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Voluntary intake and digestibility of lambs fed hay of forage soybeans cv. 'Hinson Long Juvenile' (*Glycine max* L. Merr.) and Lablab cv. 'Rongai' [*Lablab purpureus* (L.) Sweet][1,2]

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ABSTRACT

Sun cured hays of two legumes, forage soybean (*Glycine max* L. Merr.) cv. 'Hinson Long Juvenile' and Lablab [*Lablab purpureus* (L.) Sweet] cv. 'Rongai', were compared in terms of voluntary intake and digestibility of dry matter (DM), crude protein, and neutral detergent fiber, in six individually caged lambs (28.4 ± 4 kg body weight). Treatments were arranged in a completely randomized design with three replicates (animals). The lambs were fed periodically during a seven-day adaptation period, and data collection was carried out over five days. 'Hinson' and 'Rongai' did not differ in crude protein (15.8 vs. 15.5%) and neutral detergent fiber (56.2 vs. 55.1% of DM). Lambs fed cv. 'Hinson' consumed more DM (P<0.05) than those fed 'Rongai' (945 vs. 853 g/d). 'Hinson' also registered higher DM digestibility (56.2 vs. 49.6%) than 'Rongai'. Based on their agronomic characteristics, chemical composition, voluntary intake, and digestibility, both legumes exhibit good potential for use as hay. Large-scale planting of these legumes could supply hay for ruminant feeding to supplement low quality tropical grasses and reduce the need for imported protein sources for ruminant feeding.

Keywords: agronomic characteristics, chemical composition, legumes

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RESUMEN

Ingesta voluntaria y digestibilidad por corderos alimentados con henos forrajeros de soja cv. 'Hinson Long Juvenile' (*Glycine max* L. Merr.) y Lablab cv. 'Rongai' [*Lablab purpureus* (L.) Sweet]

Heno de dos leguminosas secadas al sol, soja forrajera (*Glycine max* L. Merr.) cv. 'Hinson Long- Juvenile' y Lablab [*Lablab purpureus* (L.) Sweet] cv. 'Rongai', se compararon en términos de ingesta voluntaria, digestibilidad de materia seca (MS), proteína bruta y fibra detergente neutra, utilizando seis corderos enjaulados individualmente (28.4 ± 4 kg de peso corporal). Para el estudio, se usó un diseño completamente aleatorio con tres réplicas (animales). Los corderos se alimentaron por un período de adaptación de siete días y los datos se recolectaron por cinco días. 'Hinson' y 'Rongai' no diferían en proteína bruta (15.8 vs. 15.5%) y fibra detergente neutra (56.2 vs. 55.1% de MS). Los corderos alimentados con cv. 'Hinson Long Juvenile' consumieron más MS (P<0.05) que los alimentados con 'Rongai' (945 vs. 853 g/d). 'Hinson Long Juvenile' también registró una mayor digestibilidad de MS (56.2 vs. 49.6%) que 'Rongai'. Basándose en sus características agronómicas, composición química, ingesta voluntaria y digestibilidad, ambas leguminosas presentan un buen potencial para su uso como heno. La plantación en gran escala de estas leguminosas podría suministrar heno para la alimentación de los rumiantes como complemento de las gramíneas tropicales de baja calidad y reducir la necesidad de fuentes de proteínas importadas para la alimentación de los rumiantes.

Palabras claves: características agronómicas, compuestos químicos, leguminosas

INTRODUCTION

In Puerto Rico, naturalized grasses usually do not satisfy most of the nutritional requirements of high producing dairy cows. Forage consumption, especially the fibrous part, is of vital importance in the diet of ruminants, which require effective fiber for proper functioning of the rumen, feed efficiency and productive performance (Ren et al., 2016). Therefore, imported alfalfa in dehydrated and compressed form and concentrate feeds are commonly fed to local livestock. Skerman et al. (1992) proposed that in the tropics, locally produced forage legumes could offer an economic alternative to promote ruminant animal production and reduce dependence on imported feedstuffs. Adding legumes to the diet of ruminants in the tropics tends to improve nutrition through increased crude protein content, passage rate of food intake and voluntary intake (Kretschmer and Pitman, 2001).

