

Original Article

Prevalence and Associated Risk Factors of Bruise in the Bovine Carcass Slaughtered Jimma Municipal Abattoir, Ethiopia

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ABSTRACT

Background: Bruising bovine carcasses is a significant concern in the meat industry and affects both animal welfare and economic outcomes.

Objective: This study aimed to determine the prevalence of and associated risk factors for bruises in bovine carcasses in the Jimma Municipal Abattoir, Ethiopia. **Methods:** A cross-sectional study was conducted from October 2022 – May 2023; 384 randomly selected cattle were examined during ante- and postmortem inspections. Data on potential risk factors, including age, sex, breed, body condition, and causes of bruising, were collected. Visual inspection, palpation, and incision techniques were employed during the postmortem examination to identify and record the prevalence, anatomical location, and severity of bruises. Statistical analysis was performed via SPSS version 16.00, with nominal regression used to determine bruise rates and chi-square tests used to assess the associations between risk factors and bruise occurrence. A 95% confidence interval was applied, and differences were considered statistically significant at $p < 0.05$. **Results:** The study revealed a 24.48% prevalence of bruising, with stick beating (8.9%) being the most common cause. The anatomical distribution of the bruises varied, with the highest condemnation rates observed in the back and loin (6.25%). Statistical analysis revealed significant differences in bruise incidence based on age, sex, and body condition ($p < 0.05$). **Conclusion:** A high prevalence of bruising has a substantial economic impact on the local meat industry. Factors such as improper handling during transportation significantly contribute to this issue. Recommendations include implementing awareness programs for stakeholders and enhancing animal welfare measures to mitigate economic losses and improve carcass quality.

KEYWORDS

Bovine, global health, Bruise, carcass slaughtering, animal health, disease prevention, one health

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INTRODUCTION

Bruising is the foremost site of injury/contusion and can be defined as extravasation of blood beneath an intact epidermis due to injury. Bruising can also be defined as a special type of hematoma that has a focal point of discoloration caused by a blood collection that can be seen with the naked eye due to trauma to the body [1]. This widespread phenomenon represents a significant challenge in the meat industry, affecting both animal welfare and economic outcomes. Some methods commonly used to drive cattle, such as hitting or poking with a sharp or blunt object, result in not only physical injuries and pain to the animal but also aversive emotional states and fear. Frequently, these practices coincide with shouting by handlers, tail twisting, or shocking with electric products, which may negatively affect animal welfare [2].

Three core criteria must be met for a bruise: the skin and tissues must be stretched or crushed with enough force to cause the small blood vessels to rupture but not break the surface of the skin (the trauma must be caused by a blunt force so that the skin is not punctured to cause a laceration), there must be sufficient blood pressure within the blood vessels to move the blood from the damaged vessels to the surrounding areas, and the blood that leaves the blood vessels must be close to the surface of the skin to be visible with the naked eye for surface bruises [1]. Understanding these fundamental criteria is crucial for developing effective prevention strategies and assessment protocols in the meat industry.

Bruising is considered a constraint that limits the wholesomaking of carcasses and is defined as the escape of blood from damaged blood vessels into the surrounding muscle tissues. The economic impact of this issue is substantial, with industry estimates suggesting losses of several million dollars annually. Bruising is caused by a physical blow with a stick or stone, an animal horn, metal projections, or animal falls. These activities occur during handling, transportation, and stunning activities. The damage caused by bruises has a significant effect on meat quality [3]. The identification of bruise patterns serves as a valuable diagnostic tool for assessing animal welfare conditions throughout the production chain. Carcass-slaughtered bruising is very common, and its economic losses are substantial problems in the meat value chain, estimated at several million dollars annually by several authors [4]. Bruises are an important source of information on animal welfare. In cattle, bruising is used to determine whether animal welfare is suboptimal. The shape of a bruise is often directly associated with the causative event. For example, circular-shaped bruises, which are deep and small in extent, are most likely caused by horns; parallel red bruises with a tramline appearance are most likely caused by sticks; and mottled bruises can be the result of the use of pointed sticks [5,6].

