Spanish Journal of Agricultural Research
19 (4), e0611, 9 pages (2021)
eISSN: 2171-9292
https://doi.org/10.5424/sjar/2021194-16780
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

RESEARCH ARTICLE

OPEN ACCESS

Growth rate, scrotal circumference, sperm characteristics, and sexual behavior of mixed-breed goat bucks fed three leguminous trees

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Abstract

Aim of study: To investigate the effect of feeding foliage of leguminous trees on growth rate, semen characteristics, and sexual behavior of bucks.

Area of study: Northeastern Mexico.

Material and methods: Twenty-two young goat bucks were randomly allocated to one of four treatment groups: 33% alfalfa hay (dry matter basis), 33%; *Acacia farnesiana*; *Leucaena leucocephala*; or *Prosopis laevigata* foliage (n=4 for alfalfa; n=6 for the rest of groups).

Main results: Average daily gain (ADG) did not differ between bucks fed alfalfa, *A. farnesiana*, or *L. leucocephala* (120 ± 26, 134 ± 37, and 103 ± 29 g/d, respectively), but ADG of bucks offered *P. laevigata* was the lowest (72 ± 8 g; $p<0.05$). Bucks fed alfalfa had the highest feed efficiency (6.59 ± 1.25 kg of feed consumed/kg of gain; $p<0.05$) and bucks offered leguminous trees had the lowest (average 9.85 ± 2.3). Bucks offered alfalfa, and *A. farnesiana* had increased ($p<0.05$) scrotal circumference (26.6 ± 0.4 and 25.8 ± 1.5 cm) than bucks fed *L. leucocephala,* or *P. laevigata* (24.3 ± 1.2 and 24.1 ± 2.0 cm). Mean ejaculate volume was two-fold higher in alfalfa-fed bucks than all other dietary treatments. Sexual behavior did not differ among bucks fed the different legumes.

Research highlights: Foliage of both *A. farnesiana* and *L. leucocephala* could totally replace alfalfa hay for rearing growing goat bucks in confinement without affecting daily weight gain, most semen characteristics, and copulation ability. *P. laevigata* reduced body weight and reproductive function.

Additional key words: *Acacia farnesiana*; *Leucaena leucocephala*; *Prosopis laevigata*; weight gain; semen characteristics

Authors' contributions: Data acquisition: CZ, JS, JMM. Study design and drafted the manuscript: MM. Analyzed the results: AS, MM. Revised the manuscript and reviewed the pertinent literature: FGV, JEG. All authors read and approved the final version of the manuscript.

Citation: Zapata, C; Salinas, J; Moran-Martínez, J; de Santiago, A; Véliz, FG; García JE; Mellado, M (2021). Growth rate, scrotal circumference, sperm characteristics, and sexual behavior of mixed-breed goat bucks fed three leguminous trees. Spanish Journal of Agricultural Research, Volume 19, Issue 4, e0611. https://doi.org/10.5424/sjar/2021194-16780

Received: 02 Apr 2020. **Accepted:** 18 Oct 2021.

Funding agencies/institutions	Project / Grant
Sectorial Fund SAGARPA-CONACYT (Mexico) for Research in Agriculture, Animal Production, Aquaculture, Agrobiotechnology, and Phytogenetic Resources	2017-4-291691

Competing interests: All authors declare no actual or potential conflicts of interest between the authors and other people or organizations that could inappropriately bias their work.

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Introduction

Goat rearing in arid and semi-arid regions of the world is primarily an activity of small low-income farmers who raise their animals on natural vegetation and occasionally crop by-products. Fodder trees serve as a potential source of feed during most of the year (Vandermeulen *et al.*, 2018); thus, goats spend most of their time browsing and only switch their diets to forbs and grasses when sufficient herbaceous vegetation is available during the rainy season (Goetsch *et al.*, 2010). Goats in the study site exhibit a broad-scale, flexible, generalist/opportunistic feeding tactic consuming mainly foliage of trees and shrubs, forbs, and rarely grasses when browse availability is limited (Mellado, 2016). In arid zones, goats consume high amounts of *Acacia* and *Prosopis* species without negatively impacting these plants' regeneration. In areas of greater rainfall, goats also consume high amounts of *Leucaena leucocephala*. Thus, goats under traditional low-input production systems are exploited in chemically diverse grazing ecosystems, which ingest a great variety of plant secondary compounds. Goats provided with a choice of a large variety of shrubs containing a large diversity of phytochemicals consume combinations of shrubs that presumably reduced adverse effects associated with consumption of a particular toxin alone (Rogosic *et al.*, 2007).