Soybean (*Glycine max* L. Merr.) cv. 'Hinson Long Juvenile' and Lablab [*Lablab purpureus* (L.) Sweet] cv. 'Rongai' are two highly nutritious tropical legumes that are candidates for improving livestock production systems. Soybean is considered one of the best annual forages for the high protein content of its seeds and good baling characteristics when preserved as hay (Sheaffer et al., 2001). Soybean is also a good

supplier of protein and digestible energy when used as a feed supplement (Rotz et al., 2001). As for 'Rongai', it is used for grazing and also preserved as hay or silage; its leaves are high in protein content and digestibility (Murphy and Colucci, 1999). Additionally, one of its most attractive features is high palatability (Valenzuela and Smith, 2002).

The objective of this research was to compare the voluntary intake and digestibility of dry matter, neutral detergent fiber, and crude protein fractions of baled 'Hinson' and 'Rongai' hays fed to lambs.

MATERIALS AND METHODS

Soybean cv. 'Hinson' was planted on an Oxisol soil at the Isabela Agricultural Experiment Substation, University of Puerto Rico. The initial growth of 'Hinson', 62 days after planting, and an 8-week regrowth of 'Rongai' (previously planted) was cut, field dried and baled. The feeding experiment was conducted at Finca Alzamora, University of Puerto Rico, Mayagüez Campus. Six lambs were used (28.4 ± 4 kg body weight, BW). Before initiation of the experiment the animals were dewormed with Cydectin®[5] at 1 mL/kg BW. Lambs were placed in individual cages, each provided with a feeder and a bucket to supply water ad libitum.

The experiment consisted of a seven-day adjustment period to familiarize the lambs with the diet and conditions of housing and management, followed by five days of experimental data collection. The two hays were assigned randomly, 'Hinson' to three lambs and 'Rongai' to the other three, and constituted the experimental treatments. Both hays were manually cut with scissors to a particle size of about 10 cm in length to reduce waste and facilitate animal selection. Each lamb was provided daily with a quantity of hay equal to 4% of BW on a dry matter (DM) basis.

During the five-day consumption period, hay offered and rejected was weighed and sampled, and feces were collected from each lamb equipped with a cloth fecal collection bag, which was weighed, and sampled. Samples represented 10% aliquots. The daily food samples, offered and rejected, and feces from each lamb were combined to form a composite sample for chemical analysis.

The samples were oven-dried at 65° C for 72 h and ground in a Wiley mill and passed through a 1 mm sieve. Inorganic matter (IM) con-

[5]Boehringer commercial brand (10 mg Moxidectin active ingredient). Company or trade names in this publication are used only to provide specific information. Mention of a company or trade name does not constitute an endorsement by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

tent was determined by incinerating the samples in a Muffle Furnace (Fisher Scientific®). The percentage of organic matter was calculated (OM = 100-IM) following the methodology of AOAC (1991).

Nitrogen concentration was determined by the micro-Kjeldahl method using a nitrogen analyzer (Kjeltec system model 1002), and crude protein (CP) was calculated by the formula %CP = N*6.25%. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined following the procedure of Van Soest et al. (1991). Cell content (CC) was obtained as 100-%NDF. Hemicellulose concentration (HC) was calculated as the difference between NDF and ADF. Apparent digestibility of DM, NDF and CP were obtained assuming that the ingested material not recovered in feces was digested. Experimental data of voluntary intake and DM, CP, and NDF digestibility were subjected to analysis of variance (ANOVA). Mean separation was performed using Fisher LSD.

RESULTS AND DISCUSSION

Harvest age is a determining factor in the chemical composition of forages (Shehu et al., 2000). Table 1 shows the chemical composition of 'Hinson' hay harvested at 62 days after planting and the hay of 'Rongai' regrowth. The two hays contained less than 15% moisture and showed no presence of fungus growth, indicating that sun drying was effective. This result is important to prevent decomposition and nutrient loss, which affects hay quality, physical appearance and sensory perception by the animals (Muck and Shinners, 2001; Nworgu and Ajayi, 2005).

Although not statistically significant, chemical composition of 'Rongai' hay showed slightly lower moisture content (10 vs. 11.2%),

TABLE 1.—*Chemical composition of 'Hinson' and 'Rongai' hays fed to lambs.*

	'Hinson'	'Rongai'
Component	%	
Humidity	11.2	10.0
Dry matter	88.7	89.9
Inorganic matter[1]	1.39	2.00
Organic matter[1]	98.6	97.9
Crude protein[1]	15.8	15.5
Cell content[1]	43.8	44.8
NDF[1]	56.2	55.1
ADF[1]	42.2	40.4
Hemicellulose[1]	13.9	14.8

[1]Dry matter basis
NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber

probably due to a morphological difference between the two legumes. 'Rongai' stem is more succulent (herbaceous) compared to the woody stem of 'Hinson' which slows forage drying. 'Hinson' hay also showed a small advantage in protein concentration compared to 'Rongai' (15.8 vs. 15.5%). However, these levels are well below the protein concentrations higher than 20% reported for both legumes by other authors (Ramos and Cruz, 2002; Tobía and Villalobos, 2004; Nworgu and Ajayi, 2005).

