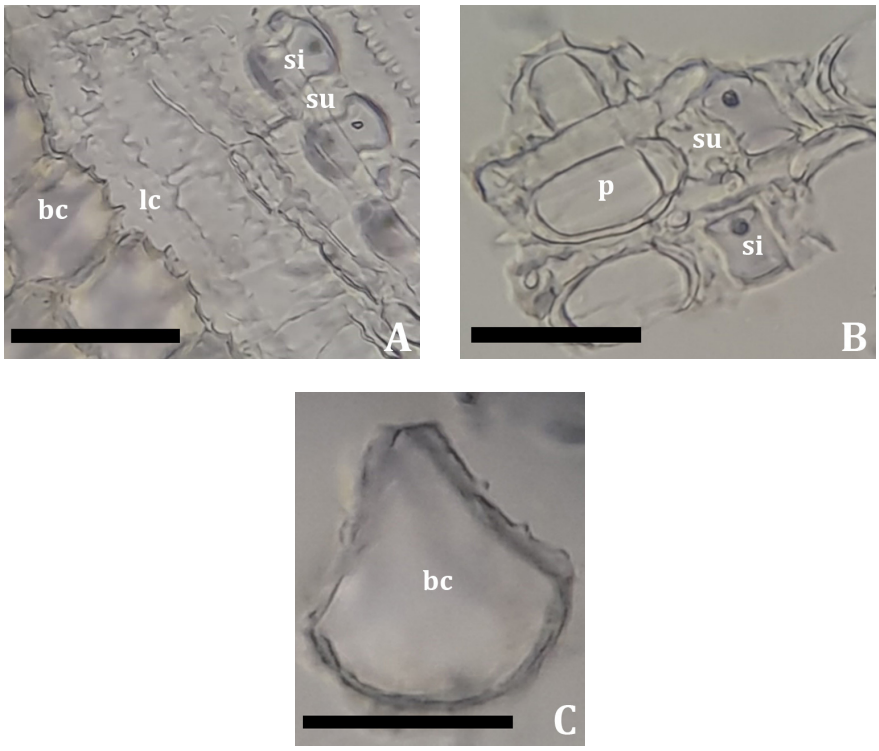
Figura 3. Lámina de *Phyllostachys aurea* en transcorte.



A-B: adaxial epidermis. C-D: abaxial epidermis. h: hook; lc: long cell; m: bicellular microhair; p: prickle; sc: stomatal complex; si: silica cell; su: suberous cell. Scale bars: A: 200 µm; B-D: 100 µm.

A-B, epidermis adaxial. C-D, epidermis abaxial. h, aguijón; lc, célula larga; m, micropelo bicelular; p, gancho; sc, aparato estomático; si, célula silícea; su, célula suberosa. Escalas: A, 200 µm; B-D, 100 µm.

Figure 4. Leaf blade of *Phyllostachys aurea* observed with a Scanning Electron Microscope.
Figura 4. Lámina de *Phyllostachys aurea* observada con Microscopio Electrónico de Barrido.



A: Fragment of leaf blade adaxial epidermis, general view. B: Prickles, silica and suberous cells, detail. C: Fan-shaped bulliform cell. bc, bulliform cell; lc, long cell; p, prickle; si, silica cell; su, suberous cell. Scale bars: 50 µm.

A: Fragmento de epidermis adaxial de la lámina foliar, vista general; B: Detalle de aguijones, células silíceas y suberosas. C: Célula buliforme con forma de abanico. bc, célula buliforme; lc, célula larga; p, gancho; si, célula silícea; su, célula suberosa. Escala: 50 µm.

Figure 5 / Figura 5. *Phyllostachys aurea.*

Chemical-nutritional evaluation

P. aurea did not present differences between seasons in DM, CP and aNDFom. Averages exceeded 500 g/kg HM and 133 and 623 g/kg DM of CP and aNDFom, respectively (table 1). The inorganic fraction reached 193 g/kg DM while 81% of leaf blades constituted organic matter. Structural carbohydrates predominated with a low concentration of water-soluble non-structural carbohydrates (*i.e.* 623 and 26 g/kg DM, aNDFom and WSC, respectively) and moderate CP contents (table 1). The high silica content (*i.e.* 82% of total ash) suggests the presence of indigestible material and lower organic matter for animal feed.