The nature and role of some plant secondary compounds of forages ingested by goats are known (Estell, 2010), but some of their effects on reproductive function are incomplete. For example, the toxicity of *L. leucocephala* on specific reproductive organs has been well illustrated in Ethiopian highland sheep where testicular and epididymal size decreased (Dana *et al.*, 2000a). In addition, foliage of this tree (>40% DM) in diets for Myanmar goats reduced sperm cell concentration (Zun Wut Hmohn *et al.*, 2017). Likewise, dietary phenolic amines of *Acacia berlandieri* and *Acacia rigidula* reduces fertility of male goats (Forbes *et al.*, 1993; Vera-Avila *et al.*, 1997). Also, mesquite (*Prosopis juliflora*) pod extract fed to rats reduced testicular and glandular weights and decreased sperm motility, viability, and count (Retana-Márquez *et al.*, 2016).

We tested the hypotheses that secondary compounds concentration of leaves and twigs from mature *Prosopis laevigata*, *Acacia farnesiana* and, *Leucaena leucocephala* disrupts reproductive variables of male goats without interfering with the growth rate of these animals. The objective was to determine whether substituting alfalfa hay by leaves of *P. laevigata, A. farnesiana*, or *L. leucocephala* in diets for growing male goats affects weight gain, scrotal circumference, semen characteristics, and sexual behavior.

Material and methods

Study site

Animals were housed, fed, and managed in compliance with the guide for the care and use of agricultural animals, and all work with animals was approved by the Autonomous Agrarian University Antonio Narro (3001-2418). The study was conducted in northeastern Mexico (23°, 44' N, 99° 8' W) with an average maximum temperature of 31ºC and relative humidity of 65% during the study period.

Chemical analysis of diets

Feed samples offered to bucks were collected in triplicate and were ground to pass a 1 mm mesh using a Wiley mill. The dry matter of feeds was determined by oven drying at 105°C for 24 h (AOAC, 1995; ID 950.01). The crude protein (CP) concentration was calculated by determining the nitrogen content by the Kjeldahl method (AOAC, 1995; ID 976.05). The techniques described by Van Soest *et al.* (1991) were followed to assess neutral detergent fiber (NDF) and acid detergent fiber (ADF) using the Ankom 200 Fiber Analyzer (Ankom Technology, Macedon, NY, USA) with the addition of amylase and sodium sulfite solutions (AOAC, 1995; ID 989.03).

The condensed tannins (CT) of the leguminous trees were determined using the HCl-butanol method of Swain & Hillis (1959), using catechin as the reference standard. Given that CTs of alfalfa are only found in the bark of the seeds, this secondary compound was not determined in alfalfa.

Feeding trial

Twenty-two young goat bucks of undefined genotype (mixture of genotypes due to indiscriminate use of various-breed bucks for many years) of approximately 4 months of age and weighing on average 16.5 ± 2.1 kg were used in this study. This low weight-for-age was because young bucks were reared on natural rangeland without concentrate supplementation. The leguminous trees used in the feeding trial were abundant in the rangeland; therefore, these animals were accustomed to ingesting these forages. The animals were vaccinated against clostridiosis, dewormed, and kept in individual open-dirt pens. Bucks were randomly assigned to four diets containing 33% legume forage (dry matter basis). The control group (n=4) received alfalfa hay, whereas the other groups were offered *P. laevigata* (n= 6), *A. farnesiana* (n=6), and *L. leucocephala* (n= 6). The proportion of ingredients and nutritional compositions of experimental diets are listed in Table 1. The 30% forage of leguminous trees included in diets was chosen based on previous feeding trials with these forages (Ondiek *et al.*, 2000; Mahgoub *et al.*, 2005; Delgadillo-Puga *et al.*, 2019). All bucks had free access to water.

