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Use of native forages for regional nutritional blocks as goat feed supplement

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Abstract

A completely randomized experimental design with three treatments and three replicates was used to evaluate the technical-productive and economic viability of incorporating tree foliage from the epiphytic native plant called graft (graft plant) (*Psittcanthus calyculatus*) into regional nutritional blocks (RNB). Two RNB were prepared in a first phase. One of them, named RNB-1, was prepared with 5 % urea, 40 % molasses, 4 % common salt, 6 % lime, 4 % cement, 24 % ground sorghum residues, 2 % minerals, and 15 % ground tree foliage from the plant graft. The other, named RNB-2, was prepared with 5 % urea, 40 % molasses, 4 % common salt, 6 % lime, 4 % cement, 14% ground sorghum residues, 2 % minerals, and 25 % ground tree foliage from the plant graft. Three treatments were formed, one called T-0, with goats that did not receive any type of RNB, another, called T-1, with goats that received RNB-1, and the third, called T-2, with goats that received RNB-2. RNB-2 showed better physical (hardness) and chemical characteristics (24.70 % crude protein and 10.65 % crude fiber), with costs of 4.40 pesos·kg^{-1}. In a second phase, the test of productive behavior was carried out, being both RNB preferred in the same way by goats ($P > 0.05$) and the supplementation with any of the RNB improved the increment of weight ($P < 0.05$). The artisanal elaboration of RNB was simple, economic, and promoted the efficient use of regional natural resources. This fact emphasizes the importance of rescuing and strengthening the roots of the rural population in local productive agricultural activities under schemes of sustainability and technological innovation and with own resources.

Keywords: Feeding, goats, grazing, supplementation, tree foliage.

Introduction

The Bajío region of Guanajuato includes regions in Guanajuato, Michoacán, and Jalisco, with high productivity for irrigated agriculture, but the productive potential may be low in some rainfed areas. The problems affecting the area are overexploitation of aquifers, which has led to depletion of groundwater tables, and deforestation of vegetation, which has reduced water catchment in aquifers (CONABIO, 2012). The low productive potential of rainfed and socially marginalized rural areas with scarce natural resources is a serious situation, due to the limited availability of traditional foods to sustain animal production and, thus, generate efficient and sustainable use of regional natural resources.

With respect to the scarcity of food for animal production, it is important to use other food alternatives that improve the living conditions of the rural population without causing problems in the ecosystems. However, the search for other regional food sources faces the problem of the presence of parasitic plants that develop on some trees and shrubs that produce foliage for small domestic ruminants, whose original potential distribution is poorly known. In this regard, there is a lack of knowledge of biology, physiology and other aspects of the species called grafts or mistletoes (Vazquez-Collazo and Madrigal-Huendo, 2005). On the other hand, knowledge of the attributes of forage resources is fundamental for planning successful efforts in their agricultural use, reforestation and the maintenance of biodiversity. In

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this context, growth of the urban sprawl, reduced space for each tree, pollution, extinction of water tables, and lack of maintenance have favored the infestation of trees with this type of plant.

There are 4 000 species of parasitic plants worldwide, 300 of which are hemiparasites, and 200 of these species are located in the Americas (Press and Phoenix, 2005). These plants affect competition between species, including community structure and diversity, resource availability, plant-pollinator and plant-herbivore interactions, and seed dispersers, which is why they are considered key elements within ecosystems, because they have a great influence within the community, out of proportion to their own abundance or biomass.

The species *Psittacanthus calyculatus* (graft or mistletoe), which grows preferentially on mesquite trees (*Prosopis glandulosa*), has been found in the state of Guanajuato, causing intense damage and even the death of the host (Figure 1). This preference for mesquite could be explained by the fact that both have occupied the same environment for a long time, to the fact that the parasitic plant chooses hosts with good nutrient supply such as legumes and specifically to the efficiency to extract potassium from mesquite. There is concern about the frequency of graft infestation of trees throughout the Bajío region, clearing areas where mesquite forests were exterminated for agriculture. The presence of mesquite trees has provided great benefits to the soil, such as fertilization, due to nitrogen fixation, water conservation and infiltration, as a melliferous plant and firewood producer, in addition to the fact that its wood is highly valued for its hardness (CONABIO, 2012).

The graft is an endemic plant considered to have some nutritional value for goats, as local producers decide to carry out manual activities to harvest tree foliage to be fed to these animals, recently reporting that the proximal chemical analysis of leaf, stem and flower showed adequate crude protein content (Serrano, 2010).