The severity of a bruise is related to the force applied and the part of the body that is damaged. Bruises inflicted over the gluteus muscles of cows were deeper than those inflicted over the lumbodorsal fascia. Overall, the severity of bruising strongly depends on the thickness and density of the affected tissue and its vascularity. The method of selling animals is commonly associated with the number of bruises and their distribution on slaughtered carcasses [2]. Recent research has highlighted the complex interplay between transport conditions, handling practices, and bruising outcomes. Higher numbers of bruised carcasses have been reported for marketed animals than for animals transported directly from farms. Marketed animals present more bruises on the hip, buttocks, and rump loins than animals transported directly from farms to the slaughterhouse [7]. These animals are exposed to extra loading and unloading procedures and group mixing, which is likely associated with more bruises. A recent epidemiological study carried out in Chile revealed that animals from markets are at greater risk of being bruised than are animals coming directly from farms [8,9].

Transport stress is a complex stressor involving temperature fluctuations, food and water withdrawal, mixing with unfamiliar animals, and motion. Contemporary research emphasizes the multifaceted nature of transport-related stress and its impact on meat quality parameters. The stress response to road transport in cattle varies depending on the type of animal and the conditions during the journey. The distance that cattle travel to the abattoir and the occurrence of bruising seem to be positively correlated, and the level of bruising increases with distance traveled. Increasing the time from the farm to the abattoir usually harms meat quality, with longer transport times increasing stress indicators such as cortisol, creatine kinase, and lactate

[8,10]. Research has shown that cattle transported at distances less than 400 km are unlikely to have carcass slaughtering with above-normal pH values, whereas cattle transported at distances greater than 2,000 km or longer than 24 h are likely to have above-normal pH values [11,12].

While previous studies have examined various aspects of bruising in cattle processing, significant knowledge gaps remain regarding local conditions and specific risk factors in different geographical contexts. The least bruising that was found at the left forequarter and at the but indicated that there was less injury to cattle while the doors of the weighing scale and stunning box at abattoirs were closed. Among the total slaughtered cattle, the Arsi breed accounted for 54.54%, the Boran breed accounted for 64.29%, and the Harar breed accounted for 85.71% of the normal carcasses slaughtered. Rump and loin bruises might be associated with mounting on each other during their stay in the abattoir, injury during loading, collision of bulls with abattoir facilities (scales, gates, crush), and the body of the truck that was performed at Elfora, Bishoftu, Ethiopia [13].

However, no research has been conducted on the prevalence and associated risk factors for bruising in bovine carcasses slaughtered at Jimma municipal abattoirs. Therefore, the objectives of these studies were to identify the prevalence and associated risk factors for bruises in bovine carcasses slaughtered at the Jimma municipal abattoir. Given these considerations and the lack of comprehensive data in certain regions, this study aims to identify the prevalence and associated risk factors for bruises in bovine carcasses slaughtered at the Jimma municipal abattoir, addressing a critical gap in our understanding of local bruising patterns and their determinants.

MATERIALS AND METHODS

Study design and setting

A cross-sectional study was conducted through an abattoir survey from October 2022 to May 2023 to identify the prevalence and associated risk factors for bruises in cattle slaughtered at the Jimma municipal abattoir [14]. This design was chosen to capture both temporal variations in bruising patterns and to ensure representative sampling across different seasons. A total of 384 cattle were examined ante- and postmortem via standard examination procedures.

Antemortem examinations and regular visits were made four (4) days per week to Jimma municipal abattoirs. Each examination day was randomly selected within the week to avoid selection bias. The visit was made for antemortem inspection of individual animals to assess animal origins, age, and body conditions before the animals were slaughtered. During each visit, each animal was identified on the basis of an enumerated code given to the butcher shops before slaughter. The average number of animals slaughtered at the Jimma municipal abattoir is 45 cattle per day, and approximately 9,360 cattle are slaughtered annually.

Antemortem inspection was conducted on individual animals while they entered individually and in mass before they reached lair age. For ante mortem inspection, records of breed and body conditions were recorded. A cross-sectional study based on an abattoir survey was conducted during a detailed meat inspection of 384 randomly selected cattle slaughtered at the Jimma municipal abattoir. In this study, animals were selected during antemortem inspection (AMI), and related risk factors, such as sex, origin, breed, and body condition, were recorded before slaughtering. The codes of the study animals were properly recorded during the AMI that was given to the slaughterhouse. All observations were recorded using standardized data collection forms to ensure consistency in data recording.

