USE OF *Crescentia alata* AND *Guazuma ulmifolia* FRUITS IN LAMB FEEDING IN SUBTROPICAL REGION OF GUERRERO, MEXICO

Uso del fruto de *Crescentia alata* y *Guazuma ulmifolia* en la alimentación de corderos en la región subtropical de Guerrero, México

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RESUMEN

Se determinó la composición química, producción de gas *in vitro* (PGIV) y digestibilidad de frutos de *Guazuma ulmifolia* y *Crescentia alata* en Pungarabato, Guerrero, México, y se usaron para alimentar corderos y se evaluó la aceptabilidad y la respuesta animal. Se utilizaron seis y 15 corderos Pelibuey x Dorper, peso corporal entre 13,9 y 15,6 kg en la prueba de aceptabilidad y respuesta productiva, respectivamente. En el estudio de aceptabilidad desarrollado en 22 días (d), los tratamientos fueron los dos frutos. En el estudio de respuesta productiva desarrollado en 55 d, los tratamientos fueron: T1: heno de avena y 50 g de maíz (*Zea mays* L.) T2: heno de avena y fruto de *G. ulmifolia*, T3: heno de avena y fruto *C. alata*. Los datos de composición química, PGIV, digestibilidad de frutos, el número y duración de visitas al comedero (NVC y DVC), el consumo de materia seca (CMS) y ganancia diaria de peso (GDP) se analizaron completamente al azar. Los datos de la dinámica del consumo de frutos se analizaron completamente al azar con arreglo factorial 2 x 6. En ambos diseños se utilizó Tukey para comparación de medias (P<0,05). El contenido de proteína (82,0 g kg^{-1} materia seca (MS); P<0,030), energía (5,6 Magajoules (MJ) kg^{-1} MS; P<0,010) y fenoles totales (22,7 g kg^{-1} MS; P<0,001) fue mayor para *G. ulmifolia*. En la aceptabilidad el CMS, NVC y DVC fue mayor (P<0,05) sobre frutos de *G. ulmifolia* con 189, 4 g d^{-1}, 15,5 visitas y 3,2 minutos, respectivamente. En respuesta productiva, el CMS total fue mayor (P<0,05) en corderos del T2 con 830,0 g^{-1} d^{-1}, que representó mayor consumo del fruto de *G. ulmifolia* (686,0 g^{-1} d^{-1}), lo que aumentó la GDP (81,0 g^{-1} d^{-1}) de los animales. Se concluyó que el fruto de *G. ulmifolia* incrementó el CMS y la GDP en los corderos, lo que hace factible utilizarlo como suplemento en épocas críticas.

Palabras clave: Corderos, frutos, *G. ulmifolia*, *C. alata*, cambio de peso.

ABSTRACT

Chemical composition, *in vitro* gas production (PGIV) and digestibility of *Crescentia alata* and *Guazuma ulmifolia fruits* in Pungarabato, Guerrero, Mexico, were determined and were used to feeding lambs and evaluated the acceptability and animal response. Six and 15 male lambs Pelibuey x Dorper with body weight between 13.9 and 15.6 kg, respectively were used in the test of acceptability and productive response test. The acceptability study developed in 22 days (d), treatments were the two fruits. In the study of productive response developed in 55 d, treatments were: T1: oat hay and 50 g of corn, (*Zea mays* L.) T2: oat hay and *G. ulmifolia* fruit, T3: oat hay and *C. alata* fruit. The data, chemical composition, PGIV, digestibility of fruits, the number and duration of visits to the feeder (NVF and DVF), dry matter intake (DMI) and daily weight gain (DGW) were analyzed completely random. The data on the dynamics of fruit consumption were analyzed in a factorial design arrangement 2 x 6. In both designs Tukey test was used to compare means (P<0.05). The protein content (82.0 g kg^{-1} dry matter (DM); P<0.030), energy (5.6 MJ kg^{-1} DM; P<0.010) and total phenol (22.7 g kg^{-1} DM; P<0,001) was higher for *G. ulmifolia*. In the acceptability DMI, NVF and DVF was higher (P<0.05) about fruits of *G. ulmifolia* with 189.4 g^{-1} d^{-1}, 15.5 hits