The forage consisted of leaves and twigs of full-grown leguminous trees in 5 ha. Leaves and edible soft stem parts of the foliage were dried in the air for two days and finely chopped with scissors (chops length 5-8 cm). The feeding test was carried out from January 31 to April 9, 2018. The feed was served once a day, calculating a feed rejection of approximately 5% of the feed offered.

The initial and final weight of the goats were recorded, as well as the daily weight gain, feed consumption, feeding efficiency, initial and final scrotal circumference, and initial and final body condition score (scale 1 to 5, where 1 is emaciated and 5 obese).

At the end of the feeding trial, bucks were trained for semen collection using an artificial vagina filled with water at

Table 1. Goat buck diet ingredients and chemical composition[1].

Item	Alfalfa	*A. farnesiana*	*L. leucocephala*	*P. laevigata*
Ingredient composition, % DM				
Sorghum hay	6.03	6.03	6.03	6.03
Alfalfa hay	32.7	—	—	—
Acacia farnesiana	—	32.57	—	—
Leucaena leucocephala	—	—	33.45	—
Prosopis laevigata	—	—	—	33.36
Sorghum grain	46.27	46.27	46.27	46.27
Soybean meal	7.87	8.0	7.12	7.21
Molasses	6.03	6.03	6.03	6.03
Mineral premix [2]	1.0	1.0	1.0	1.0
Salt	0.1	0.1	0.1	0.1
Chemical composition				
DM, %	85.0	84.2	83.9	85.3
Ash, % of DM	5.0	4.6	5.4	5.8
Neutral detergent fiber, % of DM	29.2	30.3	31.0	31.9
Acid detergent fiber, % of DM	15.6	15.8	16.9	17.6
Crude protein, % of DM	13.9	13.7	14.1	14.0
Ether extract, % of DM	2.0	2.2	2.1	2.7
Condensed tannins of trees, mg CE/g [3]	—	13.5	19.4	20.6

[1] Chemical composition and secondary compounds of the leguminous trees used in the present study are described in Zapata-Campos *et al.* (2020). [2] Premixed provided per kilogram of product: Mg: 20 g; Na: 120 g; S: 15 g; Cu: 100 mg; Zn: 2800 mg; Mn: 1000 mg; Co: 100 mg; Se: 25 mg; I: 80 mg. [3] CE= catechin equivalent; aqueous extract. DM: dry matter.

55°C. For this purpose, bucks were exposed to an estrogenized doe injected with 2 mg estradiol cypionate intramuscularly every third day. After the feeding trial, two ejaculates were collected at 7-day interval from 7:30 to 8:30 a.m from all bucks, except those offered *P. laevigata*. The scrotal circumference was measured during semen collection using a measuring tape surrounding the widest area of the testicles.

Immediately after semen collection, the volume of the ejaculate was determined by direct reading of a graduated semen collection tube. Sperm concentration was determined using a hemocytometer diluting a semen sample of 20 µL into 2 mL of distilled water (1:200 dilution). Gross motility was scored within 10 minutes of collection considering the swirling movement (from no swirling wave to rapid swirling wave on a 1–5 scale at a magnification of 400×). Several stained smears were prepared using nigrosine/eosin stain for estimating head and tail defects of sperm cells and the percentage of live spermatozoa. For these determinations, a total of 200 spermatozoa were examined using oil-immersion light microscopy using 1000× magnification.

Sexual behavior

Sexual behavior tests were conducted after the morning feeding, once a week during the last two weeks of the feeding trial. The test consisted of placing one buck into a small (2×2 m) enclosure with an estrogenized doe and allowing them to interact for 10 min. Variables recorded were frequencies of courtship (anogenital sniffs and leg kicks) and mounting (approaches and mount attempts) behaviors, flehmen lip curls and ejaculations (vigorous pelvic thrust followed by sexual inactivity for several minutes).

Statistical analyses

For growth traits, final body condition score, and scrotal circumference, a completely randomized design using the MIXED procedure of SAS (SAS Institute, Cary, NC, USA) was performed, with four diets and six or four replicates. The initial body weight was included in the model as a covariate. Means of treatments were compared for differences using the PDIFF option of SAS; pH, ejaculate volume, and sperm concentration per mL were analyzed using the MIXED procedure of SAS with the repeated measures function. The significant differences between group means were compared using the PDIFF procedure of SAS. The microscopic characteristics of sperm cells were subjected to an analysis of variance using the MIXED procedure of SAS for repeated measures as a function of the legume included in diets.

