Scientific Paper

Beef production from natural pastures and supplementation with concentrate feeds of meal from protein plants

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Objective: To evaluate the effect of supplementation with concentrate feeds of meal from protein plants on bull fattening on natural pastures.

Material and Methods: One hundred crossbred bullocks (1/4 Holstein x 3/4 Zebu and 5/8 Holstein x 3/8 Zebu) were used, distributed in a complete randomized design. Two treatments were established. A) grazing on natural pastures plus supplementation with a concentrate feed formulated with meal from the protein plants *Morus alba* L. and *Tithonia diversifolia* (Hemsl.) A. Gray and B) grazing on natural pastures plus supplementation with a concentrate feed formulated with *Glycine max* (L.) Merr. Each treatment had grazing divided into two paddocks and an area of 36,84 and 53,0 ha, respectively, with rotation time of 15 days. The prevailing pastures in the pastureland were *Paspalum notatum* Alain ex Flügé and *Dichanthium annulatum* (Forssk.) Stapf. The initial stocking rate was 1,1 animals/ha (0,46 LAU/ha).

Results: No significant differences were found for the live weight and daily weight gain in the 10 months the research lasted. The animals were slaughtered at 10 months, with live weight of de 379-380 and 380-383 kg for the crossbred R1 (1/4 Holstein x 3/4 Zebu) and Siboney (5/8 Holstein x 3/8 Zebu) animals in treatments A and B, respectively. The average daily live weight gains were 0,454-0497 and 0,510-0,467 in the dry season and 0,65-0,636 and 0,59-0,489 kg/animal/d in the rainy season in treatments A and B, in the crossbred animals R1 and Siboney, respectively.

Conclusions: The utilization of concentrate feed formulated with the inclusion of meal from *M. alba* and *T. diversifolia* allowed live weight gains in fattening bullocks similar to the animals supplemented with concentrate feed based on soybean meal and the costs were more economical for Cuba than when *G. max* was used.

Keywords: meal, natural pastureland, beef production

Introduction

The current animal husbandry requires throughout the year a constant supply of feedstuffs capable of providing the essential nutrients to guarantee the productive levels of the herds (Saavedra-Montañez and Rodríguez-Molano, 2018; Roncallo-Fandiño *et al*., 2020).

This problem acquires high complexity, if it is considered that tropical grasses show marked seasonality of their yields related to the climate conditions.

Feed deficiency during the dry season brings about the search for solutions to balance the supply of nutrients throughout the year and, thus, achieve high milk and beef production per hectare.

With the utilization of trees in animal feeding, the nutrition of ruminants reached a new dimension. The forage potential in trees for animal feeding is acknowledged because it offers edible biomass with high protein content. However, their fundamental role is in enriching the diet with nitrogen and providing the deficit elements in pastures (Sandoval-Pelcastre *et al*., 2020).

In the cut and carry exploitation systems (protein forage banks) it is possible to preserve, in the form of meal, in a certain season of the year, the forage of protein woody plants, although the surplus of edible biomass that is not totally within the reach of the animals, can also be used. This can be lost due to plant defoliation, and thus the minerals, protein and carbohydrates present in those leaves, and which are important for animal feeding, especially in the dry season, are wasted.

This preserved feedstuff can be utilized as supplement in the diets to elaborate multinutritional blocks, prepare artisanal concentrate feeds, among other uses; besides the fact that it can be used as feedstuff for other animal species: poultry, pigs, rabbits, etc. The use of protein meals has been little studied in Cuba, and requires their evaluation under conditions of an animal husbandry enterprise to determine the response of the animals in this production system (Cordero-Hernández *et al*., 2020; MINAG, 2021).

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The objective of this study was to evaluate the effect of the supplementation with concentrate feeds formulated with meals from protein plants and soybean on the fattening of bulls on natural pastures-

Materials and Methods

Location. The study was conducted in cattle fattening areas of the Basic Entrepreneurial Unit Pancho Pérez, belonging to the Animal Husbandry Enterprise Macun, in the Sagua La Grande municipality, Villa Clara province, Cuba. This facility is located between 22°50'53" North latitude and 80°11'30" West longitude, at 7 m.a.s.l., in the Sagua La Grande municipality, Villa Clara province, Cuba.

Animals, treatments and experimental design. One hundred animals were selected, 44 of the Siboney phenotype (5/8 H x 3/8 Zebu) and 56 of the backcross R1 (3/4 Zebu x ¼ Holstein). A group received supplementation (table 1) with concentrate feed, which included meal from the protein plants *Morus alba* L. and *Tithonia diversifolia* (Hemsl.) A. Gray (treatment A); while the other one (treatment B) received concentrate feed with soybean [*Glycine max* (L.) Merr.] as protein component (table 2).

