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Influence of the supplementation with concentrate feed on the milk production of Holstein x Zebu cows under silvopastoral conditions

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ABSTRACT: The study was conducted in order to evaluate the effect of the supplementation with concentrate feed on the milk production and quality of crossbred Holstein x Zebu cows under silvopastoral system conditions. Eight animals that grazed in an association of Guinea grass (*Panicum maximum*) and leucaena (*Leucaena leucocephala*) were used, in a Switch Back design, with two treatments: SS (without supplementation) and CS (0,5 kg of concentrate feed per kilogram of milk produced from the eighth kilogram). The pasture and leucaena availability was measured and the chemical composition of the feedstuffs was estimated. In the animals, the body condition (BC) was monitored, the milk production was measured and the concentrations of fat, protein, lactose, total solids (TS) and non fatty solids (NFS) were determined. The pasture availability was 6,4 t DM/ha/rotation, which, together with the browsing of leucaena, allowed offers higher than 100 kg DM/animal/day. The CP of the Guinea grass was 11,4 % and in the case of leucaena, 25,2 %. The milk production of treatment CS was similar to that of the control (9,7 and 9,8 kg/animal/day, respectively), just like the milk composition (fat, protein, lactose, TS and NFS) and the BC of the cows (2,70 for both treatments). The data suggest that the supplementation with concentrate feed in Holstein x Zebu dairy cows, managed in an association of Guinea grass and leucaena with high forage offer, does not increase the milk production or improve its nutritional quality.

Key words: body condition, *Leucaena leucocephala, Panicum maximum*

INTRODUCTION

The world population arrived in 2011 to 7 000 million people and it is estimated that by 2050 it will be 9 550 millions (United Nations Population Fund, 2013). For such reason, around 70 % more food should be produced with regards to the present, while hunger and poverty are fought, the scarce natural resources are more efficiently used and the production systems are adapted to the climate change. This implies that the annual production of cereals has to increase in almost 1 000 million tons; the meat production, in more than 200 million tons; and the milk production should be doubled during such period (ONU, 2004).

At present, most cattle production systems of tropical countries are developed under pasture monocrop conditions, due to concepts and technologies inherited from the Green Revolution, which has generated environmental problems such as soil degradation, water contamination and emission of greenhouse gasses (Navas, 2007). These conditions determine, at long and medium term, a negative effect on the productive and economic indicators of the herds.

In Cuba, during the last two decades, a progressive deterioration in cattle herds has occurred, which has caused a remarkable decrease in the animal stock, as well as the detriment of its main productive, reproductive and economic indicators (OficinaNacional de Estadísticas en Información de Cuba, 2013).

Thus, to achieve the development of a more efficient and sustainable cattle production, it is necessary to implement systems resilient to the climate change, which guarantee cattle feeding based on pastures and forages (both herbaceous and tree) adapted to the edaphoclimatic conditions of each locality and capable of covering the requirements of the animals from their own nutritional potentialities, as well as contribute to reduce to the minimum the emission of greenhouse gasses and the use of fossil fuels in the livestock production sector (Senra *et al*., 2013).

In that sense, silvopastoral systems with an integrated and rational management allow to increase

the sustainable production of each of their components and, thus, to increase and diversify the yield of the system as a whole. In addition, they guarantee the reduction of the use of inputs in agricultural farms (Souza *et al*., 2010) and the increase of forage production and quality (Sánchez *et al*., 2011; López *et al*., 2012), and minimize the unbalance in feed production between the rainy and the dry season.

In these systems the supplementation of cows with large quantities of concentrate feed does not constitute an advantageous practice, due to the increase of feeding costs (Benavides, 1994). However, the diets with concentrate feed allow to increase the dry matter (DM) intake and the production of short chain fatty acids (SCFA) in the rumen (Van Ackeren *et al*., 2009). For such reason, its use in the diet of dairy cows under silvopastoral system conditions could improve the balance and utilization of the energy contained in it, and, consequently, optimize the milk production and/or quality.

The objective of this study was to evaluate the effect of supplementation on the milk production and quality of crossbred Holstein x Zebu cows, managed in an association of *Panicum maximum* and *Leucaena leucocephala*.