Somewhat lower levels of NDF and ADF were observed in 'Rongai' (55.1% and 40.4%) compared to 'Hinson' (56.2% and 42.2%, respectively). Thus 'Rongai' presented a higher proportion of cell contents, which are almost completely digestible and important to rumen bacterial flora.

Table 2 presents results for voluntary intake and apparent digestibility of the two hays fed the lambs. The two hays differed ($P<0.05$) in voluntary intake, with daily DM intake of 945 g (equivalent to 3.2% BW) for 'Hinson' and 853 g DM (3% BW) for 'Rongai' hay. The percentage of feed on offer consumed (dry basis) was 80% for 'Hinson' and 75% for 'Rongai'. These results reflect high acceptance of both hays by lambs. Houston et al. (2007) estimated daily DM intake for maintenance of a 100 kg BW sheep at 1.77 kg (1.77% BW) with total digestible nutrient of 0.94 kg, which approximates to 53% DM digestibility. In this study, apparent digestibility of 'Hinson' was 56.2%, 6.6 percentage points higher than 'Rongai' (49.6%).

Mupangwa et al. (2000) reported daily voluntary intakes higher than 4% of BW for *Lablab purpureus* (Lablab), *Macroptilium atropurpureum* (Siratro) and *Stylosanthes guianensis* (Stylo), but much lower consumption for *Cassia rotundifolia* (Cassia). In our study, lambs fed 'Hinson' and 'Rongai' consumed DM daily equal to or greater than 3% of BW. No signs of appetite loss or abnormality were observed. Other legumes such as *Leucaena leucocephala*, *Acacia farnesiana* and *Prosopis juliflora* (Sw) D.C. sometimes cause digestive problems or toxicity resulting in alopecia (Benavides et al., 2010); while *Calliandra calo-*

TABLE 2.—*Voluntary intake and apparent digestibility of DM of hays made from the legumes cv. 'Hinson' and 'Rongai'.*

Variable	'Hinson'	'Rongai'
Voluntary intake (g/d)	945.0 a	853.0 b
Percentage of offering consumed (%)	80.1 a	75.0 a
DM digested (g/d)	531 a	423 a
Digestibility (%)	56.2 a	49.6 a

Means with common letter are not significantly different ($P>0.05$) by Fisher LSD.

thyrsus and *Desmodium* spp. possess high levels of tannins in their leaves which reduce intake due to astringency (Skerman, 1991).

Our study results show a good acceptance of 'Hinson' and 'Rongai' by lambs. This is a key factor in determining forage quality (Allison, 1985; and Skerman, 1991). Probably the lower voluntary intake of 'Rongai' hay (75.0 vs. 80.1%) reflects an effect of the lower leaf to stem ratio compared to 'Hinson' hay. The leaves tend to be digested more rapidly in the rumen while the stems, which have a higher content of structural support components and longer ruminal retention time, contribute to satiety in the animal and lower food intake (Allison, 1985). The higher proportion of leaves in 'Hinson' may be the main cause of its higher intake because the leaves are more palatable and digestible than woody fractions. Van Soest (1994) indicated that on average, the readily digestible portion of tropical forages varies between 25 and 35%, the potentially digestible between 47 and 63% and the completely indigestible between 12 and 18%. Pirela (2005) concluded that a digestibility of 65% or greater in forages is indicative of high nutritional value and the capacity to provide adequate energy for high producing cattle. The 56 and 50% digestibility found for 'Hinson' and 'Rongai' hays, respectively, are indicative of lower quality than the stated standard, but these were compatible with high consumption.

The values we obtained for chemical composition, voluntary intake, and apparent digestibility, exceed those observed by Sandoval et al. (2009) in Rhodes grass hay (*Chloris gayana*, 7% CP), harvested at 42 days, and a mixture of grass (*Urochloa maxima*) and Clitoria (*Clitoria ternatea*) at 14% CP. Several other researchers have found similar digestibility values for 'Rongai' (Hedricksen and Minson, 1985; Makembe and Ndlovu, 1996), but higher digestibility for these legumes has also been reported (Murphy and Colucci, 1999).