The animals supplemented in treatments A and B had similar protein and energy concentration. A complete randomized design was used for the interpretation of the results.

The area used in each treatment, stocking rate and number of animals are shown in table 3.

Characterization of the plant community of the grazing areas used. Two grazing areas of the Pancho Pérez entrepreneurial unit (UEB) (grazing areas 55 and 56), established with natural pastures. The most represented species in the area were *Paspalum notatum* Alain ex Flügé and *Dichanthium annulatum* (Forssk) Stapf. The research was conducted in a humic grayish brown soil (Hernández *et al.,* 2015), of moderate fertility.

Elaboration of protein meals. For the elaboration of the meals there was an additional area of *M. alba* (1,3 ha) and *T. diversifolia* (1,28 ha). To guarantee a quality product these species were cut at an age of 60-75 days, in the rainy season, and of 90-120 days, in the dry season, for *T. diversifolia* and *M. alba*, respectively.

The area dedicated to protein plants had an irrigation system in the dry season, where a norm of 50 mL of water every 15 days was applied.

The forage cut from the protein plants was transferred to the concentrate feed elaboration factory of the animal husbandry enterprise Macun, where it was dried and ground to prepare the concentrate feed later according to the quantities proposed in tables 1 and 2.

Table 1. Concentrate feed formulated with the inclusion of meal from *M. alba* and *T. diversifolia*.

Feedstuff	Humid basis (kg)	DM (%)	Quantity (kg)	CP (kg)	CF (kg)	Ca (kg)	P (kg)	ME (Mcal)
M. alba meal	16,0	91,9	14,7	2,7	5,0	0,4	0,0	0,4
Mineral salt	1,0	99,0	0,99			0,1	0,1	
Tithonia diversifolia meal	16,0	85,0	2,7	3,3	0,3	0,1	0,5	0,5
Triticum aestivum L. bran	40,0	91,3	36,5	5,7	4,6	0,3	1,0	1,0
Zea mays L. meal	22,0	85,7	18,9	1,8	0,8	0,1	0,6	0,6
Molasses	5,0	81,2	4,1	0,2		0,0	0,1	0,1
Total	100		88,7	14,8	15,3	1,1	0,6	2,9

Table 2. Concentrate feed formulated with the inclusion of meal from *G. max.*

Feedstuff	Humid basis (kg)	DM (%)	DM (kg)	CP (kg)	CF (kg)	Ca (kg)	P (kg)	ME (Mcal)
Mineral salt	1,0	99,0	0,99			0,1	0,1	
T. aestivum bran	44,0	91,3	40,2	6,3	5,0	0,0	0,3	1,1
Z. mays	41,0	85,7	35,1	3,4	1,4	0,1	0,1	1,1
Glycine max (L.) Merr.	9,0	90,0	8,1	3,2	0,5	0,0	0,0	0,3
Final molasses	5,0	81,2	0,2	0,0	0,1	0,0	0,1	0,2
Total	100		88,5	14,8	7,8	0,4	0,7	3,0

Table 3. Grazing area, stocking rate and genotypes.

Treatment	Area, ha	Stocking rate, animals/ha	Animals		
			R 1	Siboney	Total
A-Supplementation with concentrate feed formulated with meal from ***M. alba*** and *T. diversifolia*	36,84	1,1	23	18	41
B-Supplementation with concentrate feed formulated with *G. max*	53,00	1,1	33	26	59
Total					100

Floristic composition of the pastureland. It was estimated by the method of steps, described by EEPFIH (1980), which consists in walking by the diagonals in each paddock. The observer classifies the pasture species every four steps, when it coincides with the tip of the shoe. This measurement was carried out at two moments: at the beginning and at the end of the experiment (fattening cycle).

Pasture availability and dry matter. It was evaluated by the alternative method proposed Martínez *et al.* (1990), which considers average pastureland height. The height was determined with the same method as the floristic composition (every four steps). Sampling was carried out bimonthly and two samples were taken per month to determine the DM content of the pasture.

M. alba and T. diversifolia population. The population was determined by counting the plants in a 100-m^2 area (10 m x 10 m), which was replicated in three places through the diagonal (beginning, middle and end) of the forage area, which allowed to calculate the plant density in the area. The stem height and diameter at 20 cm from the soil were also measured, at the beginning and the end of the experiment, using a graduated ruler and a metric tape. Afterwards, the values were averaged.