Table 1. Chemical composition of *P. aurea* leaf blades in winter and spring.
Tabla 1. Composición química de láminas de *P. aurea* en dos épocas del año.

	Winter	Spring	SE_{mean}	Significance
DM (g/kg MH)	490	458	3.5	0.003
Ashes	204	181	19.7	0.452
Silica	171	143	19.2	0.365
Crude protein	137	129	5.4	0.387
aNDFom	623	622	11.6	0.945
ADFom	298	281	4.2	0.044
ADLom	69	44	3.8	0.010
WSC	22	30	3.5	0.204

DM: dry matter; aNDFom: insoluble fiber in neutral detergent with α-amylase and free of ash; ADFom: ash-free acid detergent fiber insoluble fiber; ADLom: lignin in acid detergent in sulfuric acid and free of ashes; WSC: water-soluble carbohydrates; SE_{mean}: standard error of the mean.

Data are expressed in g/kg DM, unless indicated.

MS: materia seca; aFDNmo: fibra insoluble en detergente neutro con α-amilasa y libre de cenizas; FDAmo: fibra insoluble en fibra detergente ácida sin cenizas; LDAmo: lignina en detergente ácido en ácido sulfúrico y libre de cenizas; CS: carbohidratos solubles en agua; EE_{media}: error estándar de la media.

Los datos se encuentran expresados en g/kg MS, excepto que se indique lo contrario.

Phyllostachys aurea presented lower moisture content and higher concentration of ADFom and ADLom in winter than in spring, with increases of 7, 6 and 57% ($P < 0.05$), respectively (table 1). ADLom accumulation in the cell wall of winter leaf blades coincides with a 9% decrease in DMD_{in} in winter compared to summer harvest ($P < 0.05$; table 2, page 147). However, increases in ADF and ADL did not translate into statistically significant changes in IVNDF ($p = 0.16$), possibly given the greater SE_{mean} magnitude concerning DMD_{iv} (9.1 and 21.5 SE_{mean} for DMD_{iv} and $NDFD_{iv}$, respectively). Additionally, digestibility determined at 48 h, corresponding to potential values, could promote difference fading. *P. aurea* high cell wall content and greater winter lignification promoted digestibility not exceeding 54% and 36% for DM and aNDFom, respectively.

Leaf blade CP content was slightly below the threshold (13%DM) recommended for the ruminant diet. Moreover, since average soluble carbohydrates were 26 g/kg DM and aNDFom was over 600 g/kg DM, *P. aurea* foliage can be classified as medium-quality feed.

GP kinetics coincided with that described for ADFom, ADLom and digestibilities, being RGP_{Av} 1.8 times higher in spring and 1.7 in the PGAN at 24, 48 and 72 h, compared to winter (table 2, page 147; $P < 0.05$). This could be due to 36% less lignin of summer leaf blades, and 89% more organic matter not associated with the cell wall (*i.e.* 1000 - (Ash + CP + aNDFom) = 68 vs 36 g/kg DM; table 1). This hypothesis was supported by the greater DMD_{iv}, although no significant differences were detected for $DNFD_{iv}$.

Although the *c* rate was higher in spring leaf blades, the adjusted rate was 39% lower than in winter (*i.e.* 0.011 and 0.018 h^{-1}, respectively; table 2, page 147; $P = 0.047$). The model describing GP kinetics may overestimate *c* when the curve does not reach the plateau (figure 6, page 147). However, spring foliage showed GP net rates of 3.2 fold and twice higher at hour 1 and 18, respectively (*i.e.* E × T; $P = 0.034$; figure 6, page 147). In all cases, T_{RGPmax} was 3 hours after incubation. Higher GP rates at 1 and 3 hours could be due to WSC fermentation, while the later reduced rate is given by the lower availability of cell-wall carbon skeletons.

Table 2. *In vitro* nutritional evaluation of *P. aurea* leaf blades in winter and spring.
Tabla 2. Evaluación nutricional *in vitro* para dos estaciones del año de láminas de *P. aurea*.

