Colegio de Postgraduados

In Situ degradability of *Guazuma ulmifolia* Lam. fruits used in targeted nutrition for pelibuey sheep

Sosa-Pérez, Gustavo[1]; Flores-Santiago, Ever J.[2]; González-Garduño, Roberto[2]; Pérez-Hernández, Ponciano[3]; López-Ortiz, Silvia[3*]

[1] Universidad Autónoma Chapingo, Departamento de Preparatoria Agrícola. Km. 38.5 Carretera México-Texcoco, Chapingo, Edo. de México, México. C.P. 56230.
[2] Universidad Autónoma Chapingo, Unidad Regional Sur Sureste. Km 7 Carretera Teapa-Vicente Guerrero Teapa, Tabasco, México. C.P. 86800.
[3] Colegio de Postgraduados, campus Veracruz. Km. 88.5 Carretera Federal Xalapa-Veracruz, vía Paso de Ovejas entre Paso San Juan y Puente Jula, Tepetates, Veracruz, México. C.P. 91690.
* Correspondence: silvialopez@colpos.mx

ABSTRACT

Objective: To determine the chemical composition and in situ degradability of *Guazuma ulmifolia* Lam. fruits and assess whether targeted nutrition (TN) with 300 g of fruit meal for seven days before the withdrawal of a progestogen influences reproductive variables in Pelibuey ewes.
Design/Methodology/Approach: A proximal chemical analysis and in situ degradability assessment of dry matter and protein from *G. ulmifolia* fruits were conducted using two Rambouillet rams fitted with rumen cannulas at different incubation times (0, 6, 12, 24, 48, and 72 h). To evaluate the effect of TN on reproduction, 71 Pelibuey ewes were assigned to one of two treatments: CIDR (n=36) or CIDR+TN (300 g of *G. ulmifolia* fruit meal) for seven days (n=35). On day 9, CIDRs were removed, and TN was discontinued.
Results: Estrus synchronization response was similar ($p>0.05$) between treatments. However, ewes supplemented with *G. ulmifolia* fruits exhibited a shorter time to estrus onset (28.68±1.15 h). Fertility rates were comparable between treatments ($p>0.05$), while fecundity was higher in the CIDR+TN group.
Study Limitations/Implications: The use of *G. ulmifolia* fruits as a dietary supplement promotes their conservation and integration into agroforestry and silvopastoral systems in tropical regions.
Findings/Conclusions: TN with 300 g of *G. ulmifolia* fruit meal for seven days before progestogen withdrawal reduced the time to estrus onset and increased fecundity in Pelibuey ewes.

Keywords: Local resources, Estrus synchronization, Prolificacy, Food supplement.

Citation: Sosa-Pérez, G., Flores-Santiago, E. J., González-Garduño, R., Pérez-Hernández, P., & López-Ortiz, S. (2025). *In Situ* degradability of *Guazuma ulmifolia* Lam. fruits used in targeted nutrition for pelibuey sheep. *Agro Productividad*. https://doi.org/10.32854/qpddec63

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: June 30, 2024.
Accepted: March 18, 2025.
Published on-line: May XX, 2025.

Agro Productividad, 18(4). April. 2025. pp: 61-68.

INTRODUCTION

The productive efficiency of sheep production systems depends, among other factors, on reproductive efficiency. However, this is influenced by the lambing interval and the number of offspring per birth (Martínez-González *et al.*, 2017). One strategy to enhance productivity and profitability in these production units is to improve flock reproductive capacity, thereby increasing the number of lambings per ewe per year and reducing production costs (Hinojosa-Benavides *et al.*, 2019). Among the reproductive