Mupangwa et al. (2000) used Dorpel sheep (31 ± 1.3 kg BW) fed ad libitum Cassia, Lablab, Siratro and Stylo to estimate DM intake and digestibility. The digestible OM consumption (kg/d) of Cassia hay was lower (12.1) ($P<0.001$) than that of Lablab (48.2), Siratro (52.6) and Stylo (50.9). Although no supplementary feeding was used in the Mupangwa study, Makembe and Ndlovu (1996) found that a diet containing 50% maize stover supplemented with 50% *Lablab purpureus* resulted in higher intakes of DM, OM and nitrogen, as well as greater birth weight of breeding goats, higher milk production and weight gain in both mothers and kids, compared with diets of 70:30 maize: *L. purpureus*. Murphy and Colucci (1999) reaffirmed that *L. purpureus* is palatable to livestock, suitable as a protein resource and versatile for use as forage for grazing, fresh cut hay and silage, and mixed with corn. The authors cite daily voluntary intakes of sheep fed hay of *L. purpure-*

us and forage in the vegetative state reaching levels as high as 53.8 to 73.7, and 60.8 g/kg BW. Those results contrast with this study's finding in which values were below 30 (g/kg BW); however, this occurred with a forage offering equivalent to only 4% of BW, which does not allow for maximum voluntary consumption.

The intake and digestibility of NDF in the 'Hinson' and 'Rongai' hays are presented in Table 3. The respective hays offered contained 42.6 and 41.7% of NDF. Therefore, the corresponding cellular content values were estimated at 57.4% and 58.3%, indicating high levels of easily degradable material in the rumen. The daily offerings of 'Hinson' and 'Rongai' hays included 505 g and 474 g of NDF, which were significantly different. Similarly, the quantities of NDF consumed and excreted were significantly greater for 'Hinson' hay.

Tobía et al. (2006) analyzed various parts of soybean cv. Cigras O6 harvested to 90 days of growth (R6 stage in pod filling) and found NDF contents of 26.5% in the leaves, 64% in stems, 29% in pods and 42% in total aerial parts. Lao et al. (2006) studied six legumes (Centro, Siratro, Mucuna, Dolichos, Glycine and Jack bean) harvested in the vegetative state and found higher contents of NDF than the present values.

Table 4 shows the distribution of CP use by the animals. The voluntary intakes of 74.9 g and 65.6 g of CP represented 94.1% and 89.6% of the amount offered in 'Hinson' and 'Rongai' hay, respectively. The amount of CP apparently digested and the corresponding digestibility coefficient were 46.95 g (62.56%) for 'Hinson' and 45.09 g (68.29%) for 'Rongai'. According to Houston et al. (2007), the amount of protein (g) required daily by lambs is estimated by multiplying BW (kg) by the factor 1.28, which equals, in this case, 36.4 g of protein per day. This minimum requirement was greatly exceeded by the forages consumed in this study. In fact, these intakes cover the minimum protein requirements of growing animals.

TABLE 3.—*Lambs' consumption and apparent digestibility of NDF of 'Hinson' and 'Rongai' forages.*

Component	'Hinson' (g/d)	'Rongai' (g/d)
NDF offered	505.0 a	474.0 b
NDF rejected	61.9 a	80.9 a
NDF consumed	443.0 a	393.0 b
NDF excreted	212.0 a	163.0 b
NDF digested	230.0 a	230.0 a
Digestibility NDF (%)	52	58.4

NDF: Neutral Detergent Fiber. Means with common letter are not significantly different (P>0.05) by Fisher LSD.

TABLE 4.—*Consumption and digestibility of crude protein in 'Hinson' and 'Rongai' hays fed lambs.*

Crude Protein	'Hinson' (g/d)	'Hinson' (%)	'Rongai' (g/d)	'Rongai' (%)	SE
CP Offered	79.6 a	15.8	73.2 b	15.7	29.4
CP Rejected	4.71 a	7.54	7.64 b	9.49	6.75
CP Consumed	74.9 a	94.1	65.6 b	89.6	33.7
CP Excreted	28.0 b	13.1	20.7 a	12.5	24.2
CP Digested	46.9 a	62.6 a	45.1 a	68.3 b	65.6

Percentage values on dry basis. SE=Standard Error. Means with common letter are not significantly different (P>0.05) by Fisher LSD.

