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Sex and animal behavior on yield and bruises in different beef cuts

Sexo e comportamento animal no rendimento e contusões em diferentes cortes de carcaça de bovinos

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Highlights

Animal behavior influences carcass bruising.
Negative correlation between animal behavior and carcass yield.
There is an interaction effect between sex and behavior on carcass bruising.
Carcass bruising depend on animal behavior.
Greater exposure of the cut is a determinant of bruising.

Abstract

The objective of this study was to examine the effects of behavioral differences in cattle on bruising on different cuts and on carcass yield. A total of 4,061 lots of cattle were evaluated, which corresponded to 199,026 carcasses. Animal temperament was classified as calm, anxious, or excited. The following carcass cuts were evaluated: round, rump, shin, thin flank, tenderloin, and rib. Of the total number of slaughtered animals, 68.26% had at least one type of bruise with complete removal of the affected tissue. There was an interaction effect between sex and temperament on the occurrence of bruises on the different cuts and on carcass yield. In castrated males, bruises on the round, rump, shin, and tenderloin cuts did not differ between temperament classes, but the excited males showed more bruises on the thin flank and rib cuts. Among the females, for all cuts, the number of bruises was higher ($P<0.05$) in those with excited temperament than in the anxious and calm animals, which did not differ ($P>0.05$). Additionally, carcass yield

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relative to plant weight decreased (P<0.05), with the calm females exhibiting the highest values, followed by those with anxious and excited temperament. In the castrated males, however, although performance declined, those with anxious and excited temperament did not differ (P>0.05). Females and more reactive animals have more bruises on their carcass.
Key words: Agroindustry. Animal welfare. Beef production chain. Cattle transport. Meat-packing industry.

Resumo

O objetivo desta pesquisa foi avaliar os efeitos das diferenças comportamentais dos bovinos e seus reflexos nas contusões nos diferentes cortes e nos valores de rendimento de carcaça. Foram avaliados 4.061 lotes de bovinos, perfazendo 199.026 mil carcaças. O temperamento animal foi classificado em calmo, ansioso e excitado. Foram avaliados os cortes das carcaças divididas em coxa, alcatra, dianteiro e lombo, vazio e costela. Do total de lotes de animais abatidos, 68,26% apresentaram pelo menos um tipo de contusão com remoção completa do tecido afetado. Ocorreu interação entre o sexo e temperamento animal para os diferentes cortes na ocorrência de contusões e no rendimento de carcaça. Nos machos castrados as contusões dos cortes da coxa, alcatra, dianteiro e lombo não diferiram entre as classes de temperamento, tendo os animais agressivos mais contusões nos cortes do vazio e costela. Nas fêmeas em todos os cortes, as quantidades de contusões verificadas foram superiores (P<0,05) para animais com comportamento excitado do que animais ansiosos e calmos, não ocorrendo diferença entre os mesmos (P>0,05). O rendimento de carcaça em relação do peso de frigorífico quanto as classes comportamentais, nas fêmeas foi decrescente (P<0,05) com maiores valores para animais calmos, seguidos dos animais ansiosos e com menores rendimentos para animais com temperamento excitado, enquanto nos machos castrados, embora o rendimento tenha sido decrescente, animais com temperamento ansioso e excitado não diferiram (P>0,05). Carcaças oriundas de fêmeas e de animais com maior reatividade apresentam mais lesões.
Palavras-chave: Agroindústria. Bem-estar animal. Cadeia produtiva da carne bovina. Indústria frigorífica. Transporte de bovinos.

Introduction

Beef livestock has great prominence in Brazilian agribusiness, as the country holds the largest commercial herd on the planet 196 million head and is the world's largest exporter of beef (Associação Brasileira das Indústrias Exportadoras de Carnes [ABIEC], 2022). Although the production and productivity of these herds have increased, concern and demands regarding the welfare of cattle throughout their life and in the pre-slaughter period are important not only for the animals themselves, but also for the maintenance and opening of new Brazilian beef markets. To provide animal welfare, care must be taken with the environment, facilities, and adopted management (Hocquette et al., 2012; Paranhos da Costa et al., 2012), which strongly interact with the temperament and reactivity of the animal in the face of adversities encountered in these aspects.