Experimental methodology

Location. The study was conducted in areas of the Pasture and Forage Research Station Indio Hatuey, of the Perico municipality –Matanzas province, Cuba–, located between 22º 48' 7" North latitude and 81º 2' West longitude, at 19,01m.a.s.l.

Edaphoclimatic characteristics. The soil of the experimental area is classified as Ferralitic Red (Hernández *et al*., 2006), with plain relief. The chemical characteristics are shown in table 1.

The climate is tropical warm (Centro del Clima-Instituto de Meteorología, 2013), with an average annual temperature and relative humidity of 24,4 ºC and 82,6 %, respectively. The average annual rainfall is 1 300 mm. The values of the climate variables in the experimental period are shown in table 2.

Table 1.Chemical composition of the soil in the system.

Indicator	Mean
Total nitrogen (%)	0,26
Phosphorus (ppm)	77,4
Calcium (cmol/kg)	2,88
Magnesium (cmol/kg)	0,25
pH	6,7
Organic matter (%)	4,5

Description of the experimental area and the management. A grazing area of 10 ha, divided into 9 paddocks of approximately 1,1 ha each, was used. Twelve animals with an average weight of 486 kg were managed, which represented a stocking rate of 1,2 LAU/ha. The occupation time was 5 days and the resting time, 40 days.

The prevailing pasture species was *P. maximum* cv. Likoni, associated to the tree *L. leucocephala* cv. Cunningham, which had been established for more than 15 years and initially planted with a density of 555 plants/ha (6 m between rows and 3m between plants).

Treatments and design. Eight cows were used in a Switch Back design to compare two treatments: control (without supplementation, SS) and supplementation (0,5 kg of concentrate feed per kilogram of produced milk from the eighth kilogram, CS). The experimental periods comprised 14 days of adaptation and 7 days of data collection for each treatment.

Characteristics of the animals. The cows were clinically healthy; were 7,1 (± 1,8) years old, had a weight of 474,5 (± 44,4) kg and 3 (± 1)lactations as average.

Measurements in the pastureland

Height and diameter of L. leucocephala. Ten representative trees of each paddock were selected and the individual height of each was measured with a metric tape. The diameter of the trunk was estimated with a caliper at 1,3 m above the soil level.

Number of L. leucocephala plants. The quantity of leucaena plants was counted in three characteristic rows of each paddock, the average among them was found and the value was multiplied by the quantity of rows in the paddock.

Availability from pruning in L. leucocephala. The pruning availability in leucaena was estimated in five representative plants of each paddock, cut with a height bigger than 3,5 m. For such purpose, the edible material was manually separated from the non edible material and both fractions were weighed. From the average values the foliage yield per hectare was calculated, for which the plant density and the number of trees that were pruned per day were considered, according to the methodology described by Iglesias (2003).

Availability from browsing in L. leucocephala. To estimate the browsing availability in leucaena the leaves and edible fresh stems (up to approximately 3 mm of diameter) were manually collected in 10 of the trees established in the paddock, simulating the

Table 2.Performance of the climate variables in the experimental period.

Variable	Month		
	March	April	May
Mean temperature (ºC)	22,8	23,8	25,1
Average relative humidity (%)	74	71	82
Cumulative rainfall (mm)	15,3	167,0	298,7
Total evaporation in 24 h (mm)	6,8	7,5	5,7

browsing made by the animals up to a height of 2 m (Lamela, 1998).

Pasture availability. The pasture availability was estimated through the alternative method proposed by Martínez *et al*. (1990). The samplings were performed when the animals entered and left each paddock, and 80 observations were made per hectare.

Proximal chemical analysis.Every two days, during the week in which the measurements in the animalswere performed, a homogeneous sample of 300 g of foliage from the pruning and browsing of leucaena was sent to the laboratory; as well as 300 g of pasture, harvested according to the methodology proposed by Herrera (2006). The following indicators were measured: DM, ashes, crude protein (CP) and calcium, according to the techniques described by the AOAC (1995); and phosphorus, through the colorimetric method, using a UV/V spectrophotometer. The fibrous fractions –neutral detergent fiber (NDF), acid detergent fiber (ADF)– and lignin were analyzed by means of the procedures referred by Goering and Van Soest (1970).

Floristic composition of the pastureland. The floristic composition of the pastureland was estimated through the method of steps, described by Anon (1980). The data are shown in table 3.

Table 3.Floristic composition of the grazing area.