management strategies that enhance ewe performance, the use of biotechnologies such as estrus synchronization stands out. This technique involves the application of effective and easily implementable pharmacological methods to manipulate reproductive physiology, improving both productivity and economic efficiency in sheep production systems (Lozano-González *et al.*, 2012). Nutrition is the key determinant of economic efficiency in livestock production units. Consequently, there is constant pressure to minimize both the quantity and duration of supplementation periods to optimize the cost-benefit ratio of this practice (Baldi *et al.*, 2008). Supplementing with energy- and protein-rich concentrates during specific periods and in appropriate amounts —an approach known as "Targeted Nutrition" (TN)— can enhance reproductive efficiency in females (Martin & Reza, 2016). The fruits and foliage of tropical trees and shrubs (Piñeiro-Vázquez *et al.*, 2013) can serve as valuable feed sources, improving livestock productivity by increasing dietary protein levels (Ku-Vera *et al.*, 2014). Some of these plants contain secondary compounds capable of modifying nutrient degradation rates and transit through the gastrointestinal tract (Getachew *et al.*, 2000; Pirela *et al.*, 2010). The guácimo tree (*Guazuma ulmifolia* Lam.), belonging to the Sterculiaceae family, is widely distributed in the tropical regions of Mexico and adapts well to various soil and climatic conditions (Manríquez-Mendoza *et al.*, 2011). From a producer's perspective, it represents an alternative forage resource that mitigates seasonal feed shortages for livestock during drought periods (Villa-Herrera *et al.*, 2009). The fruits of *G. ulmifolia* contain up to 13.6% crude protein, 56.0% neutral detergent fiber, 41% acid detergent fiber, 1.5% ether extract, and 49.5% *in vitro* dry matter digestibility (Cervantes-Marín *et al.*, 2015; Hernández-Hernández *et al.*, 2017). Their chemical-nutritional composition makes them a viable supplement to meet the dietary requirements of small ruminants. Based on this, the aim of the present study was to determine the chemical composition and in situ degradability of dry matter and crude protein in *G. ulmifolia* fruits. Additionally, the study aimed to evaluate whether TN with 300 g of mature *G. ulmifolia* fruit meal for seven days prior to progestogen withdrawal influences estrus synchronization, prolificacy, and fecundity in Pelibuey ewes.

MATERIALS AND METHODS

Study site

The study was conducted from June to December 2015 at the commercial production unit "La Gloria," located in the community of Tequexquináhuac, Texcoco municipality, State of Mexico (98° 82' W, 19° 47' N, 2,480 m.a.s.l.). The climate is classified as temperate sub-humid, with an average annual temperature of 15.9 °C and an average annual precipitation of 686 mm (INEGI, 2023).

Fruit collection and processing

Mature *G. ulmifolia* fruits were manually collected during the fruiting season (February-March) when they turned dark brown and naturally detached from the tree. Collection took place in pastures within the community of Angostillo, Paso de Ovejas municipality, Veracruz, Mexico (96° 54' 19" W, 19° 21' 80" N, 260 m.a.s.l.). After collection, the fruits were sun-dried for approximately two days, then ground using a hammer mill equipped with a 1/8-inch sieve. The processed fruit meal was stored in sealed containers to prevent moisture absorption. A subsample was further ground using a Thomas Wiley® Model 4 mill with a 1.0 mm retention sieve for chemical composition analysis and ruminal incubation to determine in situ degradability.

Chemical composition

Proximal chemical analysis of the ground fruits was performed following the methods of the Association of Official Analytical Chemists (2016). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined using the ANKOM filter bag technique. All analyses were conducted at the Animal Nutrition Laboratory of the Colegio de Postgraduados, Montecillo Campus.

In situ ruminal degradability of dry matter and protein

To estimate the in situ degradability of dry matter and protein, two adult Rambouillet rams (65.06±1.75 kg body weight) fitted with permanent rumen cannulas (50 mm diameter) were used. The animals were housed in individual cages and fed 2.0 kg DM animal^{-1} day^{-1} of a total mixed ration consisting of 30% commercial concentrate (Borrega Plus; Alimentos Unión Tepexpan®) and 70% oat hay. The degradability of *G. ulmifolia* fruits was assessed over two 72-hour experimental periods, following a 7-day adaptation period designed to stabilize rumen conditions. During adaptation, rams were supplemented with 300 g animal^{-1} day^{-1} of *G. ulmifolia* fruit meal.

For ruminal incubation, 5×5.5 cm multilayer polyester filter bags (F57 bags, Ankom Technology Corp., Macedon, NY) were used. Each bag was filled with 0.5 g of fruit sample (dry basis) and placed inside a mesh tied to a 70 cm nylon cord with a metal weight to ensure immersion in the ventral sac of the rumen. The bags were incubated at 0, 6, 12, 24, 48, and 72 hours (n=4 bags per incubation time) in reverse order, ensuring all were retrieved simultaneously. After removal, the bags were washed under low-pressure running water until clear, then dried in a forced-air oven at 65 °C for 24 hours and weighed.

