Investigation note

Chemical composition of four forage grasses from the state of Jalisco

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Abstract

In the Mexican tropics, livestock farming is based on extensive production systems, and it is important to know the nutritional content of forages, therefore the objective of this study was to evaluate the chemical composition of: *Cenchrus ciliaris* L., *Megathyrsus maximus cv* Guinea, *Ixophorus unisetus* and *Megathyrsus maximus cv* Tanzania, grasses established and frequently used in the Tropics for animal feed. The samples from the locality 'San Luis Tenango', Tonaya, Jalisco were analyzed at the Laboratory of Animal Nutrition, Department of Zootechnics, Chapingo Autonomous University. The following was determined: ashes (Ash), crude protein (CP), ethereal extract (EE), neutral detergent fiber (NDF), cellular content (CC), acid detergent fiber (ADF) and cellulose (Cel). Data analysis was performed with three repetitions and each repetition was considered an experimental unit. Pearson's correlation and the separation of means by Tukey ($p< 0.05$) were performed. CP was positively correlated with Ash and CC and negatively correlated with NDF and ADF ($p< 0.05$). *Megathyrsus maximus cv* Guinea was the forage species with the highest amount of CP (12.9 g $(100\ g)^{-1}$), followed by ($p< 0.05$) *Megathyrsus maximus cv* Tanzania (8.7 g $(100\ g)^{-1}$). *Megathyrsus maximus cv* Guinea showed the highest percentage of Ash, 11.7 g $(100\ g)^{-1}$ and the lowest values of ADF and Cel and its NDF value (74.8 g $(100\ g)^{-1}$) was low ($p< 0.05$), slightly higher than that of *Ixophorus unisetus* (73.5 g $(100\ g)^{-1}$). Therefore, *Megathyrsus maximus cv* Guinea was the grass with the highest nutritional value.

Keywords: crude protein, neutral detergent fiber, nutritional value, proximate analysis, Van Soest method.

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Mexico ranks eighth in the world in cattle population, with an inventory of more than 31 million heads, a figure that corresponds to 2.31% of the world herd (SADER-SIAP, 2021). Villegas *et al*. (2001) mention that the livestock activity of our country is of great importance, both for the economic participation and for the considerable sector that works in it. Also, (Enríquez *et al*., 2011) indicate that: in the tropical regions of Mexico, 64% of the cattle herd is kept, in 33% of the national territory, where 35% of the meat and 25% of the milk that the country produces are generated.

The livestock areas of Mexico are derived mainly from the ecology of the places, since the country has a great diversity of soils, topographies and climates, extending from the arid and semiarid zones of the north to the tropical regions of the Gulf and the Yucatan Peninsula. Due to the climatic characteristics and the soil-plant-animal relationship, the Mexican geography has been divided into the regions: arid and semiarid, temperate, dry tropical and humid tropical (SEMARNAT, 2021), some authors mention the mountain region (Herrera *et al*., 2008; López-Carmona *et al*., 2021).

Grasses are the basis of animal feed in the Mexican tropics. According to a study by Cruz *et al*. (2011) in the humid tropics, the seasonal distribution of the total yield, on average of 24 genotypes of *Brachiaria* grass, was: 83% in the rainy season, 9% in the north wind season and 8% in drought. The component with the greatest contribution to yield was that of leaves, with the following seasonal trend: north winds>dry>rainy, with averages of 77.6, 71.7 and 57.6%, respectively. The highest growth rate occurred in June (rainy season) with an average of 189 kg DM ha^{-1} d^{-1}, which gradually decreased to 4 kg DM ha^{-1} d^{-1} in May of the following year (dry season), a result that coincided with that obtained by Ramírez *et al*. (2010) in the dry tropics of the state of Guerrero.
The soil factors that limit the production and persistence of forages are: acidic pH, high levels of exchangeable aluminum, manganese, poor meadow management and low availability of nutrients and organic matter, factors that together cause low persistence in most introduced forage species (Cruz *et al*., 2011).

