Pastos y Forrajes, Vol. 36, No. 2, April-June, 246-251, 2013

Finishing of British steers under grazing conditions, supplemented with high-tannin sorghum grain

A. E. Fernández[1], R. J. Stuart[2], Bertha Chongo[2] y P. C. Martín[2]

[1]*Instituto Nacional de Tecnología Agropecuaria (INTA)*
Ruta Provincial. 76 km 36,5 (8187) Bordenave, Buenos Aires, Argentina
E-mail: afmayer56@yahoo.com.ar
[2]*Instituto de Ciencia Animal, Mayabeque, Cuba*

ABSTRACT

The objective of this experiment was to fatten British steers with 18 years of age and 380 kg of LW, with the lowest possible production cost. The impact of high-tannin sorghum grain on meat production was also evaluated. The research was conducted at the experimental field Cesáreo Naredo of the INTA Bordenave, in Buenos Aires, Argentina, during two stages; in the first one (254 days) the treatments were: T1) 20 pure red Aberdeen Angus (AAr) calves, of 183,4 kg LW and T2) 18 bull calves AAr x Shorthorn (AAr x Sh) of 183,6 kg LW; and in the second one (247 days), 45 calves AAr x Sh of 218,4 kg LW, in just one treatment. A mixed pasture based on alfalfa and supplements of dried and ground sorghum grain at a rate of 1 % of the LW were used. The grain intake was 2,97 and 3,38 kg grain head^{-1} day^{-1}, while the daily weight gain was 0,891 and 0,969 kg^{-1} head^{-1} day^{-1} for the first and the second stage, respectively. Meat production was 452,12 and 567,24 kg ha^{-1}, and the production cost was 0,57 and 0,54 USD per produced kilogram, respectively. In the first stage the quadratic model showed a better adjustment with high R^2 (0,99) and lower mean squared error (MSE 33,26). In the second stage the linear model showed the best adjustment with high R^2 (0,99) and lower MSE (44,78). The productive and economic values were very adequate. No negative effect of tannins was observed in the evaluated indicators.

Key words: steer, meat production, *Sorghum bicolor*

INTRODUCTION

The utilization of suitable energetic supplementation increases weight gain and stocking rate in grazing systems, indicators that reduce fattening duration and propitiate significant increases in meat production per hectare. These results are explained by the better nutrient balance provided by the energetic supplement to the pasture diet (Fernández Meyer, 2006).

Sorghum grain stands out for its nutritional characteristics and for being tolerant to water stress, because it requires 30 % less water per kilogram of produced DM as compared with corn. This provides the former with higher harvest safety and lower cost as compared with the latter, in many agroecological regions around the world; Bragachini, Cattani, Ramírez and Ruiz, 1997). The good results in cattle fattening with the use of high-tannin sorghum grain (HTS) (8-14 grams per kilogram of DM) is one of the factors that would explain its great demand in recent times (Zamora, Massigoge y Melin, 2009; Massigoge, Zamora and Melin, 2009).

Taking into account these antecedents, an experiment was conducted under grazing conditions based on alfalfa, in order to evaluate the productive and economic response of fattening pure red Aberdeen Angus steers (AAr) and their crossing with Shorthorn (AAr x Sh), as well as the effects of HTS as energetic supplement.

MATERIALS AND METHODS

The essay was conducted at the demonstrative experimental field Cesáreo Naredo of the INTA Bordenave, in Guaminí (Buenos Aires, Argentina), where entic and typical Hapludoll soils predominated (SAGYP-INTA, 1989).

The work was divided in two stages: the first one lasted 254 days (September, 2004-May, 2005), while the second one lasted 247 days (August, 2005-April, 2006). The rainfall from August to May was 650 and 553 mm, during both stages, respectively. In the first stage 38 calves of 8 ± 1 months of age were used, divided in two treatments: T1: 20 AAr calves (183,4 ± 15 kg LW head^{-1}) and T2: 18 Aar x Sh calves (183,6 ± 10 kg LW head^{-1}); and in the second stage, 45 Aar x Sh calves, distributed in just one treatment, with average weight of 218,4 ± 22 kg LW head-1. The resulting stocking rate in the first stage was 2,0 heads ha^{-1} or 593,6 kg LW ha^{-1}, and in the second one, 2,37 heads ha^{-1} or 801,53 kg LW ha^{-1}.

