Ciência Rural, Santa Maria, v.53:6, e20210635, 2023
http://doi.org/10.1590/0103-8478cr20210635
ISSNe 1678-4596
ANIMAL PRODUCTION

# A comparison of the economic results obtained by Holstein steer calves with different feedlot arrival body weights

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**ABSTRACT**: The study compared the economic results between five groups of Holstein steers with different arrival body weights (ABW) but similar ages in the feedlot. The average ABW were 105, 112, 117, 123 and 129 kg (30, 90, 87, 60, and 30 calves, respectively) with an age of 113 ± 1d. The calves were randomly distributed using an unbalanced design. The calves were weighed upon arrival at the feedlot and subsequently on days 112, 224, and 361 of the study. The calves were fed a steam- flaked corn-based diets. A receiving diet (2.21 Mcal of $NE_m$/kg DM) was provided during the initial 112 days of feeding. From day 112 until harvest all steers received a finishing diet (2.27 Mcal of $NE_m$/kg DM). Because two different diets were used, two partial (day 1 to day 112 and day 113 to day 361), and one full period (day1 to day 361) feeding periods were evaluated. Statistical differences between the final weights of all the groups were observed, which allowed a profit estimation, obtained by subtracting the purchase cost of calves plus the total feed cost from the revenue obtained from the sale of the steers. Overall weight gain and feed intake were higher with increased ABW, feeding efficiency was better for intermediate ABW groups (112 and 117 kg), with the calves with ABW of 112 kg being the most profitable (USD 15.8 more profit than the 117 Kg. group)
**Key words**: holstein steers, feedlot, arrival weight, economic results.

## Uma comparação dos resultados econômicos obtidos por bezerros Holstein com diferentes pesos vivos na entrada do confinamento

**RESUMO**: O estudo comparou os resultados econômicos entre cinco grupos de bezerros de raça holandesa com pesos vivos de chegada diferente, mas com idades semelhante em confinamento. Os pesos corporais médios de chegada foram 105, 112, 123 e 129 kg (30, 90, 87, 60 e 30 bezerros, respectivamente) com idade de 113 ± 1-d. Os bezerros foram distribuídos em um desenho não balanceado completamente aleatório. Os bezerros foram pesados da chegada ao confinamento e, posteriormente, nos dias 112, 22 e 361 do estudo. Os bezerros foram alimentados com dietas à base de milho floculado. A dieta de adaptação (2,21 Mcal de NEm / kg MS) foi fornecida durante os 112 dias iniciais de ração. Após 112 até o final do estudo todos os novilhos receberam a dieta de terminação (2,27 Mcal de NEm /kg MS). Diante do exposto, foram avaliados dois períodos parciais de alimentação e um período completo (1 a 112, 113 a 361 e 1 a 361 d, respectivamente). O lucro de cada grupo foi estimado subtraindo o custo de compra dos bezerros mais o custo total da alimentação da receita obtida com a venda dos novilhos. O ganho de peso geral e o consumo de ração aumentaram com o aumento do ABW, mas a eficiência alimentar foi melhor para os grupos intermediários ABW (112 e 117 kg), sendo os novilhos com ABW de 112 kg os mais lucrativos (USD 15, 8 a mais do que o grupo de 117 kg.)
**Palavras-chave**: novilhos Holstein, peso à chegada, resultados econômicos.

## INTRODUCTION

Beef production with Holstein steers has played an important part in the feedlot business and has been used to satisfy market needs that native cattle cannot readily fulfill (MAYNARD et al., 2004). It has been reported that the arrival of weight Holstein bull–calf beef operations has a significant relationship with mortality (MOORE et al., 2002); however, little information is available on the survival, and growth performance of recently weaned Holstein steers.