Grasses are used as the main food source for ruminants and represent the largest volume of the diet, as they are cheaper, have a large production capacity and grow easily (Martínez *et al*., 2017). On the other hand, nutrient consumption is one of the main factors that restricts animal production in the tropics and can only be controlled if the nutritional value of forages does not constitute a limiting factor (Olafadehan and Okunade, 2018).

The relationship between the chemical composition and the availability of dry matter of the grass largely defines the productive potential of a cattle production system under grazing conditions (Torres *et al*., 2020). If the management criteria related to defoliation frequencies and cut heights are applied correctly, benefits in terms of productivity can be obtained from this system (Patiño *et al*., 2018).

Likewise, cut frequency and height influence the structure of the canopy of a meadow and affect the leaf:stem ratio, growth rate, stem population, leaf expansion rate and the removal of apical meristems, variables related to production (Rojas *et al*., 2020) and forage quality, in addition to influencing the longevity of plants by affecting their reserve carbohydrates (Cruz *et al*., 2011). This paper aims to study the chemical composition of four tropical grasses used for animal nutrition in the state of Jalisco: *Cenchrus ciliaris* L., *Megathyrsus maximus cv* Guinea, *Ixophorus unisetus* and *Megathyrsus maximus cv* Tanzania.

Location

The samples were collected at the locality 'San Luis Tenango' located in the Municipality of Tonaya, Jalisco, coordinates 19° 47' north latitude and 103° 58' west longitude, 820 m altitude. The characteristic soil of the municipality is chromic cambisol and the associated soils are eutric regosol and pelic and chromic vertisols. Two types of climates were distinguished at the site: warm-subhumid and semi-warm-semi-humid, which correspond to 57.6 and 42.4% of the area, respectively. The average annual temperature is 22.4 °C, with an average maximum of 33.4 °C and an average minimum of 10.9 °C. The average annual rainfall is 800 mm (IIEG-Jalisco, 2018).

Obtaining of samples

On November 15, 2019, approximately at five weeks of regrowth, the plants were manually cut, bagged and labeled and dried at 55 °C in a forced air oven to constant weight. Subsequently, they were ground (1 mm mesh) and identified, placed in plastic bags for their analysis in the Laboratory of Animal Nutrition of the Department of Zootechnics of the Chapingo Autonomous University, State of Mexico.

Determined variables

The following variables were determined: crude protein (CP), ethereal extract (EE), ashes (Ash), neutral detergent fiber (NDF), cellular content (CC), acid detergent fiber (ADF), cellulose (Cel) and hemicellulose (Hcel) (AOAC, 1990; Van Soest *et al*., 1991), all in g (100 g)$^{-1}$ of dry sample.

Experimental design and statistical analysis

A completely randomized experimental design was used, with the four grasses as treatments, three repetitions for each variable. After performing the analysis of variance and the Tukey test for mean separation ($p< 0.05$), a Pearson correlation analysis was performed among all pairs of variables. The statistical package used was Statistical Package for the Social Sciences (SPSS, 2011) version 8.0.

Ashes (Ash)

For Ash of *Megathyrsus maximus cv* Guinea, a value of 12.2 g (100 g)$^{-1}$ has been reported (Castrejón *et al*., 2017). In this study, values of 11.6 g (100 g)$^{-1}$ were found (Table 1). For Ash in *Cenchrus ciliaris* L., values of 8.9 g (100 g)$^{-1}$ (Ramírez *et al*., 2003) and 9.1 g (100 g)$^{-1}$ (Castrejón *et al*., 2017) were found, the latter similar to that of the present study, 9.6 g (100 g)$^{-1}$ (Table 1). It was observed that the ash content is high (close to 10%) in these grasses.

Table 1. Proximate analysis of four grasses from the state of Jalisco, g (100 g)$^{-1}$ on a dry basis.

Species	Ash	OM	CP	EE
Megathyrsus maximus cv Tanzania	10.5 c	89.5 b	8.73 b	1.2 b
Cenchrus ciliaris L.	9.6 d	90.4 a	7.9 c	1.1 b
Ixophorus unisetus	11.1 b	88.9 c	7.6 c	2.1 a
Megathyrsus maximus cv Guinea	11.6 a	88.4 d	12.9 a	1.2 b

Means in the same column with a different letter are statistically different ($p< 0.05$). Ash= ashes; OM= organic matter (100- Ash); CP= crude protein; EE= ethereal extract.