Study area

This study was conducted in Jimma Zone, southwest Ethiopia, at the Jimma municipal abattoir. Jimma town is located in the Oromia regional state of Ethiopia, approximately 355 km from Addis Ababa. It is located at an altitude of 1704 m above sea level and is geographically located at a latitude of 7°41'N and 36°50'E longitude (Figure 1). The annual rainfall ranges from 1200–2000 mm, and the minimum and maximum temperatures range from 25–30°C. The maximum rainfall occurred from May to September. Most Oromia species enjoy excellent climatic conditions in terms of both temperature and precipitation. This area includes cool highlands and warm

lowlands [15]. These diverse geographical and climatic conditions potentially influence cattle transportation conditions and subsequent bruising patterns. The most prevalent agroclimatic conditions vary from locality to locality and tend to cool in temperature and moist to subhumid in moisture. The climate of the region is governed by the global air circulation system, which is locally affected by topographic conditions and altitude [16].



Figure 1. Maps of the study area (Ethiopia, Oromia, Jimma Zone and Jimma town)

Study animals

The study animals were cattle brought to the abattoir for slaughter from different districts around Jimma town, such as Dedo, Kersa, Omo Nada, Gomma, Seka Chekorsa, Shebe Sombo, Sigmo, Manna and others, which were selected via a simple random sampling method irrespective of age and sex. The randomization process involved assigning unique identification numbers to all cattle arriving at the abattoir each day and using a random number generator to select study subjects. The study population consisted of local and crossbred cattle originating from different localities and markets in the Jimma zone. Body condition scoring was conducted using a standardized 1-5 scale, where 1 represents emaciated, 2-poor, 3-moderate, 4-good, and 5-obese conditions, based on visual and physical assessment of muscle and fat coverage.

Sample size determination

The total number of cattle in the study was calculated via the formula given by Thrusfield with a 95% confidence interval and 5% absolute precision via a simple random sampling method [17]. The use of 50% expected prevalence was chosen as a conservative estimate to yield the maximum sample size needed, given the absence of previous prevalence studies in the region. In this study, 50% prevalence was used to calculate the sample size. For this particular study, the sample size was determined at a 95% confidence level, 5% precision, and 50% expected prevalence of 384.

Postmortem examination

Organs of randomly selected cattle were examined via visual inspection, palpation, and incision. The examination followed a systematic approach, evaluating each carcass region (forequarter, hindquarter, and midsection) using standardized criteria for bruise assessment including size, color, and shape. The organs of each slaughtered animal infected with bruises

were identified systematically following the standard routine postmortem inspection procedure. Postmortem inspection systems should include procedures and tests that are risk-based to the extent possible and practicable, confirmation of proper stunning and bleeding, availability of inspection as soon as it is practicable after the completion of dressing, visual inspection of the Carcass Slaughtered, and other relevant parts, including inedible parts, as determined by the competent authority, palpation and/or incision of the Carcass Slaughtered, and other relevant parts, including inedible parts, as determined by the competent authority according to a risk-based approach [18].

Statistical analysis

Data generated from ante- and postmortem meat inspection were recorded in Microsoft Excel 2010™, and statistical analysis was performed using IBM SPSS Inc. version 16. Descriptive statistics were computed for all variables, including frequencies and proportions for categorical data and means with standard deviations for continuous variables. Nominal regression was used to determine the level of bruised carcass slaughter rates, defined as the proportion of bruised carcasses that were slaughtered. Chi-square tests were employed to assess associations between categorical variables, while odds ratios with 95% confidence intervals were calculated to measure the strength of associations. The data obtained during the study were subjected to 95% confidence interval statistical analysis for possible variation between rejection rates of specific organs, the origin of the animals, the body condition, the sex of the animals and the breeds of the animals, and the differences were regarded as statistically insignificant when the 95% confidence intervals drawn did not overlap with each other.

RESULTS

Prevalence and causes of bruises

Out of the 384 cattle examined at Jimma Municipal abattoir, 94 (24.48%) had various causes of bruising during antemortem inspection, and the details of the lists are shown in Table 1. The table shows bruises related to the force applied to animals or may be due to fatty animals controlling their body weight poorly during stunning. Bruised meat reduces beef quality and grade. This means diminished profits and, in the worst-case scenario, unsalable meat when ranchers and cattle producers go to the market. Bruised meat is more likely to grow bacteria and is therefore discarded. Loss is approximately 2 to 3 pounds for small bruises and up to 100 pounds for large bruises.