Supplement offer and quality. The animals of treatments A and B were offered the concentrate feed supplement at the end of the morning in the shed of the grazing area, at a rate of 1,0 kg/animal/day, according to the experimental treatments. Besides, they received mineral salts at will in addition to the pasture.

The quality of the offered concentrate feed was determined at two moments in each season.

Live weight and mean daily gain. The live weight (LW) of the fattening bulls was determined with a livestock scale in 100 % of the animals, with monthly frequency.

Instantaneous feeding balance. The instantaneous feeding balance for the growing animals, with LW of 346 kg, was calculated through the computer program CALRAC, version 1.0, elaborated by the Institute of Animal Science (ICA, 1996).

Economic analysis. The economic analysis of the elaboration of the concentrate feeds was done with information gathered from the unit and the enterprise.

Statistical analysis. Descriptive statistics was done to the variables DM availability, LW and MDG.

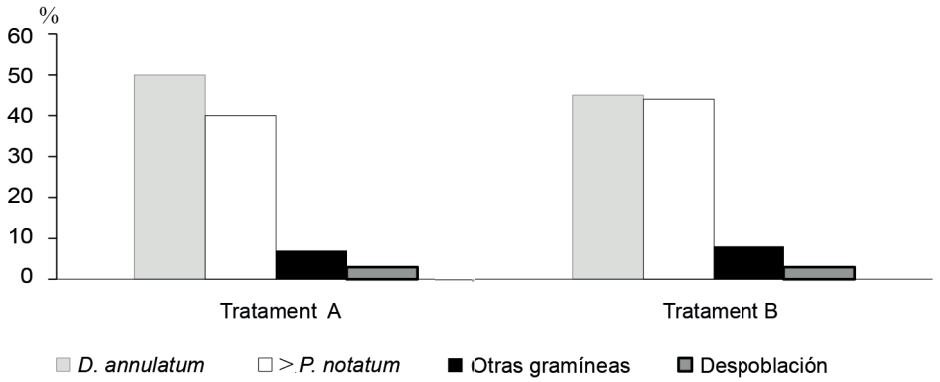
Results and Discussion

The floristic composition of the grasses did not indicate in any of the two grazing areas marked differences among the species present (fig. 1). There was predominance of the natural pastures *D. annulatum* and *P. notatum*, and low presence of other grasses, represented by *Cynodon nlemfuensis* Vanderyst, and little area without cover of pastures.

P. notatum and *D. annulatum* constitute the species that prevail on the soils of the Cuban animal husbandry (Menocal, 2017; Loyola-Hernández *et al*., 2021). They are pastures that adapt to partially floodable soils (Leyva *et al*., 2018; Sieiro-Miranda *et al*., 2018). In this research, these species covered 90 % of the grazing area. If encouraging productive results based on pastures are to be achieved, this proportion of natural pastures is unfavorable, when the energy-protein supplementation with concentrate feeds is not used or when it is minimal.

Table 4 shows the productive performance of the protein forage plants used for elaborating the meals.

The best results in protein plants are reported with populations of 20 000-40 000 plants/ha (Paz-Rojas, 2005; Noda and Martín, 2014). In this study, the results were obtained with low plant densities (table 4) and were slightly higher than those reported by Boschini *et al.* (1998). They could have been influenced by the soil where the research was conducted, because it has the characteristic of



A-Supplementation with concentrate feed formulated with meal from *M. alba* and *T. diversifolia*
B-Supplementation with concentrate feed formulated with *G. max*.

Figure 1. Floristic composition in the grazing areas in each treatment.