	Winter	Spring	SE_{mean}	Significance
***In vitro* digestibility at 48 hours**				
DMD_{iv} (g/kg DM)	497	543	9.1	0.023
$NDFD_{iv}$ (g/kg NDF)	312	364	21.5	0.164
Cumulative gas production (ml/g DM) at different incubation times (h)				
24	33	59	3.4	0.006
48	51	85	4.2	0.004
72	73	114	5.3	0.006
Parameters of the kinetics of gas production				
RGP_{Max} (ml/g DM.h)	2.5	3.3	0.25	0.078
RGP_{Av} (ml/g DM.h)	1.2	2.1	0.09	0.003
a (ml/g DM)	2.0	2.0	1.20	0.736
b (ml/g DM)	154	138	17.0	0.539
a + b (ml/g DM)	140	156	16.5	0.514
c (h^{-1})	0.018	0.011	0.0018	0.047

SE_{mean}: mean standard error; DMD, dry matter digestibility; NDFD: insoluble fiber in neutral detergent digestibility; RGP_{Max}: maximum rate gas production; RGP_{Av}, average rate gas production; a: GP of soluble fraction; b: GP of potentially degradable fraction; c: *b* degradation rate (CNGP = a + b x (1 - e^{-ct}); Ørskov and McDonald, (1979).

Digestibility and kinetics of gas production.

EE_{media}: error estándar de la media; DMS: digestibilidad de la materia seca; DFDN: digestibilidad de la fibra insoluble en detergente neutro; TPG_{Max}: tasa máxima de producción de gas; TPG_{Prom}: tasa promedio de producción de gas; a: PG de fracción soluble; b: PG de fracción potencialmente degradable; c: tasa de degradación de b (PGNA = a + b x (1 - e-ct); Ørskov y McDonald, (1979).

Digestibilidad y cinética de producción de gas.

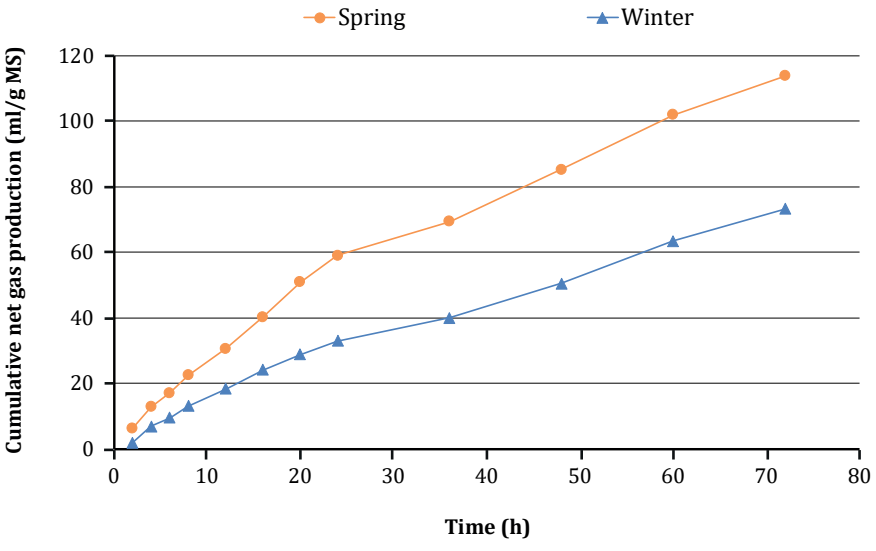


Figure 6. Cumulative net gas production (ml/g DM incubated) as a function of incubation hours of *P. aurea* leaf blades in spring and winter.

Figura 6. Producción de gas acumulada neta (ml/g MS incubada) en función de las horas de incubación de las láminas de *P. aurea* en dos estaciones del año.

Discussion

Morpho-anatomically, *P. aurea* foliage leaves presented predominant parenchyma and scarce sclerenchyma, desirable traits for forage use. As foliage matures, silica is deposited in bulliform cells, microhairs, hooks, and prickles, and to a lesser extent in suberous, long, and subsidiary cells in the stomatal complex (50). This study coincides with our anatomical and nutritional results showing that silica in different cell types could limit digestion. Silica in epidermis, trichomes, cell walls or lumen of grasses acts as a structural inhibitor of microbial digestion leading to lower acceptability and DMD (26). Thus, low DMDiv and NDFDiv could be explained by high epidermal Si contents preventing wall enzymatic degradation.