Table 1. Bruise-attributable factors for bruising occurrence during ante mortem inspection

Causes of bruises	No of Cattle Affected (%)	Judgment
Stick beating	34 (8.85%)	Judgment depends on the degree of the bruise
Falling	23 (6%)	
Horn thrust	21 (5.47%)	
Bite	9 (2.3%)	
Unknown	7 (1.8%)	
Total	94 (24.48%)	

Anatomical sites of bruises

The analysis of anatomical sites affected by bruising in cattle prior to slaughter revealed a pattern with significant implications for meat quality and economic value. As presented in Table 2, the distribution of bruises across various body parts indicates that most injuries occur in areas highly valued for human consumption (Figure 2). The back and loin regions presented the highest prevalence of bruising, at 6.25% (24 cattle), followed by the ribs, at 5.46% (21 cattle). The brisket, another prized cut, caused bruising in 4.7% (18) of the examined animals. Lower but still significant rates of bruising were observed in the hip (3.6%, 14 cattle), thigh (2.6%, 10 cattle), and forequarter (1.8%, 7 cattle). Cumulatively, these bruises affected 24.48% (94 cattle) of the total sample (n=384), indicating a substantial issue with preslaughter handling and transport. The

prevalence of bruising in these prime anatomical locations is particularly problematic, as it directly impacts the quality and usability of high-value meat cuts, potentially leading to significant economic losses in the form of trimmed or discarded meat.

Table 2. Bruise anatomical site preslaughter

Anatomical site	No of Cattle Affected (n, %)
Back and loin	24 (6.25%)
Ribs	21 (5.46%)
Brisket	18 (4.7%)
Hip	14 (3.6%)
Tigh	10 (2.6%)
Forequarter	7 (1.8%)
Total	94(24.48%)