Pre-slaughter handling causes stress to animals (Moura et al., 2021), which in turn influences the occurrence of bruising (Mendonça et al., 2016a, 2019; Bethancourt-

Garcia et al., 2019a,b), a determining factor for carcass losses and decreased yields. The human-animal-environment interaction on farms or in slaughterhouses can aggravate animal stress, warranting a more profound understanding of this situation, besides proper management. This is because when faced with situations of adversity, animals change their behavior, increasing their degree of reactivity and consequently the incidence of bruises, which translates into decreased carcass yields and meat quality (Cruz-Monterrosa et al., 2016).

The quantification of carcass yield is a controversial issue that leads to errors in the beef production chain (Pascoal et al., 2011). It is impossible to predict its exact result, since in addition to being influenced by several factors inherent to the animal and the production system, losses related to injuries during transport and animal reactivity cannot be measured before slaughter. Therefore, the present study was undertaken to examine the influence of behavioral differences in cattle on the occurrence of bruises on different cuts and on carcass yield.

Material and Methods

The study was developed after approval by the Animal Experimentation Ethics Committee (CEEA) of the Federal University of Pelotas, under case no. 3110.008794/2013-31 (Pelotas - RS, Brazil; CEEA no. 8794).

Location and data collection period

Data were collected at the Frigorífico Silva Indústria e Comércio Ltd. (S.I.F 1733) packing plant from August 2019 to October 2021, totaling two years and two months of information collection. The packing plant is located in the municipality of Santa Maria - RS, Brazil (geographical coordinates: between 54º19'32" and 53º30'22" S and between 29º20'28" and 30º00'16" W).

Experimental unit

This study involved 4,061 lots of slaughtered cattle (2,124 lots of castrated males and 1,937 lots of females). Each lot had six to 457 head, with an average of 49 animals and a total of 199,026 carcasses. The slaughtered animals came from different regions of the state of Rio Grande do Sul. The total studied group consisted of 125,707 steers (63.16%) and 73,319 females (cows and heifers; 36.84%) with average slaughter weights of 495.0 and 470.0 kg and cold carcass weights of 250.0 and 225.0 kg, respectively. For statistical analysis, the lots represented experimental units.

Animal management

The cattle used in the experiment were loaded in the early morning hours of the day before slaughter and transported always by the same company, which was outsourced. This company was instructed and monitored to follow animal welfare protocols during the trip, in accordance with good production practices. For this purpose, all the transporter's employees were periodically trained on proper handling practices during animal transport.

In the production systems, whenever scales were available, the animals were weighed and then loaded onto the trucks at a planned load density to ensure their comfort during transport. Upon arrival at the slaughterhouse, the animals were unloaded as soon as possible, when the lairage pens were ready. Once unloaded, the lots of animals were weighed, the owners were identified, and the cattle were classified as to sex and led to the lairage pens, where they were fasted for a minimum period of 12 h, only having access to water. Animal handling during the lairage period followed the normal daily routine of the company, complying with the rules of the local Federal Inspection Service (S.I.F. 1733).

Data collection

Behavioral assessments were performed after the animals had spent one hour in the lairage pens so that they could drink water and acclimatize to the facilities (Moura et al., 2021). Animal temperament was measured according to the behavior of the lot in the face of human presence, which was quantified by a subjective assessment based on the reaction and movement of the animals. Three different ratings were assigned to the behavior of the lot: calm - animals static, quiet, and displaying no resistance to human approach; anxious - some resistance and constant movement; and excited - vigorous movements, attempts to escape, very agitated, frightened, and wild movements.