An area of 19 ha was used in the two stages (14 ha were occupied by a poliphytic pasture and 5 ha were equivalent to the sorghum grain used and expressed in ha^{-1}). In the first stage a pasture planted in 2000 was used, and in the second one, a pasture planted in 2005. The floristic composition was similar in both stages: alfalfa (*Alfalfa sativa*) (5 kg ha^{-1}), red clover (*Trifolium repens*) (1 kg ha^{-1}) and rescuegrass (*Bromus unioloides*) (5 kg ha^{-1}).

The sorghum grain, dried and ground, had a high content of condensed tannins (11 ± 0,40 and 10,8 ± 0,08 g kg of grain^{-1} for the first and second stage, respectively). Moreover, the hay obtained from the same pasture was offered, when the DM production of alfalfa decreased, which is typical of the end of winter and the beginning of autumn in this region. Conventional vaccinations (against blackleg, gas gangrene and enterotoxaemia) and strategic antiparasitics were also applied.

For the chemical analysis of pastures, samples were taken from ten randomly selected sites, according to the hand-plucking technique (Dulau, 2007); this was done with an interval of 30 to 35 days. In each site five subsamples were extracted, cutting the forage with the hand at the height it was eaten by the animals (15-25 cm) and respecting the leftover. The five subsamples site^{-1} were mixed, a pool was made (1,0 kg GM sample^{-1} site^{-1}) and were placed in a nylon bag, with the corresponding identification and it was preserved in a freezer (-5 °C) until their arrival at the laboratory.

From the sorghum grain five samples were randomly extracted (0,500 kg sample^{-1}) and were collected in nylon bags, with the corresponding identification. The chemical analysis was conducted in the INTA laboratory (Bordenave, Argentina). The dry matter (DM), crude protein (CP) and starch (AOAC, 1995); in vitro digestibility of DM (IVDDM) (Tilley and Terry, 1963, modified by the direct acidification method, Ankom Technology, 2008); soluble carbohydrates (SNSC) (Antrona method, Silva, Monteiro, Alcanfor, Assis and Asquier, 2003); neutral detergent fiber (NDF) (Van Soest, 1994, with ANKOM equipment) and tannins (Folin Ciocalteu method, Makkar, 2003) were determined.

To estimate pasture availability (kg DM ha^{-1}) ten metallic rings (subsample) of radius 0,57 (total: 10 m^2 sampling^{-1}) were randomly thrown and cut with scissors at 20 cm of height, with an interval between cuttings from 25 to 30 days, before each grazing moment. The forage of each subsample was dried in a stove at 60ºC until reaching constant weight to determine the DM percentage. The values obtained were converted into kg DM ha^{-1} (Trasmonte, 2002). The pasture offer represented the amount assigned to each animal, according to its requirements and pasture availability and it was expressed in kg DM/100 kg LW day^{-1} (Romera, Gartía, Marino and Agnusdei, 2008).

The DM intakes of pasture were determined by the difference between availability and the leftover, adjusted by the DM level (Gallegos, 2010). The management of pastures was done through variable paddocks with electric fencing, according to the forage offer, with rotations every two to three days. The offer was variable, in function of the live weight, in order to satisfy the nutritional needs of the animals under study (Gallegos, 2010).

The experimental unit used in this essay was the animal. The mean daily gain (MDG) was determined through periodic weighing –with mechanic scale– of 20 animals (repetitions) randomly selected in each stage. This weighing was made with an interval from 25 to 35 days and always at the same hour. The meat production (MP) was expressed as the kilograms produced per hectare. To compare the chemical parameters and the intake between the stages, a simple classification model was used; while in the case of the LW performance the regression analysis was used, through the adjustment of linear and non-linear models and the evaluated statistical criteria were: determination coefficient (R^2), mean squared error (MSE), least-squares estimation methods for the linear model and the Levenbeng-Marquardt method (2009) for non-linear models, significance of the model parameters and autocorrelation of the residues through Durbin-Watson (DW) (Fernández, 2004).