The sexual behavior variables had non-normal distribution according to the UNIVARIATE procedure of SAS. Therefore, these data were subjected to logarithmic transformation [log (X + 1)]. The transformed data were analyzed using the proc MIXED procedure of SAS for repeated measures to assess the effects of diets. Significant differences between groups were compared using the PDIFF option of SAS. For all statistical analyses, differences were considered significant at $p<0.05$.

Results

Table 2 shows the growth variables of goat bucks during the feeding trial. There were significant differences between diets in daily weight gain, with the lowest gain ($p<0.05$) for bucks offered *P. laevigata*; bucks offered all other legumes presented similar daily gains. There were significant differences between diets in daily dry matter intake, with the highest ($p<0.05$) intake for bucks offered *A. farnesiana* and the lowest ($p<0.05$) feed intake for bucks offered *P. laevigata* (38% less than *A. farnesiana*). Bucks fed alfalfa hay presented the greatest ($p<0.05$) feed efficiency compared with bucks fed the other legumes. Feed efficiency did not differ between bucks offered all other leguminous trees.

Diets significantly influenced final scrotal circumference; the widest ($p<0.05$) circumference was observed in bucks fed alfalfa and *A. farnesiana,* whereas scrotal circumference was similar for bucks offered all other leguminous trees. Change in scrotal circumference did not differ in goat bucks offered alfalfa or *A. farnesiana*; goat bucks offered *P. laevigata* had the lowest ($p<0.05$) change in scrotal circumference during the feeding trial. Diets did not significantly influence body condition score at the end of the trial.

Semen variables for young goat bucks fed alfalfa and leaves of leguminous trees are presented in Table 3. At the end of the feeding trial, four bucks receiving *P. laevigata* showed signs of illness and eventually died. Blood was collected post-mortem from the right chamber of the hearth, and its composition was analyzed. A common feature of the deceased bucks was thrombocytosis, neutrophilia, low serum creatinine concentrations, and high serum globulin levels. The remaining two animals in this treatment did not show libido; therefore, this treatment was discarded to compare semen traits and sexual behavior.

The diet containing alfalfa increased ($p<0.05$) the volume of the ejaculate compared to bucks fed either *A. farnesiana* or *L. leucocephala*. Compared with semen from bucks fed leguminous trees, semen pH of bucks offered alfalfa was 0.6 units lower ($p<0.05$). No differences in buck ejaculate concentration were detected between animals fed alfalfa hay or foliage of leguminous trees. Likewise, sperm gross motility, live sperm cells, and head and tail characteristics of sperm cells did not differ ($p>0.10$) among dietary treatments. Sexual behavior during the sexual performance test did not differ among bucks fed the different dietary treatments (Table 4).

Discussion

Feeding trial

Following 69 d of treatment, bucks on the *P. laevigata* treatment had a decreased daily weight gain compared with bucks offered all other leguminous trees or alfalfa. This response was due, in part, to the reduced feed intake of goat bucks offered *P. laevigata,* a response previously observed with increasing levels of this forage in goat´s diets (Mahgoub *et al.*, 2005). In fact, at the end of

Table 2. Body weight traits, feed intake, scrotal circumference, and body condition score of young mixed-breed (native × dairy breeds) goat bucks fed alfalfa or three leguminous trees. Values are means ± standard deviation.