After the slaughter and skinning procedures, the carcasses within the lot were identified individually. Bruises were counted according to their region of occurrence on the carcass, which were here defined as the *shin, tenderloin, rib, thin flank, rump,* and *round* cuts. Only serious bruises, which cause total loss or downgrading of the cut preventing its sale in its entirety, were considered.

At the end of the slaughter line, before washing, the carcasses were weighed and 2% was deducted from this weight to determine cold carcass weight. Farm and slaughterhouse ('plant') carcass yields were determined by dividing cold carcass weight by the weight measured in the production system, before loading the animals onto the truck, and by the weight measured upon arrival at the slaughterhouse, respectively.

Statistical analysis

The experiment was laid out in a completely randomized design with three treatments (animal temperament ratings) and different numbers of replicates. Data were analyzed statistically by analysis of variance and the t-test was applied to compare means at 5% significance.

First, a combined analysis was performed between the sexes; then, the data were analyzed separately and the number of animals in the lot was used as a covariate, according to the following model:

$$Y_{ijk} = TEMP_i + S_j + TEMP*S_{ij} + N_k + e_{ijk},$$

where Y_{ijk} is the dependent variable; $TEMP_i$ is the effect of animal temperament i (i=1 calm; i=2 anxious; i=3 excited); S_j is the effect of animal sex j (j=1 castrated male; j=2 female); $TEMP*S_{ij}$ is the interaction effect between animal temperament i and animal sex j; Nk is the covariate (number of animals in the lot); and e_{ijk} is the residual.

Results and Discussion

Of the 4,061 lots of slaughtered cattle, 2,772 had bruises in some of the studied regions, totaling 68.26% of bruised lots. In terms of sex, 1,264 and 1,508 lots showed at least one bruise for males and females, which represent 59.48 and 77.89% of bruised lots, respectively. With respect to temperament, 39.08, 46.23, and 14.69% of the lots of castrated males and 28.45, 50.33, and 21.22% of the female lots were classified as calm, anxious, and excited, respectively.

Bruising and carcass yield results revealed an interaction effect between animal sex and temperament. Among the males, bruises on the *round, rump, shin,* and *tenderloin* cuts did not differ between temperament classes. The *thin flank* and rib cuts were more bruised in the animals classified as excited than in those classified as anxious and calm (Table 1). In the females, the *round, rump, shin, tenderloin,* and *rib* cuts showed more bruises ($P<0.05$) in the excited animals than in the anxious and calm animals, which did not differ ($P>0.05$). The number of bruises on the *thin flank* of females increased with temperament (calm, anxious, and excited) ($P<0.05$).

The behavior of animals in relation to man, generally ascribed to fear, is denominated "temperament" (Burrow & Dillon, 1997). Temperament can also be correlated with situations beyond human presence (Réale et al., 2007), and the individuality of each animal in being more or less fearful, aggressive, agile, attentive, curious, docile, smart, stubborn, timid, among others, should be evaluated collectively (Paranhos da Costa et al., 2002).

Table 1
Means and standard errors for the number of bruises on different cuts of carcasses of male and female cattle with different pre-slaughter ratings in southern Brazil

Cut	Males			Females		
	Calm	Anxious	Excited	Calm	Anxious	Excited
Round	2.12±0.31^{b}	1.53±0.28^{b}	1.71±0.48^{b}	2.06±0.36^{b}	2.20±0.28^{b}	4.05±0.44^{a}
Rump	0.29±0.05^{c}	0.28±0.04^{c}	0.26±0.07^{c}	0.35±0.05^{bc}	0.48±0.04^{b}	0.69±0.07^{a}
Shin	0.98±0.10^{cd}	0.79±0.09^{d}	0.86±0.16^{cd}	1.15±0.12^{bc}	1.44±0.09^{b}	2.67±0.15^{a}
Tenderloin	2.37±0.21^{c}	2.92±0.17^{bc}	2.90±0.31^{bc}	2.94±0.22^{bc}	3.26±0.15^{b}	3.92±0.23^{a}
Thin flank	2.93±0.29^{d}	3.34±0.25^{d}	3.79±0.40^{c}	3.49±0.31^{d}	4.70±0.21^{b}	6.29±0.31^{a}
Rib	2.31±0.33^{c}	2.54±0.27^{bc}	3.31±0.37^{b}	2.72±0.27^{bc}	2.89±0.18^{bc}	4.77±0.23^{a}
Mean bruises	0.16±0.01^{cd}	0.14±0.01^{d}	0.13±0.02^{d}	0.19±0.02^{c}	0.24±0.01^{b}	0.40±0.02^{a}

