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Original

Behavior, performance and carcass yield of steers with different comfort conditioning during the fattening period

Comportamiento, desempeño y rendimiento de la canal mediante la creación de condiciones de confort durante la ceba

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ABSTRACT

Objective. The aim of this study was to evaluate the behavior and performance of steers in two different housing areas (10 vs. 100 m^2/animal) and two feeding models (daily supply vs. self-feeding) during the fattening period. **Materials and methods:** Forty-eight Hereford steers with initial live weight (LW): 214,0 kg were housed under four treatments: 100DS (100 m^2/animal and daily supply), 100SF (100 m^2/animal and self-feeding), 10DS (10 m^2/animal and daily supply), 10SF (10 m^2/animal and self-feeding) until reaching a final LW of 370 – 390 kg. Behavior was recorded by observation. Dry matter intake (DMI) and average daily gain (ADG) were recorded to estimate feed conversion ratio (FCR). Back fat thickness (BFT) and *Longissimus* muscle area (LMA) were measured. Steers were sent to a commercial abattoir to evaluate carcass yield. **Results:** The frequency of rest and walking was higher in steers in the largest housing area. Self-feeding contributed to the intake distribution during the day. No differences were detected in DMI, ADG and FCR. However, the confined animals (10DS and 10SF) produced more BFT and less LMA. In addition, they had less carcass yield at slaughter. **Conclusions:** Therefore, a larger

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housing area and the self-feeding model could contribute to express steers' natural behavior and improve their performance.
KEYWORDS: animal welfare, cattle, feedlot, housing area, feeding (*Source: MESH*)

RESUMEN

Objetivo. EL propósito de este estudio es evaluar el comportamiento y desempeño de bueyes en dos zonas de estancia (10 vs. 100 m^2/animales) y dos modelos de alimentación (suplementación diaria vs autoalimentación) durante el periodo de ceba. **Materiales y métodos:** Se emplearon un total de 48 bueyes Hereford con un peso inicial (PI) de 214,0 kg con dos tratamientos diferentes: 100 SD (100 m^2/animal y suplementación diaria), 100 AA (100 m^2/animal y auto alimentación), 10 SD (10 m^2/animal y suplementación diaria), 10 AA (10 m^2/animal y auto alimentación) hasta alcanzar un peso final (PF) de 370 – 390 kg. Se registró el comportamiento mediante observación. Igualmente, se registró el consumo de materia seca (CMS) junto a la ganancia promedio diaria (GPD) para estimar la relación de conversión alimentaria (RCA). Se midieron el grosor de la grasa posterior (GGP) y la zona muscular *Longissimus* (ZML) y se enviaron los bueyes al matadero para evaluar el rendimiento de la canal. **Resultados**: La frecuencia de descanso/marcha fue mayor en los bueyes que permanecieron en la mayor área de estancia. La auto alimentación contribuyó a distribuir el consumo de alimentos durante el día. No se detectaron diferencias en CMS, GPD y RCA. Sin embargo, los animales confinados (10 SD y 10 AA) produjeron más GGP y menos de ZML. Por otra parte, mostraron un menor rendimiento de la canal durante el sacrificio. **Conclusiones:** Un área de estancia mayor, junto al modelo de autoalimentación, contribuyó a un comportamiento natural de los bueyes y un mejoramiento de su desempeño.
Palabras claves: bienestar animal, ganado bovino, nave, área de estancia, alimentación (*Fuente: MESH*)

INTRODUCTION

Beef cattle is mostly fattened under intensive production systems that are generally restrictive in terms of access to valuable resources such as living space, freedom of movement and interaction with natural substrates. In many countries, they are housed in places where muddy condition is a major problem for animal welfare (Grandin, 2016).

Despite the fact that confinement increases emerging diseases and transmission of pre-existing diseases (Rossanigo *et al.*, 2009), it is a widely used alternative for cattle fattening. However, due to the multifactorial influence, confinement may not achieve higher yields compared to grasslands or semi-confinement systems. In addition, it is important to highlight that consumers increasingly demand better quality, good production practices, animal welfare, traceability and sustainability (Mota and Marçal, 2019).

The first method to keep cattle clean is a correct stocking density (Grandin, 2016). Mader and Colgan (2007) found that lower cattle density in feedlots resulted in lower muddy conditions. These results indicate that more space could improve animal comfort and performance.