Variables	Alfalfa	*A. farnesiana*	*L. leucocephala*	*P. laevigata*
Initial body weight, kg	15.5 ± 1.3	18.2 ± 2.6	14.8 ± 1.6	17.3 ± 2.6
Final body weight, kg	27.0 ± 1.4^b	31.1 ± 4.2^a	24.7 ± 2.2^b	25.0 ± 3.2^b
Average daily gain, g	120 ± 26^a	134 ± 27^a	103 ± 29^{ab}	72 ± 8^b
Feed intake, g/day	777 ± 67^c	1147 ± 38^a	1024 ± 18^b	710 ± 21^d
Feed efficiency, kg of feed consumed/kg of gain	6.53 ± 1.25^b	8.52 ± 2.01^{ab}	9.98 ± 2.87^a	9.82 ± 1.0^a
Initial scrotal circumference, cm	16.7 ± 2.9	15.4 ± 2.0	14.9 ± 2.1	16.4 ± 1.7
Final scrotal circumference, cm	26.6 ± 0.4^a	25.8 ± 1.5^a	24.3 ± 1.2^b	24.1 ± 2.0^b
Change scrotal circumference, cm	9.9 ± 1.9^a	10.4 ± 2.1^a	9.4 ± 2.0^b	7.7 ± 1.9^c
Initial body condition score [1]	1.8 ± 0.2	1.9 ± 0.3	1.8 ± 0.4	1.9 ± 0.6
Final body condition score [1]	2.6 ± 0.3	2.3 ± 0.4	2.0 ± 0.6	1.8 ± 0.9

[1] Scale 1 to 5, where 1 is emaciated and 5 obese. [a,b]Within rows means bearing different superscripts differ at $p\leq0.05$.

Table 3. Semen variables on fresh semen collected with artificial vagina for young goat bucks fed alfalfa hay, *A. farnesiana* and *L. leucocephala.* Values are means ± standard deviation.

Semen variables	Alfalfa	*A. farnesiana*	*L. leucocephala*
Ejaculate volume, mL	1.13 ± 0.62[a]	0.58 ± 0.14[b]	0.66 ± 0.23[b]
pH	7.0 ± 0.1[b]	7.6 ± 0.53[a]	7.6 ± 0.55[a]
Concentration, sperm cells/mL, ×10^6	1.22 ± 0.65	1.96 ± 1.11	1.36 ± 0.36
Total sperm per ejaculate, ×10^6	1.39 ± 0.62	1.13 ± 0.30	0.90 ± 0.28
Gross motility [1]	4.8 ± 0.4	4.7 ± 0.5	4.2 ± 0.4
Live sperm cells, %	84.1 ± 21.9	86.7 ± 28.5	86.1 ± 31.0
Sperm with abnormal head [2]	6.2 ± 1.3	5.3 ± 1.6	6.9 ± 1.9
Coiled principal piece, %	1.8 ± 0.9	0.4 ± 0.7	1.9 ± 0.9
Bent principal piece, %	1.7 ± 0.4	0.6 ± 0.5	1.5 ± 0.9

[1] Score 0-5; 0 = no swirls, 5 = rapid swirls. [2] Deviation in form and size. [a,b]Within rows means bearing different superscripts differ at p≤0.05.

the feeding trial, bucks consuming *P. laevigata* showed inappetence, drowsiness, dehydration, and shaggy hair. The lower feed intakes of the *P. laevigata* ration in the present study may be due to poor ration palatability due to the excessive ingestion of toxic chemicals present in the foliage of this leguminous tree (Shachi, 2012; da Silva *et al.*, 2018). The ingestion of these secondary compounds also explains the adverse health effects that eventually caused the death, at the end of the feeding trial, of four young bucks consuming *P. laevigata.* Even though *Prosopis* spp. is used mainly for feeding ruminants and horses around the world (William & Jafri, 2015), serious toxicity problems in goats have been reported in different countries when this plant constitute >50% of the diet (Tabosa *et al.*, 2000; Washburn *et al.*, 2002; Misri *et al.*, 2003).

However, diets containing 75% *P. cineraria* did not reduce goat weight gain (Bhatta *et al.*, 2007). Likewise, contrary to the present study, other authors have reported that daily weight gain of lambs (Obeidat *et al.*, 2008) and kids (Sirohi *et al.*, 2017) was not affected when *P. juliflora* pods were included at rates of 20% in diets. Under range conditions, despite the abundance of *P. glandulosa,* goats typically restrict the consumption of this tree to <20% of their diet (Mellado *et al.*, 2003, 2004), a strategy for reducing toxins ingestion through limiting the consumption of the foliage of this tree.

