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Productive response of creole lambs fed integral diets with *Samanea saman* (Jacq.) Merr. pods

Herrera-Pérez, Jerónimo[1]; Carbajal-Márquez, Ulises[2]; Torres-Salado, Nicolás[1*]; Sánchez-Santillán, Paulino[1]; Ramírez-Reynoso, Omar[3]; Rojas-García, Adelaido R.[1]; Ayala-Monter, Marco Antonio[1]

[1]Universidad Autónoma de Guerrero, Facultad de Medicina Veterinaria y Zootecnia No. 2. Cuajinicuilapa, Guerrero, México. [2]Universidad Autónoma de Guerrero, Maestría en Producción de Bovinos en el Trópico, Cuajinicuilapa, Guerrero, México. [3]Universidad Autónoma de Guerrero, Centro Regional de Educación Superior de la Costa Chica. Florencio Villareal, Guerrero, México.
***Corresponding author**: nivigas@yahoo.com.mx

ABSTRACT

Objective: To evaluate the productive variables and the digestibility of the nutrients of an integral diet for lambs with increasing inclusion of *Samanea saman* pods.

Design/methodology/approach: 24 creole lambs (initial weight of 20.6±0.3 kg) distributed in a completely randomized experimental design were used. The treatments were: T1, 0%, T2, 12.5%, and T3, 25% of *Samanea saman* pod inclusion. The productive variables and the digestibility of the nutrients were evaluated and compared with the Tukey test (α=0.05); meanwhile, the response to the increasing content of *Samanea saman* was evaluated by orthogonal contrasts. The variables dry matter intake (DMI), daily weight gain (DWG) and feed conversion (FC) showed no differences ($p>0.05$) between treatments.

Results: Dry matter digestibility (DMD) and organic matter digestibility (OMD) increased ($p<0.05$) linearly, with increasing pod content. The digestibility of the neutral detergent fiber (DNDF) and acid (DADF) decreased ($p<0.05$) linearly as the inclusion of *Samanea saman* pod increased in the diets.

Limitations on study/implications: The substitution of soybean pulp by *Samanea saman* pod in integral diets does not affect the productive response of fattening lambs.

Findings/conclusions: The use of *S. saman* pod is proposed as a regionally available food alternative in the feeding of ruminants in the tropics.

Key words: pod, *Samanea saman*, lambs, productive response, tropic

INTRODUCTION

Sheep are economically important ruminants due to their meat, milk, and wool production (Galaviz *et al*., 2011). In tropical regions, grazing is the main sheep feeding strategy (Palma, 2005; Partida *et al*., 2013; Vélez *et al*., 2016). However, in these regions, the low availability of forage is an important limiting condition, specifically during the dry season. Therefore, it is essential to look for appropriate alternatives to meet the nutritional requirements of sheep (Pearson *et al*., 2008; Delgado *et al*., 2014).

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In the Mexican tropic, arboreal legume pods are produced during the dry season and have potential use in animal feed (Zamora *et al*., 2001). These pods represent an alternative feeding strategy that could reduce dependence on commercial concentrates in tropical regions (García *et al*., 2008; Clavero, 2013; Delgado *et al*., 2014). *S. saman* pods contain 14 to 18% of crude protein (CP) (Anantasook and Wanapat, 2012; Flores, 2016; Mazo et al., 2016), 60.5 to 93.1% of dry matter (DM), 1.3 to 5.0% of ashes (Ash), 29.2 to 53.0% of neutral detergent fiber (NDF), 23.7 to 42.0% of acid detergent fiber (ADF), 4.7 to 20.0% of lignin, 1.1 to 15.0% of ether extract (EE), 0.2 to 0.3% of calcium (Ca), and 0.2 to 0.3% of phosphorus (P) (Juárez *et al*., 2013; Delgado *et al*., 2014; Hernández-Morales *et al*., 2018). These pods also contain alkaloids, tannins, saponins, nitrogen compounds, glycosides, and mucilage (Juárez *et al*., 2013; Delgado *et al*., 2014).

Previous *in vitro* (Juárez *et al*., 2013; Hernández-Morales *et al*., 2018; Torres-Salado *et al*., 2018) and *in vivo* (Pirela *et al*., 2010) studies have indicated the relevance of using *S. saman* pods as a supplement in ruminant feeding. Therefore, this study aimed to evaluate the productive variables of lambs and the digestibility of the nutrients of an integral diet with increasing concentrations of *S. saman* pods.

MATERIALS AND METHODS

This study was carried out in the School of Veterinary Medicine and Zootechnics No. 2 of the Universidad Autónoma de Guerrero, under the supervision of the Academic Committee. The university is located in km 197 of the Acapulco-Pinotepa Nacional highway, Cuajinicuilapa, Guerrero (16° 58′ N and 98° 45′ E, at 30 m).

Experimental diets

Diets were made with regional ingredients (Table 1) and adjusted according to the sheep's growth rate and physiologic stage (NRC, 2007). In the Spring of 2016, the physiologically mature pods of selected wild *S. saman* trees were collected. Pods were ground in a hammer mill with and in-built blower (Azteca No. 20, Mexico).

