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Productive parameters and carcass yield of rabbits supplemented with *Leucaena leucocephala* (Lam.) de Wit., and *Guazima ulmifolia* Lam. foliage

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ABSTRACT

Objective: To determine the effect of the addition of *Leucaena leucocephala* and *Guazima ulmifolia* foliage on the production parameters and carcass yield of New Zealand rabbits.

Desing/methodology/approach: 30 rabbits (15 females and 15 males) of the New Zealand breed were used, distributed in three treatments (five females and five males), which consisted in feeding 200 g of concentrated food per day + 100 g of fresh *L. leucocephala* or *G. ulmifolia* foliage, and a control group with no supplementation.

Results: The total voluntary intake was not affected by the treatments or gender of the rabbits; an average value of 158.9 g day^{-1} was recorded. Weight gain was 27.2 g day^{-1} on average. The average slaughter weight of the rabbits was 2523 g. The carcass weight was 1,297 g and the average carcass yield was 51.6%. The dissectable fat content was lower in rabbits on supplements (F=6.70, P=0.001) with values of 1.6, 1.8 and 2.11% with fresh foliage of *G. ulmifolia*, *L. leucocephala* and without supplementation, this variable was not affected by gender. The viscera proportion was on average 24.3%. The average meat: bone ratio was 5.6.

Limitations on study/implications: It was not possible to carry out bromatological analyzes of the foliages or their digestibility.

Fingings/conclusions: Supplementation of rabbits with foliage of *G. ulmifolia* and *L. leucocephala* decreases the proportion of dissectable fat and did not affect the production parameters and carcass yield.

Keywords: Weight gain, meat:bone ratio, rabbit breeding, carcass quality.

INTRODUCTION

Livestock is the main source of protein for human populations. It is also an excellent source of nutrients of high biological quality, calcium, iron, zinc, vitamin A availability (Black *et al.*, 2008), and easily provides the necessary amount and variety of essential amino acids (Ayala, 2018). It has also been shown

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that manipulating the diet can increase in rabbit meat the presence of functional compounds, such as essential fatty acids, short-chain fatty acids, EPA, DHA, CLA, vitamin E, and selenium (Dalle and Szendrö, 2011). In 2018, the meat production of the main livestock species (cattle, pigs and poultry) was 337.3 million tons (FAO, 2019) with a forecast increase of 13% by 2026 (OECD / FAO, 2017). However, the high consumption of red meat has been directly related to the presence of cardiovascular and degenerative diseases (Pino *et al.*, 2009). In this sense, white meats present a dietary option, due to a higher content of essential nutrients and lower fat and sodium content (Cossu and Capra, 2014; Dalle 2002). Rabbit meat is a white meat that despite its excellent biological quality, its consumption has lagged in Mexico, even with government programs to encourage its production and consumption (Olivares *et al.*, 2009). It is currently proposed as a promising species to supply high quality meat from sustainable production models, which given the current levels of natural resources deterioration is widely accepted by society (SAGARPA/SENASICA, 2015; Criado-Flórez and Deháquiz-Mejía, 2019). For this species, the foliage of arboreal and shrub species can be used, due to the presence of a caecum that allows them to select and excrete indigestible fiber from their tract, and extract low-quality protein (Mora-Valverde, 2010). This allows a low dependence on grains and other inputs, a reason that explains the acceptance of this activity by small producers in backyard systems (Gutiérrez *et al.*, 2017), where the inputs are minimal, with low productivity rates (Olivares *et al.*, 2009).

The acceptance of rabbit meat and its by-products in Mexico is still low and is mainly focused on the central region of the country where cultural factors have a high impact on such acceptance (Olivares *et al.*, 2009; SADER, 2015). However, in rural areas throughout the different geographical regions of the country, wild rabbits are consumed (Fernández *et al.*, 2015) and are preferred over farms raised rabbits because consumers differentiate the products from both (González-Redondo *et al.*, 2008). This is due to the genetic differences of rabbits and the way of life (González-Redondo *et al.*, 2010) including food. It has been proposed that the organoleptic characteristics of the meat from herbivores are associated or influenced by the number of compounds or metabolites in the foliage they consumed. In this sense, an option to improve the profitability of rabbit production units and the quality and acceptance of their meat is to use shrub and arboreal plant species with forage properties. Therefore, the objective of the present research was to determine the effect of including foliage from *L. leucocephala* and *G. ulmifolia* on the productive parameters and yield of rabbit carcass.