$^{a, b, c, d}$ in the same row differ ($P<0.05$) by the t test.

In the comparison of number of bruises between temperament ratings, the females showed more considerable differences across classes. When compared with females, male cattle showed fewer commercial cuts affected with severe injuries and/or bruises (Mendonça et al., 2016a). Bethancourt-Garcia et al. (2019b) and Mendonça et al. (2016a) found that males are 73.0 and 74.0%, respectively, less likely to have bruised carcasses than females. Males are usually better managed in production systems, having greater interaction with other animals and humans (Huertas et al., 2010; Romero et al., 2013; Brandão & Cooke, 2021), which can be a determinant of less reaction to handling. Cattle that interact more with humans have better quality of life, are less stressed, and sustain fewer accident-related injuries (Lensink et al., 2000).

Cattle display specific reactions depending on the type of experience, which may have positive or negative effects on the productive activity (Paranhos da Costa et al., 2002). The worse management and nutrition conditions and longer time spent in adverse situations by females in production systems increases their ability to memorize unpleasant events, thereby increasing their reactivity and, consequently, exposure to the occurrence of bruises. Another relevant factor are the effects of motherhood and offspring protection, which induce females to be more reactive than castrated males.

In this study, the sex categories evaluated were not matched by age and, as usual, most of the slaughtered females are adult cows, which leads to the assumption that the females were older at slaughter than the castrated males. The older an animal is, the more likely it is to have witnessed some event of aggressiveness it instinctively keeps in its memory. Brandão and Cooke (2021) worked with adult and growing females and found that the temperament of adult females does not change with improved management of production systems; however, when well-managed, growing females tend to improve their temperament by being less reactive.

The similar numbers of bruises on the round, rump, shin, and tenderloin cuts between temperament ratings show that bruises are not solely due to animal behavior, but several pre-slaughter factors may be decisive for their occurrence.

The greater number of bruises on the thin flank and rib cuts of cattle with excited temperament is due to their greater exposure in the animal anatomy in the handling process during loading and unloading. This is because the persons performing these functions have access to the side of the animals, to drive them to walk.

In fights between animals, the rib and the thin flank are also the most targeted cuts by the aggressor, as they correspond to the region where the attacked animal is least able to defend itself, since the greatest mobility occurs in the limbs and neck. Mendonça et al. (2016b) found that the presence of horns in lots destined for slaughter increased the occurrence of bruises on the rib cut.

Unlike the present study, Huertas et al. (2015) evaluated the location of bruises on the carcasses of cattle slaughtered in Uruguay and found that the shank was the cut most affected by bruises and had the greatest muscle depth, which could imply a less favorable transport condition or even greater restraint of the animals in the chutes for weighing and sanitary treatments. This

divergence of results shows not only that temperament is the determining factor for the occurrence of injuries, due to the reactivity of the animal and its fights in the lots, but also that bruising is associated with worse facilities (Bethancourt-Garcia et al., 2019a,b), transport (Cruz-Monterrosa et al., 2016), poor handling (Mendonça et al., 2019), and the animal genetics (Mendonça et al., 2016b).

Cold carcass weight did not differ between temperament ratings, regardless of animal sex (P>0.05). In the females, plant yield decreased across the temperaments (P<0.05), with higher values found in animals with a calm temperament, followed by anxious and, finally, excited animals (Table 2). In the males, despite decreasing, plant yield did not differ (P>0.05) between the anxious and excited temperaments.