A sample of each diet was dehydrated at 60 °C until constant weight in a forced-air oven (Felisa® FE-293A, Mexico). All samples were ground using a 1 mm sieve in a Thomas-Wiley Mill (Thomas Scientific®, Swedesboro, NJ, USA). Samples were analyzed using the methods described by the AOAC (2005) to determine the dry matter (DM), organic matter (OM), crude protein (CP), and ash (Ash) content. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) content were determined following the ANKOM Technology® method, as per Van Soest *et al*. (1991), and the acid-insoluble ash (AIA) with the Van Keulen and Young (1977) method.

Animals

Creole lambs (n=24, initial weight of 20.6±0.3 kg) were housed in individual 2 m^2 feedlots provided with shadow and equipped with feeding and drinking troughs; clean and fresh water was freely available. Before the experiment, lambs were weighed (kg) and received prophylactic treatment with 5% Closantel (Panavet®; 10 mg kg^{-1} orally) and ADE+B12 vitamins (Polivit®; 5 mL intramuscularly); lambs were also immunized (Ultrabac® 7; 2.5 mL subcutaneously). Animals were handled following the internal bioethics and well-being regulation of the Universidad Autónoma de Guerrero, which is based on the Official Mexican Standard NOM-062-ZOO-1999.

Feeding and productive response

Lambs had an adaptation period of 15 days to feeding and handling conditions. During the experiment, daily

Table 1. Ingredients and chemical composition of the diets.

Ingredients, g kg^{-1} DM	T1	T2	T3
Corn	550	550	490
Urea	10	20	20
Soybean meal	100	-	-
S. saman pods	-	125	250
Molasses	70	70	70
Pangola hay	240	205	140
Mineral premix°	20	20	20
Sodium bicarbonate	10	10	10
Bromatological analysis (g kg^{-1} MS)			
DMI	883	875	875
OM	848	851	835
CP	128	124	126
NDF	349	262	273
ADF	153	106	125

T1, integral diet with 0% of *Samanea saman* pods; T2, integral diet with 12.5% of *Samanea saman* pods; T3, integral diet with 25% of *Samanea saman* pods. Mineral premix P, 6.0%; Ca, 15.0%; Na, 6.8%; Cl, 10.2%; Zn, 3500 ppm; Cu, 500 ppm; Fe, 1800 ppm; I, 12 ppm; Co, 6 ppm; Mg, 1000 ppm; Se, 12 ppm; Mn, 2000 ppm. DMI, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber.

dry matter intake (DMI) and feeding trough readings were recorded to assure that the offered feed was 10% higher than the feed consumed the previous day (Harris, 1970). Feed was supplied at 08:00 and 17:00 h; water was freely accessible. The fattening period was 56 d; every 15 d weight changes were recorded using an electronic scale (Rhino, BAR-9TX®). Feed conversion (FC) was calculated according to the procedure described by McDonald *et al*. (2011).

Nutrient digestibility

Five days before the end of the fattening period, feces from each lamb were collected directly from their rectum. Feces were dehydrated at 60 °C until constant weight in a forced-air oven (Felisa® FE-293A, Mexico) for 48 h; these samples were then ground in a Thomas-Wiley mill (Thomas Scientific®, Swedesboro, NJ, USA) using a 1 mm sieve. DM, TP, Ash, OM, NDF, ADF, and AIA were determined. The digestibility of DM, OM, NDF, ADF, and CP was calculated using the equations described by Church (1988) and Van Keulen and Young (1977).

Experimental design

The experiment followed a completely randomized design (CRD), with eight repetitions per treatment and each repetition an experimental unit. The productive variables and digestibility of the nutrients were analyzed with the GLM procedure. Average values were compared using the Tukey test ($p \leq 0.05$); the linear and quadratic orthogonal contrasts were performed with the CONTRAST option in SAS® (2013).

RESULTS AND DISCUSSION

The DMI, DWG, and FC remained the same ($p>0.05$) with the different treatments (Table 2). The average DMI of 945 g d^{-1} was 71.8 and 5.2% higher than that reported by Álvarez *et al*. (2003) and Peralta *et al*. (2004). These researchers used lamb diets with up to 30% of *Enterolobium cyclocarpum* pods. Velázquez *et al*. (2011) used diets with 40% of *Acacia farnesiana* and reported a DMI 53.9% lower than the one observed in this study. These variations in DMI could be attributed to the type of forage included in the diets, the physiologic age, and the breeds used in each experiment (Abu-Hafsa *et al*., 2017). Peralta *et al*. (2004) reported a DWG of 160 g d^{-1} in lambs fed a diet with 20% of *Enterolobium cyclocarpum*, similar to the DWG observed in this study with the diet including 25% of *S. saman* pods. However, Velázquez *et al*. (2011) reported a DWG of 77.8 g d^{-1} in lambs fed a diet with 20% of *Acacia farnesiana*, which is lower than the results reported in this study. The differences in DWG are attributed to the diets' ingredient composition; protein sources were different in each study. These results were reflected in the FC. Peralta *et al*. (2004) and Velázquez *et al*. (2011) reported a FC of 3.9 and 7.7, respectively. These results were higher and lower than those observed in lambs fed a diet with 25% *S. saman* pods.

