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ADDITION OF PROTEIN SOURCES FOR CALVES SUPPLEMENTED WITH HIGH MOISTURE SORGHUM GRAIN SILAGE GRAZING LOW-QUALITY PASTURES

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ORIGINAL ARTICLE

ABSTRACT: *Three experiments were conducted to determine the effect of protein addition to high moisture sorghum grain silage (HMS) daily supplemented to calves at a rate of 1% of body weight (BW) grazing low-quality pastures. In exp. 1 addition of sunflower expeller or a protein ration to increase crude protein (CP) of HMS from 7.1% to 12% increased average daily gain 56% compared with calves fed only HMS (0.39 and 0.25 kg/a/d, respectively). Calves supplemented with protein sources were more efficient than calves supplemented only with HMS as feed conversion numerically decreased from 6.0 (HMS) to 4.5 (HMS + sunflower expeller) and 4.1 (HMS + protein ration). In exp. 2 CP of HMS (9.1%) was increased to 15.5% by adding sunflower expeller, urea or combination of both. Protein supplementation increased ADG and final BW (0.20 kg/a/d and 196 kg) compared with only HMS (0.03 kg/a/d and 176 kg). Protein source had no effect on animal performance. In exp. 3 CP concentrations in the supplement had a significant effect on ADG when increased from 8.9 to 16.1% (0.32 and 0.50 kg/a/d). Performance of calves fed either 16.1% or 20.8% CP supplements did not differ possibly because energy was becoming the limiting factor at the highest CP concentration level. Rib eye area and fat thickness were not affected by treatment although supplemented calves registered 7% and 10% greater values in those variables, respectively, than un-supplemented animals at the end of the experiment. The addition of protein sources to HMS increased performance of calves grazing low-quality pastures.*

Key words: *Calves, Pastures, Sorghum Silage, Protein Addition, Supplementation*

INTRODUCTION

Land use has changed in traditional livestock operations driven by an increase in economic returns of agriculture, dairy and forestry sectors reducing the total land under beef farming. To achieve acceptable levels of production and keep the sector competitive livestock producers supplement grazing cattle. In recent years it has become more popular the use of high moisture sorghum grain silage (HMS) as supplement due to the increased problems of availability and price variability of dry feed grains. This supplement is defined as the grain harvested with 22–30% moisture, ground and conserved under conditions of anaerobiosis in silo bags in the producer's own farm (Fassio et al., 2009).

The use of HMS in intensive beef grazing systems based on high-quality pastures (i.e. ryegrass, legumes) increases animal performance due to the high level of soluble carbohydrates available for rumen fermentation (Alvarez et al., 2001; Abdelhadi et al., 2005). However, when HMS are offered to animals grazing low-quality pastures ruminal ammonia concentrations are very low leading to decrease microbial crude protein synthesis and growth (Chase and Hibberd, 1987; Sanson and Clanton, 1989; Sanson et al., 1990; Bodine et al., 2000). This situation is becoming more common as beef farming depends more on extensive low-quality pastures due to the advance of dairy and agriculture in more fertile lands. The addition of an adequate amount of ruminally degraded protein can alleviate the deficit of nitrogen believed to result from feeding high-energy supplements with low-quality pastures increasing beef cattle performance (Del Curto et al., 2000). The current serie of studies were designed to determine whether the performance of calves grazing low-quality pastures and supplemented with HMS could be improved by different sources of supplemental protein.

MATERIALS AND METHODS

Three independent experiments were conducted at the National Institute of Agricultural Research (INIA) Experimental Station located in eastern Uruguay (latitude 33' 14'S, longitude 54' 15'W) during the period 2009-

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2011. The Meat and Wool Research Program of INIA approved all operational and ethical procedures involving animals. At the beginning of each experiment calves were treated for internal and external parasites. Health status of the cattle was recorded periodically based on fecal egg counts to determine further treatments. In each year calves 8-month old continuously grazing low-quality natural pastures (2.4-3-2 calves/ha) were assigned to different supplementation treatments. Supplements were offered once daily from Monday to Sunday at 09.00 h at a level of 1.0% of body weight (BW) on a dry matter (DM) basis.