Crude protein (CP)

For CP in *Megathyrsus maximus* cv. Guinea, the following values have been reported: 6.95 g (100 g)$^{-1}$ (Ardila and Laredo, 1984), 8.09 g (100 g)$^{-1}$ (Reyes *et al*., 2009), 10.49 g (100 g)$^{-1}$ (Núñez *et al*., 2019), 10.1 g (100 g)$^{-1}$ (Schnellmann *et al*., 2020) and 6.5 g (100 g)$^{-1}$ (Bautista-Tolentino *et al*., 2011). Values lower than that found in the present study, 12.9 g (100 g)$^{-1}$ (Table 1). For CP in *Cenchrus ciliaris* L., values of 10.2 g (100 g)$^{-1}$ (Ramírez *et al*., 2003) and 14.85 g (100 g)$^{-1}$ (Sánchez *et al*., 2017) have been obtained. Values higher than those obtained in the present study, 7.9 g (100 g)$^{-1}$ (Table 1). For CP in *Ixophorus unisetus*, values of 9.6% g (100 g)$^{-1}$ (Molina *et al*., 1985), 12.88 g (100 g)$^{-1}$ (Guevara *et al*., 1962) were found, which were higher than those found in the present study, 7.6 g (100 g)$^{-1}$ (Table 1). Therefore, in this study, *Megathyrsus maximus cv* Guinea surpassed the others in CP.

Ethereal extract (EE)

A study by Guevara *et al*. (1962) indicates that the EE content of *Ixophorus unisetus* was 2.13 g (100 g)$^{-1}$, a value higher than that obtained in the present study, 2.1 g (100 g)$^{-1}$ (Table 1), in the experiment carried out no coincidences were recorded.

For EE in *Megathyrsus maximus* cv. Guinea, a value of 4.71 g (100 g)$^{-1}$ has been reported (Castrejón *et al*., 2017), higher than that found in the present study, 1.2 g (100 g)$^{-1}$ (Table 1). For EE in *Megathyrsus maximus cv* Tanzania, a value of 5.19 g (100 g)$^{-1}$ (Castrejón *et al*., 2017) has been reported, a value higher than that found in the present study, 1.24 g (100 g)$^{-1}$ (Table 1). Therefore, in this study, the grasses studied showed low EE value.

Table 2. Van Soest analysis of four grasses from the state of Jalisco, g (100 g)$^{-1}$ on a dry basis.

Species	NDF	CC	ADF	Cel	Hcel
Megathyrsus maximus cv Tanzania	78.9 a	21.1 d	44.3 b	36.1 c	34.6 a
Cenchrus ciliaris L.	77.2 b	22.8 c	47.3 a	39.4 b	29.9 b
Ixophorus unisetus	73.5 d	26.5 a	48.3 a	42.8 a	25.2 c
Megathyrsus maximus cv Guinea	74.8 c	25.2 b	39.1 c	32 d	35.7 a

Means in the same column with a different letter are statistically different ($p < 0.05$). NDF: neutral detergent fiber or cell walls; ADF= acid detergent fiber; CC= cellular content (100-NDF); Cel= Cellulose; Hcel= hemicellulose (NDF-ADF).

Neutral detergent fiber (NDF)

For NDF or cell walls in *Megathyrsus maximus* cv. Tanzania, values of 72.2 g (100 g)$^{-1}$ (Patiño *et al*., 2018), 74.6 g (100 g)$^{-1}$ (Reyes *et al*., 2009) have been reported. The latter was similar to that found in the present study: 78.9 g (100 g)$^{-1}$ (Table 1). For NDF in *Cenchrus ciliaris* L., 72.2 g (100 g)$^{-1}$ (Ramírez *et al*., 2003), 62 g (100 g)$^{-1}$ (Valle *et al*., 2004) and 68.85 g (100 g)$^{-1}$ (Sánchez *et al*., 2017) have been reported. In the present study, values similar to those of the first two authors were found, 77.21 g (100 g)$^{-1}$ (Table 2).