Holstein calves generally arrive at feedlots with lighter body weight and remain for longer periods than beef breeds (DUFF & MCMURPHY, 2007; ZINN et al., 2016); It has been reported that Holstein calves enter the feedlot weighing between 115 and 180 kg (TORRENTERA et al., 2017). Initial body weight in the feedlot is related to the productive growth performance and feed cost, total cost and market price (KOKNAROGLU et al., 2005 (b), ZINN et al., 2008 and HICKS et al., 2015). This is important because the purchase costs of the steers and those of the feed represent the largest proportion (> 50%) in

Received 08.20.21 Approved 07.05.22 Returned by the author 08.16.22
CR-2021-0635.R2
Editors: Rudi Weiblen Márcia Helena Machado Da Rocha Fernandes

the variation of profitability in feedlots (DARRELL et al., 2000 and KOKNAROGLU et al., 2005 (b)). The present study tested the hypothesis that calf-arrival body weight influences the economic results of calf-fed Holstein steers.

## MATERIALS AND METHODS

The study was conducted in the Desert Research and Extension Center of UC Davis, Holtville California. Three hundred Holstein calves were used in a 361 day experiment to evaluate the influence of arrival weight at similar age on feedlot growth performance. Two feeding periods were considered because the feedlot uses an initial and a final diet. The treatment groups initial ABWs were: 105 kg ± 0.04 kg, 112± 0.48 kg, 117± 0.38 kg, 123± 0.47 kg and 129± 0.18 kg. Considering that the calves of all five groups were classified as lightweight a single calf price per kg was used for all treatments. All the animals were randomly assigned to 50 pens, 6 steers/pen within treatment groups. Pens were 78 $m^2$ with 33 $m^2$ of overhead shade, automatic drinkers, and fence-line feed bunks. Calves were fed with steam-flaked corn-based diets (Table 1). The receiving diet (2.21 Mcal $NE_m$/kg DM) was fed during the initial 112 and from days 112 until harvest all steers received a finishing diet (2.27 Mcal $NE_m$/kg DM). Diets were prepared weekly and stored in plywood boxes located before of each pen. Steers were allowed *ad libitum* access to feed, provided twice daily. On days 120 and 224, all steers were again injected subcutaneously with 500,000 IU vitamin A, and implanted with Revalor-S (Intervet, Millsboro, DE).

The arrival and final BW were reduced 4% to account for digestive tract filling (NASEM, 2016) to estimate steer performance. Pens were used as the experimental units. The experimental data were analyzed using a completely unbalanced randomly design according to the following statistical model: $Yij = \mu + Wi + \varepsilon ij$ (HICKS, 1993), where $\mu$ is the common experimental effect, Wi represents the initial weight effect (df = 4), $\varepsilon ij$ represents the residual error (df = 45) and is ~ IIN (0, $\sigma^2$). Treatments effects were tested using the linear and quadratic orthogonal polynomials. In addition Tukey´s honestly significant difference test was performed between treatments, considering unequally replicated groups. A significant difference between the means was determined when the p-value was ≤ 0.05 (SAS Inst. Inc., Cary, NC).

The final average weight for each group was 583.7 ± 6.7 kg, 616.8 ± 5.8 kg, 623.7 ± 5.2 kg, 614.5 ± 6.4 kg, and 639.8 ± 7.3 kg. The required result to be able to determine the economic results is that a statistical difference is observed in the final body weight between groups, in case of no final weight difference, then there is no need to do the economic evaluation because from a practical standpoint the average final weight is the same for all groups.

The costs: diets prices, time spent in the pen price paid for the Holstein calves and price paid per finalized steer were the same for each group; however, the feeding costs were different as a result of dissimilar intake between groups these elements

Table 1 - Receiving and finishing diets ingredients prices and costs.

