



## Influence of feedlot living space on production variables, carcass and meat quality traits in Holstein steers



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### Abstract:

A determination of how the amount of allotted feedlot living space influences both production indicators as well as carcass and meat quality traits obtained from Holstein steers was performed by forming two treatment groups, T14: 65 steers/pen (14 m<sup>2</sup>/head of space allowances) and T16: 57 steers/pen (16 m<sup>2</sup>/head of space allowances), with five replications each treatment. The average arrival weight 238 ± 0.74 kg. During the fattening period the cattle was feed twice a day with commercial diets. The steers were slaughtered after a 261-d period. At the moment of the first reimplant a greater average body weight was found in T16 vs T14 (384.25 vs 378.38 kg; *P*<0.05) and the difference

continued until day 261 (612.35 vs 595.54 kg;  $P<0.05$ ); regarding ADG, hot carcass weight and cold carcass weight the result were: 1.50 vs 1.46 kg ( $P<0.05$ ), of ADG kg/d; 367.34 vs 360.35 kg ( $P<0.05$ ) and 366.68 vs 358.78 kg ( $P<0.05$ ). No difference between treatments were found in dorsal fat, marbling, pH and meat color. The results suggest that an increase from 14 m<sup>2</sup>/animal to 16 m<sup>2</sup>/animal improves the production results as well as the hot and cold carcass weight, with no effect on the quality traits of the carcass and beef.

**Keywords:** Living space, Holstein steers, Feedlot, Carcasses, Meat quality.

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## Introduction

During their stay in the pen beef cattle require enough space to express its natural behavior<sup>(1)</sup>. According to Lagos *et al*<sup>(2)</sup> it is necessary to provide at least 18.5 m<sup>2</sup>/head to ensure the ideal conditions of space for each animal however in case that during the fattening period increases it is recommended that additional space is provided based on the increase in body weight, for cattle with a weight up to 300 kg, the recommended space is 15 m<sup>2</sup>/head, for cattle with weights higher than 400 kg a 20 m<sup>2</sup> area is suggested. In Mexico, the manual of good practices for intensive beef cattle production published by the Agriculture Secretary (SAGARPA)<sup>3</sup> estimates that a space between 12 and 12.5 m<sup>2</sup>/animal is enough for cattle to display its natural behavior.

Holstein calves have become an important input for feedlot beef production<sup>(4)</sup>, so that it accounts for 20 % of the total amount of cattle fatten in the United States of America<sup>(5)</sup>, a similar situation is now being observed in northern Mexico. Holstein steers offer certain advantages since show desirable carcass traits like a superior distribution of intramuscular fat and better dorsal fat width<sup>(6)</sup>. It has been reported that adult Holstein cattle fatten in feedlots exhibit an unpredictable and aggressive behavior<sup>(7)</sup>, and for this reason this race of cattle requires a larger amount of space than the beef producing races. Another fact to take into consideration is that Holstein cattle more and more often so that the ground condition in the pens is not good<sup>(8,9)</sup>. Taking into consideration what has been above stated an increase in the feedlot vital space per animal would have a positive impact the cattle's welfare and thus better beef production results<sup>(10)</sup>.

The objective of this study was to evaluate the effect that pen space had on the production variables, as well as on the quality traits of carcass and meat obtained from Holstein steers.

## **Material and methods**

This study was review and approved by Veterinary Sciences Research Institute ethics committee, with the project number 201/2399.

### **Geographical location**

This study was carried out in Mexicali, Mexico, which is found at 32° 32'00 N, 115° 12'41 W. The region is characterized by a dry desert climate with an average temperature of 34.7 °C (-5 °C winter and 50 °C summer), with an annual rainfall of 37 mm, and a relative humidity above 50 %<sup>(11)</sup>.

### **Animals and design of the study**

The study was performed using castrated Holstein calves between the ages of 7 and 8 mo, with an average weight of  $238 \pm 0.74$  kg. Twenty four hours after the cattle arrived to the feedlot they were vaccinated, dewormed and implanted with a product that contained trembolone acetate, estradiol and tilosine. On arrival during spring (April-June) the animals were assigned to one of two groups so that two treatments may be established. Each treatment included five pens. The first treatment included 65 Holstein steers, in this case each animal had a space allowance of 14 m<sup>2</sup>/per animal (T14), in the second treatment a 16 m<sup>2</sup>/animal (T16) was allocated to each of 57 Holstein steers. The cattle were fed twice a day using a feeding program that included three different diets given during the fattening and finalization periods. In different proportions the ingredients of all diets were: sudangrass, wheat hay, tallow, dried distillers grains (DDGs) and a premix minerals.