The formulas used were:

- Linear: $LW = \alpha + \beta$ (weighing)
- Quadratic: $LW = \alpha + \beta$ (weighing) $+ \gamma$ (weighing)^2
- Logistic: $LW = \alpha / (1 + \beta * \exp(-\gamma * \text{weighing}))$

Pastos y Forrajes, Vol. 36, No. 2, April-June, 246-251, 2013

- Gompertz: PV= α *exp (- β *exp (-γ *weighing))

The chemical parameters of the feedstuffs were statistically analyzed through SAS/STAT 2005. The data processing was made through the statistical software SPSS (2006) for Windows.

To elaborate the production costs (PC) the average values of the Argentinean market were taken into account (last 10 years). The sorghum grain and hay cost was 110 USD and 40 USD t^{-1} respectively; the pasture cost was 50 USD $ha^{-1}year^{-1}$ with an annual amortization of 200 USD/4 years duration; while the staff and veterinary services cost was 10 and 5 USD ha^{-1}, respectively.

RESULTS AND DISCUSSION

Table 1 shows the results of the chemical analysis of the feedstuffs used; there were significant differences in the IVDDM of the pastures and the hay, in both stages, although the floristic composition of the pasturelands was similar and the pasture of the second one had been established for few months. However, these values were high, which is a characteristic of temperate pastures and are in correspondence with the CP and NDF values found in them (Mosley, 2001).

The total intake of sorghum grain was 754,0 and 835,0 kg $head^{-1}$, during the first and second stage, respectively; while the average intake was 2,97 and 3,38 kg $head^{-1}day^{-1}$. The grains were ground at a particle size of ± 2 mm, which propitiates higher ruminal degradability of DM, CP and starch (Stock and Mader, 2006). Meanwhile, the pasture hay intake was 156,0 and 175,0 kg hay $head^{-1}$, respectively.

The weight gain (table 2) showed differences between both stages of the essay that can be ascribed to the different availability of the pastures used. In the first stage these were finishing their productive cycle (five years), while in the second one a new pasture was used (one year). The meat production per hectare was 452,88 and 567,24 kg ha^{-1}, respectively; which widely exceeds the average values (220-300 kg ha^{-1}) obtained in livestock production enterprises of the subhumid and semiarid region of the country (Aello and Dimarco, 2004; Rearte, 2010).

Table 1. Bromatological analysis (%) of the feedstuffs used in both stages (I and II).

Feedstuff	DM	CP	IVDDM	ME*	SNSC	NDF	ADL	Tannins ($g\ kg^{-1}$)
Pasture I	29,37	14,25	68,02	2,45	17,55	59,74	2,92	
	(0,82)	(0,47)	(0,47)	(0,02)	(0,45)	(0,84)	(0,12)	
Pasture II	27,88	13,44	65,44	2,36	13,42	62,22	3,25	
	(0,42)	(0,35)	(0,57)	(0,09)	(0,85)	(0,77)	(0,25)	
SE ±	1,85	1,54	1,88	0,09	0,272	2,08	0,075	
Significance	NS	NS	P<0,05	NS	P<0,01	NS	NS	
Hay I	88,8	9,94	57,16	2,06	8,50	69,15	6,0	
	(0,56)	(1,06)	(0,36)	(0,01)	(1,0)	(0,5)	(0,2)	
Hay II	89,22	7,88	54,05	1,95	5,50	67,98	5,4	
	(0,35)	(1,44)	(0,65)	(0,08)	(1,0)	(0,56)	(0,2)	
SE ±	2,56	1,55	2,35	0,07	1,07	2,47	0,089	
Significance	NS	NS	P<0,05	NS	P<0,05	NS	NS	
Sorghum I	88,82	8,40	83,52	3,01	33,54	29,0		11,0
	(0,72)	(0,21)	(1,07)	(0,04)	(1,24)	(0,8)		(0,1)
Sorghum II	88,15	7,55	84,85	3,05	23,54	28,22		10,8
	(0,68)	(0,75)	(1,25)	(0,08)	(1,32)	(2,7)		(0,08)
SE ±	2,08	1,78	1,59	0,05	2,45	0,05		1,66
Significance	NS	NS	NS	NS	P<0,01	NS		NS

SE: standard error; standard deviations between parentheses;*Mcal kg DM^{-1}

Table 2. Evolution of weight gain (kg head^{-1} day^{-1})

	Genotype	Daily weight gain
Stage I	AA	0,901 (0,257)
	AAxSh	0,882 (0,307)
Stage II	AAxSh	0,969 (0,239)

Standard deviation between parentheses.