Table 2
Means and standard errors for carcass weights and yields of male and female cattle with different pre-slaughter behavioral ratings in southern Brazil

Cut	Males			Females		
	Calm	Anxious	Excited	Calm	Anxious	Excited
Cold carcass weight, kg	250±0.96[a]	250±0.86[a]	254±1.57[a]	224±1.24[b]	226±0.91[b]	224±1.41[b]
Plant yield, %	52.7±0.07[a]	52.2±0.07[b]	52.0±0.12[b]	50.6±0.10[c]	49.9±0.07[d]	49.5±0.11[e]

[a, b, c, d, e] in the same row differ (P<0.05) by the t test.

In the males, the average number of bruises per animal did not differ between the calm, anxious, or excited temperaments. In the females, however, the mean number of bruises per animal increased with temperament (P<0.05).

Animal physiological and behavioral parameters are influenced by irregularities in equipment and facilities, as well as by the use of unskilled labor (Bethancourt-Garcia et al., 2019a,b). Therefore, the behavior of an animal is influenced by its interaction with and how it is handled throughout life by humans, mostly during pre-slaughter management, a moment that causes stress for the animal (Gallo & Néstor, 2008; Huertas et al., 2015). Stress from pre-slaughter handling can lead to the occurrence of bruising in different regions of the carcass and, consequently, losses in carcass yield and meat quality (Sant'Anna et al., 2019).

Bruising indicates a lack of animal welfare and causes economic damage such as weight loss, disfigurement of muscle cuts, and carcass downgrading (Cruz-Monterrosa et al., 2016; Mendonça et al., 2016b), besides indirect stress-related damage involving the quality of the product (Cruz-Monterrosa et al., 2016; Sant'Anna et al., 2019).

The lower carcass yields found in animals with anxious and excited temperaments, compared with those classified as calm, are due to factors related to production (León-Llanos et al., 2022) or to

losses related to pre-slaughter handling and bruising (Estévez-Moreno et al., 2021).

Higher carcass yields in calm animals are a result of their greater production capacity, provided by the intake of feed and its efficiency of transformation two factors that determine greater weight gain and, mainly, carcass gain. Barbosa Silveira et al. (2012) evaluated taurine and zebu animals kept in feedlots and found that, regardless of genotype, the calmer steers showed higher feed intake and better feed conversion than the steers with an excited temperament. Also working with a feedlot system, Francisco et al. (2015) classified the animals as to their temperament as "adequate" or excited and found better feed efficiency in those with adequate temperament. The authors also observed, at the end of the confinement period, 30 kg higher body weight and 21 kg higher carcass weight in the animals whose temperament was deemed adequate, which amounted to 70% conversion into carcass (Francisco et al., 2015). In addition, bruises on the carcass may be removed during the removal of the hide, as the injured tissues are not prioritized to remain adhered to the carcass during skinning, in the slaughter line.

The results of this study show that it is essential to adopt good management practices in production systems, as well as during transport to slaughter, to prevent animals from being more reactive in human presence. These good practices must also be present during adversities encountered in acclimatization with the facilities of the plant, thus improving animal welfare, facilitating pre-slaughter handling, and reducing economic losses in the beef production chain.

Conclusion

Carcasses of animals with an excited temperament have more bruises. The greatest losses from bruising due to animal temperament occur on the think flank and rib cuts. Among castrated males, cold carcass yield is higher in those classified as calm than in males with anxious and excited temperaments. In females, cold carcass yield decreases as their temperament worsens.

Conflict of interest

The authors declare that there is no conflict of interest.

Statement of animal rights

The animals and people involved in the study were treated according to ethical principles, and the project was submitted to and approved by the Ethics Committee for Animal Experimentation (CEEA) at UFPel (Pelotas - RS, Brazil; CEEA no. 8794).

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