Composition	Percentage
Improved pastures	85,6
Twining legumes	1,6
Natural pastures	12,3
Weeds	0,5

Measurements in the animals

Body condition. The body condition (BC) was weekly monitored in a scale from 1 to 5 points, according to the methodology described by Álvarez (1997).

Estimation of the live weight. The live weight was estimated from the measurement of the thoracic perimeter of the animals, with a metric tape, according to the methodology proposed by Álvarez (2005).

Calculation of the instantaneous feeding balance. The feeding balance was calculated in both treatments, through the computer program CALRAC® –version 1.0 of 1996–, elaborated by the Institute of Animal Science (ICA).

Milk production and quality. The milk production was controlled two times per day (5:00 a.m. and 3:00 p.m.), during a week of data collection, through individual weighing performed on 100 % of the cows in the experiment. The total milk production was determined, and samples were also taken to determine the fat percentage, protein, lactose, total solids and non fatty solids, by the infrared method (FIL-141: B, 1997), using the MilkoScan 104 A/S Foss Electric.

Statistical analysis. For the statistical analysis of the milk production the general linear model, belonging to the statistical pack SPSS® version 11.5 for Windows XP, was used.

RESULTS AND DISCUSSION

Table 4 shows the results of the performance of leucaena in the system. The size of the trees exceeded 8 m of height, which, together with their density (420 plants/ha), allowed to obtain a foliage yield of 1,1 t DM/ha; which is in the range reported by Sánchez (2007) in a system with 5 000 plants/ha, but in the second and third year of exploitation (1,4 and 1,0 t DM/ha, respectively). It is convenient to emphasize that the density in this study was lower than the one reported by Iglesias (2003) in that same grazing area (555 trees/ha); this shows that the

Table 4.Performance of leucaena in the system.

Indicator	Mean
Height (m)	8,2
Trunk diameter (cm)	10,7
Density (plants/ha)	420
Yield in foliage (t DM/ha)	1,1

continuous livestock production activity in the system (around 15 years) has provoked the deterioration of the woody component, which brings about the loss of more than 1 300 leucaena trees during that period.

The grass availability during the evaluation period (table 5) was 6,5 t DM/ha/rotation, similar to the one reported by Sánchez *et al*. (2010). This was, partly, due to the fact that the system was subject to a resting period previous to the beginning of the experiment –approximately 60 days–. In addition, the performance of the climate variables (table 2) also favored pasture growth.

The high value of pasture availability, along with the moderate stocking rate, allowed offers higher than 100 kg DM/cow/day. However, the foliage availability for browsing was low, due to the elevated height of leucaena; hence the need to perform the daily pruning of some plants to increase the offer of edible biomass of the tree legume.

When the foliage offer for browsing was complemented with the foliage contributed through the pruning, 2,3 kg DM/animal/day were supplied to the animals, similar value to the one reported by Sánchez (2007). This is within the range referred by Funes and Jordán (1987), from which an intake of 1,9 kg DM/animal/day can be achieved; as well as within the level reported by Mahecha *et al*. (2004) so that a leucaena intake between 1,5 and 2,0 kg DM/animal/day could be achieved.

According to these last authors, more than 80 % of the leucaena intake is explained by the availability and/or forage offer to the animals and by the forage digestibility. On the other hand, it can also be inferred that the net leucaena intake increases as the pasture offer and intake are increased; while the leucaena intake, with regards to the total diet, is increased when the grass offer and intake decreases. Taking into consideration these results, it can be assumed that in this study the animals made a high intake, of pasture as well as leucaena.

Table 6 shows the chemical composition of the feedstuffs that were part of the diet. The crude protein content of the grass was similar to that reported for *P. maximum* (11,4 %) in a silvopastoral

Table 5.Dry matter offer and availability of *P. maximum* and *L. leucocephala*.

Activity	Availability (kg DM/ha/rotation)	Offer (kg DM/animal/day)
Grazing	6 463,0	107,8
Browsing	12,6	0,21
Pruning	127,0	2,1
Total	6 501,0	110,1

Table 6.Bromatological composition of the feedstuffs of the diet.