To calculate in situ crude protein degradability, dry matter content (AOAC method 954.01) and crude protein (AOAC method 925.09) were analyzed in the ruminal incubation residues (AOAC, 2016). Dry matter loss was estimated as the weight difference of the sample before and after ruminal incubation, following the methodology of Ørskov & McDonald (1979).

The degradation kinetics were modeled using the equation:

$$D = a + b * \left(1 - e^{-c*t}\right)$$

Where: a=soluble fraction of the substrate; b=insoluble but potentially degradable fraction and c=degradation rate of the potentially degradable fraction; t=incubation time.

Reproductive performance

A total of 71 adult Pelibuey ewes (3.4±0.2 years old, 47.2±4.2 kg BW) were selected. All ewes were fed 2.0 kg ewe^{-1} day^{-1} of the same total mixed ration used during the adaptation period (70% oat hay, 30% commercial concentrate), which contained 12.4% CP, 42% ADF, 50% NDF, 2.0% EE, and 9% ash. Seven days before the synchronization protocol, all ewes underwent sanitary management, which included deworming (Closantil oral 5%®, Laboratorios CHINOIN) and selenium supplementation combined with vitamin E (MU-SE®, Intervet Schering-Plough Animal Health), following the recommended dosage for each product.

Treatments and estrus synchronization protocols

All ewes underwent an estrus synchronization protocol (Figure 1). Each ewe received an intramuscular injection of 1.0 mL prostaglandin $F_2\alpha$ (5 mg dinoprost, Lutalyse®, Zoetis) at the time of insertion of a CIDR intravaginal device impregnated with 0.3 g progesterone (CIDR P4), which remained in place for nine days. Seven days before CIDR removal, ewes were randomly assigned to one of two treatments: CIDR (n=36); CIDR+Targeted Nutrition (n=35) (300 g of *G. ulmifolia* fruit meal per day for seven days before CIDR removal). Supplemented ewes received 300 g/day of a wet-based mixture containing ground *G. ulmifolia* fruits, processed to a particle size of 1-4 mm.

Evaluated variables

Estrus response: number of ewes in estrus relative to the total number of ewes per treatment; time to estrus onset: time elapsed from progestogen removal until the first signs of estrus; fertility rate: number of pregnant ewes relative to the total number of inseminated ewes; prolificacy: number of lambs born per ewe that gave birth; fecundity: number of lambs born per ewe exposed in each treatment. Estrus detection began four hours after CIDR removal and was subsequently monitored every four hours using a teaser ram fitted with an apron; ewes displaying external estrus signs were separated from the group for natural mating, with a second service 12 hours after the first. Fertility was determined 45 days post-insemination via abdominal ultrasound (Contec CMS600P2VET); ewes were classified as pregnant (positive) or non-pregnant (negative) based on the presence or absence of well-defined fetal structures; prolificacy and fecundity were recorded at lambing by counting the number of lambs born per ewe.

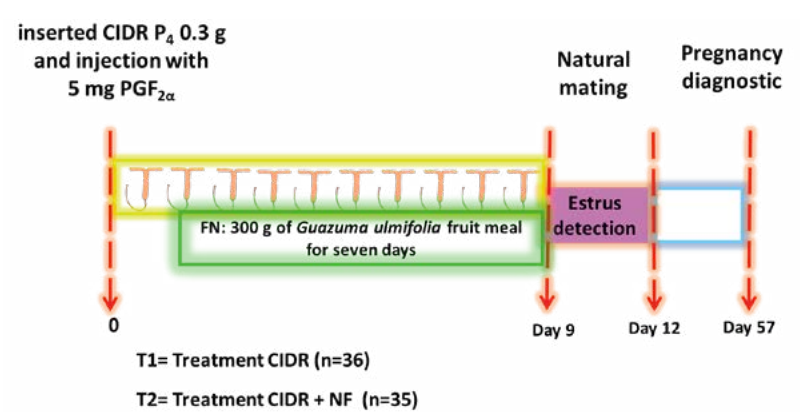

Figure 1. Estrus synchronization protocol implemented in Pelibuey ewes treated with progestogens (CIDR) and Targeted Nutrition with *Guazuma ulmifolia* fruits.