In exp. 1 the study was carried out from 1 July to 8 October 2009 (100 days). Sixty four Hereford x A. Angus calves averaging 188 ± 14 kg of body weight (BW) were randomly assigned into 4 supplementation treatments without replication. Treatments were: T1) control without supplementation, T2) 100% high moisture sorghum grain (HMS), T3) 78% HMS + 22% sunflower expeller (SE), T4) 78% HMS + 22% commercial protein supplement (CPS). Composition of supplements were (DM basis): 7.1% CP and 12.8% ADF (HMS); 29.6% CP and 22.8% ADF (SE); 31.1% CP and 32.8 ADF (CPS). The CPS had a maximum level of urea of 6.5% according to label instructions.

In exp. 2 the study was carried out from 26 May to 14 September 2010 (111 days). Sixty four Hereford x A. Angus calves averaging 172±14 kg of body weight (BW) were randomly assigned into 4 supplementation treatments without replication. Treatments were: T1) 100% high moisture sorghum grain (HMS), T2) 75% HMS + 25% sunflower expeller (SE), T3) 86.7% HMS + 12.1% SE + 1.2 urea (U), and T4) 97.7% HMS + 2.3% U. Composition of supplements were (DM basis): 9.1% CP and 6.3% ADF (HMS); 34.7% CP and 32.7% ADF (SE); and 285% CP (U).

In exp. 3 the study was carried out from 24 June to 4 October 2011 (102 days). Sixty Hereford x A. Angus calves averaging 143±13 kg of body weight (BW) were randomly assigned into 5 supplementation treatments without replication. Treatments were: T1) control without supplementation, T2)100% high moisture sorghum grain (HMS), T3) 97% HMS + 3% slow released urea (SRU), T4) 94% HMS + 6% SRU, and T5) 75% HMS + 6% SRU + 19% sunflower expeller (SE). Composition of supplements were (DM basis): 8.9% CP and 5.9% ADF (HMS); 35.0% CP and 25.1% ADF (SE); 140% CP and 1.35% ADF (SRU).

Analytical procedures and measurements were similar for all three experiments. Pasture height and availability were registered for each treatment every 28 days by clipping 10 random 0.1 m^2 quadrants in each treatment at ground level. Forage samples were dried in a forced-air oven at 60ºC during 48 hours to estimate % DM and forage availability. The nutritive value of feeds and pastures was estimated following the standard procedures performed in the Animal Nutrition Laboratory of INIA and reported by Fassio et al. (2009). Each year the sorghum grain was harvested at physiological maturity (28-32% moisture), grounded and stored in the absence of oxygen in pressed-silo bags (60 m of length) using a commercial grain bagger machine. Bags were hermetically sealed for at least 21 days before feeding.

Protein supplements were thoroughly hand-mixed with the high moisture sorghum grain when it was extracted daily from the silo bag and then the combined feeds were delivered to the animals in the feed troughs. The quantity of supplement provided per animal increased gradually during a 2 weeks habituation period until it reached the level of 1% of BW per day. This period of adaptation was not included in the analysis of data. Animals were weighed early in the morning without previous fasting every 14 days to adjust the amount of supplement to be delivered in each treatment. Fasted BW was registered every 28 days to estimate average daily gain (ADG). In addition, calves were evaluated for rib eye area and subcutaneous fat at the *Longissimus dorsi* muscle between the 12^{th} and 13^{th} rib by the use of ultrasound performed by trained personal during experiments 2 and 3. Feed efficiency of supplemented treatments was calculated as the kg of supplement (DM basis) per kg of added gain above the performance of control calves.

Variables of body weight and average daily gain were analyzed as a completely randomized design using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Treatment means were compared when a significant ($P<0.05$) F-test was observed using LSM test.

RESULTS AND DISCUSSION

In each experiment treatment had no effect on herbage mass, sward height or chemical composition of pasture so data is presented averaged over treatments (Table 1). Natural pastures species are the main source of feed for ruminants in Uruguay all year around. Uneven seasonal growth and availability of pastures can be compensated through the transfer of herbage mass from high (spring) to low (winter) growing seasons but at expenses of lower quality. In each year average pasture allowance was high (>2,000 DM kg/ha) but low in nutritive values, as reflected by its low CP concentration, high proportion of dead (dry) forage and high concentration of neutral detergent fiber (NDF). Animal intake was limited by the low quality of forage as NDF is negative associated with forage intake (Holecheck and Vavra, 1982) and the low CP concentration supported the concept that protein supplementation is a major factor in natural pastures grazing by growing cattle.