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and 3.2 minutes, respectively. In productive response the DMI total was higher (P<0.05) in lambs of T2 with 830.0 g a^{-1} d^{-1}, which represented more consumption of *G. ulmifolia* fruit (686.0 g a^{-1} d^{-1}), this increased DGW (81.0 g a^{-1} d^{-1}) of animals. It was concluded that the *G. ulmifolia* fruit increased, the DMI and weight gain in lambs, which makes it feasible to use it as a supplement in critical times.

Key words: Lambs, fruits, *G. ulmifolia*, *C. alata*, nutritional value, weight change.

INTRODUCTION

Sheep (*Ovis aries*) production in tropical regions is based on the use of natural or induced fodder as the main source of food; however, pastures in the dry season are scarce, low in protein, high in fiber and low digestibility, with negative effects on dry matter intake and animal production [5, 23, 30].

Studies have been conducted to use biomass of trees as alternative food source in animal production, with paying attention to the nutritional properties and behavior of the animal to consume [1, 2]. Cafeteria tests developed in ruminants in different regions of the world have identified the preference, the degree of acceptability and productive response that animals have to provide fodder tree biomass as a food source [17, 19]. Feed selection by animals depends on the palatability of the feeds and palatability is a complex phenomenon being determined by both plant and animal factors [18].

The purpose of study was to determine the feeding value of fruits *Guazuma ulmifolia* and *Crescentia alata*, as food in growing lambs, for which it was determined the chemical composition, *in vitro* digestibility parameters and were developed tested of acceptability and growth performance in lambs males.

MATERIALS AND METHODS

This study was conducted in the Pungarabato Municipality, Guerrero (18° 20' 30" NL and 100° 39' 18" WL) located in the region of Tierra Caliente, Mexico. The prevailing climate is AW_0. The average temperature is 28°C. Altitude of 250 meters above sea level (m.a.s.l), with an average annual rainfall of 750 mm [10].

Collection of fruit

The fruits of *G. ulmifolia* and *C. alata* were collected from December 2009 to February 2010, were dehydrated by exposing them directly to the sun, then ground into particles of ten mm.

Chemical composition

The ground fruit, oat, hay and corn were analyzed for crude protein content by the method proposed by the Association of Official Analytical Chemist [3], neutral detergent fiber and acid detergent fiber were determined by the method of Van Soest *et al*. [28] (TABLE I).Total phenolic and condensed tannins by the methodology proposed by Waterman and Mole [29] (TABLE I).

In vitro gas production and digestibility of fruits

A sample of each fruit was digested triplicate and was estimated gas production *in vitro* (IVGP), and *in vitro* digestibility of dry matter and organic (IVDMD and IVOMD) (TABLE I), by the gas production technique, proposed by Theodorou *et al*. [27], based on the methodology Menke and Steingass [16] modified by Herrero and Jessop [14]. The rumen fluid was collected from three sheep Dorper x Katahdin, morning (07:00 h) before feeding a standardized diet 70:30 ratio of forage and concentrate.

The gas volume (mL g^{-1} dry sample) was recorded every hour (h) for the first 8 h, then every 4 h to 60 h and subsequently at 72, 84 and 96 h of incubation technique using pressure reading (RPT; DELTAOHM, Italy) of Theodorou *et al*. [27]. With data from organic matter digestibility was calculated metabolizable energy in each fruit with equation: metabolizable energy (ME) (MJ kg^{-1} DM) = 0.0157*IVOMD postulated by the Agricultural Food and Research Council (AFRC) [4] (TABLE I).