| Ingredients | Ingredients price/kg, (USD) | Receiving diet ingredient costs/Kg (USD) | Finishing diet ingredient costs/Kg (USD) |
|---|---|---|---|
| Fishmeal | 1.63 | 0.40 | - |
| Corn grain flaked | 0.21 | 0.15 | 0.14 |
| Distillers dried grains plus solubles | 0.28 | - | 0.041 |
| Canola meal | 0.31 | 0.02 | - |
| Alfalfa hay | 0.20 | 0.01 | 0.01 |
| Sudangrass hay | 0.13 | 0.01 | 0.007 |
| Molasses, cane | 0.24 | 0.01 | 0.01 |
| Yellow grease | 0.68 | 0.02 | 0.02 |
| Urea | 0.49 | 0.002 | 0.002 |
| Trace mineral salt | 0.30 | 0.001 | 0.0010 |
| Monensin | 20.94 | 0.002 | 0.002 |
| Limestone | 0.13 | 0.001 | 0.001 |
| Magnesium Oxide | 0.66 | 0.0008 | 0.0008 |
| Total cost/kg | | 0.27 | 0.24 |

were taking into account to determine total cost. Regarding revenue, it was assumed that a difference between group profits would be the result of different final body weight as this is the variable that was statistically different and used with the sale price of the cattle to determine total income.

The purchase cost of the calves for each group was estimated by multiplying the total weight of each of the groups of animals times the market price paid for a kilogram weight of Holstein calves in this case was 1.47 USD/lbs (3.24 USD/Kg). In the experimental phase two different rations were used in the experimental phase, with a receiving diet fed from day 1 to 112 and a finishing diet, from d 113 to 361. The ingredients and costs of both diets are shown in table 1.

The methodology used for the economic analysis considered the estimation of relevant costs and revenues to calculate the profit for each group (SANCHEZ et al., 2018)

Because the costs of the rations are dissimilar, two partial feeding costs (PFC) were obtained, feed cost for the receiving period (1 to 112 days) and for the finishing period (offered from 113 to 361 days), and consequently the total price of feed was obtained by adding the cost of these two diets.

The following procedure was used to estimate each feeding period cost:

PFC = FI× P

where:

PFC = Partial feeding costs

FI = Feed intake, as fed basis (kg.)

P = Price of a kilogram of feed (USD)

The two-group costs were added to obtain the total feeding costs (TFC).

The cost resulting from the purchase of Holstein calves (PCs) was calculated using the ABW (off-truck) and the price per kilogram of live weight (PLW) for light Holstein calves.

PC = ABW × PLW

where:

PC = Purchase cost (USD)

ABW = Arrival body weight, kg

PLW = Price per kilogram of live weight

To determine the total profit (TP) obtained in each of the five groups the Holstein calves' total feeding cost and purchase cost were subtracted from RG. Using the final average weight the unit profit (PU) was estimated for each group, and, with these values, it was possible to compare the results.

The cost of daily feed intake (CFI) was estimated using the following formula:

RG = TWG × PLW

where:

RG = Revenue per group

TWG = Total weight per group

PLW = Price of one Kilogram of live cattle (USD).

To determine the total profit (TP) obtained in each of the five groups the total feeding cost and purchase cost of the Holstein's calves were subtracted to RG. Using the final average weight a unit profit (PU) was estimated for each group and with these values, it was possible to compare the results.

The cost of daily feed intake (CFI) was estimated using the following formula.

CFI = TFC/FP

CFI = Cost of daily feed intake (USD)

TFC = Total feed cost (USD)

FP = Full feeding period (361 days)

## RESULTS AND DISCUSION

The results of comparing average arrival and final weight, feed intake and weight gain are presented in table 2; Statistical differences were reported between groups in average arrival and final weight and feed intake. The final live weight increased for AWB (linear effect, $P < 0.01$).The heavier group (129 kg of ABW) reached an 8.8% higher final live weight than lighter steers (105 kg of ABW). Body weight gain increased during the first feeding period (1 to 112 days) and complete study period (1 to 361days) as ABW increased (linear effect, $P < 0.01$). On average, the heaviest group (129 kg of ABW) reached a weight gain 3% higher that of the other groups of steers. However, during the finishing phase no effects on weight gain were reported among the steer groups (113 - 361 days , $P = 0.49$. SALINAS-CHAVIRA et al. (2009) found similar results and CANO et al. (2017), observed greater ADG for calf-fed Holstein steers with heavier versus lighter initial arrival weights. However, KOÇAK et al. (2004), when evaluating the effects of initial weight and season on some fattening traits on Holstein steers reported that the groups with lower initial body weights gained higher live weights during 210 days of feeding.