For NDF in *Megathyrsus maximus cv* Guinea, values of 68.36 g (100 g)$^{-1}$ (Ardila and Laredo, 1984), 72.7 g (100 g)$^{-1}$ (Reyes *et al*., 2009), 62.3 g (100 g)$^{-1}$ (Schnellmann *et al*., 2020) and 80.2 g (100 g)$^{-1}$ (Bautista-Tolentino *et al*., 2011) have been reported. In the present study, a value of 74.79

g (100 g)$^{-1}$ was obtained, similar to that obtained by Reyes *et al*. (2009). The value of NDF or cell wall obtained in the present study was high, so these grasses are not recommended for young ruminants, but for animals with well-developed rumen.

Acid detergent fiber (ADF)

For ADF in *Ixophorus unisetus*, values of 32.8 g (100 g)$^{-1}$ (Molina *et al*., 1985) have been reported, a much higher value of 48.3 g (100 g)$^{-1}$ was found in this work (Table 2). For ADF in *Megathyrsus maximus cv* Guinea, a value of 47.44 g (100 g)$^{-1}$ was found (Ardila and Laredo, 1984). A value higher than that found in the present work, 39.1 g (100 g)$^{-1}$ (Table 2). Low ADF values compared to high NDF values are an indication that these grasses contain high hemicellulose values.

Cellulose (Cel)

For Cel in *Megathyrsus maximus* cv. Guinea, a value of 12.2 g (100 g)$^{-1}$ has been reported (Castrejón *et al*., 2017). A very low value compared to that of the present study, 31.9 g (100 g)$^{-1}$ (Table 2) probably due to the older age of this plant with respect to that studied by Castrejón *et al*. (2017).

Correlations

Positive correlations were found between Ash and CP and negative correlations between CP with ADF and CP with Cel (Table 3). This probably means that the most mineral-accumulating grass is also the most protein accumulating. In this study, the grass with the highest Ash content was *Megathyrsus maximus cv* Guinea and it was also the one with the highest CP content (Table 1). The negative correlations between CP and ADF and between CP and Cel are also reflected in *Megathyrsus maximus* cv. Guinea, which, although it produced high CP values, also showed the lowest ADF and Cel values. In contrast, *Cenchrus ciliaris* and *Ixophorus unisetus*, which produced the highest ADF and Cel values, also produced the lowest CP values. Negative correlations between CP and NDF and between CP and ADF have recently been observed by other researchers in grasses (Sánchez *et al*., 2017) and it is suggested that the harvest age should be carefully monitored, so that the plant does not become so fibrous, and its crude protein does not decrease so much.

Table 3. Pearson correlation coefficients between the variables determined in four grasses from the state of Jalisco.

	Ash	CP	EE	NDF	ADF	Cel	CC	Hcel
Ash	1	0.702*	0.335	-0.637*	-0.631*	-0.428	0.637*	0.227
CP		1	-0.393	-0.215	-0.956**	-0.882**	0.215	0.722**
EE			1	-0.715**	0.496	0.678*	0.715**	-0.791**
NDF				1	0.009	-0.228	-1**	0.496
ADF					1	0.968**	-0.009	-0.864**
Cel						1	0.228	-0.955**
CC							1	-0.496
Hcel								1

*= $p < 0.05$, **= $p < 0.01$. Ash= ashes; CP= crude protein; EE= ethereal extract; NDF= neutral detergent fiber or cell walls; ADF= acid detergent fiber; Cel= cellulose; CC= cellular content (100-NDF); Hcel= hemicellulose (NDF-ADF).

Conclusions

Megathyrsus maximus cv. Guinea was the forage grass with the highest crude protein and ash contents: 12.9 g (100 g)$^{-1}$ and 11.6% g (100 g)$^{-1}$, respectively. *Ixophorus unisetus* had the highest values of EE, ADF and cellulose. *Megathyrsus maximus cv* Tanzania had the highest value of NDF.

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