When comparing the treatments of the first stage, the non-linear models did not have the significant adjustments (table 3). For both genotypes the model of best adjustment was the quadratic one, because it had a high determination coefficient, high statistical significance in the adjustment of the model and low mean squared error, compared with the remaining models.

Regarding the performance of the LW of the Angus pure red x Shorthorn genotype, in both stages of the experiment (table 4), the quadratic model also showed a better adjustment during the first stage; however, during the second one, the model of better adjustment was the linear one, with a high determination coefficient, highly significant adjustment and a lower mean squared error.

In the second stage the linear model was selected for the LW performance because the analysis of residues indicated that the quadratic model was not suitable; this could have been due to the fact that the animals in this stage started with a slightly higher weight and, at the end of the experiment, they still had possibilities of continuing to grow up, because they had not shown all their growth potential. This corroborates that, although the feeding system was the same, the productive response (weight gain) was influenced by the effect of the hybrid vigor (crossing), although they were genotypes with closely related genetic lines (Mezzadra, Melucci, Villareal, and Faverin, 2003).

In confined fattening with young bulls of the same breed and similar live weight, Monje (2002) used diets with high levels of sorghum grain (45 % of the diet DM) and obtained a slightly higher MDG (1,007 kg day^{-1}) than the one reached in this essay. The gains obtained by Lagrange, Larrea and

Table 3. Results of the models evaluated during the first stage (I)

Adjusted models	alpha	beta	gamma	R^2	Signif. model	MSE
Quadratic model	178,98	1,17	-0,0010	0,99	***	31,36
Angus red steers I						
SE ±	1,40	0,03	0,0001			
Quadratic model	180,31	1,21	-1,20E-03	0,99	***	33,26
Angus x Shorthorn steers I						
SE ±	1,44	0,03	9,90E-05			

***P<0,001

Table 4. Results of the evaluated models (I stage vs. II stage).

Adjusted models	alpha	beta	gamma	R^2	Signif. model	MSE
Quadratic Model	180,31	1,21	-0,0012	0,99	***	33,26
Red Angus x Shorthorn I						
SE (±)	1,44	0,03	0,0001			
Linear Model	220,04	1,06		0,99	***	44,78
Red Angus x Shorthorn II						
SE (±)	1,32	0,01				

***P<0,001

Fernández Mayer (2006) (1,18 ± 0,04 kg head^{-1} day^{-1}) were also higher when providing sorghum grain at 1 % of the LW, together with oat (*Avena sativa*) and polyphytic pastures (alfalfa + temperate grasses). The difference between the meat production of this work and the above-mentioned essay could be due to the high nutritional quality of the forages used (oat and pasture).

However, the gains of this experiment are higher than the ones obtained in the grazing systems with strategic supplementation in Argentina, where the average for this region oscillated between 0,400 and 0,600 kg head^{-1} day^{-1} (Rearte, 2010).

Moran and Wales (2001) obtained similar results with animals of the same genotype, although they used as basis a better-quality pasture (Ray grass var. Apanui + *Trifolium repens*) together with silage and corn grain (1,6 % of LW) and a stocking rate of 2,5 heads ha^{-1}

Of all the weight gains, the ones reached during the summer months were significantly high (± 1,0 kg head^{-1} day^{-1}) and relevant for this season of the year; in which, normally, these pastures are unbalanced, with fiber excess (NDF > 60 %), low proportion of rumen degradable proteins (< 10 %) and moderate levels of SNSC (8 to 12 %) (Fernández Mayer, 2006; Pordomingo, Juan y Pordomingo, 2007). Such situation causes weight gains below 600 g daily, when no correcting concentrate is added (Rueda, Taborda and Correa, 2006; Tas, 2006).