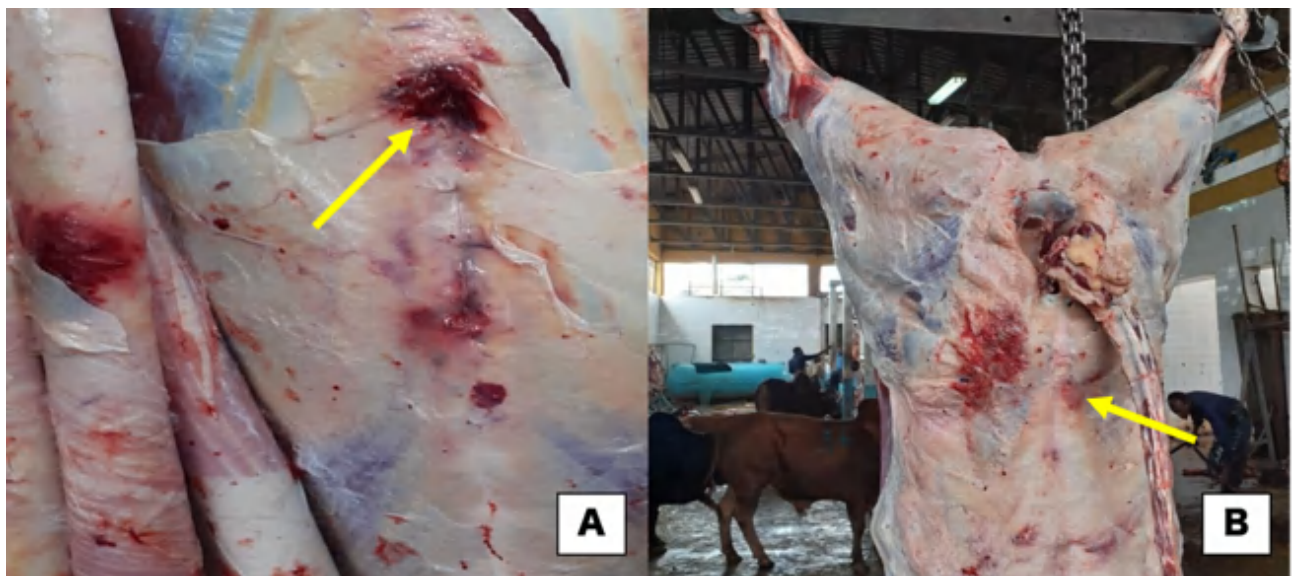


Figure 2. Bruises on the back and loin muscles

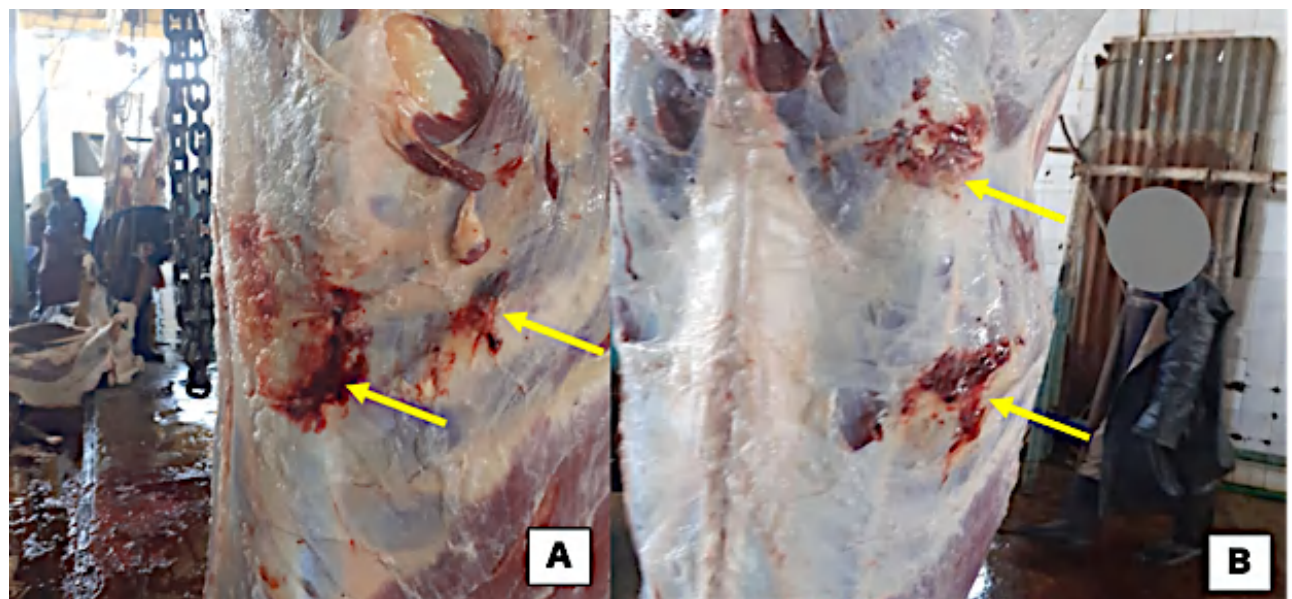


Figure 3. Local bruises in bovine carcasses (A, B)

Risk factors associated with bruising

The majority of slaughtered breeds were local breeds; however, relatively few exotic breeds were also slaughtered (Table 3). According to the information obtained from the abattoir, an average of 45 cattle were slaughtered per day, and the ages of all animals presented for slaughter were young (<4 years) and adults (>4 years). The body condition scores of the sampled cattle with bruising rates were also compared, with prevalence rates of 31 (8.07%), 39 (10.15%), and 24 (6.25%), resulting in poor, medium, and good body condition scores, respectively, with statistical significance ($p < 0.05$), which means that bruising is strongly related to body condition or may be due to fatty animals controlling their body weight poorly during stunning. Carcass-slaughtered cattle arriving at slaughterhouses from different woreda markets around Jimma town presented significantly greater bruising than those that came directly from Jimma town (Figure 3).

Table 3. Anatomical sites of bruises observed during preslaughter

Risk factor		Number of observation (n)	N (Prevalence)	X ²	p-value
Sex	Male	337	78 (20.31%)	5.677	0.017*
	Female	47	16 (4.17%)		
	Total	384	94 (24.48%)		
Age	Young	89	24 (6.25%)	6.150	0.013*
	Adult	295	70 (18.22%)		
Breed	Local	332	90 (23.43%)	15.321	0.000***
	Exotic	52	4 (1.04%)		
Body Condition	Poor	77	31 (8.07%)	14.456	0.001*
	Medium	162	39 (10.15%)		
	Good	145	24 (6.25%)		

Remarks: * indicates there is a significant difference ($p < 0.05$); more annotation indicates highly significant with a significance level of 95%.

Associations between attributable factors and the anatomical sites of bruises

The analysis of attributable factors and anatomical sites of bruises in cattle, as presented in Table 4, revealed significant associations and patterns in injury prevalence. This study, which examined 384 cattle, identified several key risk factors contributing to bruising. Among the attributable factors, stick beating emerged as the most prevalent cause, affecting 8.85% of the animals, followed by falling (6%), horn thrust (5.47%), biting (2.3%), and unknown causes (1.8%).