After a 261 fattening period the steers were slaughtered, the average weight of the group was  $604 \pm 5.67$  kg. On the day the steers were slaughter they were transported 36 km by truck to the slaughter house where they were put in waiting pens for 3.5 h, during this time only water was provided. The steers were slaughter in a Federal Inspection Type slaughter house (FIT) following the procedure described in the Mexican Official Norm NOM-033-SAG/ZOO-2014, "Slaughter methods to be used in domestic and wild animal"

## Production behavior

The following production result: initial weight, weight after first reimplant, weight after second reimplant, final weight, average daily gain (ADG) and food conversion, were obtained from the company's records. Each of the animals slaughter weight was obtained in the stunning box.

## Carcass and meat evaluation

Carcasses from both treatments were chilled at 2 °C for 24 h and ribbed between the 12th and 13th ribs to collect additional carcass data. A total of 178 carcasses from T14 and 176 carcasses from the T16 were available by the slaughterhouse to be considered for the study of all the variables. The measurements of hot carcass weight (HCW) and cold carcass weight (CCW), dorsal fat, marbling, ribeye area, pH and color of each carcass were taken. Dorsal fat was measured in mm using a metric ruler. The ribeye area was evaluated using a plastic grid method suggested by Iowa State University and the marbling score (scale of slight; small; modest; moderate; slight abundant; moderately abundant), were both evaluated following the methodology described by AMSA<sup>(12)</sup>. The pH was determined using a potentiometer (HANNAH INSTRUMENTS Inc. pH 101), the color values (L\*, a\*, b\*, C\*, H\*) were measured on the surface of the cut from the *Longissimus dorsi* muscle between the twelfth and thirteenth intercostal space using a MINOLTA CM-2002 spectrophotometer (Minolta camera, Co., Ltd., Japan) with a specular component included (SCI), a D65 illuminant, and a 10° observer, where L\* is the index of luminosity, a\* is the red color intensity and b\* is the yellow color intensity and C\* measure color saturation.

## Statistical analysis

Productive data was analyzed using the following statistical linear model:  $Y_{ij} = \mu + \tau_i + \beta_j + \varepsilon_{ij}$  where  $Y_{ij}$  is the response variable,  $\mu$  is the true mean effect,  $\tau_i$  is the fixed treatment effect,  $\beta_j$  is the fixed pen effect and  $\varepsilon_{ij}$  is the random residual error iid  $N(0, \sigma_e^2)$ . The hypothesis that treatment effects do not differ, was performed by F test statistic in the ANOVA. Differences between treatments were declared when  $P \leq 0.05$ .

Carcass and meat quality data were analyzed as a randomized complete block design with sampling, with pen as the experimental unit and carcass as the observational unit. The statistical linear model was as follows:  $Y_{ijk} = \mu + \tau_i + \beta_j + \varepsilon_{ij} + \delta_{ijk}$ , where  $Y_{ijk}$  is the response variable,  $\mu$  is the true mean effect,  $\tau_i$  is the fixed treatment effect,  $\beta_j$  is the fixed

pen effect,  $\varepsilon_{ij}$  is the random residual error iid  $N(0, \sigma_e^2)$  and  $\delta_{ijk}$  is the random sampling error iid  $N(0, \sigma_d^2)$ . The hypothesis that treatment effects do not differ, was performed using an F test statistic in the ANOVA. Differences between treatments were declared when  $P \leq 0.05$ .

The hypothesis that treatment effects do not differ for proportions within each marbling class was done using a Chi-square test statistic in one frequency table. Differences between treatments were declared when  $P \leq 0.05$ . The analysis was made using the MIXED and FREQ procedures of the SAS 9.4 (TS1M7) statistical package.

## Results and discussion

### Production results

A relevant finding of this study was that steers with a larger pen space had a higher weight during all the fattening period; these results are presented in Table 1 and show that after receiving the first reimplant (day 94 after arrival to the feedlot), the steers from T16 showed an average higher weight when compared to the animals in T14 ( $P < 0.05$ ); this same result was observed after the second reimplant and through all the fattening period ( $P < 0.05$ ); the observed weight difference between the groups was 16 %. Similar results regarding weight differences have been reported by other authors<sup>(13)</sup>, who found a higher final weight in Hanwoo steers when they were provided with a larger pen space.