Exp. 1 evaluated the use of two protein sources, either sunflower expeller (29.6% CP) or a protein commercial supplement (31.1% CP), mixed with high moisture sorghum grain silage (HMS) to increase CP concentration from 7.1% to 12.0%. Average daily gain (ADG) was increased ($P<0.05$) by overall supplementation compared with the control group (0.34 and -0.08 kg/a/day, respectively) (Table 2). Calves without supplementation were 18% lighter ($P<0.05$) at the end of the experiment compared with supplemented animals (182 and 222 kg, respectively) as the intake of low-quality pasture does not provide sufficiently digestible energy to meet the animals' maintenance energy requirements (Hunter and Vercoe 1987; Dicker et al., 2001). There was a greater response in ADG in treatments with protein sources compared with only HMS supplementation (0.39 and 0.25 kg/a/day, respectively).

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No difference (P>0.05) was detected between sunflower expeller (T3) and the commercial supplement (T4) as protein source for ADG. This result confirms that supplementation with protein is necessary to optimize production in ruminants consuming low-quality forages (Bohnert et al., 2002; Moss et al., 2003). The improvement in animal performance may be related to increased concentration in ruminal ammonia as a result of greater nitrogen supply resulting in a more favorable environment for rumen microbes and increased forage utilization (DelCurto et al., 1990; Ludden et al., 1995; Koster et al., 1996). The amount of increase in dry matter intake seems to be associated with the level of protein in the forage as well as the maturity of the forage (Kunkle et al., 1999). Calves supplemented with high moisture grain plus protein sources were more efficient than calves supplemented only with high moisture grain as feed conversion numerically decreased from 6.0 (T2) to 4.5 (T3) and 4.1 (T4).

Table 1 - Mean (± SD) pasture allowance, sward height and chemical composition (%DM) of the natural pasture for each year

Item	Year		
	2009	2010	2011
Pasture allowance, DM kg/ha	2,649±1,124	2,827±1,419	2,235±926
Sward height, cm	10.8±4.9	10.7±5.4	6.0±2.3
Green to dead forage ratio	36:64	39:61	28:72
Crude Protein (CP), %	7.8±1.5	6.4±0.5	7.9±1.3
Acidic Detergent Fiber (ADF), %	44.9±1.6	50.7±2.0	46.2±2.8
Neutral Detergent Fiber (NDF), %	74.3±2.2	72.0±1.3	64.6±5.6

Table 2 - Average daily gain (ADG) and feed efficiency (FE) for calves grazing natural pastures and fed high moisture sorghum grain with or without different protein sources (media ± SEM)[1]

Item	Treatment [2]				Prob.
	T1	T2	T3	T4	
% CP in supplement[3]	-	7.1	12.0	12.0	-
Initial weight, kg	$189^{a}\pm5$	$182^{a}\pm4$	$192^{a}\pm4$	$190^{a}\pm3$	0.25
Final weight, kg	$182^{a}\pm5$	$206^{b}\pm5$	$227^{c}\pm4$	$232^{c}\pm4$	<0.05
ADG, kg/a/day	$-0.08^{a}\pm0.03$	$0.25^{b}\pm0.02$	$0.36^{c}\pm0.03$	$0.42^{c}\pm0.04$	<0.05
FE[4]	-	6.0	4.5	4.1	-

[1] Means within a row with different superscripts differ (P<0.05). [2] T1: control without supplementation, T2: 100% high moisture sorghum grain (HMS), T3) 78% HMS + 22% sunflower expeller (SE), T4) 78% HMS + 22% commercial protein supplement (CPS). [3] CP: Crude Protein; supplement offered daily at 1% of body weight (DM basis). [4] Kg of supplement (DM basis) per kg of added gain above the performance of control calves

Table 3 - Average daily gain (ADG), rib eye area (REA) and fat thickness (FT) for calves grazing natural pastures and fed high moisture sorghum grain with or without different protein sources (media ± SEM)[1]