Space influences feedlot cattle behavior and there is evidence that housing modifications could promote livestock welfare (Park *et al.,* 2020). Livestock behavior and welfare play an important role in body development and carcass composition of beef cattle. Physical comfort and nutritional conditions integrate the five domains model: nutrition, environment, health, behavior, and mental state (Mellor *et al.,* 2020).

Moreover, delivering feed daily is not an option for producers with limited time or equipment. Feed availability is a major limiting factor for production and animal welfare. Feeding characteristics associated with low ruminal fluid pH are: high dry matter intake and ingestion of large meals. It is because of the greater amount of acid production per period of time, high eating rate because of lower feed insalivation, short time spent chewing while eating and ruminating because of lower daily saliva production, and large variations in feeding behavior patterns throughout the day such as less frequent meals and rumination. Adaptation of feeding behavior to diets with greater proportion of concentrates also plays an important role, as smaller meals and more even distribution of intake throughout the day lead to a better synchronization in time between acid production and elimination or neutralization (González *et al.,* 2012). Many farmers feed their livestock only once a day to minimize the cost of labor. Self-feeders can be used to provide ad libitum food. Final weight and yield are indicators of animal welfare (Park *et al.,* 2020). Because of high concentrate diets and sedentary lifestyles cattle in confinement could be prone to display poor health (Macitelli *et al.,* 2020). Feeding behavior can also improve performance. An increase in feeding frequency during the fattening period may contribute to promoting a better rumen environment for fermentation. Furthermore, more stable ruminal conditions can decrease dry matter intake (DMI) as feeding frequency increases (De Souza Teixeira *et al.,* 2018). Therefore, the aforementioned feeding model and homogeneous distribution of consumption along the day may contribute to express innate behavior of displacement and rest in cattle (Oberschätzl *et al.*, 2016).

Farmers must provide adequate conditions in order to meet livestock physiological and behavioral needs (Fernandez-Novo *et al.,* 2020). It is necessary to promote a more sustainable and efficient production system than the current agricultural and livestock systems. Thus, livestock conditions have to improve animal welfare and reduce environmental problems. Based on this information, the aim of this study was to evaluate behavior and performance in steers with two housing areas (10 vs. 100 m^2/animal) and two feeding models (daily supply vs. self-feeding) during the fattening period.

MATERIALS AND METHODS

This research was carried out at the INTA Agricultural Experimental Station, located in the city of Concepción del Uruguay, Entre Ríos, Argentina (32°48’S, 58°34W). Forty-eight Hereford steers with an initial age of 9 months and live weight (LW) of 214,0 ± 23,7 kg were housed using four treatments: 100DS (100 m^2/animal and daily supply), 100SF (100 m^2/animal and self-feeding), 10DS (10 m^2/animal and daily supply) and 10SF (10 m^2/animal and self-feeding).

Previous to the experience, animals underwent 35-day adaptation period. The fattening period diet was formulated with 77% whole corn, 20% ground corn, 2% slow released urea (43% N) and 1% mineral supplement. Animals were fed according to the assigned treatment. The daily supply treatments meant that 3.2% LW animals were offered feed every day whereas animals' feeders were filled every four days in self-feeding treatments.

Steers were identified with numbers written on both sides of their bodies. Behavioral data was collected by observation performed during the first 7 days of the experience. Animals were observed for one hour three times during the day (09:00= morning, 13:00= noon and 17:00=afternoon). Food intake (access to feeder) and displacement (resting, walking, static standing) were recorded by registering the number of times the animals executed these activities.

LW was registered at 14-day intervals in order to estimate average daily gain (ADG). Intake was determined as the difference between the amount of food provided and residual food, divided by the number of animals in each treatment. Feed conversion (FC) was determined by the ratio intake/ADG. DMI and ADG were recorded individually to determine the feed conversion ratio (FCR).

Back fat thickness (BFT) and *Longissimus* muscle area (LMA) were measured in steers at 28-day intervals until slaughter. A real time ultrasound machine (FALCOVET 100, PieMedical, Holland) was used to measure LMA and BFT between the 12th and 13th rib and vegetable oil was used as a coupling agent.