Acceptability test

The test was conducted from 10 to 26 March 2010, six male lambs were used (15 ± 0.60 kg body weight (BW)) Dorper x Pelibuey, housed in individual pens of 1 m². The animals were adapted by 10 days (d) and the time of evaluation was in two periods of six d. Animals were fed at the same time with 500.0 g of each fruit ground of *C. alata* and *G. ulmifolia* in separate feeders by a period of two h daily between 07:00 and 09:00 h, before the oat hay based diet. The fruits position was rotated daily to avoid animal conditioning.

Study productive response

The study was conducted between April 13 to May 28, 2010, (10 d of adaptation and 45 d of evaluation), and were used 15 male lambs (13.9 ± 1.79 kg BW) Pelibuey x Dorper dewormed (Closantel 10 mg kg^{-1} BW) and ADE Vigantol vitaminized with 1 mL $animal^{-1}$. Animals were housed in individual pens for 1 m² and randomized into three treatments T1: oat hay (*ad libitum*: 0.6 kg dry matter (DM) basis) and 50 grams of ground corn, T2: oat hay (0.6 kg DM basis) and ground fruit of *G. ulmifolia ad libitum* (1.2 kg dry matter (DM) basis), T3: oat hay (0.6 kg DM basis) and ground fruit of *C. alata ad libitum* (1.2 kg DM basis).

Variables measured in animals

The study evaluated the acceptability of dry matter intake (DMI) of fruits, (NVF) to the feeder lambs in each fruit and duration of the visit (DVF). In response the study measured the dry matter intake (DMI) production and daily weight gain

(DGW). The DMI was measured by the difference of dry matter offered and rejected on each study day. The number of visits and the length was measured by direct observation during 2 h in the fruits that were provided. Body weight was recorded at 0, 15, 30 and 45 d [22]. The DGW was calculated by difference of the final weight minus initial weight and divided between testing days.

Experimental design and statistical analysis

The variable data were analyzed by variance and Tukey test at an alpha of 0.05 for comparison of means [24]. The chemical composition and digestibility parameters in fruits, the number and duration of visits to feeders, dry matter intake and weight gain in lambs were analyzed in a completely randomized design [24]. Dynamics of fruit consumption was analyzed in a factorial design arrangement 2 x 6, two fruits and six d of evaluation as periods with the Statistical Analysis Systems software (SAS) [24].

RESULTS AND DISCUSSION

Chemical composition and fruit digestibility

The fruit of *G. ulmifolia* had higher crude protein (CP) content (P<0.030) organic matter (OM) (P<0.020) and ME (P <0.010) with 82.0 g kg^{-1} DM, 950.3 g kg^{-1} DM and 5.6 MJ kg^{-1} DM, respectively (TABLE I). The fruit of *C. alata*, had higher neutral detergent fiber (NDF) content (P<0.007) with 489.0 g kg^{-1} DM (TABLE I). The fruit of *G. ulmifolia*, had higher total phenols (TP) content with 22.7 g kg^{-1} DM, however did not exceed 6.0% content of secondary compounds suggested for biomass of trees used in animal feed [19]. The chemical composition of the fruit is similar to that reported by other researchers for these species [7, 13, 21] which has justified its use in animal feed without risks to health.

In vitro gas production differences only at 24 and 48 h of incubation to 39°C between fruit indicate only that the fruit of *C. alata* is digested more rapidly, however, was not sufficient to reflect a difference in the digestibility of dry and organic matter (TABLE I).

Acceptability of fruit in lambs

The lambs had preference over the fruit of *G. ulmifolia* with 15.5 visits (P<0.007) and 3.2 minutes per visit to the feeder (P<0.001), which was associated with the highest intake of dry matter (189.4 g a^{-1} d^{-1}, P<0.001), compared to that observed on the fruit of *C. alata* (TABLE II). These results demonstrate higher palatability of fruit *G. ulmifolia*, due to higher content of crude protein (CP), metabolizable energy (ME), organic matter (OM) and lower neutral detergent fiber (NDF) content (TABLE I), reports palatable in this fruit have been published previously [6]; additionally Palma and Roman [20] observed that fruit of *G. ulmifolia* had greater acceptability in lambs with 160.8 g DM consumption.