Item	Treatment [2]				Prob.
	T1	T2	T3	T4	
% CP in supplement[3]	9.1	15.5	15.5	15.5	-
% CP from urea	0	0	22	42	-
Initial weight, kg	$172^{a}\pm4$	$172^{a}\pm3$	$172^{a}\pm4$	$172^{a}\pm3$	0.92
Final weight, kg	$176^{a}\pm5$	$195^{b}\pm4$	$197^{b}\pm5$	$192^{b}\pm5$	<0.05
ADG, kg/a/day	$0.03^{a}\pm0.02$	$0.20^{b}\pm0.02$	$0.22^{b}\pm0.03$	$0.18^{b}\pm0.04$	<0.05
Initial REA (cm^2)	$24.3^{a}\pm0.9$	$23.7^{a}\pm1.0$	$23.7^{a}\pm0.9$	$23.9^{a}\pm0.6$	0.96
Final REA (cm^2)	$27.8^{a}\pm0.9$	$27.6^{a}\pm1.0$	$27.3^{a}\pm1.0$	$28.1^{a}\pm0.9$	0.87
Initial FT (mm)	$2.37^{a}\pm0.06$	$2.36^{a}\pm0.09$	$2.44^{a}\pm0.07$	$2.57^{a}\pm0.09$	0.21
Final FT (mm)	$2.63^{a}\pm0.06$	$2.77^{a}\pm0.12$	$2.62^{a}\pm0.06$	$2.47^{a}\pm0.07$	0.10

[1] Means within a row with different superscripts differ (P<0.05). [2] T2: 100% high moisture sorghum grain (HMS), T2) 75% HMS + 25% sunflower expeller (SE), T3) 86.7% HMS + 12.1% SE + 1.2% urea (U), T4) 97.7% HMS + 2.3% U. [3] CP: Crude Protein in the supplement offered daily at 1% of body weight (DM basis).

Table 4 - Average daily gain (ADG), feed efficiency (FE), rib eye area (REA) and fat thickness (FT) for calves grazing natural pastures and fed high moisture sorghum grain with or without different protein sources (media ± SEM)[1]

Item	Treatment [2]					Prob.
	T1	T2	T3	T4	T5	
% CP supplement[3]	-	8.9	12.5	16.1	20.8	-
% CP from urea	-	-	30	48	47	-
Initial weight, kg	$143^{a}\pm6$	$141^{a}\pm4$	$143^{a}\pm4$	$144^{a}\pm4$	$142^{a}\pm4$	0.91
Final weight, kg	$148^{a}\pm3$	$174^{b}\pm4$	$172^{b}\pm7$	$195^{c}\pm5$	$185^{c}\pm5$	<0.05
ADG, kg/a/day	$0.05^{a}\pm0{,}03$	$0.32^{bc}\pm0{,}04$	$0.29^{c}\pm0{,}05$	$0.50^{d}\pm0{,}05$	$0.42^{bd}\pm0{,}03$	<0.05
Initial REA (cm^2)	$24.7^{a}\pm1.5$	$24.4^{a}\pm0.9$	$23.9^{a}\pm1.3$	$24.3^{a}\pm1.1$	$24.6^{a}\pm1.1$	0.98
Final REA (cm^2)	$26.6^{a}\pm0.8$	$29.4^{a}\pm0.8$	$27.1^{a}\pm1.6$	$28.0^{a}\pm1.3$	$29.1^{a}\pm1.0$	0.41
Initial FT (mm)	$2.02^{a}\pm0.15$	$2.15^{a}\pm0.12$	$2.25^{a}\pm0.11$	$2.20^{a}\pm0.07$	$2.12^{a}\pm0.12$	0.74
Final FT (mm)	$2.07^{a}\pm0.15$	$2.23^{a}\pm0.09$	$2.31^{a}\pm0.04$	$2.27^{a}\pm0.07$	$2.32^{a}\pm0.05$	0.38
FE[4]	-	5.2	6.4	3.6	4.2	-