MATERIALS AND METHODS

Location

The research took place at the rabbit area of the Colegio de Postgraduados, Campus Campeche. Located at kilometer 17.5 of the federal highway Haltunchén-Edzná in Champotón municipality, Campeche. Located at 19° 29′ 56.80″ N - 90° 32′ 34.65″ W; 19° 29 ′46.02″ N - 90° 32′ 21.89″ W; 19° 29 ′48.01″ N - 90° 31′ 56.64″ W; 19° 30′ 11.56″ N - 90° 32′ 13.55″ W. The region is dominated by a warm subhumid climate with rains in summer (García, 2004). Annual precipitation varies between 900 and 1200 mm. The site has a mean annual temperature of 25.5 to 26.4 °C and an elevation of 21 m. The slaughter and evaluation of the carcass were carried out in the Meat Workshop of the Instituto Tecnológico de Chiná.

Treatments description

Three treatments were evaluated, treatment 1 (T1) consisted of 200 grams of commercial balanced food+100 grams of fresh *L. leucocephala* foliage. Treatment 2 (T2) consisted of 200 grams of commercial food+100 grams of fresh *G. ulmifolia* foliage and a control treatment (TC) that consisted of 200 g of commercial balanced food with 17% CP. The foliage of the two evaluated species consisted of leaves with tender stems.

Handling of rabbits

Thirty rabbits (15 females and 15 males) of the New Zealand breed were used, weaned at 45 days age with an average initial weight of 275±25 g. Ten animals per treatment (five females and five males) were randomized. They were housed in three metal cages with a capacity of 10 rabbits each, with individual housings of 0.4×0.6×0.9 m. Each cage had an automatic nipple drinker and a hopper-type feeder (Figure 1). At the beginning of the experiment, the animals were dewormed and vitaminized. They were adapted to the experimental diet for one week.

Variables

Voluntary consumption: during the six weeks that the field phase lasted, the rabbits were fed at 8:00 am. Next, the food offered was weighed and left for 24 h. The next day the rejected food was removed and weighed. The values of the fresh weight of the food offered and

Figure 1. Distribution of treatments T1: *Leucaena leucocephala*, T2: *Guazuma umlifolia*, T3: commercial concentrated food.

rejected were converted on a dry basis, using the equation

$$vc = Of - Rf$$

where *vc* = voluntary consumption, *Of* = offered food (g) and *RF* = rejected food (g).

Daily weight gain: rabbits were individually weighed every seven days after a six-hour fast. The weighing was carried out on an electronic scale with a 40 kg capacity. To calculate the daily gain, the following formula was used:

$$DWG = \frac{Fw - Iw}{7}$$

where *Fw* = final weight (g), *Iw* = initial weight (g) and 7 = number of elapsed days. At the end of the field stage, the rabbits were sacrificed based on NOM-033-SAG / ZOO-2014.

Carcass performance: is the percentage relationship between the carcass weight (after removing blood, viscera, skin, head and legs) and the live weight, before slaughter. The performance in fresh carcass was assessed during gutting, then kept for 24 hours in a cold room at 4 °C where the carcass yield in cold was determined. The formula

$$CY(\%) = \left(CW(g) \div LW(g)\right) \times 100$$

was used. Where: *CY* = carcass yield, *CW* = carcass weight and *LW* = live weight.

Meat: bone ratio: after slaughter, the carcasses were left for 24 h in 4 °C refrigeration where the carcasses were weighed. Boning was then carried out, thus obtaining the meat weight and bone weight, for which the following formula was used.

$$M{:}B = \text{Meat weight}/\text{Bone weight}$$

Data Analysis

The data were organized in a random block design, where the levels were male and female. Subsequently, an ANOVA was performed with a GLM model and a test of means comparison via the Tukey test, $P<0.05$, in the Statistica 7.1 statistical software (StatSoft, 2005)

RESULTS AND DISCUSSION

Consumption of concentrated food was not influenced by treatments, sex, or their interaction ($P>0.05$). Consumption of 156.3, 162.4 and 158.2 g were recorded in rabbits supplemented with *L. leucocephala*, *G. ulmifolia* and with no supplementation. Therefore, it is assumed that the usage of the evaluated species of foliage of does not affect balanced feed consumption. Regard gender, average consumption of 145.6 and 172.3 g was observed for males and females respectively. The total consumptions observed in this study were higher than those reported by Deshmukh *et al*. (1993), who reported a total of 68.5 g DM day^{-1} from *Morus alba*.