The daily weight gain of bucks did not differ between animals receiving alfalfa, *A. farnesiana*, and *L. leucocephala*, which showed that the foliage of these leguminous trees provided enough nutrients to maintain a body growth rate comparable to alfalfa and that these leguminous trees at the rate fed in the present study did not hamper the health of goat bucks. An extensive review by Patra (2009) showed that foliage of trees can be added to goat diets at levels up to 500 g/kg for improving feed utilization and animal performance. In coincidence with the present study, Srivastava & Sharma (2002) did observe pathological changes in vital organs in goats receiving pelleted diets containing 97% of *L. leucocephala*. However, diets containing 40-60% *L. leucocephala* (dry matter basis) resulted in body weight loss, salivation, dullness, and alopecia in Myanmar goat bucks (Zun Wut Hmohn

Table 4. Behavior frequencies during 10 minutes sexual performance tests for young goat bucks offered diets containing alfalfa hay, *A. farnesiana* and *L. leucocephala.* Values are mean ± SD.

Sexual behaviors	Alfalfa	*A. farnesiana*	*L. leucocephala*
Anogenital sniff	2.2 ± 2.3	3.7 ± 3.1	3.2 ± 3.9
Leg kick	4.8 ± 6.5	2.0 ± 1.7	7.1 ± 9.0
Vocalization	2.8 ± 3.5	1.2 ± 1.2	7.3 ± 8.1
Approaches to does	5.0 ± 6.2	2.8 ± 2.7	5.3 ± 5.6
Penile protrusion	3.2 ± 2.7	1.5 ± 1.2	4.7 ± 5.4
Flehmen lip curl	1.6 ± 2.6	1.0 ± 1.5	0.5 ± 0.8
Mount attempt	3.2 ± 2.8	1.5 ± 1.2	3.2 ± 2.5
Mount with ejaculation	0.8 ± 1.1	0.5 ± 0.6	0.8 ± 1.3
Latency to first mount, min	3.3 ± 1.5	3.4 ± 0.9	2.3 ± 0.6

For all variables, no statistical differences were detected (p>0.10).

et al., 2017). Also, Phaikaew *et al.* (2012) documented subclinical toxicity of goats fed *L. leucocephala* as the primary dietary component. The considerable discrepancies in animal responses to supplementation of *L. leucocephala* are the high variability in mimosine content of this leguminous tree (Soltana *et al.*, 2017).

Feed intake varied amply with diets; the highest feed intake was observed in bucks fed *A. farnesiana*, while goat bucks with the lowest feed intake were those offered *P. laevigata.* Again, secondary compounds of this leguminous tree such as alkaloids, flavonoids, prosogerin D, procyanidin, ellagic acid, tannins, and polystyrenes, among others (Zapata-Campos *et al.*, 2020) reduce palatability (Misri *et al.*, 2003) which explains the decreased feed intake. It is unknown specifically which of these secondary compounds negatively affect palatability of *P. laevigata,* but this effect derives from a post-ingestive feedback (Baptista & Launchbaugh, 2001).

It is worth mentioning that condensed tannins of *A. farnesiana*, *L. leucocephala*, and *P. laevigata* were far below the forage level in the forage to acts as a feeding deterrent (Provenza, 1995). Compared to the diet based on alfalfa, the higher feed intake of the diet, including *A. farnesiana,* can be due to the high nutritional quality of *A. farnesiana* for goats because of its high crude protein content (17.3%; Zapata-Campos *et al.*, 2020) and medium tannin contents (2.8%; Zhou *et al.*, 2011). This tannin concentration benefits ruminants in improving protein utilization without negatively affecting feed intake and nutrient digestion (Waghorn, 2008). Ramírez & Ledezma-Torres (1997) reported that replacing alfalfa with *A. farnesiana* did not affect forage intake and N utilization of goats. Also, the higher intake of diets containing *A. farnesiana* could be due to a lower nutritional quality of this diet, which forced bucks to increase feed intake to fulfill their nutrient requirements. Indeed, kg of feed/kg of weight gain was higher in bucks offered *A. farnesiana* than alfalfa (apparently bucks needed more feed to obtain a weight gain similar to that obtained with the diet containing alfalfa).