The increasing content of *S. saman* pods in the integral diets linearly increased ($p<0.05$) dry (DMD) and organic matter digestibility (OMD) (Table 3).

Nitrogen compounds have been shown to improve microbial growth in the rumen (Mendoza *et al*., 1993; McDonald *et al*., 2011), and the CP content of *S. saman* pods is an estimated 16% (Anantasook and Wanapat, 2012; Hernández-Morales *et al*., 2018), which explains the higher DMD and OMD observed in this study. Moreover, these pods contain 43% of soluble carbohydrates (Pizzani *et al*., 2006) that, when combined with nitrogen

Table 2. Effect of increasing levels of *Samanea saman* pods on the productive variables of creole lambs fed an integral diet.

Variables	Treatments			SEM	Effect°	
	T1	T2	T3		linear	quadratic
Starting weight (kg)	20.89	20.16	19.86	0.49	0.41	0.84
Final weight (kg)	31.86	29.13	29.02	0.93	0.22	0.52
CMS (g d^{-1})	1030	837	968	0.05	0.59	0.11
GDP (g d^{-1})	202	148	189	0.01	0.63	0.06
CA, CMS/GDP	5.48	5.52	4.88	0.17	0.16	0.34

Means with different letters in the same column indicate significant difference ($p<0.05$). °Probability of a significant effect with the increasing dose of *S. saman* pods (linear and quadratic effect).
DMO, dry matter intake; DWG, daily weight gain; FC, feed conversion; SEM, standard error of the mean; T1, integral diet with 0% of *Samanea saman* pods; T2, integral diet with 12.5% of *Samanea saman* pods; T3, integral diet with 25% of *Samanea saman* pods.

compounds (Pirela *et al*., 2010), could synergistically increase the digestibility of DM and OM.

Additionally, *S. saman* pods contain 2.3-7% kg MS^{-1} of condensed tannins (Ukoha *et al*., 2011), which decrease ruminal protozoa and economize ruminal nitrogen (Hu *et al*., 2005; Ukoha *et al*., 2011; Wang *et al*., 2011). It should be noted that these tannins can form covalent links with the proteins in the diet (Obasi *et al*., 2010; Pirela *et al*., 2010; Delgado *et al*., 2012), which improves the passage rate of non-degradable nitrogen compounds in the rumen (Ho *et al*., 1989; Stienezen *et al*., 1996).

Digestibility of neutral detergent fiber (DNDF) and acid detergent fiber (DADF) linearly decreased ($p<0.05$) with increasing concentrations of *S. saman* pods (Table 3).

This decrease in digestibility could be attributed to the tannin and saponin content in the *S. saman* pods (Ukoha *et al*., 2011; Millán *et al*., 2017). The antimicrobial effect of these compounds could potentially affect the hemicellulolytic and cellulolytic bacteria and thus reduce the degradation of the structural carbohydrates in the diet.

The apparent digestibility of crude protein (CPAD) was the same in all treatments ($p>0.05$). The CPAD was 513 g kg^{-1} (Table 3), which is why the CPD remained unchanged after substituting the soybean meal for urea and *S. saman* pods as the protein source in lamb feed. Abreu *et al*. (2004) reported similar results using a lamb diet supplemented with 25% of *Sapindus saponaria*. In contrast, the CPAD in this study was 17.42% lower than that reported by Roa *et al*. (2012) and Ben Salem *et al*. (2005); they reported a CPD of 64.8% in integral diets with up to 20% of *Acacia cyanophylla*, and, according to Roa *et al*. (2012), 64% of CPD at 72 h in an *in situ* test with 70% of forage and 30% of legume leaves.

Table 3. Effect of increasing levels of *Samanea saman* pods on the digestibility of creole lambs fed an integral diet.

Variable ($g\ kg^{-1}$)	Treatment			SEM	Effect°	
	T1	T2	T3		linear	quadratic
DMS	578^{b}	666^{a}	629^{a}	10.5	0.01	0.00
DMO	502^{b}	608^{a}	555^{ab}	12.5	0.03	0.00
DFDN	436^{a}	355^{b}	322^{b}	13.7	0.00	0.27
DFDA	402^{a}	195^{b}	178^{b}	23.6	0.00	0.00
DPC	498	518	518	12.3	0.21	0.13

[a,b] Means with different letters in the same row indicate significant difference ($p<0.05$). °Probability of a significant effect of increasing concentrations of *S. saman* pods (linear and quadratic effect).
SEM, standard error of the mean; DMD, dry matter digestibility; OMD, organic matter digestibility; DNDF, digestibility of neutral detergent fiber; DADF, digestibility of acid detergent fiber; CPD, crude protein digestibility; T1, integral diet with 0% of *Samanea saman* pods; T2, integral diet with 12.5% of *Samanea saman* pods; T3, integral diet with 25% of *Samanea saman* pods.

CONCLUSION

In integral diets, the complete substitution of soybean meal with *Samanea saman* pods does not affect the productive response of fattening lambs. Therefore, this study recommends using this regionally available product as sheep feed in tropical regions.

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