Statistical analysis

Estrus response and fertility variables were analyzed using a logistic regression model with the Logistic procedure in SAS; time to estrus onset, prolificacy, and fecundity were analyzed using the Log-Rank survival curve method with the Life Test procedure; mean comparisons were performed using the Bonferroni method (SAS, 2011).

RESULTS AND DISCUSSION

The fruits used for supplementation contained 5.7% moisture, 12.6% crude protein, 1.6% ether extract, 7.1% ash, 47.9% neutral detergent fiber, and 38.8% acid detergent fiber. *In situ* dry matter digestibility (Figure 2) was 58.8%; the degradation parameters were a=37.98, b=22.09, c=0.04, resulting in an effective degradation of 59.93% with a passage rate of 0.02%.

In situ crude protein digestibility was 60.2%, with degradation parameters a=42.32, b=18.26, c=0.05, leading to an effective degradation of 59.9% and a passage rate of 0.02%.

The chemical composition of *G. ulmifolia* fruits falls within the ranges reported by other authors (Cervantes-Marín *et al.*, 2015; Hernández-Hernández *et al.*, 2017) and is considered sufficient to meet the maintenance nutritional requirements of sheep (NRC, 2007). A high proportion of the fruit undergoes ruminal degradation, as *in situ* dry matter degradability reached 58.8%, differing from the 40% previously reported by Román *et al.* (2008) and Gómez-Gurrola *et al.* (2014). The high *in situ* crude protein degradability observed in this fruit may be attributed to its nutritional composition, secondary compounds, and low neutral and acid detergent fiber content, which influence the digestive dynamics of certain feed fractions, as reported in other ruminant studies (Getachew *et al.*, 2000; Piñeiro-Vázquez *et al.*, 2013). No significant difference ($p>0.05$) was observed in estrus response between treatments, as both groups had the same number of ewes in estrus (Table 1), with values similar to those reported by Ake-López *et al.* (2014) and Sosa *et al.* (2014). The estrus synchronization response exceeding 97% confirms the effectiveness of the progestogen-based hormonal treatments used to synchronize estrus in small ruminants. The mechanism of this hormonal method is based on prolonging the luteal phase of the estrous cycle, which inhibits gonadotropin activity. Upon progestogen withdrawal, progesterone action

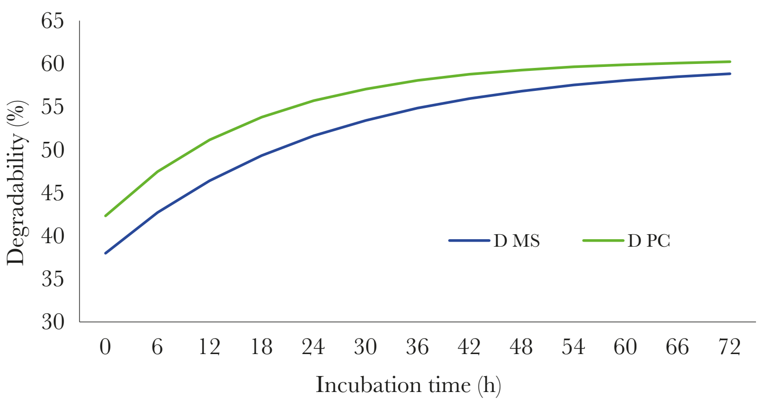

Figure 2. *In situ* ruminal degradation of dry matter (D MS) and crude protein (D PC) from *Guazuma ulmifolia* fruit meal, using the model $D=a+b*\left(1-e^{-c*t}\right)$.

ceases, leading to gonadotropin release and estrus onset in most ewes within a short period (Córdova-Izquierdo *et al.*, 2019).

However, ewes that received fruit supplementation exhibited estrus sooner after progestogen withdrawal (Table 1) compared to the CIDR group. The time to estrus onset observed in this study was shorter than the values reported by Fraire *et al.* (2013) and Sosa *et al.* (2014) in CIDR-treated ewes.