These results may be due to the positive multifactorial effect of the tannins from the sorghum grain, which is manifested: a) in its action as biological antiparasitic (Min and Hart, 2003); b) by diminishing protein solubility and degradability of the alfalfa pasture, which generates high concentrations of rumen ammonia and, thus, more energy is demanded to detoxify metabolic urea (Conti *et al*., 2007); and c) by the higher energetic efficacy of the diet by reducing methane production (Gurbuz, 2009). Such factors could play an important role in the meat production obtained (Pordomingo, Volpi Lagreca, Orienti, and Welsh, 2003; Pordomingo *et al*., 2007a), which contrasts with the criterion referred to the fact that these polyphenols cause a reduction in the intake and digestibility of protein, dry matter and mineral fractions (Godoy, Chicco, Meschy and Requena, 2005; Ojeda *et al*., 2010). In this work there was no negative effect of tannins on the evaluated indicators.

To the positive effects of the tannins the actions of some substances from alfalfa should be added, such as saponins, lysines, flavonoids, steroids, etc. (Anon, 2010). Saponins as well as tannins could have incidence on improving the efficiency in feed utilization in ruminants, by increasing the flow of microbial protein to the duodenum (Klita, Mathison, Fenton and Hardin, 1996); their effect is more evident when both substances are present and not separated. Likewise, saponins –together with other steroids and polyphenols– could exert a defauning effect on the rumen protozoa, which affect the growth of bacteria and cellulolytic fungi (Naranjo, Guiamet and Gómez de Saravia, 2009). All these substances would improve the energetic metabolism of the animal and with it, the productive response (Dimarco and Aello, 2004).

The production costs represent one of the best normalized indicators and they are the quotient between the direct costs of feeding, staff and health, with respect to the total meat production obtained per hectare (USD produced kg^{-1}) (Resch, 2010). Table 5 shows the direct production costs in both stages.

Table 5. Direct production costs.

	Stage I	Stage II
Direct costs (USD ha^{-1}):		
Sorghum grain	165,88	217,68
Poliphytic pasture	50,00	50,00
Hay	24,96	26,60
Staff	7,00	6,80
Veterinary services	3,50	3,40
Total direct costs	251,34	304,49
Total meat production (kg ha^{-1})	452,87	567,24
Production cost (USD produced kg^{-1})	0,55	0,54

The economic results showed very suitable values for a grazing system (Resch, 2010) and coincided with those obtained in studies conducted with pasture and supplements based on cereal grains (corn, sorghum) (Rearte, 2010). The studied grazing system, with supplementation based on high-tannin sorghum grain, was concluded to promote high daily weight gains in British type animals, for which fattening duration was reduced and suitable direct production costs were obtained. Also, the weight gains obtained during the summer were observed to be higher than the expected ones and they constituted a valuable antecedent to continue this line of work.

Throughout the experiment there was no negative effect of the tannins on the evaluated productive indicators.

Received: April 10, 2013
Accepted: June 3, 2013

XIII CONGRESO INTERNACIONAL DE INFORMACIÓN

El Instituto de Información Científica y Tecnológica (IDICT) del Ministerio de Ciencia Tecnología y Medio Ambiente de la República de Cuba tiene el placer de invitarlo a participar en el XIII Congreso Internacional de Información, Info'2014, y el X Taller Internacional sobre Inteligencia Empresarial y Gestión del Conocimiento en la Empresa, IntEmpres'2014, que sesionarán del 14 al 18 de abril de 2014, en el Palacio de Convenciones de La Habana, Cuba, con el lema general: "información, Integración, transformación".

Mayor información:

MSc. Modesto Zaldívar Collazo
Secretario Ejecutivo de Info'2014 e IntEmpres'2014
Telf.: (537) 207-8884 y 207-8894
info@idict.cu , www.congreso-info.cu , www.idict.cu

MSc. Katia Iris Medina
Organizadora Profesional de Eventos
Palacio de Convenciones de La Habana, Cuba
katia@palco.cu, www.cpalco.cu
Telf. (537) 2026011, ext. 1511