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Preliminary Exploration of the Accuracy of Visual Evaluation in Estimating Actual Bruise-Trim Weight of Beef Carcasses

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Abstract: Carcass bruising results in economic loss to the beef industry and is an indicator of a potential animal-welfare concern. The industry relies on visual assessment to determine the prevalence of bruising and to estimate bruise size (weight). This study examines the accuracy of using visual assessment to estimate bruise-trim weight from beef carcasses in a commercial slaughter facility. The removed bruise trim from 105 beef carcasses (84 cow and 21 steer carcasses; hot carcass weight for a subsample [mean ± standard deviation] = 768 ± 157 lb) was visually assessed by one trained observer using a protocol adapted from the National Beef Quality Audit Bruise Key visual assessment tool, and a second observer weighed the bruise trim. These data were used to assess the accuracy of the visual assessment of trim off of a carcass. A total of 68.6% (95% confidence interval: 58.7%, 77.1%) of collected bruise-trim weights were assessed correctly using the modified National Beef Quality Audit Bruise Size Key visual assessment. Because of a limited number of samples in several of the bruise-trim categories, there is not a clear trend in how accuracy of estimation changed with increased bruise weight. These findings suggest that visual assessment of bruise trim may not be providing an accurate estimate of bruise-trim weight. The development of training materials to aid in visual bruise weight/size assessment would be helpful for improving bruise estimates within the cattle industry.

Key words: bruise, trim, visual assessment, yield loss
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Introduction

Bruises are a source of economic loss in the beef industry and can be indicators of animal-welfare concerns during preslaughter animal handling and management (Jarvis et al., 1995). During processing at slaughter facilities, bruised areas of meat are trimmed from carcasses and cannot be used for human consumption (Federal Meat Inspection Act, 1906). Carcass value is lost from the rendered trimmings but also from devaluation of other cuts of meat impacted by bruise removal. During the preslaughter marketing process, cattle are exposed to various events, such as loading and unloading, transport, and in-plant movement and holding, which can often cause behavioral responses that could impact bruise prevalence at slaughter (Warriss, 1990). Preslaughter factors associated with increased risk of bruising include, but are not limited to, rough handling (Huertas et al., 2010), mixing with horned animals (Shaw et al., 1976; Strappini et al., 2010; Mendonça et al., 2016), transport through auction markets (Grandin, 2000; Strappini et al., 2012), and facilities in poor condition (Bethancourt-Garcia et al., 2019).

Several studies have quantified the economic impacts and prevalence of bruising in the beef industry. In 1994, the National Beef Quality Audit (NBQA) for non-fed beef, conducted by the National Cattlemen's Beef Association, estimated that $11.47 (United States dollars) was lost per beef carcass because of bruising (National Cattlemen's Beef Association, 1994). Additionally, in the 1999 National Market Cow and Bull Beef Quality Audit, bruising was identified as the sixth leading cause of whole-carcass condemnation (Roeber et al., 2001). The 2016 NBQA documented that fed, cow, and bull carcasses exhibited 38.8%, 64.1%, and 42.9% bruising prevalence, respectively (Eastwood et al., 2017; Harris et al., 2017). Although general reductions in bruise prevalence have been recorded since the inception of these benchmarking audits (Eastwood et al., 2017; Harris et al., 2017), industry representatives still currently estimate that bruising costs the industry millions of dollars annually (Lee et al., 2017).

Visual inspections quantifying "gross observation" are the most often used methods to assess the presence of bruising (Hamdy et al., 1957). Other research studies have documented the presence and location of carcass bruises, usually using some type of carcass map (i.e., a carcass divided into regions) (Strappini et al., 2010; Lee et al., 2017). The NBQA publishes bruise counts and locations, in addition to bruise severity, as measured by a visual assessment of bruise weight. The bruise-severity scale utilized in the NBQA data collection is a 10-point scale (Texas A & M University, 2016). These 10 categories are collapsed into broader classifications (minimal, major, critical, and extreme) in the published literature (e.g., Eastwood et al., 2017; Harris et al., 2017). When utilizing the NBQA Bruise Key, observers are tasked with estimating the weight of a bruise using a visual assessment of the bruise on the carcass surface (i.e., observers are making a two-dimensional assessment of bruise weight, a three-dimensional measure). To the authors' knowledge, both the accuracy of visual assessments of bruise-trim weight and the relationship between estimated loss due to bruise trim using two-dimensional visual bruise assessment and the actual weight of bruise trim have not been studied. Bruise size and depth are complex and multidimensional. Kline (2018) found that a large percentage of carcasses scored as not having visible bruises on the carcass surface actually were trimmed for bruising that was deep below the surface, suggesting that perhaps some of the methods currently used are underestimating the carcass loss due to bruising. Additionally, three-dimensional measures provide more accurate measurements than two-dimensional assessments.