Chemical composition (%)[Δ]	Feedstuff		
	P. maximum	*L. leucocephala*	Concentrate feed
DM	30,5	31,1	89,2
OM	84,8	91,8	91,9
Ash	15,2	8,2	8,1
CP	11,5	25,2	16,4
NDF	70,2	52,9	29,6
ADF	34,2	28,5	6,4
Hemicellulose	36,0	24,4	23,2
Cellulose	28,6	12,7	5,0
Lignin	5,6	15,8	1,4
Ca	0,67	1,19	0,73
P	0,26	0,29	0,57

[Δ]Analyzed values. All the values, except DM, are expressed based on the DM percentage.

system of high density of leucaena (Barros *et al*., 2012); nevertheless, it exceeded the values reached in systems with improved grasses (7,1-8,5 %) without fertilization (Iglesias, 2003), and even those of some improved and fertilized grasses (Pereira *et al*., 1990; Cáceres *et al*., 2006). It was also higher than the one obtained by Lamela *et al*. (2009) in *Cynodon nlemfuensis* (9,5 %) associated to leucaena.

In this sense, Alonso (2011) stated that in an association of *L. leucocephala* with *P. maximum* the CP content of the pasture tended to increase, even with the increase of the exploitation time of the system. This is due to the fact that the tree, with its capacity to fix atmospheric nitrogen to the soil, contributes to the increase of the quality of the pastures that are associated to the trees (Treydte *et al*., 2007), which was shown in this study, conducted in a system with more than 15 years of exploitation.

The elevation of the nitrogen substances in the grasses associated to tree species can also be a measure of their adaptation to the reduction of the light because of the shade projected by the trees, which influences their physiology (Ørskov, 2005).

Leucaena showed a high content of crude protein, with a similar value to the one reported by Galindo *et al*. (2005), Sánchez *et al*. (2010) and López *et al*. (2012), and higher than that reported by Pedraza *et al*. (2012). In turn, the crude protein content of the concentrate feed (16,4 %) was similar to the one informed for this feedstuff by Gutiérrez (2012).

There were no significant differences in the milk production between the cows that consumed pasture and leucaena foliage (9,8 kg/cow/day) and those which were also supplemented with concentrate feed (9,7 kg/cow/day). This could have been due to the high DM offer in the system, especially of pasture, which guaranteed an efficient selection of the most nutritional parts of the plants by the animals (Hernández *et al*., 1992). In the case of Guinea grass, this is proven even more by its erect growth habit and its adequate leaf-stem ratio, which enhances the bite size and increases the intake rate, compared with other tropical grasses (García-Trujillo *et al*., 1980).

On the other hand, the adequate nutritional quality of the diet (12,9 % of CP) and its *in vitro* dry matter digestibility, which according to López *et al*. (2014) can be higher than 640 g/kg of DM, guarantee a high contribution of microbial nitrogen to the rumen; which, with an adequate contribution in ME, allows a contribution of microbial protein to the small intestine sufficient to produce, according to the feeding balance, around 10 kg of milk per animal per day in medium-potential cows.

For such reason, when the CP content of the diet is high and/or the contribution is higher than the nutritional requirements of dairy cows –preferably at the beginning of lactation–, the milk production is stimulated even though the ME of the diet is not sufficient, because this is guaranteed at the expense of the body reserves of the animals, with the subsequent progressive loss of the body condition.

These results coincide with the ones obtained by Razz *et al*. (2004), in Venezuela, with double-purpose cows grazing Guinea grass, which had access to a protein bank of leucaena during one hour per day. The cows supplemented with 1-2 kg of concentrate feed achieved milk productions similar to those of the treatment without concentrate feed (9,1 and 9,6 kg/cow/day, respectively).

The fat content of the milk (figure 1) was similar for the two experimental groups, independently from the consumed diet; equal performance could be observed in the protein, lactose, total solids and non fatty solids.

Likewise, the fat percentage (4,0-4,1) was similar to the one reported by Hernández and Ponce (2004) in crossbred Holstein x Zebu cows managed in an association of *C. nlemfuensis* and *L. leucocephala*, and is in correspondence with that of the animals of this genotype in systems based on improved pastures (Ponce, 2009).

On the other hand, the protein content of the milk (3,2 %) was also similar to the one recorded by Hernández and Ponce (2004), for crossbred Holstein x Zebu cows, as well as for Siboney cows; but it was higher than the one reached with those same genotypes under grazing of improved grasses in monocrop (3,0 %). Nevertheless, in general, the increase in the level of crude protein of the diet affects more the production volume than the protein content of the milk (Acosta, 2001).