Chemical-nutritional composition of *P. aurea* leaf blades was statistically different between spring and winter harvests, as previously found (9, 19, 47). However, these differences did not modify productive implications in ruminant feeding, describing a forage of medium to low nutritional value (*i.e.* CP,133; aDFNom, 623; ADFom, 290; ADLom, 57; DMD_{iv}, 520; $NDFD_{iv}$, 338 g/kg DM). Other authors reported similar results (4, 40) and Bhardwaj *et al.* (2019) studying Jersey cows, characterized *P. aurea* with lower palatability and nutritional value than other bamboos like *Dendrocalamus hamiltonii* Nees & Arn. ex Munro, D. *asper* (Schult. & Schult. f.) Backer ex K. Heyne, *Melocanna baccifera* (Roxb.) Kurz, *Phyllostachys bambusoides* Siebold & Zucc. and *P. pubescens* (Pradelle) Mazel ex J. Houz.]. In contrast, Panizzo *et al.* (2017) described *Guadua chacoensis* leaf blades as better nutritional forage, with 220 g CP/kg DM, 541 g aNDFom/kg DM and 64% degradability at 48 hours.

Asaolu *et al.* (2010) and Halvorson *et al.* (2010) mentioned that bamboo is suitable for animals under maintenance conditions. The advantage of *P. aurea* is that leaf foliage blades are perennial and available when other forage species become scarce (4, 8, 9, 34). Mekuriaw *et al.* (2011), documented using bamboo foliage as feed for cattle, sheep, goats, and chickens in Ethiopia. In addition, our average aNDFmo content of 623 g/kg DM (table 1, page 146) could limit dry matter intake as for other forages (*i.e.*, aNDFom > 600 g/kg DM; Mertens, 1973). Compared to other forage species, *P. aurea* low GP and CNGP rates suggest lower rumen fermentation and a consequent negative effect on potential consumption (16, 45). However, its CP content over 120 g/kg DM would not limit rumen digestion or requirements of ruminant categories in maintenance (7).

P. aurea foliage presented lower nutritional value than most C_3 grasses and legumes grown in the temperate region of Argentina, both fresh and hayed or ensiled (*i.e.*, oats, barley, fescue, ryegrass, red clover and alfalfa; Jaurena and Danelón, 2006; Wawrzkiewicz *et al*., 2019). On the other hand, compared with C_4 (*i.e.*, rhodes grass, gatton panic, honey grass; Fernández Pepi *et al*., 2018) grasses, bamboo contributed more CP and a similar or lower cell wall content. For this reason, *P. aurea* would be an alternative to C_4 grasses, given its constant biomass production, nutritional quality and availability in winter or dry seasons.

Yayota *et al.* (2009) mention that low nutritional quality of bamboo cannot be completely explained by cell-wall quantity and composition. Factors like tannins or Si hinder microbiologic accessibility, slowing digestion (46).

Our results evidence foliar homogeneity of *P. aurea* throughout the year, for the temperate region of Argentina, and strong environmental adaptability while keeping stable chemical-nutritional characteristics. This allows considering *P. aurea* as an ingredient for ruminant supplementation in times of forage scarcity, increasing effective fiber intake. The use of foliage leaves, otherwise discarded after culms are used in construction and crafts, transforming a byproduct into an additional source of feed for ruminants.

Conclusions

Phyllostachys aurea presented morphological characteristics, growth habit, propagation form and vegetative cycle allowing high capacity for establishment and development in diverse environments. The C_3 leaf anatomy with abundant parenchyma and scarce sclerenchyma along with its chemical-nutritional composition suggest its value as feed for ruminants. Although cell wall content estimated as NDF limits potential consumption, bamboo could be used as supplement in unfavorable times and ensure fiber contribution. Finally, *P. aurea* presents homogeneous traits throughout seasons and sites (low phenotypic plasticity) constituting a food source throughout the year.

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