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Comparison of the forage tree species consumption by *Pecari tajacu* in captivity

Comparación del consumo de especies arbóreas forrajeras por *Pecari tajacu* en cautiverio

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ABSTRACT

The objective was to compare consumption of dry matter (CMS) of Mucuna fruit (*M. deeringiana*), forages of ramón (*B. alicastrum*), jabín (*P. piscipula*), and Moringa (*M. oleifera*) in Collared Peccary male adults (*P. tajacu*). The study was carried out in two parts, the first one was executed with Latin square design (DCL) 4x4 with two repetitions, and three forages with ground Mucuna fruit were offered. In the second part, the preferred forage was eliminated in the first test and DCL 3x3 was applied. Variance analysis was used for 4x4 and 3x3 DCL respectively, and Tukey test between means. Linear regression models were adjusted between the CMS and nutrient contents of each forage. The CMS in the first part showed a significant difference between the Moringa forages and the rest of them. In the second test, the CMS presented a significant difference between Ramón and the two remaining forages. Three linear regression models were highly significant, between CMS and crude protein content (PC), neutral detergent fiber (NDF) and total phenols (FT). It is concluded that peccaries have the preference for M. oleifera, which has the highest values in PC, FT and the lowest in NDF.

Keywords: intake of forage, Collared Peccary, *Mucuna deeringiana*, *Brosimum alicastrum*, *Piscidia piscipula*, *Moringa oleífera*.

RESUMEN

El objetivo fue comparar el consumo de materia seca (CMS) de fruto de mucuna (*M. deeringiana*), forrajes de ramón (*B. alicastrum*), jabín (*P. piscipula*) y moringa (*M. oleífera*), en cuatro pecaríes de collar (*P. tajacu*) adultos machos. Se realizó el estudio en dos partes, la primera se ejecutó con diseño de cuadro latino (DCL) 4x4 con dos repeticiones, se ofertaron tres forrajes y fruto de mucuna molido. En la segunda parte se eliminó el forraje preferido en la primera prueba y se aplicó DCL 3x3. Se utilizó análisis de varianza para DCL 4x4 y 3x3 respectivamente, y prueba de Tukey entre medias. Se ajustaron los modelos de regresión lineal entre los CMS y contenidos de nutrimentos de cada forraje. El CMS en la primera parte mostró diferencia significativa entre los forrajes Moringa y el resto de ellos. En la segunda prueba el CMS presentó diferencia significativa con Ramón y los dos restantes forrajes. Tres modelos de regresión lineal fueron altamente significativos, entre CMS y contenido de proteína cruda (PC), fibra detergente neutro (FDN) y fenoles totales (FT). Se concluye que los pecaríes tienen preferencia por *M. oleifera*, la cual presenta los mayores valores en PC, FT y el menor en FDN.

Palabras clave: consumo de forraje, pecarí de collar, *Mucuna deeringiana*, *Brosimum alicastrum*, *Piscidia piscipula*, *Moringa oleífera*.

INTRODUCTION

Various nutritional studies of *Pecari tajacu* show that they consume fresh fodder and silage (Montes *et al*., 2012; Borges-Ventura *et al*., 2014). Montes *et al* (2012) reported that they consume *G.ulmifolia* preferably on *B. alicastrum* and *P. purpureum* (P <0.05); however, there is no significant difference between *G. ulmifolia* and *L. leucocephala* (P> 0.05).

Additionally, Montes-Pérez *et al.* (2018), reported that collared peccaries showed preference for consumption of silage mixture containing 55% of *B. aliscastrum* with 40% of *P. purpureum* and 5% of molasses, on mixtures with other proportions of the same ingredients (P <0.05); including the ovarian activity of peccaries subjected to diets containing 50% silage and 50% corn and local fruits. Compared with animals subjected to diets based only on corn and fruits, they show no differences (P> 0.05) in blood levels of progesterone, or alteration in the proportion of females in estrus, or in the duration of ovarian cycles for 35 days continuous.