The reduced time to estrus onset in the CIDR+TN group is likely due to the nutrient intake, as follicular populations in small ruminants are highly sensitive to the availability of energy and protein, which can enhance folliculogenesis through nutrition (Martin *et al.*, 2004). Protein- and energy-rich supplementation increases plasma concentrations of metabolic signals that influence folliculogenesis (Viñoles *et al.*, 2009), ultimately affecting circulating estradiol levels, leading to a shorter time to estrus onset (Scaramuzzi *et al.*, 1999; Martin *et al.*, 2004; Ake-López *et al.*, 2014). The fertility rates obtained in this study (Table 2) were similar between treatments ($p>0.05$), with acceptable values exceeding 80%. Fertility is influenced by the number of services and body condition at mating (Salomon & Maxwell, 2000; Viñoles *et al.*, 2009). In this study, each ewe received two services, one at estrus detection and a second 12 hours later. Body condition may have also contributed to the high fertility rates, as the ewes' initial body condition scores (BCS) ranged from 3.00 to 3.75 (on a 1-5 scale; Russel *et al.*, 1969), which is considered moderate to high and had a positive effect on pregnancy rates, measured as fertility.

Targeted nutrition with *G. ulmifolia* fruits did not affect prolificacy ($p>0.05$) in this study; ewes gave birth to 1.44 to 1.66 lambs, values similar to those reported by Fraire *et al.* (2013) in ewes synchronized with progestogens alone and supplemented during the synchronization period. Fecundity (Table 2) differed between treatments ($p<0.05$) and was higher in ewes receiving targeted nutrition. This index depends on fertility and prolificacy, as well as factors influencing these parameters, including ovulation rate, number of fertilized ova, and embryo survival. These, in turn, are affected by genetic factors (*e.g.*, breed and individual variation) and environmental factors (*e.g.*,

Table 1. Reproductive variables of Pelibuey ewes synchronized with progestogens (CIDR) and Targeted Nutrition (TN) for 7 days with 300 g of *Guazuma ulmifolia* fruit meal.

Treatment	n	Sheep in estrus	%	Onset of estrus (h)
CIDR	36	35	97.22 a	32.82±1.71 a
CIDR+FN	35	35	100 a	28.68±1.15 b

a, b Values with different literals in the same column are statistically different ($p<0.05$).

Table 2. Fertility, prolificacy, and fecundity of Pelibuey ewes synchronized with progestogens (CIDR) and Targeted Nutrition (TN) for 7 days with 300 g of *Guazuma ulmifolia* fruit meal.

Treatment	n	Fertility		Prolificacy	Fertility
		n	(%)		
CIDR	36	29	80.55 a	1.44±0.09 a	1.20±0.12 b
CIDR+FN	35	33	94.28 a	1.66±0.11 a	1.57±0.12 a

a, b Values with different literals in the same column are statistically different ($p<0.05$).

nutritional status before and after mating, and the use of hormonal treatments) (Rojas & Rodríguez, 1995; Rubianes & Ungerfeld, 2002). The higher fecundity observed in the CIDR+TN group with *G. ulmifolia* fruit supplementation is likely related to the higher fertility rate in this group and the effect of targeted nutrition, which stimulates follicular development, increases the number of preovulatory follicles, and ultimately enhances the number of follicles reaching ovulation (Pérez-Hernández *et al.*, 2009). These factors contribute to an increased ovulation rate, directly impacting fecundity (Rattray *et al.*, 1981).

CONCLUSIONS

The chemical composition and degradability of *G. ulmifolia* fruits are suitable for their use in targeted nutrition for ewes. The consumption of 300 g of these fruits for seven days before progestogen withdrawal reduces the time to estrus onset and increases the fecundity of Pelibuey ewes. Therefore, this resource has potential for inclusion in targeted feeding programs to enhance the reproductive performance of Pelibuey ewes.

REFERENCES

Aké-López, J.R., Centurión-Castro, F.G., Magaña-Monforte, J.G., & Aké-Villanueva, J.R. (2014). Efecto del progestágeno y la dosis de gonadotropina coriónica equina en la sincronización del estro y tasa de gestación en ovejas Pelibuey inseminada por laparoscopia. *Ecosist Recur Agropec 1*(3): 261-268.

AOAC Official Methods of Analysis. Assoc. Off. Agric. Chem. Washington, D.C. 20 th. 2016

Baldi, F., Banchero, G., Mieres, J., La Manna, A., Fernández, E., Formoso, D., & Montossi, F. (2008). Suplementación en Invernada Intensiva: Hasta donde hemos llegado? *Revista INIA Uruguay* 1: 2-7.