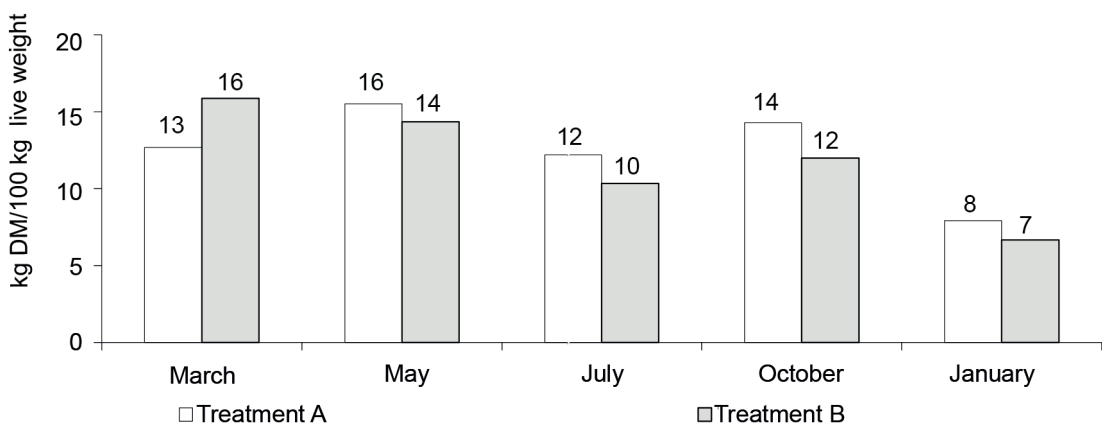
Table 4. Performance of the forage areas of protein plants under irrigation.

Species	Plants/ha	Height, cm	Diameter, mm	Yield, kg GM/ha/cutting	Yield, kg DM/ha/cutting
T. diversifolia	9 930	114	7,8	29 690,7	5 463
M. alba	6 330	106	7,9	13 900,0	3 960

maintaining humidity. The same does not occur in ferralitic soils, which show better surface and internal drainage (Hernández-Jiménez *et al*., 2015). In this sense, in literature it is indicated that by decreasing the plant density of *M. alba* (10 000 plants/ha), the yields per cutting were lower. Thus was reported by Boschini *et al*. (1998) and Noda and Martín (2014). These authors referred yields from 3 193 to 2 787 kg DM/cutting with low densities (12 000 and 6 000 plants/ha, respectively).

The work principle that was used was incorporating animal to grazing in March (late dry season). Thus, they reached the highest live weight (LW) in the rainy season, moment at which the pasture availability (fig. 2) was higher with regards to the dry season, which coincides with the report by Iglesias *et al*. (2015) and Roncallo-Fandiño *et al*. (2020) in the rearing of growing male cattle.

The pasture availability per animal was acceptable in the five moments of the year in which



A-Supplementation with concentrate feed formulated with meal from *M. alba* and *T. diversifolia*
B-Supplementation with concentrate feed formulated with *G. max*

Figure 2. Pasture availability (kg DM/100 kg LW) per treatment.

it was determined, and represented more than 7 kg DM/100 kg LW (fig. 2). These values coincide with those reported by Sánchez-Santana *et al*. (2016) and Del Prado *et al*. (2020) in silvopastoral systems.

The evaluation of the animals started when they had an average LW of 208 kg. The growth curve proved until slaughter that there were no significant differences among the animals supplemented with concentrate feeds that had in their elaboration meals from protein plants (*M. alba* and *T. diversifolia*) or *G. max*.

The supplementation allowed to increase the slaughter weight of the animals by 50 kg, when comparing this indicator with the historical data the enterprise has and with the available statistical information in Cuba, where the weight at slaughter of fattening animals is 302-317 kg (ONEI, 2019; 2020). This LW performance was similar in the R1 and Siboney animals.

In January the animals were sold with a LW of 380-383 kg, due to a decrease in weight because of the low availability of pastures in both treatments, besides the low protein content, due to the poor growth and leaf production which occurs in that season (Barbera *et al*., 2018). Nevertheless, the weight at slaughter of these animals catalogues them as of first category, in which the price of the live kilogram is 25,76 pesos (Ministerio de Justicia, 2021), much higher than the previously existing ones. They are animals that propitiate considerable profits to the UEB and the enterprise.

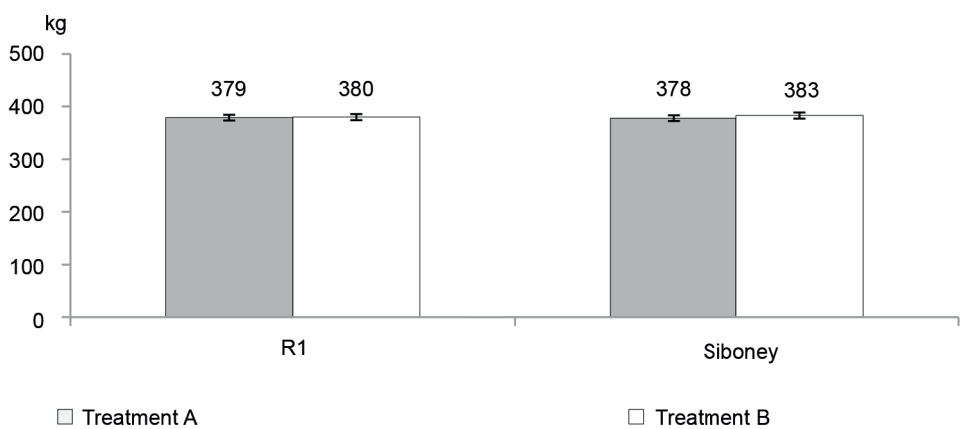
When comparing the weight at slaughter of the animals supplemented with concentrate feed, there were no statistical differences between the two breeds in both treatments (fig. 3).