In the dynamics of dry matter intake of the lambs was observed that the fruit of *G. ulmifolia* was more consumed from the first study with 153.6 g DM (P<0.001), and held for six d of

TABLE I
CHEMICAL COMPOUND (G KG^{-1} DM) FOOD AND FRUIT DIGESTIBILITY *G. ulmifolia* AND *C. alata*

Food		CP	OM	NDF	ADF
Oat hay		45.8	939.7	486.3	259.1
Corn		71.5	838.0	140.0	40.0
Nutrient		*C. alata*	*G. ulmifolia*	EEM	Pr>F
CP		68.0[b]	82.0[a]	0.43	0.030
NDF		489.0[a]	441.0[b]	1.18	0.007
ADF		375.7	340.5	1.84	0.110
OM		943.2[b]	950.3[a]	2.30	0.020
ME		5.0[b]	5.6[a]	0.18	0.010
TP		14.0[b]	22.7[a]	0.76	0.001
CT		11.9	12.0	0.38	0.760
Parameters digestibility					
IVDMD		342.0	363.0	4.00	0.560
IVOMD		322.6	345.0	3.60	0.400
IVGP (mL g^{-1} MS)	24 (h)	96.5[a]	67.2[b]	7.1	0.007
	48 (h)	136.2[a]	110.6[b]	10.0	0.035
	96 (h)	152.2	136.2	10.4	0.134

CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, OM: Organic matter, IVDMD: *In vitro* digestibility of dry matter, IVOMD: *In vitro* digestibility of organic matter, IVGP: *In vitro* gas production, ME: Metabolizable energy (MJ kg^{-1} MS), TP: Total phenols: Equivalent acid tannic, CT: Condensed tannins: equivalent to leucocyanidin. [ab] Quantities with different literal in a row indicates differences (P<0.05).

TABLE II
INGESTIVE BEHAVIOR AND CONSUMPTION *G. ulmifolia* AND *C. alata* FOR LAMBS

Treatments	Number of visits to feeders 2 h	Visiting time to feeders (minutes)	Intake (g) 2 h
G. ulmifolia	15.5[a]	3.2[a]	189.4[a]
C. alata	4.7[b]	1.5[b]	24.5[b]
SEM	5.5	0.539	25.1
Pr>F	0.007	0.001	0.001

[ab] Quantities with different literal in a column indicates differences (P<0.05). SEM: Standard error of means.

evaluation (FIG. 1). Consumption observed in lambs on the fruit of *C. alata* was low (28.0 g DM on the first d) and decreased at the end of the study to a consumption of 12.0 g DM a^{-1}, due to their low content of CP, ME and OM and the high content of NDF. Tamir and Asefa [26] reported a minimum requirement of 8.0% of CP for the proper functioning of the rumen microflora. Additionally, Espitia *et al*. [8] and Ejelonu *et al*. [9] reported that the fruit of *C. alata* containing compounds such as cyanide that could interact negatively with feed intake. Also, in other acceptability studies variations in dry matter intake were associated with the chemical composition, secondary compounds that confer organoleptic properties to food that interact with intrinsic physiological factors in the animal [6, 11].