Crude protein content of both legume hays exceeded 15%, which clearly exceeds those typical of naturalized grasses in Puerto Rico (7%). Tropical grasses as the sole diet often do not meet the minimum requirements to maintain the bacterial flora of the rumen functioning efficiently, which has been estimated to be about 12% CP (Rojas et al., 2005; Hess et al., 1992; Skerman et al., 1992). Mupangwa et al. (2000) found higher levels of CP than our study for Cassia (18.2%), Siratro (22.9%) and Stylosantes (25.3%). Lao et al. (2006) reported CP content in jack bean of 20.62%; *Mucuna puriens,* 19.5%; *Centrosema pubescens* 18.75%; Siratro, 17.88%; in contrast to a lower value for *Neonotonia wightii* of 13.5%.

CONCLUSION

Hay made from regrowth of 'Rongai' and from 'Hinson' at 62 days of initial growth exhibited higher CP, lower NDF and higher in vivo digestibility than those of tropical grasses. Both hays were well accepted by lambs that showed no sign of negative effects from consuming them. This study provides information on the chemical composition, voluntary intake, and in vivo digestibility of 'Hinson' and 'Rongai' hays demonstrating their high nutritional value. Large-scale planting of these legumes could supply hay for ruminant feeding to supplement low quality tropical grasses and reduce the need for imported protein sources for ruminant feeding. However, future studies are needed to corroborate intake and digestibility of these legume hays on average daily gains of growing lambs.

LITERATURE CITED

Allison, C.D., 1985. Factors affecting forage intake by range ruminants: A. review. *Journal of Range Management* 38(4): 305-311.

AOAC (Association of Official Analytical Chemists), 1991. Official Methods of Analysis, 13th edition. Washington, D. C.

Benavides-Mendoza, A., R. Hernández-Valencia, H. Ramírez-Rodríguez, and A. Sandoval-Rangel, 2010. Plantas tóxicas y medicinales. *En* Tratado de botánica económica moderna (pp. 1-22). Saltillo, México: Editorial Limusa.

Hedricksen R.E. and D.J. Minson, 1985. *Lablab purpureus* - A Review. *Herbage Abstracts* 55: 215-227.

Hess, H.D., H. Flores, E. González, and M. Ávila, 1992. Efecto del nivel de nitrógeno amoniacal en el rumen sobre el consumo voluntario y la digestibilidad *in situ* de forrajes tropicales. *Pasturas Tropicales* 21: 15-30. http://www.tropicalgrasslands.info/public/journals/4/Elements/DOCUMENTS/1999-vol21-rev1-2-3/Vol21_rev1_99_art5.pdf

Houston, J.E., R.G. White, B.J. Bequette, H. Dove, A.L. Goetsch, B.W. Hess, M. Huerta-Bravo, D.G. Pugh, and S.G. Solaiman, 2007. Nutrient requirements of small ruminants' sheep, goats, cervids and new world camelids. The National Academies Press, Washington, D. C., 347 pp. http://www.avpa.ula.ve/docuPDFs/libros_online/manual-ganaderia/seccion3/articulo6-s3.pdf http://www.ctahr.hawaii.edu/oc/freepubs/pdf/GreenManureCrops/lablab.pdf http://www.veterinaria.org/revistas/redvet/n050505/050509.pdf

Kretschmer, A.E. and W.D. Pitman, 2001. Germplasm resources of tropical forage legumes: pp 41-57. *In* A. Sotomayor-Rios and W.D. Pitman (eds) Tropical forage plants: development and uses. CRC Press, FL, USA.

Lao, O., B. Chongo, D. Delgado, T.E. Ruiz, M.A Solís, and O. Ruiz, 2006. Variability in ash, neutral detergent fiber, total nitrogen, and rumen degradability of six tropical legumes. *Cuban Journal of Agricultural Science* 40(3): 293-297.

Makembe, N.E.T. and L.R. Ndlovu, 1996. Dolichos lablab (*Lablab purpureus* cv. "'Rongai'") as supplementary feed to maize stover for indigenous female goats in Zimbabwe. *Small Ruminant Research* 21(1): 31-36. http://www.sciencedirect.com/science/article/pii/0921448895008098

Muck, R.E. and K.J. Shinners, 2001. Conserved forage (silage and hay): progress and priorities, *In*: International Grassland Congress 19: 753-762. São Pablo. http://naldc.nal.usda.gov/download/48355/PDF