Steers were fattened to 370 – 390 kg LW and sent to a commercial abattoir. The hot carcass weight was obtained after pelvic fat removal. Carcass yield was calculated by dividing hot carcass weight by final body weight (7% dressing).

Statistical analysis was performed using PROC GLM (4). The model includes the effect of two housing areas (HA), two feeding (F) models and the interactions between these effects (HA*F). The model also included the effect of time on data collection. The steers were considered as experimental units (n= 12). When interaction or principal factors were significant ($p<0.05$), means were compared by the Tukey test.

RESULTS AND DISCUSSION

A difference in frequency of food intake was found among different feeding models along the day ($p<0.0001$, Figure 1). The animals with daily supply (100DS and 10DS) presented higher intake frequency in the morning when compared to noon and afternoon ($p<0.05$). These treatments also showed higher intake frequency regarding 100SF and 10SF in the morning, similar at noon and lower in the afternoon. Self-feeding resulted in a homogeneous feeding pattern along the day ($p>0.05$). The higher feeding activity in the morning in 100DS and 10DS was associated with the conditioned reflex caused by the food supply.

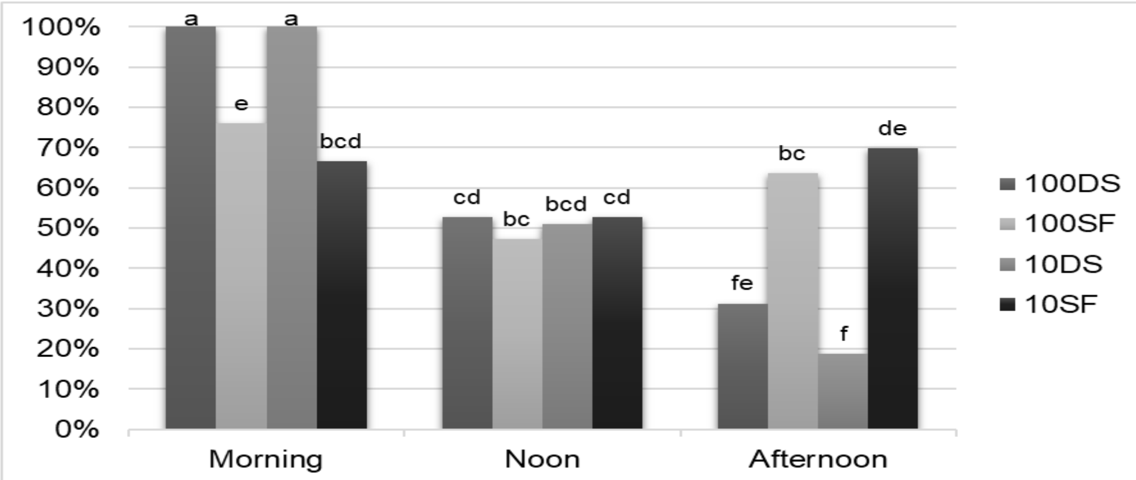

Figure 1. Food intake along the day in steers with different comfort conditions during the fattening period. 100DS: 100 m²/animal and daily supply, 100SF: 100 m²/animal and self-feeding, 10DS: 10 m²/animal and daily supply, 10SF: 10 m²/animal and self-feeding.

a, b: Mean values represented by different letters in the rows indicate statistical differences detected by the Tukey test (p<0.05).

Comfort conditions (housing area and feeding model) affected displacement in steers during the fattening period (Figure 2). Treatments with larger housing areas (100DS and 100SF) presented a higher walking frequency in the animals. Only 1% of confined animals (10DS and 10SF) walked and also had a lower frequency of rest due to the smaller space (p<0.05).