In contrast, feed intake increased throughout the study and its phases (1 - 361, 1 - 112 and 113 - 361 days) as ABW increased (linear effect, $P < 0.01$). Consistent with the present study, SALINAS-CHAVIRA et al. (2009) observed that; although, the difference in average initial weight of two weight groups of Holstein steers (lighter group, averaging 117 kg and heavier group, averaging 121 kg) was only 5 kg, the heavier group had greater (340 days) DMI associated with greater ADG. Several

Table 2 - Results of comparing average arrival and final weight, weight gain and feed intake between groups.

| | Groups* | | | | | SEM | Linear effect | Quadratic effect |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| Pen replicates | 5 | 15 | 15 | 10 | 5 | | | |
| Arrival weight | 105 | 112 | 117 | 123 | 129 | 0.75 | < 0.01 | 0.99 |
| 112-d weight | 250.3 | 264.8 | 271.6 | 282.3 | 289.9 | 3.4 | < 0.01 | 0.38 |
| 224-d weight | 413.2 | 431.6 | 439.6 | 445.5 | 458.1 | 5.6 | < 0.01 | 0.45 |
| Final weight | 583.7 | 616.8 | 623.7 | 614.5 | 639.8 | 10.1 | < 0.01 | 0.30 |
| ADG[a], kg | | | | | | | | |
| 1-112 d | 1.295[b] | 1.368[ab] | 1.376[ab] | 1.425[a] | 1.439[a] | 0.03 | < 0.01 | 0.36 |
| 112-224 d | 1.454[a] | 1.489[a] | 1.499[a] | 1.457[a] | 1.502[a] | 0.04 | 0.49 | 0.75 |
| 224-361 d | 1.279[a] | 1.339[a] | 1.315[a] | 1.231[a] | 1.379[a] | 0.04 | 0.06 | 0.26 |
| 1-361-d | 1.339[b] | 1.395[ab] | 1.391[ab] | 1.361[ab] | 1.435[a] | 0.03 | < 0.01 | 0.27 |
| DMI[a], kg/d | | | | | | | | |
| 1-112 d | 5.388[d] | 5.585[cd] | 5.724[bc] | 5.885[ab] | 6.026[a] | 0.08 | < 0.01 | 0.76 |
| 112-224 d | 8.150[b] | 8.320[b] | 8.471[ab] | 8.439[ab] | 8.893[a] | 0.15 | < 0.01 | 0.44 |
| 224-361 d | 11.031[b] | 10.926[b] | 10.631[b] | 10.328[b] | 11.436[a] | 0.12 | < 0.01 | < 0.01 |
| 1-361 d | 8.387[b] | 8.460[b] | 8.438[b] | 8.363[b] | 8.969[a] | 0.09 | < 0.01 | < 0.01 |

[a]Means in a row with different superscripts differ (P < 0.05). ADG, kg: Average daily gain per animal per period, DMI, Kg/d: average daily dry matter intake per animal in each period.
*Group arrival weight: 1=105 kg, 2=112kg, 3=117 kg, 4=123kg, 5=129 kg.

studies have shown that the DMI increases as the initial body weight is higher (HICKS et al., 1990; NRC, 1996; KOKNAROGLU et al., 2005 (a); ZINN et al., 2008 and HICKS et al., 2015), the results of DMI in the present study are similar to these reports, considering that the heaviest group showed the highest DMI (Table 2). In general, an increase in DMI with increasing ABW was consistent with a concomitant increase in body-weight gain. However, when comparing feed efficiency (which was estimated by the body weight gain on feed intake of each group) in the whole period (1 to 361 days) for each ABW group, it was found that steers with 112 kg of ABW obtained greater (3.7%) feed efficiency (0.169 vs. 0.163, respectively) than the other groups (105, 117, 123 and 128 kg of ABW). This behavior is similar to other studies, as the initial body weight increases the nutritional efficiency decreases (ZINN et al., 2008), and showed that light and intermediate weight cattle housed in confinement converted their feed more efficiently than heavier cattle (KOKNAROGLU et al., 2005 (a)).