The results were similar to the ones reported by Iglesias *et al.* (2015) in a silvopastoral system with *Leucaena leucocephala* (Lam) de Witt + *Megathyrsus maximus* (Jacqs.) B.K. Simon & S.W.L. Jacobs, where the animals F1 (50 % Holstein and 50 % Zebu) and Siboney did not differ in the LW, although the contribution of the forage woody plants used in this work was lower in DM, because the supplementation of the concentrate feed was 1 kg. The meal from the protein plants represented 0,32 kg DM/animal/day (table 1).

The LW gains did not show variation between the animals (F1 and Siboney) supplemented with the different concentrate feed formulations (figure 4) in any of the two seasons. The values in the rainy season were slightly higher than the dry season and the average reached in the fattening cycle was acceptable for pasturelands with natural pastures (figure 3).

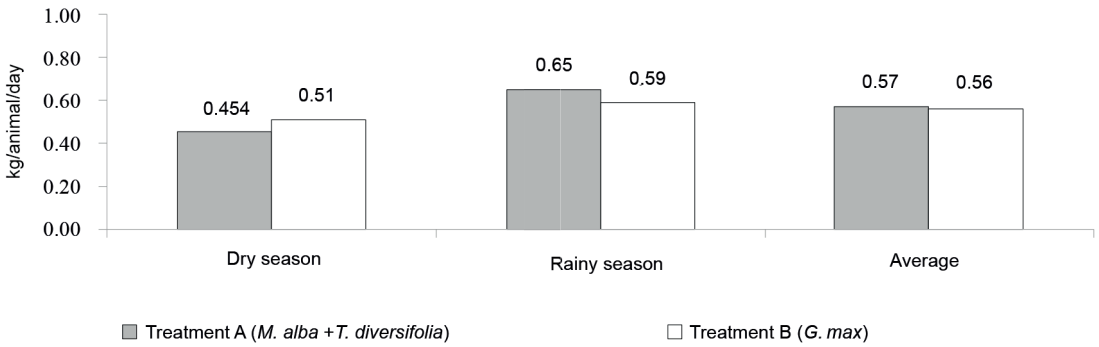
These results surpass those referred by Iglesias *et al*. (2015) under the conditions of an animal husbandry enterprise in Matanzas province, who found LW gains of the fattening cycle of 0,432; 0,364 and 0,256 for Zebu, F1 and Mambí (75 % Holstein x 25 % Zebu) animals, respectively.

The feeding balance (figures 5 and 6) was calculated for the animals with LW = 346 kg and LW gain = 0,565 g/animal/day. There was a small energy deficit for the daily gain, equivalent to 0,3 Mcal in both treatments. The requirement of the other nutrients was covered.



A-Supplementation with concentrate feed formulated with meal from *M. alba* and *T. diversifolia*
B-Supplementation with concentrate feed formulated with *G. max*

Figure 3. Live weight at slaughter of R1 and Siboney animals, supplemented with concentrate feed with different protein sources.



A-Supplementation with concentrate feed formulated with meal from *M. alba* and *T. diversifolia*.
B-Supplementation with concentrate feed formulated with *G. max*.

Figure 4. LW gain per season in animals supplemented with concentrate feed.

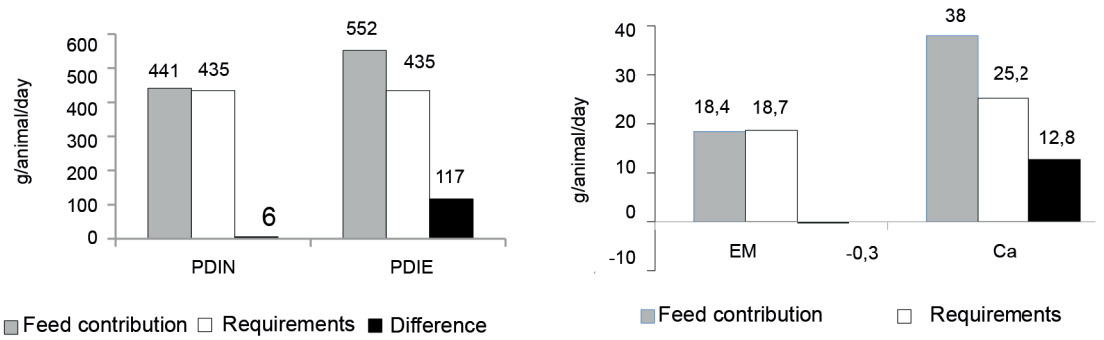


Figure 5. Feeding balance for the animals supplemented with concentrate feed based on meals from protein plants.