The national goat herd is mainly found in arid and semi-arid zones, corresponding to 60 % of the country, and extends from south to north, mainly in the states of Puebla, Oaxaca, San Luis Potosí, Guerrero, Coahuila, Zacatecas, Guanajuato and Michoacán. Currently, goat production continues to be associated mostly with lower-income strata of the rural population, with 80 % based on subsistence production systems. It is estimated that 1.5 million Mexicans make their living from goats, which are found in 450 000 production units. Goats have demonstrated aptitude to be a profitable livestock production, because they are a species resistant to drought and forage scarcity, allowing them to develop as a source of savings for many marginalized families (Andrade Montemayor, 2017; Guerrero, 2010).

Figure 1. Graft plant (*Psittacanthus calyculatus*) growing on a mesquite tree.

It has been observed (Pittoff, 2004) that goats have a great influence on agricultural activities carried out by the rural population and that they have a multiple purpose, because they play a fundamental role in food security for marginalized rural populations. However, goat production has maintained itself without significant technological changes in most of the productive situations in which it has been developed in our country. On the other hand, thanks to the capacity of the goat species to survive under difficult environmental conditions in the arid and semi-arid zones of Mexico, animal production with this species represents an extremely important activity that is developed in most cases as a complement to other agricultural activities (FAO, 2005; Morand-Fehr et al., 2004).

Goat farming in the Bajío region is characterized by an extensive transhumant grazing production system, where native animals feed on native forages that are often scarce and have little nutritional value (Figure 2). These situations require an immediate solution because of the serious deterioration of natural resources caused by inadequate goat production management (Mariscal y Pérez, 2021).

From an economic point of view, the practice of supplementing goats with commercial concentrates to satisfy nutrient demands is not very profitable for the small-scale producer, especially in the dry season with seasonal rainfall, when low nutritional quality and the small amount of available forage negatively affect animal production and reproduction. Furthermore, it is important to emphasize the technical necessity of an adequate animal supplementation for a balanced ruminal function that favors the degradation of fibrous food through the constant supply of nutrients and energy for the animal. Therefore, nutritional blocks should be used as an animal feed supplement to improve the efficiency of the basal diet at an acceptable cost (Martínez, 2010). The objective of the research was to evaluate the technical, productive and economic viability of using native tree foliage of the parasitic plant called graft (graft plant) to produce regional nutritional blocks (RNB), which contained different levels of inclusion of the graft plant in a traditional way, and the effect of using them, considering their physical and chemical characteristics and the productive behavior of goats in an extensive transhumant production system.

Materials and Methods

The experimental trial was carried out at the Centro de Bachillerato Tecnológico Agropecuario No. 105, La Estrella, Pénjamo, Guanajuato, Mexico, using a completely randomized experimental design with three treatments and three replicates. In the first phase (Phase I), regional nutritional blocks (RNB) were elaborated in an artisanal manner and manufactured following the procedure described by Sansousy (1986), using the following ingredi-

Figure 2. Goats typical of the Bajío region of Guanajuato in an extensive transhumant grazing production system.

ents in different proportions: urea, molasses, common salt, minerals, lime, cement, ground sorghum residues, ground tree foliage from the graft plant and water. RNB-1 was prepared with 5 % urea, 40 % molasses, 4 % common salt, 6 % lime, 4 % cement, 24 % ground sorghum residues, 2 % minerals, and 15 % ground tree foliage from the plant graft. The other, named RNB-2, was prepared with 5 % urea, 40 % molasses, 4 % common salt, 6 % lime, 4 % cement, 14% ground sorghum residues, 2 % minerals, and 25 % ground tree foliage from the plant graft. Three treatments were formed, one called T-0, with goats that did not receive any type of RNB, another, called T-1, with goats that received RNB-1, and the third, called T-2, with goats that received RNB-2. RNB-2 showed better physical (hardness) and chemical characteristics (24.70 % crude protein and 10.65 % crude fiber), with costs of 4.40 pesos·kg^{-1}. In a second phase, the test of productive behavior was carried out, being both RNB preferred in the same way by goats ($P > 0.05$) and the supplementation with any of the RNB improved the increment of weight ($P < 0.05$). The artisanal elaboration of RNB was simple, economic, and promoted the efficient use of regional natural resources. This fact emphasizes the importance of rescuing and strengthening the roots of the rural population in local productive agricultural activities under schemes of sustainability and technological innovation and with own resources. RNB-2 was also prepared with 5 % urea, 40 % molasses, 4 % common salt, 6 % lime, 4 % cement, 14 % ground sorghum residues, 2 % minerals and 25 % ground tree foliage from the plant graft. RNB-1 and RNB-2 were prepared as follows: urea, molasses, common salt, minerals and water were weighed and mixed until a homogeneous material was obtained with a semi-paste consistency containing ground sorghum residues and ground tree foliage from the graft plant.