Conversely, considering that price for one kilogram of Holstein´s calves at the time of purchase was 1.47 dollars, on average, the purchase cost per calf (between initial body weight groups) increased by 19 dollars as ABW increased. Essentially, feeding costs increased throughout the study phases (1 -112, 113 - 361 and 1 -361 days) as ABW was higher (Table 3). The largest increase in TFC (1 - 361 days) was for the heavier steers (129 kg of ABW), increasing costs on average 58.6 dollars more than the other groups of steers (105, 112, 117 and 123 kg, respectively). et al. (2005 (b)) evaluated factors that affect cattle performance and production costs in feedlots, and reported that with a higher initial body weight, DMI and ADG increased, results which is consistent with the results of the present study. The same authors reported that the feed cost, total cost, and breakeven price increased with increasing initial BW.

Because the final body weight increased, the revenue from steers with 129 kg of ABW was higher (average USD102.9), than that of the other groups. However, the profit per animal (RG-TC) was higher for the group that arrived at the feedlot with 112 kg of body weight (Table 4) when contrasted to others groups, due to an increase of the feed efficiency (3.7%). Similarly, RETALLICK et al. (2013) observed that feed conversion was correlated with ADG, DMI and LM area ($r^2$of 0.84) weight gain cost. They also found, that a unit improvement in feed conversion resulted in a decrease in weight

Table 3 - Revenue, partial, total and unit costs* per group.

| Group by arrival weight | 1 (105 kg) | 2 (112 kg) | 3 (117 kg) | 4 (123 kg) | 5 (129 kg) |
|---|---|---|---|---|---|
| RG | 48,137.9 | 150,951.5 | 146,982.9 | 100,486.0 | 52,932.4 |
| $PFC_1$ | 4,888.0 | 15,201.2 | 15,068.0 | 10,678.5 | 5,467.2 |
| $IFC_1$ | 162.9 | 168.9 | 173.2 | 178.0 | 182.2 |
| $PFC_2$ | 17,047.9 | 51,252.5 | 50,009.2 | 34,104.4 | 18,519.6 |
| $IFC_2$ | 568.3 | 569.5 | 574.8 | 568.4 | 617.3 |
| TFC | 21,935.9 | 66,453.7 | 65,077.2 | 44,782.9 | 23,986.9 |
| ITFC | 7,31.2 | 738.4 | 748.0 | 746.4 | 799.6 |
| CC | 10,207.7 | 32,469.4 | 32,989.7 | 23,812.5 | 12,492.1 |

RG: Revenue per group, $PFC_1$; Partial feeding cost for the receiving period (1 to 112 days);
$PFC_2$; Partial feeding cost for the finishing period (113 to 361days) $IFC_1$: Feeding cost for the receiving period (1 to 112 days) per animal; IFC2: Feeding cost for the finishing period (113 to 361 days) per animal; TFC: Total feeding cost (1-361 d); ITFC: Total feeding cost/unit; CC: Calves cost. *US dollars.

gain costs, and an improvement in feed conversion yielded decreased feed costs. A 10% improvement in feed conversion allowed for a USD0.14/kg reduction of weight gain costs. The same authors observed that profitability was the greatest (USD 34.65/steer) with a 10% improvement in feed conversion concluding that feed conversion lowers feed costs mostly because correlates with the DMI. The lower feeding cost reported in the 112 kg group is of economic importance for the feedlot owner. However, it has been observed that feedlot performance is affected by ABW. LANGEMEIER et al. (1992) reported that profit is more affected by the prices of feed when the cattle arrive at a feedlot with very light body weight; however, when the cattle arrive heavier at the feedlot, the profits are mostly affected by the costs of the feeder cattle and the average daily gain. Similarly, MINTERT et al. (1993) reported that feed conversion (as-fed) in feedlot cattle increased (3.9%) in animals with higher arrival weight when compared with lighter arrival body weights of cattle, reflecting the reduced feed efficiency of heavier cattle. The same authors also found that ADG was higher (5.8%) for heavier animals when compared to lighter cattle. Feed and cattle prices explained 70% to 80% of total profit variance, and feed conversion was the next