Table 4. Effect of increasing CD4 levels with meditation therapy in patients with HIV/AIDS

Risk factor		Number of observation (n)	Prevalence	X ²	p-value
Attributable factors	Stick beating	34	8.85%	26.183	<0.001***
	Falling	23	6%		
	Horn thrust	21	5.47%		
	Bite	9	2.3%		
	Unknown	7	1.8%		
Anatomical Site	Back & loin	24	6.2%	39.237	<0.001***
	Ribs	21	5.5%		
	Brisket	18	4.7%		
	Hip	14	3.6%		
	Tigh	10	2.6%		
	Forequarter	7	1.8%		

Remarks: * indicates there is a highly significant difference ($p < 0.05$), with a significance level of 95%.

The chi-square test yielded a value of 26.183 with a p value <0.001 , indicating a statistically significant association between these factors and the occurrence of bruising. With respect to the anatomical distribution of bruises, the back and loin regions presented the highest prevalence at 6.2%, followed closely by the ribs (5.5%) and briskets (4.7%). Lower rates were observed in the hip (3.6%), thigh (2.6%), and forehead (1.8%). The chi-square value of 39.237 and p value of <0.001 for anatomical sites suggest a highly significant nonrandom distribution of bruises across different body regions. This pattern implies that certain areas are more susceptible to injury, possibly owing to exposure during handling or transport (Figure 4). The statistical significance observed for both attributable factors and anatomical sites ($p<0.001$) underscores the nonrandom nature of bruising incidents. These findings highlight the critical need for targeted interventions in cattle handling practices, with a focus on reducing the use of sticks for animal control and improving measures to prevent falls and horn-related injuries. Additionally, the concentration of bruises in high-value meat regions, such as the back, loins, and ribs, emphasizes the potential economic impact of these injuries on meat quality and yield.

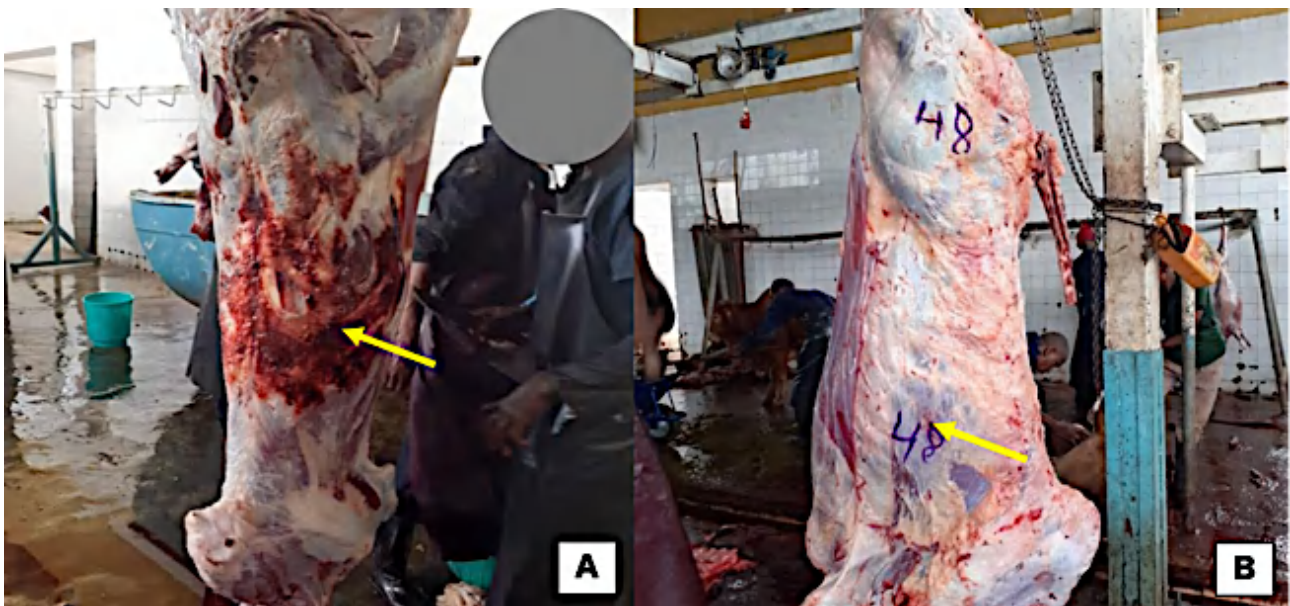


Figure 4. Highly distributed bruises in overall Carcass Slaughtered (A, B)