Then a mixture of lime, cement and water (slurry) was added and finally all the ingredients were mixed mechanically and manually with a shovel until a semi-solid preparation was produced. Finally, portions of the mixture were poured and compacted with the help of the compression lever of a square metal mold with a capacity of 5 kg. The RNB produced were placed in a shaded, dry and cool place to dry and solidify for eight days (Robles, et al., 2022). The metal mold for handmade manufacture of the RNB was designed and constructed according to the technical-zootechnical characteristics and measures 20 cm x 20 cm x 15 cm and an approximate capacity of 5 kg (Figure 3). Quality of the RNB was evaluated by means of physical, chemical and preference characteristics.

In a second phase (Phase II), a productive behavior test was carried out. Treatments were formed and characterized as: T-0: goats receiving no RNB; T-1: goats receiving RNB-1 and T-2: goats receiving RNB-2. Each pen was considered as an experimental unit housing three goats. A total of 18 male goats averaging six months of age and weighing 16-17 kg were used. The tree foliage of the graft plant was collected manually from mesquite trees (*Prosopis*

Figure 3. Metallic mold used for the handmade manufacture of the RNB. La Estrella, Pénjamo, Guanajuato.

glandulosa) in the surrounding rural communities representative of the extensive transhumant goat production system, using a piece of wood with the adaptation of a metal hook. The collection of the tree foliage of the plant graft was carried out during the months of April, May, June and July 2019. The tree foliage of the grafted plant was dried under shaded conditions and ground in a hammer mill, subsequently it was placed in boxes and stored.

Each animal was individually identified with a plastic number, castrated, vaccinated and dewormed fifteen days before the experimental period. In addition, the animals received application of vitamins A, D and E. The goat herd that was considered for the experimental trial began extensive grazing and transhumance at 10:00 a.m., feeding at the edges of rural roads, highways, railroad tracks, abandoned agricultural lands and in other irrigated agricultural areas where cereal grain had recently been harvested. Subsequently, the goat herd returned to the producer's rustic pens at 18:00 hours, for an estimated 9.0 h of grazing time.

During this period of extensive grazing and transhumance, the goats consumed botanically identified native forages such as switchgrass (*Melinis repens*), sideoats grama (*Bouteloa curtipendula*), blue grama (*Bouteloa gracilis*), rhodes (*Chloris gayana*), and African lovegrass (*Eragostis curvula)*. They consumed shrub forages such as huizache (*Acacia farneciana*), mesquite (*Prosopis glandulosa*) and tree forage of the graft plant (*Psittcanthus calyculatus*), as well as agricultural residues and residual leaves of sorghum (*Sorghum bicolor* L.). The nutritive value of the diet consumed by the goats under these conditions was not identified and it was assumed that it provided nutrients to cover limited maintenance and production requirements.

Once they returned to the corrals, the animals that were grazing extensively transhumant were housed in collective pens (6 m^2) adapted with a wooden feed trough (0.8 m long), with capacity for three animals, offering the RNB *ad libitum* in these troughs from 19:00 to 8:00 hours and in a period of 13 h. The response variables were production cost, physical characteristics (hardness) and chemical characteristics (crude protein and fiber content) of the different RNB in Phase I. During Phase II, preference, consumption and weight change of the goats were evaluated.

The cost of production per kilogram of processed RNB was estimated by a net margin analysis, using the price of each ingredient and labor. The evaluation of RNB hardness was carried out with a penetrometer and by hardness to touch and color criteria. The chemical composition of ground sorghum grain, ground tree foliage from the graft plant and each of the two RNB was determined by proximate chemical analysis (AOAC, 2000).

The animals were adapted during a period of 15 days to night supplementation and to the RNB preference test in a rustic pen with a dirt floor, protected from sun and rain, simultaneously offering these RNB in a simple wooden feed trough for 5 d. The period from day 6 to day 15 was considered the experimental period when evaluation was carried out. Daily, the voluntary consumption of each of the RNB was recorded by the difference between the amount of RNB offered and rejected from 19:00 to 8:00 hours during a period of 56 d.

The weight change of the goats was determined every 15 d with a previous fasting of 12 h using a scale with a capacity of 250 kg and by the procedure of difference between the weight of the previous record and the current weight. The data collected were organized using an Excel spreadsheet and analyzed by ANOVA and Tukey's mean comparison test (SAS Institute Inc., 2016).