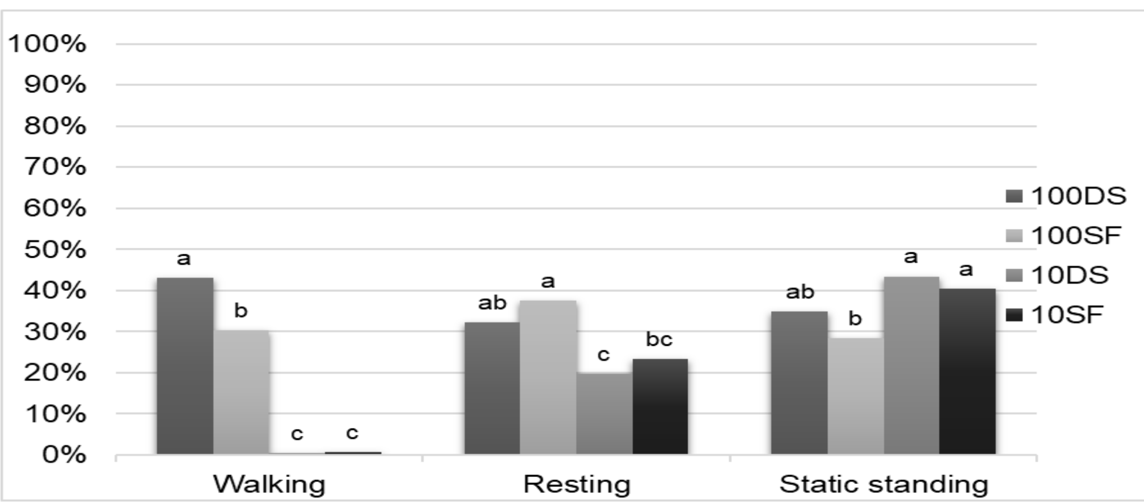

Figure. 2. Displacement in steers with different comfort conditions during the fattening period. 100DS: 100 m²/animal and daily supply, 100SF: 100 m²/animal and self-feeding, 10DS: 10 m²/animal and daily supply, 10SF: 10 m²/animal and self-feeding.

a, b: Mean values represented by different letters in the rows indicate statistical differences detected by the Tukey test (p<0.05).

Patterns of food intake agrees with the findings of Mattachini *et al.* (2011) who found that the frequency of feed delivery affected the pattern of lying down? behavior throughout the day and the lying down time following the provision of feed.

Under natural conditions, cattle display a need of spreading out their feeding behavior over the whole day (Schneider *et al.*, 2019). Results found in this work show a better intake behavior along the day in animals on a self-feeding system. Displacement behavior results are similar to Schütz *et al.* (2019) who found that cows on manure contaminated surfaces had a reduced lying time in comparison with those on dry soil. They suggested that the reduction in lying down time is predominantly due to the surface moisture content. Muddy surfaces have negative effects on the health and welfare of dairy cattle, and if possible, cows will avoid this surface.

Final weight, ADG, TWG, DMI and FCR were similar regardless of comfort conditions during the fattening period (Table 1).

Table 1. Mean values for weight evolution, dry matter intake and feed conversion ratio in steers with different comfort conditions during the fattening period.

	100DS	100SF	10DS	10SF	SEM	*p*		
						HA	F	HA*F
IW[1] (kg)	214.9	212.8	220.0	208.3	3.42	0.97	0.32	0.49
FW[2] (kg)	369.9	371.8	384.2	376.8	2.98	0.11	0.65	0.44
ADG[3] (kg)	1.3	1.3	1.3	1.4	0.02	0.13	0.33	0.97
TWG[4] (kg)	155.0	159.1	164.2	168.5	3.91	0.41	0.70	0.99
DMI[5] (kg)	1103.8	1095.3	1106.4	1139.4	25.43	0.41	0.70	0.99
FCR[6] (kg)	7.2	6.9	6.8	6.8	0.16	0.58	> 0.99	0.73

100DS: 100 m^2/animal and daily supply, 100SF: 100 m^2/animal and self-feeding, 10DS: 10 m^2/animal and daily supply, 10SF: 10 m^2/animal and self-feeding, HA: housing area, F: feeding models.
[1]Initial weight, [2]Final weight, [3]Average daily gain, [4]Total Weight gain, [5]Dry matter intake, [6]Feed conversion ratio.

Ultrasound measurement and carcass yield were affected by comfort conditions (Table 2). A significant difference in final and total gain BFT ($p<0.05$) according to housing areas was observed. At the end of the fattening period, the treatment 10DS showed a higher BFT than 100SF. Conversely, LMA final and total gain was higher for 100SF when compared to 10SD. Housing areas also affected carcass yield. Animals with more housing space presented higher values ($p=0.0010$).

Table 2. Mean values for ultrasound measurement and carcass yield in steers with different comfort conditions during the fattening period.