DISCUSSIONS

The present study revealed a prevalence of 24.48% (94 of 384) bruises in bovine carcasses slaughtered at the Jimma municipal abattoir. This prevalence was notably lower than that reported in previous studies conducted in various regions. For example, Harris et al. [19] reported a prevalence of 66.6% in beef breed cattle in the United States, whereas Kline [20] reported bruising in 64.1% of cow carcasses and 42.9% of bull carcasses. Degenhardt et al. [21] reported a prevalence of 45.33% in northern Portugal. This substantial variation in prevalence rates likely reflects complex interactions between infrastructure development, regulatory frameworks, and cultural practices in different regions. More specifically, the lower prevalence in our study may be attributed to shorter transportation distances, smaller herd sizes, and less mechanized handling systems commonly found in developing regions [22–24]. The markedly lower prevalence observed in the current study may be attributed to variations in transportation technologies and conditions between the study areas. This discrepancy underscores the importance of considering regional differences in animal handling practices and infrastructure when comparing bruising prevalence across studies [25,26].

The investigation of causative factors revealed a complex interplay between human behavior, animal characteristics, and environmental conditions [27]. This study further investigated the causative agents of bruising, revealing that stick beating is a significant factor. A statistically significant difference ($P<0.05$) was observed in the bruises associated with the different causative

agent categories. The highest prevalence of bruising was attributed to stick beating, whereas the lowest (1.8%) was associated with unknown causes. This finding aligns with studies by Mbiri et al. [28] who identified handler behavior as a critical determinant of bruising patterns in cattle. The predominance of stick beating as a causative factor suggests deeply ingrained handling practices that require systematic intervention at both training and policy levels. This finding highlights the detrimental effects of aggressive handling practices on animal welfare and carcass quality. It also emphasizes the need for improved training and awareness among handlers to minimize the use of physical force during cattle management [29–31].

Significant variations in bruising prevalence were observed across different cattle breeds ($P < 0.05$). Recent genetic studies have suggested that variations in skin thickness, muscle fiber composition, and stress responsiveness among breeds may contribute to differential bruising susceptibility [32]. This finding suggests that genetic factors or breed-specific characteristics may influence susceptibility to bruising, warranting further investigation of breed-specific handling and transport protocols. Gender analysis revealed a greater prevalence of bruises in male cattle (87.8%) than in female cattle (12.2%). This marked gender disparity may be explained by both physiological and behavioral factors, including higher testosterone levels in males affecting aggressive behavior and different muscle-to-fat ratios between sexes affecting tissue resilience. This substantial difference could be attributed to behavioral differences between the sexes, such as increased aggression or restlessness in males, or potentially to disparities in handling practices on the basis of gender. Further research is needed to elucidate the underlying reasons for this sex disparity in bruising prevalence [33–35].

Body condition was also found to be a significant factor, with the highest bruising rates recorded in cattle with poor body condition (40.25%). This finding aligns with that of a study conducted in Portugal by [1,20]. Recent biomechanical studies have demonstrated that reduced subcutaneous fat in poor-condition animals results in decreased tissue elasticity and shock absorption capacity, making these animals particularly vulnerable to mechanical trauma [5,36]. The increased susceptibility of animals with poor body condition to bruising may be due to reduced fat cover, which provides less cushioning against impacts. Additionally, these animals may be more prone to fatigue and falls during transport, further increasing the risk of bruising. This study emphasizes the critical role of cattle handling and transport conditions in the marketing and preslaughter processes [12]. Mechanical damage to animal tissues, resulting in bruises, can occur because of rough handling, violent impact, or aggression. Understanding the causative agents of bruises is crucial for developing effective strategies to reduce their prevalence, thereby improving cattle welfare and minimizing economic losses [2,37].