On the other hand, Oliveira *et al*., 2009 reported that collared peccaries can use urea as a source of non-protein nitrogen; like ruminants, up to 2% of the diet on dry basis; therefore, its digestive physiology is similar to ruminants. Also, Oliveira *et al*. (2009) and Montes-Pérez *et al*. (2012) state that the digestive physiology of the collared peccary (*P. tajacu*) is more similar to that of ruminants than to non-ruminants, because the digestive apparatus of the collared peccary (*P. tajacu*) has four compartments: the glandular stomach, a gastric pouch and two blind sacs, where volatile fatty acids are produced, because the microflora of the compound stomach ferments the food. Volatile fatty acids serve as a nutrient to animals; however, the amount of volatile fatty acids produced in the stomach of the peccary is low, the rest is generated throughout the digestive system (Sowls, 1997).

It is important to know that there are numerous forages that have not been tested for consumption in this species, and therefore the potential they have to be integrated into the systems of breeding and intensive production of breeding feet, meat or by-products has not been described; in addition, the selection of food substrates of forage tree species that have high nutritional content and adapted to tropical and subtropical climates, are adequate to include them in these animal production systems, since it directs the concept of the integration of wildlife species within of the agroecosystem (Gallego-Burbano *et al*., 2012).

Based on this context, the objective is to compare the consumption of four types of fodder: dry and ground fruit of mucuna (*M. deeringiana*), fresh foliage of ramón (*B. alicastrum*), jabín (*P. piscipula*) and moringa (*M. oleifera*) by collared peccary (*P. tajacu*) in captivity.

MATERIAL AND METHODS

The present work was carried out in the facilities of the Wildlife Management and Conservation Unit (UMA) Xmatkuil in the Mérida municipality, Yucatán, México; located at 200 51' 20" North latitude and 890 36' 55" West longitude, 10 meters above sea level. The climate is subhumid warm type, Awo classification (Orellana *et al*., 2010).

Four collared peccaries (*P. tajacu*), adult males with average weights of 20 ± 1 kg were used. The specimens were housed in a corral with a surface of 100 m^2, and the animals were subject to the same sanitary, nutritional and containment management, according to the management plan of the UMA. The bromatological analysis of the forage species was carried out in the nutrition laboratory of the Campus of Biological and Agricultural Sciences, where the techniques of Ankom Technology (without year a, b) for the determination of acid detergent fiber (ADF) and fiber were applied neutral detergent (FDN). For crude protein (PC), the technique of AOAC (2005) was used; the condensed tannins (TC) were analyzed as described by Makkar and Becker (1993) and the total phenols (FT) by the methodology of Makkar (2003).

The experiment was carried out in two stages, the first one was applied a Latin box design (DCL) 4 x 4. The test was carried out in a time of 4 hours in the morning, during 4 days. In each feeder the forages were placed to test, the distance between them was 4 meters, in the north, south, east and west positions. Fodders were rotated daily, according to the distribution of the standard MCI; this test was carried out with two repetitions of the design. The response variable was the individual average of the dry matter consumption (CMS) of each forage. In the second stage, three forage species were tested using a standard 3x3 DCL, eliminating the preferred forage in the first test; feeders were placed in the north, south and east positions, for three days for four hours each day. Two replications of the design were also made.

At the end of the period of each daily test they were provided with the daily diet that is based on fruits and vegetables of the season (cucumber, pumpkin and papaya). The response variable was the same as in the first part. The amount of food consumed was estimated by the difference of the food offered and the rejected in dry matter. The analysis of variance for the 4x4 and 3x3 Latin boxes, respectively was applied. After the multiple comparison of means of each treatment by the Tukey test, simple linear regression models were also fitted between the means of CMS and the content of crude protein (PC), neutral detergent fiber (NDF), acid (FDA), total phenols (FT) and condensed tannins (TC) of forages (Microsoft Corp, 1990-1995).