	100DS	100SF	10DS	10SF	SEM	*P*		
						HA	F	HA*F
Initial BFT[1] (mm)	6.3	6.2	6.4	6.4	0.12	0.46	0.71	0.76
Final BFT (mm)	10.7 ab	10.4 a	11.6 b	11.0 ab	0.18	0.03	0.21	0.73
Total gain BFT (mm)	4.4 ab	4.2 a	5.2 b	4.6 ab	0.16	0.04	0.29	0.54
Initial LMA[2] (cm^2)	40.3	39.6	43.3	40.1	0.98	0.38	0.34	0.53
Final LMA (cm^2)	76.8 ab	80.6 a	74.2 b	75.0 ab	1.12	0.004	0.29	0.48
Total gain LMA (cm^2)	36.5 ab	41.0 a	30.9 b	34.8 ab	1.50	0.03	0.15	0.93
Hot carcass weight (kg)	212.5	213.4	214.5	211.7	1.87	0.72	0.57	0.42

Carcass yield (%)	61.7 a	61.7 a	60.1 b	60.4 b	0.00	<0.001	0.93	0.92

[1]Back fat thickness, [2]Longissimus muscle area.
100DS: 100 m^2/animal and daily supply, 100SF: 100 m^2/animal and self-feeding, 10DS: 10 m^2/animal and daily supply, 10SF: 10 m^2/animal and self-feeding.
a, b: Mean values represented by different letters in the rows indicate statistical differences detected by the Tukey test ($p<0.05$).

According to Park *et al.* (2020), space allowance influences cattle behavior and performance and they are indicators of positive welfare state. Exposure to mud also has implications for cattle hygiene and health. In this research, a smaller housing area produced muddy conditions which resulted in poor animal hygiene (Photo 1). With more space, animals remained clean during all the fattening period (Photo 2). Prior rainfall and surface water pooling were useful measures to determine less lying down time, and thus animal welfare, are compromised (Neave *et al.*, 2022).

Chen *et al.* (2015) suggest that poor hygiene could present an increased risk of infection and immunosuppression. In addition, Macitelli *et al.* (2020) found decreasing the space allowance for beef cattle in outdoor feedlots degrades the feedlot environment and affect animal welfare.

Photo 1 and 2. Steers with different housing areas (left: 10 m^2/animal, right: 100 m^2/animal) during the fattening period.

Accordingly, Pordomingo *et al.* (2022) reported similar live weight evolution and feed efficiency in feedlot cattle. However, Grandin (2022) and Mader and Griffin (2015) found efficiency problems with confinement and muddy conditions.

According to De Souza Teixeira *et al.* (2018), intake, ADG and FCR were not impacted by behavior (food intake along the day and displacement). However, in this work, behavior affected fat deposition, LMA growth and carcass yield. It was found a high correlation between LMA and carcass yield ($p<0.05$). Carcass yield presented a significant positive correlation ($p<0.05$) with walking ($r= 0.44$) and resting (0.43). A positive canonical correlation ($p=0.03$) was also determined between behavior associated with animal welfare (walking and resting) and carcass yield. On the other hand, Dunston-Clarke *et al.* (2020) showed that sedentary cattle had lower carcass yield. In this work, similar results about behavior and its effects on fattening and carcass yield were observed.

CONCLUSIONS

More space allowance on the feedlot pens provides a better environment for the animals, offering them more choices on where to stay or lay down, and reducing the risk of diseases spread. Animals with more space walk and rest for longer periods. Improved comfort associated to self-feeding contributes to deployment of natural behavior of cattle during the fattening period. Self-feeding contributes to meal frequency along the day without affecting the animal performance.

Nevertheless, confinement increases fattening and reduces the *Longissimus* muscle area, with lower carcass yield. Larger housing areas and self-feeding under the Ecological Feedlot system are an alternative to intensive fattening systems. This study is valuable for farmers to improve animal welfare and carcass yield in cattle. Further exploration to develop a suitable system that is repeatable is recommended.

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AUTHOR CONTRIBUTION STATEMENT

Research conception and design: MEM, JSV, AB, SAR, GAT; data analysis and interpretation: MEM, JSV, AB, SAR, GAT; redaction of the manuscript: MEM, JSV, AB, SAR, GAT.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.