**Table 1:** Holstein steers Median weight values  $\pm$  SEM per treatment

Variable	Treatment		SEM	Pr>F
	14 m <sup>2</sup>	16 m <sup>2</sup>		
Initial weight, kg	238.57	237.62	0.74	0.2000
Weight at 1 <sup>st</sup> reimplant, kg	378.38 <sup>b</sup>	384.25 <sup>a</sup>	1.65	0.0004
Weight at 2 <sup>d</sup> reimplant, kg	506.73 <sup>b</sup>	515.21 <sup>a</sup>	2.52	0.0008
Final weight, kg	595.54 <sup>b</sup>	612.35 <sup>a</sup>	5.67	0.0032

SEM= standard error of the mean.

<sup>a,b</sup> Different letter indicates differences between treatments ( $P < 0.05$ ).

Table 2 shows the production results for both groups of steers. It was found that weight gain was higher for the steers in T16, however no difference was found in feed conversion and feed intake. Similarly, to this study Kim *et al*<sup>(14)</sup>, observed that Holstein steers 20 mo of age that were provided with 16 m<sup>2</sup>/animal, reached a 750.39 kg final weight and daily weight gain of 1.36 kg. A study in Holstein steers that did not considered the amount of living space per animal as a variable have reported a final weight between 613.3 a 631.4 kg, a 1.41 to 1.46 kg/d of ADG<sup>(15)</sup>, while a study carried out in Mexico found that Holstein steers reached a final weight of 604.9 kg with a daily gain of 1.46 kg and a feed

consumption of 8.41 kg per day<sup>(16)</sup>, another study performed by Carvalho *et al*<sup>(17)</sup> found that Holstein steers gained daily 1.73 kg/d with a final weight of 598 kg. Although in Mexico the federal norm<sup>(3)</sup> establishes that pen space for an animal under 400 kg should be 12 m<sup>2</sup> and for one above 400 kg 20 m<sup>2</sup> <sup>(2)</sup>. It may be expected that the world trend to reduce the space allowance per animal in cattle feedlot<sup>(18)</sup> is impacting Mexico, so it is likely that welfare and production variables will be affected because of smaller allowed space for feedlot cattle.

## Carcass and meat evaluation

**Table 2:** Median production results  $\pm$  SEM per treatment

Variable	Treatment		SEM	Pr>F
	14 m <sup>2</sup>	16 m <sup>2</sup>		
Daily weight gain, kg	1.46 <sup>b</sup>	1.50 <sup>a</sup>	0.01	0.0327
Feed conversion	7.51	7.17	0.17	0.1260
Feed consumption, kg	10.80	10.62	0.15	0.2967

SEM= standard error of the mean.

<sup>a,b</sup> Different letter indicates differences between treatments ( $P<0.05$ ).

The group of steers that was provided with the largest living space showed a difference of 7 kg both in the hot and cold carcass weight ( $P<0.05$ ), these results are shown in Table 3 and correspond with it was reported by Ha *et al*<sup>(13)</sup> who provided a greater living space to steers that were in the finalization period. A similar study<sup>(19)</sup> reported a larger hot carcass weight for feedlot steers which were provided with 16 m<sup>2</sup>/animal, when compared with two other groups of animals that had a living space of 10.6 and 8 m<sup>2</sup>/animal.

**Table 3:** Carcass median production results  $\pm$  SEM per treatment

Variable	Treatment		SEM	Pr>F
	14 m <sup>2</sup>	16 m <sup>2</sup>		
Hot carcass weight, kg	360.35 <sup>b</sup>	367.34 <sup>a</sup>	2.98	0.0196
Cold carcass weight, kg	358.78 <sup>b</sup>	366.68 <sup>a</sup>	2.96	0.0079
Dorsal fat, mm	9.1	9.3	0.83	0.1939
Ribeye area, cm <sup>2</sup>	96.14	98.66	2.31	0.9277

SEM= standard error of the mean.

<sup>a,b</sup> Different letter indicates differences between treatments ( $P<0.05$ ).