RESULTS

The highest value of dry matter was that of mucuna fruit (*M. deeringiana*), followed by ramón (*B. alicastrum*), jabín (*P. piscipula*) and moringa (*M. oleifera*); the highest FDN and FDA value was that of jabín (*P. piscipula*), and the lowest of moringa (*M. oleifera*). While for TC the highest was for jabín (*P. piscipula*) and in the rest it was not detectable. For FT the highest value corresponds to moringa (*M. oleifera*), and the lowest to ramón (*B. alicastrum*) (Table 1).

Test 1. The analysis of variance of the Latin 4x4 chart showed a highly significant difference between the treatments (P <0.01). The moringa forage (*M. oleifera*) presented the highest mean of consumption with respect to the others (P <0.01). A significant difference was observed (P <0.05) between the consumption of mucuna (*M. deeringiana*) and ramón (*B. alicastrum*); but there are no differences (P> 0.05) between jabín (*P. piscipula*) and mucuna (*M. deeringiana*).

Test 2. There was a statistically significant difference (P <0.01) between the consumptions of dry matter of ramón (*B. alicastrum*), jabín (*P. piscipula*) and mucuna (*M. deeringiana*); but between these last two there are no significant differences (P> 0.05). Table 2 shows the multiple comparisons of dry mass consumption means on dry basis of each treatment in the two tests.

Table 3 shows the simple linear regression models, determination coefficient and significance value between dry matter consumption (CMS) with crude protein content (PC), acid detergent fiber (FDA), neutral detergent fiber (NDF), total phenols (FT) and condensed tannins (TC) of the four forages tested in collared peccary. It is observed that the simple linear regression models of dry matter consumption (CMS) with PC, NDF and FT were significant; but those that correspond to CMS with FDA and TC are not.

DISCUSSION

In test 1, the preferred forage (P <0.01) was moringa (274.41 gMS/animal), well above the ramón (83.10g MS/animal) which was the second most consumed.

Table 1. Results of bromatological analysis of the species evaluated on a dry basis

Forage species	PC (%)	FDN (%)	FDA (%)	TC (%)	FT (%)
Ramón (*B. alicastrum*)	13.27	38.56	22.07	0	1.61
Jabín (*P. piscipula*)	18.29	51.08	33.38	2.68	1.63
Mucuna (*M. deeringiana*)	16.43	39.99	23.65	0	1.71
Moringa (*M. oleífera*)	30.96	18.99	21.46	0	1.87

Table 2. Mean dry matter consumption (CMS) on dry basis by the collared peccary (P. tajacu) (g MS / animal) in the two preference tests with four and three forage species

Forage species	Stage 1. Consumption of dry matter (g / animal) ± standard error	Stage 2 Consumption of dry matter (g / animal) ± standard error
Ramón *(B. alicastrum)*	83.10 a ± 19.73	311.93 a* ± 30.90
Jabín (*P. piscipula)*	13.99 ab ± 19.73	5.08 b ± 30.90
Mucuna *(M. deeringiana)*	0 b ± 19.73	3.736 b ± 30.90
Moringa *(M. oleífera)*	274.41 c* ± 19.73	-------

Literal difference in the mean values of dry matter consumption of each stage, indicates significant difference (P <0.05), the asterisk (*) in the literal indicates highly significant difference (P <0.01)

Table 3. Linear regression models, coefficient of determination (R^2) and significance values (P) corresponding to dry matter consumption (CMS) by *Pecari tajacu*, with crude protein (PC), acid detergent fiber (DFA), detergent fiber neutral (NDF), total phenols (FT) and condensed tannins (TC) in forages *M. oleifera*, *B. alicastrum*, *P. piscipula*, *M. deeringiana*.

	PC	FDA	FDN	FT	TC
Dry matter consumption (CMS)	CMS= -153.304 + 12.247*PC	CMS = 353.879 - 10.5592*FDA	CMS = 371.906 - 7.63134*FDN	CMS = -1187.54 + 748.366*FT	CMS = 110.401 - 32.8064*TC
R^2	68.5007	26.2156	78.6966	59.2737	14.6443
Value of P	0.0009	0.0888	0.0001	0.0034	0.2195

In test 2 the total consumption of the three species (320.75 g MS/animal) was lower than that of test 1 (371,515 g MS/animal); however, consumption in test 2, ramón (*B. alicastrum*) increased almost 4 times (P <0.01) with respect to the first test; which shows that it is the second forage species preferred by *P. tajacu*.