Mupangwaa, J.F., N.T Ngongonib, J.H. Toppsc, T. Acamovicd, H. Hamudikuwandab, and L.R. Ndlovu, 2000. Dry matter intake, apparent digestibility and excretion of purine derivatives in sheep fed tropical legume hay. *Small Ruminant Research* 36 (3): 261-268. http://www.sciencedirect.com/science/article/pii/S092144889900125X

Murphy, A. and P. Colucci, 1999. A tropical forage solution to poor quality ruminant diets: A Review of *Lablab purpureus*. Livestock Research for Rural Development 11(2). http://www.fao.org/livestock/agap/frg/lrrd/lrrd11/2/colu112.htm

Nworgu, F.C. and F.T Ajayi, 2005. Biomass, dry matter yield, proximate and mineral composition of forage legumes as early dry season feed. *Livestock Research for Rural Development* 11(2). http://www.lrrd.org/lrrd17/11/nwor17121.htm

Pirela, M.F., 2005. Valor nutritivo de los pastos tropicales: pp 176-182, *En:* Manual de Ganadería de Doble Propósito. Instituto Nacional de Investigaciones Agrícolas, Venezuela.

Ramos, N. and A.M. Cruz, 2002. Evaluation of seven seasonal crops for forage production during the dry season in Cuba. *Cuban Journal of Agricultural Science* 36: 271-276.

Ren, H., G. Han, P. Schönbach, M. Gierus, and F. Taube, 2016. Forage nutritional characteristics and yield dynamics in a grazed semiarid steppe ecosystem of Inner Mongolia, China. *Ecological Indicator* 60: 460-469. http://www.sciencedirect.com/science/article/pii/S1470160X1500415X

Rojas-Hernández, S., J. Olivares Pérez, R. Jiménez Guillén, and E. Hernández Castro, 2005. Manejo de praderas asociadas de gramíneas y leguminosas para pastoreo en el trópico. *Revista Electrónica Veterinaria* 6(5):1-19.

Rotz, C.A, G.W. Roth, K.J. Soder, and R.R. Schnabel. 2001. Economic and environmental implications of soybean production and use on Pennsylvania dairy farms. *Agronomy Journal* 93(2): 418-428.

Sandoval, B., E. Valencia, A.A. Rodríguez, and P. Randel, 2009. Consumo voluntario y digestibilidad en henos de pasto guinea (*Panicum maximum* Jacq.), clitoria (*Clitoria ternatea* L Dne.) y de pasto rhodes (*Chloris gayana* Kunth) cv. Callide. *J. Agric. Univ. P.R.* 93: 41-50. Doi.org/10.46429/jaupr.v93i1-2.2752

Sheaffer, C., J. Orl, T. Devine and J. Grimsbo, 2001. Yield and quality of forage soybean. *Agronomy Journal* 93(1): 99-106.

Shehu Y., W.S. Alhassan, U.R Pal and C.J.E Phillips, 2000. The effects of timing of an interim harvest on the yield and composition of *Lablab purpureus. Journal of Agronomy and Crop Science* 186: 31-36.

Skerman, P.J., 1991. Gramíneas tropicales. Colección FAO: Producción y protección vegetal 23:1-730.

Skerman, P.J., D.G. Cameron, and F. Riveros, 1992. Leguminosas forrajeras tropicales. Organización de las Naciones Unidas para la Agricultura y la Alimentación (p. 223).

Tobía, C. and F. Villalobos. 2004. Producción y valor nutricional del forraje de soya en condiciones tropicales adversas. *Revista Agronomía Costarricense* 28(1), 17-25. Retrieved Feb. 5, 2016, from http://www.mag.go.cr/rev_agr/v28n01_017.pdf

Tobía C., E. Villalobos, and R.E. Abril, 2006. Uso del forraje de soya (*Glycine max* L. Merr.) variedad Cigras 06 en la nutrición de rumiantes: pp 77-86, *En*: X Seminario manejo y utilización de pastos y forrajes en sistemas de producción agrícola. Seminario llevado a cabo en Maracaibo, Venezuela. http://www.avpa.ula.ve/congresos/seminario_pasto_X/Conferencias/A7-Carlos%20Tobia.pdf

Valenzuela, H. and J. Smith, 2002. *Lablab*: Sustainable Agriculture, Green manure crops. Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii at Mansoa.

Van Soest, P.J., 1994. Nutritional Ecology of the Ruminant. Second edition. Cornell University Press, Ithaca, NY (488 pp).

Van Soest, P.J., J.B. Robertson, and B. A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74(10): 3583-3597.