The objective of this study was to determine the accuracy of visual assessment in estimating weight of bruised trim (a three-dimensional measure). A modified NBQA bruise-assessment protocol was used in this study. Researchers hypothesize that estimating trim off the carcass may be more accurate and therefore designed this preliminary study in this manner with the understanding that future studies should assess the accuracy of bruise-trim weight estimation on the carcass prior to trimming.

Materials and Methods

Ethical statement

All animal measurements and observations that occurred at the commercial slaughter facility were noninvasive, and an exemption was granted by the Colorado State University Animal Care and Use Committee for this study.

Facility, cattle, and slaughter process

This study was conducted in March 2018 at a commercial cattle-slaughter facility in the northeastern region of the US that processes culled cows, culled bulls, and fed steers and heifers. The facility was a single-production shift plant operating one 9-h shift each day and slaughtering approximately 2,200 cattle per day at a rate of approximately 255 to 275 head per hour when operating at normal facility capacity. In brief, over 3 d of data collection, 5 cattle were selected from 10 different trucks and individually marked with livestock chalk at unloading to facilitate postmortem data collection for individual cattle. After animal selection, all cattle were handled by following the standard procedures of the slaughter facility, including lairage, antemortem inspection, movement to the stunning area, stunning with a pneumatic captive-bolt stunner in a center-track-conveyor restrainer, and subsequent processing (carcass dressing).

Because of challenges with keeping track of individual carcasses throughout the stages of processing, 140 of the targeted 150 individually identified animals were assessed for bruising. A total of 105 carcasses (84 cow and 21 steer carcasses) were trimmed, and the data from these carcasses were used in the statistical analysis reported here. Hot carcass weight was obtained for a subsample of carcasses ($n = 70$; mean ± standard deviation = 768 ± 157 lb).

Bruise identification and trim weight collection

Two researchers were positioned at the final trim rail where carcasses were examined by plant personnel for bruising. At the final trim rail, trim derived from bruises was removed from each carcass by a facility employee. One researcher collected bruise trim with the assistance of a designated facility employee and placed the trim in a clear plastic bag labeled with carcass identification. The second researcher visually assessed the bagged bruise trim, utilizing a protocol adapted from the visual assessment tool used in the NBQA to assess bruise severity by weight and size (Texas A & M University, 2016), which we describe next.

Visual bruise-assessment and weighing protocol

The NBQA Bruise Size Key categories are provided in Table 1. It should be noted that there are weight gaps in between bruise categories (i.e., category 4 ends at 1.36 kg, and category 5 begins at 1.81 kg). To train the observer assessing bruise-trim weight, the observer was shown a deck of playing cards (Bicycle, Standard Index Playing Cards) and a quarter (US currency) as visual references, and the other category weight ranges were explained prior to the study. This researcher recorded bag identification and numeric bruise-severity score (1–10) for each bag of trim. This observer was not permitted to see the screen on the scale indicating bruise-trim weight to prevent the observer from learning from the estimates. The second researcher weighed each bag of bruise trim on a designated scale and recorded the bruise-trim weight and bag identification number.

Statistical analysis

The data were analyzed using R software (R Core Team, 2019) to assess the accuracy of the observer's visual bruise-trim weight categorizations. Some of the observed bruise-trim weights fell into the weight gaps between the NBQA categories. As a result, for this assessment, the NBQA categories were expanded to remove the gaps (see Table 1). Summary statistics and 95% confidence intervals, as described below, were used to draw inferences from the data.

Table 1. National Beef Quality Audit Bruise Size Key categories and descriptions adapted from the NBQA (Texas A & M University, 2016)[a]

	lb	kg	Weight range used in study analysis (kg)
Minimal			
1	A quarter		—
2	A silver dollar		—
3	A deck of cards		0.16–0.45[b]
Major			
4	1–3	0.45–1.36	0.45–1.59
5	4–7	1.81–3.18	1.59–3.40
6	8–10	3.63–4.54	3.40–4.76
Critical			
7	11–20	4.99–9.07	4.76–9.07
8	21–30	9.53–13.61	—
9	31–40	14.06–18.14	—
Extreme			
10	An entire primal		—

[a]"—" indicates that there were no trim weights observed in this category in the current study.

[b]This range was created on the basis of preliminary testing by weighing bruise trim that was approximately the size of a deck of cards.

Results and Discussion

The percentages of trim collections assessed correctly using the bruise-severity categories are reported in Table 2. The observer accurately categorized the weight of the bruise trim 68.6% of the time. Table 2 shows a breakdown of estimates by weight category. Because of a limited number of samples in several of the bruise-trim categories, there is not a clear trend of how accuracy of estimation changed across weight categories. If trim weights are underestimated, the estimates of economic impact would be conservative. Additionally, from a cattle well-being perspective, it is important to accurately identify larger bruises, categorized as major, critical, and severe in the NBQA Bruise Key (Texas A & M University, 2016), as those likely have a greater impact on welfare.