[1] Means within a row with different superscripts differ (P<0.05). [2] T2: 100% high moisture sorghum grain (HMS), T3) 97.7% HMS + 2.3% slow-release urea (SRU), T4) 94.5% HMS + 5.5% SRU, T5) 76.5% HMS + 5.5% SRU + 18.0% sunflower expeller. [3] CP: Crude Protein in the supplement offered daily at 1% of body weight (DM basis). [4] Kg of supplement (DM basis) per kg of added gain above the performance of control calves

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Based on the high response to protein supplementation in exp. 1, CP concentration of HMS was increased to 15.5% in exp. 2. The main objective was to compare sunflower expeller, urea or a combination of both as protein sources. Overall ADG and final body weight increased (P<0.05) with the addition of protein compared to fed only HMS (Table 3). Protein source had no effect on animal performance. Similarly, Ludden et al. (1995) reported that neither rate nor efficiency of growth was improved when cattle was fed 12.4% CP diets that contained one of four sources of supplemental protein at 20, 30, or 40% of the dietary CP. In another study, calves fed soybean providing higher level of ruminal escape protein showed a similar ADG than those fed a urea and corn supplement (Fernandez-Rivera et al., 1989). Summarizing experiments evaluating the efficacy of urea in supplements fed to cattle on winter range, Clanton (1978) reported decreased performance with supplements containing greater than 3% urea compared to performance of cattle receiving similar energy densities but all-natural protein supplements. In exp. 2, urea represented 1.2% (T3) and 2.3% (T4) of the total supplement on a dry matter basis. Because calves evidently were nitrogen-deficient in the present study, positive responses to the addition of protein supplements would have been expected form any protein source. In addition, sorghum protein is resistant to ruminal degradation and it is likely that a large percentage of grain protein escaped ruminal degradation increasing the demand for nitrogen rapidly available in the rumen (Merchen et al., 1987; Cecava et al., 1991). Combining a protein source high in rumen undegradable protein with a highly rumen degradable protein source can improve animal performance of grazing cattle (McMurphy et al., 2010). Even though early studies showed that changing dietary protein level can affect rib eye area and fat deposition (Dartt et al., 1978; Perry et al., 1983), in our experiment both variables were not affected by treatment with an overall increase of 16% in rib eye are and 8% in fat thickness by the end of the experiment. The age of calves, the length of the feeding period and the level of supplementation may explain the absence of response.

The objective of exp. 3 was to evaluate the response in animal performance to increasing levels of protein in the supplement. Supplementation with only HMS (T2) increased final body weight and ADG by 17.5% and 6.6 times, respectively, compared with cattle in the control group (T1). This improvement in animal performance confirms the results obtained in exp. 1 showing that energy supplementation becomes a viable alternative when the primary objective is to avoid body weight loss in low-quality pastures. In such conditions overall intake of digestible energy is increased even though forage intake can be decreased by grain-based supplements (Lamb and Eadie, 1979; Chase and Hibberd, 1987; Sanson et al., 1990; Moore et al., 1999). Final weights and daily gains were greater (P<0.05) for cattle fed supplements with 16.1% (T4) and 20.8% CP (T5) compared with those fed 8.9% and 12.5% CP (T2 and T3). Performance of calves fed either 16.1% or 20.8% CP supplements did not differ possibly because energy was becoming the limiting factor at the highest CP concentration level. Additionally, supply of key limiting amino acids may not have been increased enough to elicit a response in performance when CP was raised to 20.8% (Merchen et al., 1987). Feed efficiency for cattle in treatments T4 (3.6) and T5 (4.2) was improved by 30% and 19% compared with cattle fed diets containing only high moisture sorghum grain (5.2) confirming the results obtained in exp. 1. Ultrasound variables were not affected by treatment (P>0.05) as it happened in exp. 1 although supplemented calves registered a rib eye area and fat thickness 7% and 10% greater at the end of the experiment than un-supplemented animals.

CONCLUSIONS

The addition of protein sources to increase the high moisture sorghum grain CP concentration from 8 to 16% significantly increased the performance of calves grazing low quality pastures and daily supplemented at 1% of body weight. The utilization of sunflower expeller appears to offer no improvement in performance compared with urea at such levels. As practical recommendation the threshold of 16% CP in the sorghum grain should be reached using the available protein source most economical to accelerate the growth period of calves in extensive conditions.

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