Results and Discussion

RNB production was simple and cost-effective, because low-cost regional ingredients from the producers were included and, in the case of the tree foliage of the graft plant, it had no added value. The two types of RNB had a hardness of 3 $kg_{f}.cm^{-2}$, without evident crumbling, with dark brown color and pleasant molasses odor, taking into account the hardness test to the touch, color and odor, supporting with this the importance of having a hard stone-like consistency in the blocks to be consumed by the animals only through the use of the tongue to favor limited and progressive consumption (Martínez, 2010).

The drying time and hardness of the two types of RNB elaborated in this research was 8 d, which is similar to the 7 d reported by Martínez (2010), when elaborating nutritional blocks using foliage from different trees. This is an important aspect, because other results published 21 d necessary to reach the desired hardness when making nutrient blocks from corn residues (Herrera, et al., 2002).

The production cost of the supplementation sources produced in this research was 60 % lower compared to the commercial block of mineral salts (7.50 pesos$\cdot kg^{-1}$). This confirms the importance of community development projects, which aim to improve livestock feeding in times of drought and create a sustainable environment in rural areas.

The development of this research allowed the elaboration of a solid nutritional supplement that offers us the opportunity to use forage resources left over during the rainy season and to transform, store and use them when there is a scarcity of forage. This is confirmed by Martínez (2010), stating that the use of nutritional blocks by livestock is an aspect that should be analyzed, since the main value of these blocks is to provide the nutrients needed by the animals as a supplement during critical periods.

Regarding the nutrient content of the RNB, the results of the proximate chemical analysis highlight the adequate

crude protein (CP) content in RNB-1 and RNB-2, with amounts of nitrogen-free extract (NFE) and crude fiber (CF) that provide good availability of digestible energy for the animals (Table 1).

Regarding the productive behavior of the goats and when evaluating preference, consumption and weight change of goats under extensive transhumant production system conditions supplemented in confinement overnight with the two types of RNB containing tree foliage of the graft plant, it was observed that the animals showed good preference for all RNB. The voluntary consumption of RNB in goats was found to be no different according to the type of RNB offered ($P < 0.05$). Supplementation of goats with RNB containing tree foliage from the graft plant showed no difference in weight change (0.06 $kg \cdot d^{-1}$ for RNB-1 and 0.05 $kg \cdot d^{-1}$ with RNB-2) ($P < 0.05$), but it was different when these two types of RNB were compared with animals that received no RNB, where the supplemented goats gained on average 0.06 $kg \cdot d^{-1}$, while the non-supplemented goats gained 0.03 $kg \cdot d^{-1}$ (Table 2).

Conclusions

The handmade production of two types of RNB was simple and promotes the economically profitable, efficient and sustainable use of native forage resources and the tree foliage of the graft plant. The two types of RNB showed good hardness and adequate nutrient content for supplementation of goats under an extensive transhumant grazing production system. RNB-1 and RNB-2 were equally preferred and consumed by goats and improved on average weight gain (55 $g \cdot d^{-1}$), compared to goats that were not supplemented with any type of these RNB (30 $g \cdot d^{-1}$). These results highlighted the importance of rescuing and strengthening the roots of the rural population in local productive agricultural activities under schemes of sustainability and technological innovation and with their own resources.

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Table 1. Proximal chemical analysis of ingredients and types of regional nutritional blocks (RNB) fed to goats in the community of La Estrella, Pénjamo, Guanajuato.

Fraction (%)	Ingredients and types of RNB			
	Ground sorghum residues	Ground foliage of the graft plant	RNB-1	RNB-2
DM	85.00[1]	90.00	90.00	92.00
CP	4.58	21.14	21.95	24.70
NFE	44.19	39.14	34.68	27.96
Ethereal extract	0.45	3.11	0.66	1.23
Crude fiber	19.87	23.44	10.64	10.65
Ash	25.81	7.74	25.50	26.25

RNB-1: regional nutritional block-1; RNB-2: regional nutritional block-2; DM: dry matter (%); CP: crude protein (%); NFE: nitrogen free extract (%); EE: ethereal extract (%); CF: Crude fiber (%); A: Ash (%). All values were estimated on a dry basis (AOAC, 2000).

Table 2. Productive performance of goats supplemented with regional nutritional blocks (RNB) under an extensive transhumant grazing production system in the community of La Estrella, Pénjamo, Guanajuato.

Experimental treatment	Production performance parameters			
	Total RNB consumption ($kg\ 56 \cdot d^{-1}$)	Daily RNB consumption ($kg \cdot d^{-1}$)	Total weight change ($kg \cdot d^{-1}$)	Daily weight change ($kg \cdot d^{-1}$)
T-1	4.66[a]	0.08[a]	3.17[a]	0.06[a]
T-2	5.22[a]	0.09[a]	2.98[a]	0.05[a]

Different letters between columns are statistically different ($P < 0.05$).

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