The treatments did not influence the daily weight gain ($P>0.05$), registering averages of 24.5, 28.4 and 28.7 g in rabbits supplemented with *L. leucocephala*, *G. ulmifolia* and without supplementation. The values observed here are higher than those reported by Villa-Ramírez and Hurtado-Villegas (2016). They report daily weight gains of 5.3 g in rabbits fed with silo grasses of *Axonopus scoparius* and *Tithonia diversifolia* (Hemsl.) and *Morus alba* foliage fodder, and 5.2 g day^{-1} with silos of the same grass and *Boehmeria nivea* foliage. For their part, Nieves *et al*. (2009) reported weight gains of 29.49 g day^{-1} in New Zealand rabbits fed with *L. leucocephala* foliage, these values are similar to those reported here. Male and female rabbits increased their weight by 27.5 and 27.2 g day^{-1}, each, with no statistical differences

(P>0.05). The interaction of the supplementation type and the gender had no statistical effect. Also, Castaño and Cardona (2015) reported higher daily weight gains than those presented here, in male and female rabbits, with diets based on concentrated food plus *Tithonia diversifolia*, *Arachis pintoi* and *Trichanthera gigantea* foliage, with averages of 47, 44 and 42 g day^{-1}.

The treatments affected the weight at sacrifice after a six weeks experimental period (F=5.377, P=0.021), with average weights of 2.399; 2.574 and 2.597 g for the rabbits supplemented with *L. leucocephala*, *G. ulmifolia* and with no supplements, respectively. The gender of the rabbits had no effect on the live weight at the time of sacrifice and averages of 2.498 and 2.548 g for males and females. Regard the interaction between treatment and gender, no differences were observed (P>0.05) (Table 1). The slaughter weight was higher than that reported by Nieves *et al*. (2009), who obtained a slaughter weight of 1.810 g on rabbits supplemented with arboreal species foliage; and that reported by Cornejo-Espinoza *et al*. (2016) with 2.050 g average in rabbits with different *ante mortem* fasting periods.

The carcass weight had no changes due to the study factors (P>0.05), with average weights of 1.354, 1.220 and 1.319 g for rabbits supplemented with fresh *L. leucocephala*, *G. ulmifolia* foliage and no supplementation, respectively. The carcass weight by gender of the analyzed rabbits had a 1.261 and 1.334 g average for males and females. In the food × sex interaction, no differences were observed (P>0.05) (Table 1). Lower carcass weights were reported by Martinez *et al*. (2010) in rabbits with *Hibiscus rosa-sinensis* L. or *Brosimum alicastrum* Sw. restricted foliage supplementation and values of 790.5 and 822.0 g, while with free access 933.5 and 951.3 g.

The treatments did not affect carcass yield (P>0.05) with mean values of 51.9, 51.7 and 51.3% in rabbits supplemented with *G. ulmifolia*, *L. leucocephala* fresh foliage and with no supplements. In this sense, the gender of the rabbit did not affect the carcass yield (P>0.05), with observed values of 51.5 and 51.7% for males and females. The supplementation × sex interaction had no statistical difference (F=12.72, P=0.001). The highest value was in females supplemented with *G. ulmifolia* foliage with 53.6%, while the lowest was in male rabbits supplemented with *G. ulmifolia* foliage (Figure 2). The carcass yields in the present study are lower than those reported by Cornejo-Espinoza *et al*. (2016) who obtained average yields of 56.1% in rabbits fed with concentrated feed under commercial conditions. Yet, higher than those reported by Martinez *et al*. (2010) of 48.9 and 48.2% in rabbits supplemented with *H. rosa-sinensis* L. or *B. alicastrum* Sw. foliage.

The dissectable fat content (scapular and perirenal) in the carcass was influenced by the treatments (F=6.70, P=0.001) 1.6, 1.8 and 2.11%, for rabbits supplemented with fresh *G. ulmifolia*, *L. leucocephala* foliage and without supplementation. Likewise, a greater dissectable fat accumulation was observed in male rabbits compared to female rabbits with averages of 2.1 and 1.5% respectively (F=10.31, P=0.001). In the interaction supplementation and rabbit gender, no effect was observed on the fat accumulation in the rabbit carcass (P>0.05) (Table 1). The dissectable fat contents were higher than those reported by Martinez *et al*. (2010) in rabbits with restricted *H. rosa-sinensis* L. or *B. alicastrum* Sw. foliage supplementation and values of 0.27 and 0.26%, while with foliage free access values of 0.96 and 1.48%.

No effect of treatment, gender and their interaction was observed (P>0.05) concerning the weight of the

Table 1. Characteristics of the carcass of rabbits supplemented with fresh *L. leucocephala* and *G. ulmifolia* foliage.