Cervantes-Marín, A., López-Ortiz, S., Martínez-Dávila, J.P., Gallardo-López, F., Guerrero-Rodríguez, J.D., & Pérez-Hernández, P. (2015). Preferencia de ovinos y bovinos por frutos de seis especies arbóreas. *Agroproductividad* 8: 10-15.

Córdova-Izquierdo, A., Iglesias-Reyes, A., Guerra-Liera, E., Villa-Mancera, A., Huerta-Crispín, R., & Sánchez-Sánchez, R. (2019). Uso de esponjas intravaginales comerciales *vs* caseras, para la sincronización de estros de ovejas anéstricas. *Abanico Agroforestal* 1: 1-10.

Fraire, C. S., Pró, M. A., Ramírez, V. G., Sánchez, C., & Gallegos-Sánchez, J. (2013). Selenio y vitamina E en la fertilidad de ovejas Pelibuey sincronizadas con progesterona. *Univ Cienc 29*(1): 33-44.

Getachew, G., Makkar, H., & Becker, K. (2000). Effect of polyethylene glycol on *in vitro* degradability of nitrogen and microbial protein synthesis from tannin-rich browse and herbaceous legumes. *Br J Nutr* 84: 73-83.

Goering, H.K., & Van Soest, P.J. (1970). Forage fiber analysis. *Agricultural Handbook*, p 1-19.

Gómez-Gurrola, A., Partida-Hernández, M., Ramírez-Duran, R., Ramírez-Ramírez, J., Gómez-Gurrola, J.A., González-Mormita, M., & Sanginés-García, L. (2014). Efecto de la inclusión del fruto de *Guazuma ulmifolia* como sustituto de maíz en la dieta sobre el comportamiento productivo y rendimiento en canal de ovinos Pelibuey. *Trop Subtrop Agroecosystems 17*(2): 215-222.

Hernández-Hernández, E., López-Ortiz, S., Villarruel-Fuentes, M., Pérez-Hernández, P., Velasco-Velasco, J., & Salinas-Ruíz, J. (2017). Feeding rabbits (*Oryctolagus cuniculus*) with tree fruits from tropical deciduous forest. *World Rabbit Sci* 25: 135-145. https://doi.org/10.4995/wrs.2017.3838

Hinojosa-Benavides, R.A., Andia-Salinas, C.T., Lunazco-Gamboa, R., Núñez-Quispe, K., Ruíz-Vilca, W.M., Farfán-Mauri, R., & Vitor-Valladolid, J. (2019). Mirada retrospectiva a la inseminación artificial en ovinos. *PURIQ 1*(01): 99-108. https://doi.org/10.37073/puriq.1.01.14

INEGI. (2023). Instituto Nacional de Estadística y Geografía. https://www.inegi.org.mx/temas/climatologia/

Ku-Vera, J.C., Briceño, E.G., Ruiz, A., Mayo, R., Ayala, A.J., & Aguilar, C. F., *et al.* (2014). Manipulación del metabolismo energético de los rumiantes en los trópicos: opciones para mejorar la producción y la calidad de la carne y leche. *Rev Cuba Cienc Agríc 48*(1): 43-53.

Lozano-González, J.F., Uribe-Velásquez, L.F., & Osorio, J.H. (2012). Control hormonal de la reproducción en hembras ovinas (Ovisaries)." *Veterinaria y Zootecnia 6*(2): 134-147. https://revistasojs.ucaldas.edu.co/index.php/vetzootec/article/view/4413

Martin, G.B., Milton J.T., Davidson, R.H., Banchero-Hunzicker, G.E., Lindsay, D.R., & Blache, D. (2004). Natural methods for increasing reproductive efficiency in small ruminants. *Anim Reprod Sci* 82-83: 231-245.

Martin, G.B., & Reza, T. (2016). Clean, Green, Ethical (CGE) Management: What Research Do We Really Need?. *Int J Trop Vet Biomed Res* 1: 1-9.

Martínez-González JC, Castillo-Rodríguez SP, Villalobos-Cortés A, Hernández-Meléndez J. (2017). Sistemas de producción con rumiantes en México. *Ciencia Agropecuaria. 26*(1):132-152.