The forage that presented the highest PC content was moringa (*M. oleifera*) (30.96%), as well as the lower content of NDF (18.99%) and FDA (21.46%); which could favor its assimilation in the digestive system of the collared peccary (*P. tajacu*); the opposite of ramón (*B. alicastrum*), which was the species with the lowest PC value (13.27%); however, it was the second preferred forage species, possibly because it had a low content of NDF (38.56%) and FDA (22.07%); after the moringa (*M. oleifera*).

The species that presented lower consumptions of dry matter (CMS), were jabín (*P. piscipula*) and mucuna (M. deeringiana); whose PC values were above ramón (*B. alicastrum*) (18.29, and 16.43% respectively), but lower than that of moringa (*M. oleifera*), however, its NDF contents (51.08 and 39.99%) and FDA (33.38 and 23.65%), presented superior values with respect to the preferred forages.

These findings indicate that the combination of high values of ADF and NDF influences the ingestive behavior of the forages by the collared peccary (*P. tajacu*), which is also consistent with the negative slope values of the linear regression models between CMS and FDA and FDN.

Paredes *et al*. (2014), showed that there is a decrease of the CMS in alpaca (*Vicugna pacos*) as the amount of NDF increases, since where a higher NDF content was found because the forages with more cell wall, affects the passage time of food in the digestive system and digestibility of dry matter; Quiroz-Cardoso *et al*. (2015) mention that in sheep and lambs the consumption of fruits and palatability of *A. farnesiana*, *A. macilenta*, *A. cochliacantha* (legumes), show negative correlation with the contents of NDF and FDA in forages tested; but the fruits of *A. farnesiana* and *A. cochliacantha* are more consumed because they have lower content of NDF and ADF. These findings allow supporting the consumption behavior presented by the collared peccary (*P. tajacu*), and at the same time confirm that their feeding

behavior is similar to ruminants; also that his stomach is composed, but does not play the role of rumination; therefore, it is considered pseudo-disruptive or pre-interrupting (Montes-Pérez *et al*., 2012).

Di-Marco (2011) makes reference in that a forage is of high quality when it has less than 50% of neutral detergent fiber (NDF) and more than 15% of crude protein; this supports what was found in this study on the preference for moringa (*M. oleifera*), since due to its high PC content and low levels of NDF, they make this forage high quality, compared to the rest of the forages.

The relationship between the TC and CMS is not significant, this result may be due to two possible circumstances, the first to the absence of TC content in the forages tested, except in *P. piscipula*, and the second to the low amount of TC in this last forage, whose content is less than 5%; value that is considered the limit to avoid the decrease of the voluntary consumption of fodder in ruminants; however, values between 2 and 4% of MS trigger an increase in forage consumption, due to the fact that they favor the intestinal absorption of proteins (Márquez and Suárez, 2008).

However, the regression between CMS and FT contained in forages was significant, which is different from that reported by García *et al.* (2008), who report that in goats they found no relationship between the content of FT, alkaloids and lactone compounds. Probably the consumption of fodder by peccaries is the combination of the high level of PC, low amount of NDF and ADF, and high amount of FT; combination that corresponds to the moringa. Gutiérrez *et al.* (2008), report that they are around 8000 compounds that are measured in the bromatological analysis in FT; among them the most studied are the flavonoids, which have the property of being antioxidants, and therefore decrease the oxidative damage caused by free radicals in the energy metabolism.

CONCLUSION

Moringa forage (*M. oleifera*), had more preference in dry matter consumption by collared peccary (*P. tajacu*), and followed by Ramon (*B. alicastrum*). The higher quantity of PC and NDF contained in the forages increase and decrease respectively, in dry matter consumption by *P. tajacu*.

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