The analogy in the values of NFS (8,6 % in both treatments) and TS (12,7 and 12,8 % for CS and SS, respectively) between both treatments constitutes a logical performance, due to the similarity of the protein, fat and lactose values.

The protein:fat ratio of the milk was 0,8 in the two treatments, which indicates an appropriate content of both nutrients and, thus, an adequate energy:protein balance in the ration of the animals (Acosta, 2001).

The BC of the cows was 2,70 as average for the two treatments, in a range that varied between 2,0 and 3,25. The absence of significant differences was due to the fact that the BC was one of the factors that were

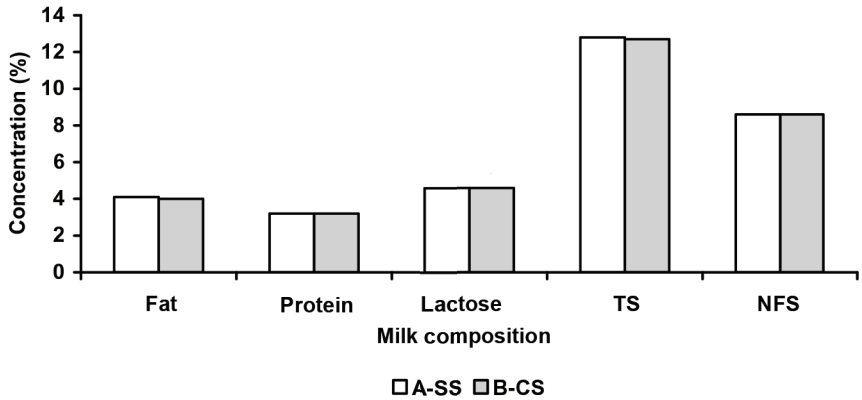

Figure 1. Effect of the supplementation with concentrate feed on the milk components.

taken into consideration when selecting the animals to form the experimental groups, so that this indicator did not affect their homogeneity. On the other hand, the experimental period was not long enough for the animals to show significant changes in this indicator, especially when they had an abundant diet of good nutritional quality, which made it possible that there were no differences in milk production or quality.

However, the highest milk production (table 7) was obtained in the animals that showed the lowest BC (2,0-2,5), which is in correspondence with the report made by López *et al*. (2012) in Mambí de Cuba cows which grazed in an association of improved pastures (*P. maximum* and *C. nlemfuensis*) with *L. leucocephala*. In this study the animals started with a BC of 3,0-3,5 and utilized from 0,5 to 1,0 units between the calving and the peak of milk production; for which at the moment of higher production they showed a BC of 2,0-2,5.

In this sense, it is known that cows, at the moment of calving, have a reduced ingestion capacity, because of the contraction of the gastrointestinal tract which occurs during pregnancy. For such reason, after parturition and during the milk production peak (first 60-100 days of lactation), have an energy unbalance and deviate nutrients from the body reserves to supply the energy requirements and guarantee the milk production, with an adequate fat content; so that they lose weight and decrease their BC. This occurs preferably, in multiparous Holstein x Zebu cows, managed under grazing conditions (Roche *et al*., 2009; López *et al*., 2014).

Table 7.Effect of body condition on the milk production of the cows.

BC	Milk production (kg/cow/day)	SE ±
2,0-2,5	11,1[a]	0,261
> 2,5-3,0	8,1[b]	0,161
> 3,0	7,8[b]	0,329

[a, b]The averages with different superscript in the same column differ at $p < 0,001$.

In general, the results of milk production and chemical composition and its protein:fat ratio, as well as the appropriate BC of the cows in both treatments,showthe adequate nutritional quality of the consumed diets, and also allow to infer that there was a high selectiveness in grazing, with the subsequent increase of the DM digestibility and intake, which allowed the control treatment to equilibrate the balance of nutrientsachieved by the animals of the treatment with supplementation from the eighth liter.

CONCLUSIONS

In an association of *P. maximum* and *L. leucocephala*, with high forage offers of good nutritional quality, the supplementation with concentrate to Holstein x Zebu dairy cows, with an adequate BC, does not contribute to increase the production or to improve the bromatological quality of milk, when the productive yields of the animals are lower than 10 kg/cow/day.

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