In this study, bruise key categories 1 and 2 were not represented, so the accuracy of estimation at these sizes cannot be evaluated. For category 3, the bruise weight is designated as the size of "a deck of cards." A deck of cards is an object that many people are familiar with and is therefore likely to be more easily relatable, leading to improved visualization. Categories 4 through 7 provide weight ranges only, with no associated object to visualize for comparison. The observer was trained by discussing these weight categories, but there was no visual component of the training to provide a reference

Table 2. Modified NBQA Bruise Size Key score, actual bruise-trim weight, and percentage of trim collections assessed correctly ($n = 105$)[a]

Category[b]	Modified NBQA bruise-trim weight ranges (kg)	Number of total bruise-trim collections	Number of bruise-trim collections assessed correctly	Number of bruise-trim collections assessed incorrectly	Percentage of incorrect assessments that were underestimates (%)	Percentage of trim collections assessed correctly, % (95% CI)
3	0.16–0.45	11	7	4	25.0	63.6 (35.63, 92.37)
4	0.45–1.59	69	56	13	46.2	81.2 (71.74, 90.26)
5	1.59–3.40	19	8	11	100	42.1 (19.81, 64.19)
6	3.40–4.76	4	0	4	75	0.0[c]
7	4.76–9.07	2	1	1	100	50.0[c]
Total	—	105	72	33	66.7	68.6 (58.7, 77.1)

[a]Carcasses with zero trim not included in table.

[b]No bruises were scored for bruise-severity categories 1, 2, 8, 9, or 10. See Table 1 for a description of the categories.

[c]Sample size was too small to make a meaningful CI.

CI = confidence interval; NBQA = National Beef Quality Audit.

for those weight categories. In this study, categories 8 through 10 were not represented, as no bruises in the sample were that large. Future studies could explore tendencies of multiple observers to over- or underestimate bruise-trim size, as this perhaps could be explained by individual observer variation.

Researchers have indicated that the method of visual assessment on the slaughter floor to assess the weight of an amount of bruise trim is difficult for the observer and requires consistent visual training (L.C. Eastwood with H. C. Kline, personal verbal communication, April 2018). However, visual assessment has long been the most practical and easiest method for bruise identification (Trujillo et al., 1996). The NBQAs have utilized visual methods to determine bruise-trim weights from 1991 to 2016 (Lorenzen et al., 1993; Smith et al., 1994; Boleman et al., 1998; McKenna et al., 2002; Roeber et al., 2002; Garcia et al., 2008; McKeith et al., 2012; Nicholson et al., 2013; Eastwood et al., 2017; Harris et al., 2017). The current study modified the NBQA Bruise Key by assessing the weight of trim removed from the carcass rather than on the carcass. This study was performed as a way to begin to understand an observer's ability to accurately visually estimate the weight of trim. Current visual weight assessments attempt to estimate a three-dimensional measure (bruise-trim weight/loss) using a two-dimensional parameter (visible bruising on the carcass surface). Because of the complexity and large-scale design of the NBQA, the visual bruise-assessment method is the most practical method to assess bruises and bruise-trim loss. It still remains unclear how accurate the estimates of bruise-trim loss are from visual assessments. Thus, weighing of some of the bruise trim in these larger studies in order to assess the accuracy of these visual assessments would enable validation of or a means to update current estimates of the economic impact of bruising.

Video training tools that demonstrate the trimming of carcasses and the different trim weight categories could help observers calibrate their estimates of trim weights. This tool would also allow the observer to see different bruise trimming amounts that fit into the bruise-severity categories utilized in the NBQAs. By visually assessing bruises on the carcass, the observer is unable to determine the depth of the bruise. Once the limitations of visual assessment of bruises on and off carcasses are completely understood, the appropriate adjustments could be made when calculating economic loss from bruising in the cattle industry.

Conclusions

Identifying the most practical, yet accurate, method to assess the impact of bruising on the livestock industry is critical for allowing the industry to make decisions with the most current and reliable information. This preliminary study suggests that visual assessment of bruise-trim weight may not always be accurate, therefore resulting in potential inaccuracies in the estimated severity of and economic loss caused by bruises identified. Training materials related to visual bruise assessment may help improve bruise estimates. Incorporating actual weighing of bruise trim during benchmarking and research studies may also provide additional details regarding carcass loss due to bruising. During future industry benchmarking exercises such as the NBQA, it may be valuable to include some estimation of bruise severity in conjunction with collection and weighing of bruise trim to further understand the relationship between visual bruise weight estimation on and off the carcass with actual weight. As the livestock industry continues to progress toward new methods and improve current methods of bruise trimmings assessment, it will be able to quantify the economic impact of bruising in the livestock industry with more accuracy.

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