Even though feed intake was higher in bucks offered *A. farnesiana* or *L. leucocephala* as compared to alfalfa, the highest feed efficiency was recorded in bucks fed either alfalfa or *A. farnesian*a, signifying the overall adverse effect of secondary compounds on the growth performance in bucks offered *L. leucocephala* and *P. laevigata* forage. The lack of differences between diets containing alfalfa and *A. farnesiana* in terms of feed efficiency indicates that *A. farnesiana* forage would likely have similar digestibility. The high in vitro dry matter disappearance of *A. farnesiana* compared to other fodder leguminous trees has been previously documented (Garcia-Montes de Oca *et al.*, 2011). Other studies offering ≥40% *L. leucocephala* (Kanani *et al.*, 2006) or *A. farneisana* (Velázquez *et al.*, 2011) presented similar feed efficiency than diets containing alfalfa.

Reproductive traits

P. laevigata showed a detrimental effect on the health of bucks, which means that bucks were incapable of regulating absorption of ingested toxin or could not biotransform the secondary metabolites of this leguminous tree. The deteriorated health of the two survival goat bucks receiving *P. leavigata* impeded semen collection, and therefore this treatment was excluded for analysis of reproductive variables.

Both scrotal circumference and volume of ejaculate of bucks offered alfalfa was greater than that of bucks receiving leguminous trees. The mechanism of leguminous trees to substantially reduce these traits is uncertain; it could be that plant secondary metabolites of the trees fed to bucks in the present study somehow slowed down testicular functions. It is worth mentioning that, despite the highly toxic effect of *P. laevigata* on bucks in the present trial, consumption of this leguminous tree did not reduce testicular development when compared to bucks fed *A. farnesiana* and *L. leucocephala*. Partially in agreement with the present study, Mellado *et al.* (2006) observed that bucks on rangeland with higher levels of *Acacia greggii* in their diets yielded up to 50% less semen than bucks with a low proportion of this shrub in their diets. Contrary to the present results, other researchers have found an increased semen volume with supplementation of *Acacia* spp. or *L. leucocephala* in breeding rams (Dana *et al.*, 2000b; Gebreslassie *et al.*, 2021). The reduction in ejaculate volume with the addition of leguminous trees to diets could not be considered adverse since semen volume values were within the normal range for various breeds of goat bucks (Mellado, 2020).

Except for pH, which was lower in semen of bucks fed alfalfa, all other semen characteristics were not influenced by the forage source. In ruminants, pH of semen is slightly acidic, even though semen has a very high buffering capacity, higher than that of most other body fluids (Zhou *et al.*, 2015). It is important to note that the high semen pH values found in the present study do not seem to alter sperm physiology, and therefore, can be interpreted as standard, because this value is within the pH range in ram semen (Oláh *et al.*, 2013; Ozer Kaya *et al.*, 2020).

Results of the present study are in line with Akingbade *et al.* (2002), who did not find evidence that feeding *L. leucocephala* was detrimental to semen quality of Nguni goat bucks. Likewise, Dana *et al.* (2000b) documented the improvement of semen quality supplemented with *L. leucocephala* leaf hay compared with bucks receiving only chickpea haulm (*Cicer arietinum*). On the contrary, Zun Wut Hmohn (2017) observed a marked reduction in sperm concentration in the ejaculate of bucks fed 60% *L. leucocephala* compared to bucks not receiving foliage of this tree.

All sexual conducts of bucks did not differ among groups, which implies that bucks' libido, mating ability, and copulatory capacity were not impaired with 33% of *A. farnesiana* and *L. leucocephala* in the buck diets. These results also suggest that the plant secondary compounds of *L. leucocephala* and *A. farnesiana* did not perturb the synthesis of androgens and the release of LH and FSH from the pituitary gland.

In summary, these data indicate that alfalfa can be totally replaced by *A. farnesiana* and *L. leucocephala* in diets for young goat bucks where these legumes constitute 33% (dry matter basis) of the diet, without altering daily weight gain, feed efficiency, scrotal circumference, most semen characteristics, and copulating ability. Thus, these leguminous trees constitute important sources of nutrients for goats in confinement. However, 33% of *P. laevigata* in the diet for young bucks severely impaired the health of these animals, although it took nearly three months to become a recognizable health problem. Clearly, high levels of foliage of this leguminous tree should not be included in diets for growing goat bucks in confinement.

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