To address these issues, the implementation of careful handling and management measures is recommended. These measures may include segregating cattle on the basis of sex, age, and body condition during transport and lairage as well as providing appropriate training to handlers on low-stress handling techniques [38]. Additionally, the use of well-designed loading and unloading facilities, along with proper vehicle maintenance, can contribute to reducing the incidence of bruising during transportation. The study of carcass bruises serves as a valuable welfare indicator during the preslaughter stages, encompassing both the farm and transport phases [39–41]. By systematically documenting and analyzing bruising patterns, stakeholders in the meat industry can identify critical control points in the preslaughter process where interventions can be most effective [42–44]. This approach not only enhances animal welfare but also contributes to improved meat quality and reduced economic losses due to trimming waste.

During the study period, both ante- and postmortem examinations were performed. Antemortem inspection revealed various types of anatomical bruising in 24.48% (94 of 384) of the cattle examined at the Jimma municipal abattoir. The causative factors identified for these bruises were stick beating (8.9%), falling (6.00%), horn thrust (5.50%), bites (2.30%), and unknown causes (1.8%). This detailed breakdown of causative factors provides valuable insights into targeted interventions in handling and transporting practices [45–47]. The study concluded that bruising during transport remains a major concern, with significant implications for carcass quality and economic value. The impact of bruising is particularly evident in partially condemned

carcasses, highlighting the need for a holistic approach to mitigate this issue throughout the preslaughter process.

Practical implications

The findings of this study have significant practical implications for the cattle industry and abattoir management in Jimma and other similar regions. The prevalence of bruising highlighted the need for improved handling practices throughout the supply chain. The implementation of better training programs for handlers, transporters, and abattoir workers can significantly reduce the incidence of bruising. The identification of stick beating as the primary cause of bruising suggests that alternative, less harmful methods of cattle control should be adopted. Furthermore, the higher prevalence of bruising in cattle with poor body conditions indicates that special care should be taken when handling these animals. Abattoirs and transporters should consider implementing softer flooring and padding in vehicles and holding areas to minimize injuries from falling, which accounts for 6% of bruises.

Clinical implications

This study underscores the importance of ante- and postmortem examinations for identifying and managing bruising in cattle. The anatomical distribution of bruises, with the highest prevalence in the back and loin areas, suggests that veterinarians and meat inspectors should pay particular attention to these regions during examinations. The higher incidence of bruising in male cattle than in female cattle may necessitate sex-specific handling protocols. Moreover, the strong statistical associations between bruising and various factors, such as breed, body condition, and causative agents, provide valuable information for developing targeted interventions. Veterinarians and animal welfare officers can use these findings to advise on best practices to reduce bruising and improve overall cattle welfare during the preslaughter stages.

Limitations

Despite its valuable insights, this study has several limitations that should be acknowledged. First, the research was conducted in a single location (Jimma Municipal Abattoir), which may limit the generalizability of the findings to other regions or countries with different handling practices and transportation systems. Second, the study relied on visual inspection for bruise detection, which may have led to an underestimation of the true prevalence of bruising, particularly for deeper tissue injuries that are not visible on the surface. The cross-sectional nature of the study also prevents the establishment of causal relationships between the identified risk factors and bruising occurrence. Additionally, this study did not account for seasonal variations in bruising prevalence, which could be influenced by factors such as weather conditions and seasonal cattle movements. Finally, the economic impact of bruising was not quantified in this study, which could have provided additional context for the significance of the findings. Future research addressing these limitations may provide a more comprehensive understanding of cattle bruising and its implications.

CONCLUSIONS

This study provides valuable insights into the prevalence and risk factors associated with the bruising of bovine carcasses at the Jimma municipal abattoir. The findings revealed that 24.48% of the examined cattle (94 of 384) exhibited bruises, indicating a significant issue in terms of animal welfare and potential economic losses. The high prevalence of bruising suggests inadequate care during antemortem procedures, transportation, lairage, and slaughter at the abattoir. Transport has emerged as a major source of bruising, highlighting the critical role of handling and transport conditions in the preslaughter phase. This study also identified several influential factors contributing to carcass bruising, including causative agents, sex, age, breed, and body condition score of the cattle. Notably, the hip region was the most severely affected area, with bruises often extending into the muscle tissue intended for human consumption. These findings underscore the need for improved animal welfare practices and handling procedures in

the meat production chain. The prevalence of bruising not only reflects suboptimal animal welfare conditions but also represents significant economic losses for the industry. By identifying specific risk factors and patterns of bruising, this study provides a foundation for developing targeted interventions to reduce the incidence and severity of bruising.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision: AAM, WR. SAM.

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