Manríquez-Mendoza, L.Y., López-Ortíz, S., Pérez-Hernández, P., Ortega- Jiménez, E., López-Tecpoyotl, Z.G.& Villarruel-Fuentes, M. (2011). Agronomic and forage characteristics of *Guazuma ulmifolia* Lam. *Trop Subtrop Agroecosystems 14*(2): 453-463.

NRC. (2007). Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids. The National Academies Press, Washington, DC. https://doi.org/10.17226/11654

Orskov, E.R., & McDonald, I. (1979). The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *J Agric Sci* 92: 499-503.

Pérez-Hernández, P., García-Winder, M., & Gallegos-Sánchez, J. (2002). Postpartum anoestrus is reduced by increasing the within-day milking to suckling interval in dual purpose cows. *Anim Reprod Sci* 73: 159-168.

Piñeiro-Vázquez, A.T., Ayala-Burgos, A.J., Chay-Canul, A.J., & Ku-Vera, J.C. (2013). Dry matter intake and digestibility of rations replacing concentrates with graded levels of *Enterolobium cyclocarpum* in Pelibuey lambs. *Trop Anim Health Prod* 45: 577-583.

Pírela, M., Perozo, A., Montero, M., Contreras, G., Valbuena, E., & Zambrano, S. (2010). Producción y calidad de la leche de vacas criollo limonero suplementadas con harina de frutos de samán (*Pithecellobium saman*). Rev Fac Agron LUZ 27: 607-625.

Rattray, P.V., Jagusch, K.T., Smith, J.F., Winn, G.W., & MacLean, K.S. (1981). Effects of genotype, liveweight, pasture type and feeding level on ovulation responses in ewes. *Proceedings of the Australian Society of Animal Production* 41: 174-182.

Rojas, R.O., & Rodriguez, R.O. (1995). Factores que modifican la prolificidad en ovejas Blackbelly en clima tropical. *Tec Pecu Mex 33*(3): 159-167.

Román, M.M.L., Palma, J.M., Zorrila, J., Mora, A., & Gallegos, A. (2008). Degradabilidad in situ de la materia seca de la harina del fruto de guácima (*Guazuma ulmifolia*), con dietas de frutos de especies arbóreas. *Zootecnia Trop* 26: 227-230.

Rubianes, E., & Ungerfeld, R. (2002). Perspectivas de la investigación sobre reproducción ovina en América Latina en el marco de las actuales tendencias productivas. *Arch Latinoam Prod Anim 10*(2): 117-125.

Russel, A., Doney, J.M. & Gunn R.J. (1969). Subjective assessment of body fat in live sheep. *J Agr Sci* 72: 451-454

Salamon, S., & Maxwell, M. (2000). Storage of ram semen. *Review Anim Reprod Sci* 62: 77-111.

SAS. (2011). JMP. Statistic visual. Version 9.2 institute inc. campus Drive. Cary. NC 27517.

Scaramuzzi, R.J., Murray, J.F., Downing, J.A., & Campbell, B.K. (1999). The effects of exogenous growth hormone on follicular steroid secretion and ovulation rate in sheep. *Domest Anim Endocrinol 17*(2-3): 269-277.

Sosa-Pérez, G., Pérez-Hernández, P., Vaquera-Huerta, H., Salazar-Ortiz, J., Sánchez del Real, C., Cadena-Villegas, S., & Gallegos-Sánchez, J. (2014). Somatotropina bovina recombinante en sincronización de estros y prolificidad de ovejas Pelibuey. *Arch Zootec 63*(241): 219-222.

Villa-Herrera, A., Nava-Tablada, M., López-Ortiz, S., Vargas-López, S., Ortega-Jimenez, E., & Gallardo-López, F. (2009). Utilización del guácimo (*Guazuma ulmifolia* Lam.) como fuente de forraje en la ganadería bovina extensiva del trópico mexicano. *Trop Subtrop Agroecosystems 10*(2): 253 -261.

Viñoles, C., Banchero, G., Quintans, G., Pérez, C.R., Soca, P., & Ungerfeld, R., *et al*. (2009). Estado actual de la investigación vinculada a la Producción Animal Limpia, Verde y Ética en Uruguay. *Agrociencia 13*(3): 59-79.