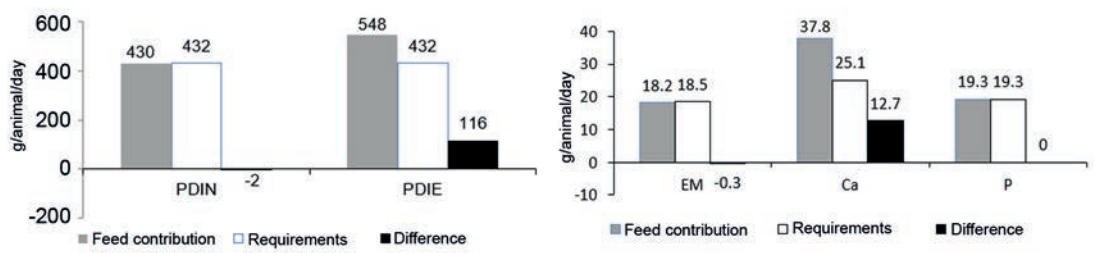


Figure 6. Feeding balance of the animals supplemented with concentrate feed formulated with *G. max*.

The cost of the ton of concentrate feed (table 5) was calculated according to the prices that the Ministry of Agriculture of Cuba assigned to the raw materials of the animal husbandry enterprises of the country in 2018 (pre-mixture, bran, calcium phosphate, corn, mineral salt and *G. max*), with the exception of the meals from protein plants, whose price was estimated by the cost sheet available at the concentrate feed factory, because they are in its agricultural areas. Under these conditions, when utilizing the meals, the ton of concentrate feed is more economical (Ybran and Lacelli, 2018) than with the use of *G. max*.

Conclusions

The utilization of concentrate feed formulated with the inclusion of meals from *M. alba* and *T. diversifolia* allowed in fattening bullocks LW gains similar to the ones obtained in animals supplemented with concentrate feed based on soybean meal, with more economical costs for Cuba than with the utilization of *G. max*.

Tabla 5. Costo del concentrado formulado con harina de plantas proteicas ($/t).

Tratamiento		Tratamiento A			Tratamiento B		
Producto	UM	Norma Consumo	Precio, $	Importe, $	Norma Consumo	Precio, $	Importe, $
Premezcla	t	0,010	1 475,10	14,75	0,010	1 475,10	14,75
Afrecho	t	0,400	156,00	62,40	0,440	156,00	68,64
Fosfato calcio	t	0,010	566,58	5,67	0,010	566,58	5,67
Z. mays	t	0,25	1 878,99	469,75	0,440	1 878,99	826,76
Sal mineral	t	0,01	868,62	8,69	0,010	868,62	8,69
T. diversifolia	t	0,16	733,85	117,42	-	-	-
M. alba	t	0,16	1 276,83	204,29	-	-	-
G. max (importada)		-	-	-	0,090	1 710,00	153,90
∑		1 000		882,96	1,000		1 078,40

A-Suplementación con concentrado formulado con harina de ***M. alba*** y *T. diversifolia*
B-Suplementación con concentrado formulado con *G. max*.

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Conflicts of interests

The authors declare that there is no conflict of interests among them.

Authors' contribution

- Luis Lamela-López. Generated the idea of the research, searched for bibliographic information, reviewed and controlled the execution of the research protocol.
- Iván Lenin Montejo-Sierra. Executed the experiments with the corresponding measurements, carried out the statistical analyses and searched for bibliographic information.
- Luis Ramón Amechazurra-Rodríguez. Contributed to the execution of the experiments with the corresponding measurements, controlled the quality of the meals, the concentrate feed production and searched for bibliographic information.
- María Teresa Lay-Ramos. Contributed to the execution of the experiments with the corresponding measurements and searched for bibliographic information.
- Diosnel García-Fernández. Generated the idea of the research and controlled the execution of the research protocol.

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