Productive response in lambs

The Total DMI was higher (P <0.001) in lambs of T2 with 801.5 g a^{-1} d^{-1}, the difference was attributed to higher DMI, of animals to fruit of *G. ulmifolia* with 686.3 g a^{-1} d^{-1} (TABLE III), which is explains by higher preference of animals to this fruit (TABLE II) and chemical composition (TABLE I). Sikosana *et al*. [25] observed the same behavior in goats (*Capra hircus*) fed fruit *Acacia erioloba* and *A. erubescens*. Also Mahgoub *et al*. [15], Álvarez *et al*. [5] and García *et al*. [12] have demonstrated the utility of the fruits of *Prosopis juliflora*, *Enterolobium cyclocarpum* and *Acacia farnesiana* in small ruminants with intakes between 291.0 and 550.0 g a^{-1} d^{-1}

The DMI of lambs in the T3 was higher (P<0.001) on oat hay (360.2 g a^{-1} d^{-1}) which was due to low (P<0.01) consumption of fruit of *C. alata* (48.8 g a^{-1} d^{-1}) that had the animals (TABLE III) as a result of lower nutritional quality and low acceptability (TABLE I and II). The behavior in lambs of T3 indicates that some fruit trees used in animal feeding tests do not favor the consumption of dry matter. Sikosana *et al*. [25] report that DMI decreased in goats fed fruit of *Acacia nilotica*.

The oat hay intake by lambs of T1 was due to the low amount of dry matter provided in 50.0 g of ground corn (*Zea Mays*) (TABLE III). Daily weight gain (DGW) was higher (P <0.034) in lambs of T2 with 81.0 g a^{-1} d^{-1} compared to T1 and T3 lambs, which was associated with the highest DMI. Sikosana *et al*. [25] observed in goats fed with five fruits, which only

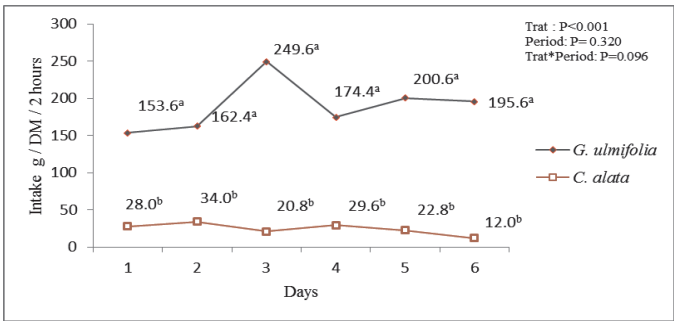

FIGURE 1. DYNAMICS OF CONSUMPTION OF THE FRUITS OF *G. ulmifolia* AND C. *alata*.

TABLE III
PRODUCTIVE PERFORMANCE OF LAMBS FED FRUITS OF *G. ulmifolia* AND *C. alata*

Parameter	T1	T2	T3	EEM	Pr>F
*DMI g/day^{-1}	400.5[b]	801.5[a]	409.1[b]	47.7	0.001
DMIOH g	350.5[a]	115.1[b]	360.2[a]	17.4	0.001
DMIF g	-	686.3[a]	48.8[b]	49.1	0.001
DGW g	2.9[b]	81.0[a]	3.7[b]	33.5	0.034

T1: oat hay (*ad libitum*) and 50 grams of ground corn; T2: oat hay and ground fruit of *G. ulmifolia ad libitum*; T3: oat hay and ground fruit of *C. alata ad libitum*; DMIOH: Dry matter intake oat hay, DMIF: Dry matter intake of fruits, DGW: Daily weight gain. [ab] Quantities with different literal in a column indicates differences (P<0.05). *The total dry matter intake (DMI) represents consumption based dry oat hay more corn on the T1 and fruits T2 and T3.

fed fruits of *D. cinerea* and *A. tortilis* won 4.8 and 13.3 g daily weight. Mahgoub *et al*. [15] used fruits of *P. juliflora* in small ruminants and obtained daily weight gain (DGW) of 76.0 g per animal.

CONCLUSIONS

The content of CP, OM and ME was higher in the fruit of *Guazuma ulmifolia*. The lambs had a preference for consumption of the fruit of *G. ulmifolia* and were basically determined by the contents of CP, OM and DM. The preference of lambs to the fruit of *G. ulmifolia* found more productive response in lambs fed oat hay more fruit of *G. ulmifolia*.

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