Treatment	Sex	Weight (g)	PFC (g)	Viscera (%)	Fat (%)	R. C:H
Leucaena leucocephala	M	2589±13	1352±68	20.9±1.00	1.9±0.25^{a}	5.6±0.9
	H	2560±52	1315±44	25.1±1.32	1.7±0.12^{ab}	5.1±0.2
Guazuma ulmifolia	M	2411±14	1215±151	25.8±4.21	2.1±0.51^{a}	5.6±0.1
	H	2386±48	1288±45	24.1±0.73	1.1±0.05^{b}	5.5±1.2
Commercial concentred food	M	2494±185	1302±122	25.0±5.67	2.4±0.41^{a}	6.5±0.2
	H	2699±86	1368±104	24.9±1.02	1.9±0.34^{ab}	5.4±0.3

^{ab} Different literals in the same column indicate significant difference (P<0.05). PFC=Cold carcass weight. R. C:H: Relationship meat: bone.

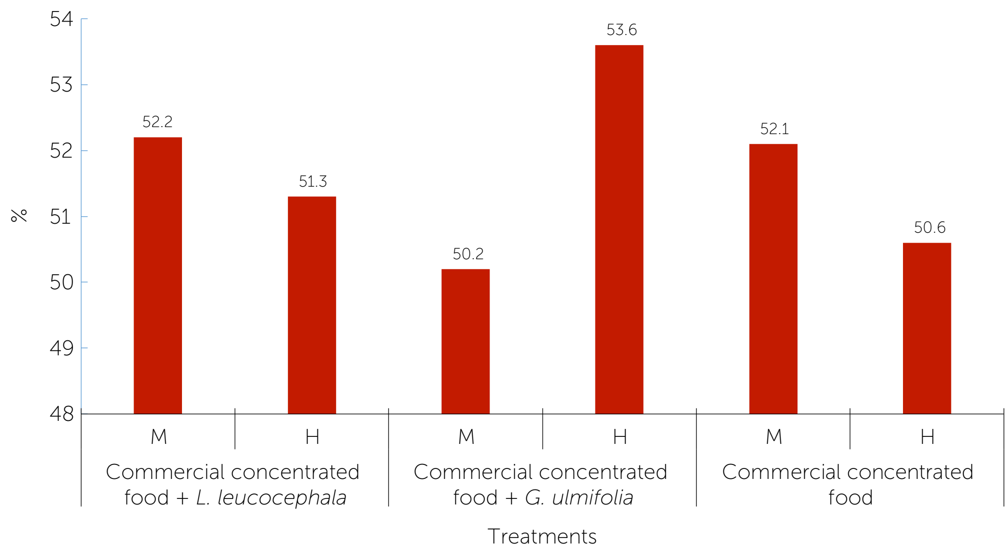

Figure 2. Carcass yield on rabbits supplemented with of *L. leucocephala* and *G. ulmifolia* foliage.

viscera. Values of 23.0, 24.9 and 25.0% were observed in the rabbits supplemented with *L. leucocephala*, and *G. ulmifolia* foliage and no supplements. In females and males, the weight of the viscera was 23.9 and 24.7% of the live weight of the animals. Values of 22% in the proportion of the weight of the viscera with respect to the live weight at the time of sacrifice of rabbits fed with concentrated food were reported by Cornejo-Espinoza *et al*. (2016), which relates to the fact that fibrous foods consumption can affect the development of the digestive tract site in which it is digested (Abad *et al*., 2012).

The meat: bone relation shows no significant difference in the study factors or their interaction (P>0.05). Mean values of 5.35, 5.57 and 5.92 were observed; in rabbits supplemented with *L. leucaena*, *G. ulmifolia* foliage and with no supplementation; and 5.30 and 5.94 for females and males. The total average of this variable in the experiment was 5.6 (Table 1), with consistent values, except for male rabbits fed with concentrated food and no supplements. But they coincide with that reported by Pascual *et al*. (2005) from 5.48 in rabbits in a synthetic R line. Lower values were reported by Capra (2014) in rabbits supplemented with alfalfa and without supplementation of alfalfa (3.32 and 3.57) and as in the present work, the lowest relation was found in animals that received green foliage supplements.

CONCLUSIONS

The foliage of *G. ulmifolia* and *L. leucocephala* used as supplementary food in rabbits fed with concentrated feed had no effect on the total consumption and weight gain of the rabbits. Carcass performance and the meat : bone ratio were similar in rabbits with foliage supplements from both species and rabbits with no supplement. The inclusion of fresh foliage of the two species had a significant effect on the reduction of dissectable fat (scapular and perirenal) in the rabbits after six weeks of fattening. The proportion of the weight of the viscera did not increase with the addition of foliage as a supplement in the rabbit's diet.

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