In the present study dorsal fat and ribeye space showed no statistical difference between groups ( $P>0.05$ ), this result corresponds to what is reported in Hanwoo cattle carcasses<sup>(19)</sup>. In contrast with this study, researchers<sup>(20)</sup> found no differences ( $P>0.05$ ) between Hanwoo carcasses obtained from animals that were provided with different living spaces. Other authors have reported lower dorsal fat numbers, 5.15 mm<sup>(14)</sup>; 5.8 mm<sup>(17,21)</sup>; while Carvalho *et al*<sup>(15)</sup> reported a dorsal fat measurement between 8.6 and 9.3

mm, Torrentera *et al*<sup>(16)</sup> observed a dorsal fat depth of 10.9 mm results that are similar to what was observed in the present study.

Authors have found that dairy cattle tend to deposit greater amounts of fat in the abdominal cavity and to accumulate less subcutaneous fat<sup>(22)</sup>, in this context bovine races that are bigger and take more time to mature have a larger proportion of inter and intramuscular fat when compared with smaller races which mature earlier<sup>(23)</sup>.

In the case of ribeye area, the present study found that they were larger than the ones reported by Ha *et al*<sup>(13)</sup> for Hanwoo steers (91.0 and 94.6 cm<sup>2</sup> for 10 and 16.7 m<sup>2</sup> of living space) likewise other studies in Holstein steers reported ribeye areas of 72.36 cm<sup>2</sup> <sup>(17)</sup>; 73.7 cm<sup>2</sup> <sup>(21)</sup>; 74.9-82.5 cm<sup>2</sup> <sup>(15)</sup>; 77.21 cm<sup>2</sup> <sup>(14)</sup>; 81.22 cm<sup>2</sup> <sup>(16)</sup>.

Regarding the amount of intramuscular fat in the meat (Table 4) the results indicate that there is no difference between the groups, however the findings support the reports from other researchers that in the case of Holstein steers choice beef is the grade that is observed<sup>(16,17,21)</sup>. In this study, 130 of the steer's carcasses produce beef that was classified as small while a second group of 159 carcasses yielded modest beef.

**Table 4:** Marbling score per treatment

Variable	Treatment		Pr> $\chi^2$
	14 m <sup>2</sup> n = 178	16 m <sup>2</sup> n = 177	
Slight	10	14	0.4142
Small	57	73	0.1605
Modest	87	72	0.2342
Moderate	23	17	0.3428
Lightly abundant	1	1	---

Table 5 show both groups physicochemical results, it was found that in the case of pH, L\*, a\* y C\* no differences were observed ( $P>0.05$ ), and although the values for b\* y H\* showed differences ( $P<0.05$ ), this dissimilarity does not result in noticeable differences in color between treatments.

**Table 5:** Meat physicochemical median results  $\pm$  SEM per treatment

Variable	Treatment		SEM	Pr>F
	14 m <sup>2</sup>	16 m <sup>2</sup>		
pH	5.67	5.60	0.06	pH
L*	29.97	31.96	0.85	L*
a*	17.08	16.79	1.24	a*
b*	15.45 <sup>a</sup>	15.02 <sup>b</sup>	0.83	b*
C*	23.08	22.59	1.47	C*

SEM= standard error of the mean.

<sup>a,b</sup> Different letter indicates differences between treatments ( $P<0.05$ ).

In regard to pH, values between 5.5 and 5.8 are considered as normal for bovine meat<sup>(24)</sup>; so, the results obtained by the present study may be viewed as typical. Similar pH values and have been reported in studies done with Holstein by other authors<sup>(6,25)</sup>. In the case of meat color, based in what has been reported by others authors<sup>(24)</sup>, the meat obtained from both groups is considered as dark cutting, another research have reported similar results ( $L^* = 37.50$ ,  $a^* = 14.69$  y  $b^* = 12.39$ )<sup>(26)</sup> and ( $L^* = 38.02$ ,  $a^* = 19.86$ ,  $b^* = 8.19$ ,  $C^* = 21.49$ )<sup>(14)</sup>; the reason for this may be explained by the pre slaughter stress that the animals were submitted to, which depleted blood glycogen and affected the beef's color<sup>(27)</sup>. Authors have informed that the way animals are handled, the novelty of environment and fatigue, are factors that contribute to stress<sup>(28)</sup>.

## Conclusions and implications

It is very important that feedlot cattle is provided by sufficient living space during the whole fattening period and considering that there is a trend to reduce the space allowance per animal, it is very important to better understand the negative impact that a reduce pen space has on the animal welfare and how this impacts beef production. As suggested by the results of the present study a relatively small increase of living space has a positive impact on carcass weight which at the end will translate into an increase of income.

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## Conflict of interests

The authors declare that they have no conflict of interest.

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