Table 4 - Results of profit estimation per group and unit*.

| Group by arrival weight | 1 (105 kg) | 2 (112 kg) | 3 (117 kg) | 4 (123 kg) | 5 (129 kg) |
|---|---|---|---|---|---|
| Steers per group | 30 | 90 | 87 | 60 | 30 |
| ----------COSTS---------- | | | | | |
| Calves | 10,207.7 | 32,469.4 | 32,989.7 | 23,812.5 | 12,492.1 |
| TFC | 21,935.9 | 66,453.7 | 65,077.2 | 44,782.9 | 23,986.9 |
| TC | 32,143.6 | 98,923.0 | 98,066.9 | 68,595.5 | 3,6478.9 |
| ----------REVENUE---------- | | | | | |
| R | 48,137.9 | 150,951.5 | 146,982.9 | 100,486.0 | 52,932.4 |
| ----------PROFIT---------- | | | | | |
| PG | 15,994.3 | 52,028.5 | 48,915.9 | 31,890.5 | 16,453.5 |
| PU | 533.1 | 578.1 | 562.3 | 531.5 | 548.4 |

TFC: Total feeding cost, TC: Total cost/group, R: Revenue/group, PG: Profit/group, PU: profit/animal.
*USD.

most important explanatory variable, explaining 3% to 5% of profit variance.

Because this study did not have access to carcass weight and meat quality traits, the influence of this variables were not included; however, considering that it has been reported that most Holstein steer carcasses (59.4%) receive a yield grade of 2 (DUFF & MACMURPHY, 2007), the post mortem quality traits were viewed as having a moderate influence on income estimation. Nevertheless, the fact that the impact of meat quality on income is not evaluated by this study is viewed as a limitation

Considering that slaughter weight has a positive influence on weight, and cold carcass yield (OSORIO et al., 2018), this variables are seen as relevant to determine profitability.

Although, there are other costs besides feed and the price paid for calves in a feedlot, LOPES & MAGALHÃES (2005) have reported that these two costs accounts for nearly 98% of the production costs. Since this study was not done in a commercial feedlot it can be considered that the obtained results are useful to understand better the economic relationship between the initial and final weights of Holsteins cattle used for meat production.

In a feedlot the receiving period is one of the most critical within its beef production cycle (DE SOUZA et al., 2018). The fact that 297 out of 300 initial calves that were part of this study remained until its completion indicates good management during the pre-weaning and receiving periods.

The initial weight of a calf that enters a feedlot is a variable that has been reported to greatly influence mortality (MOORE, et al., 2002); however, once the calf survives little information is available regarding initial weight and production results. Considering that it has been reported that for 1.5 kg of additional weight the value of a Holstein calve increase Can$ 11 (DEVON et al., 2020) a limitation of this study is that the calf price difference between groups associated to weight dissimilarity was considered. However, taking into account that all groups were classified as lightweight the results are useful for ranchers in making better managerial decisions.

## CONCLUSION

The DMI and ADG increased with body-weight at the feedlot. The group of steers with 129 kg of ABW had the highest total cost and the highest revenue. However, steers with an intermediate arrival body weight reached the higher profits and therefore should be considered the best option by feedlot owners when they purchase Holstein calves. The improvement in profits was attributed to an improvement in feed efficiency for steers with 112 kg of ABW.

## ACKNOWLEDGEMENTS

This project was supported through University of California (UC) Agricultural Experiment Station with Hatch funding from the USDA National Institute of Food and Agriculture (CA-D-ASC-6578-H).

## DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

## AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

## BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

Procedures for animal care and management were conducted under protocols (#20548, #20615) approved by the University of California Use and Care Advisory Committee 32.

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